Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
2250	Computational Biology	Introduction to Computational Biology	This class provides a general introduction to computational tools for biology. The course is divided into two halves. The first half covers computational molecular biology and genomics. It examines important sources of biological data, how they are archived and made available to researchers, and what computational tools are available to use them effectively in research. In the process, it covers basic concepts in statistics, mathematics, and computer science needed to effectively use these resources and understand their results. Specific topics covered include sequence data, searching and alignment, structural data, genome sequencing, genome analysis, genetic variation, gene and protein expression, and biological networks and pathways. The second half covers computational cell biology, including biological modeling and image analysis. It includes homework requiring modification of scripts to perform computational analyses. The modeling component includes computer models of population dynamics, biochemical kinetics, cell pathways, and neuron behavior. The imaging component includes the basics of machine vision, morphological image analysis, image classification and image-derived models. The course is taught under two different numbers. The lectures are the same for both but recitations and examinations are separate. 02-250 is intended primarily for computational biology, computer science, statistics or engineering majors at the undergraduate or graduate level who have had prior experience with computer science or programming. 03-250 is intended primarily for biological sciences or biomedical engineering majors who have had limited prior experience with computer science or programming. Students may not take both 02-250 and 03-250 for credit. Prerequisite: (02-201 or 15-110 or 15-112), or permission of the instructors.	U	4, 9, 8	focused
2251	Computational Biology	Great Ideas in Computational Biology	This 12-unit course provides an introduction to many of the great ideas that have formed the foundation for the recent transformation of life sciences into a fully-fledged computational discipline. Extracting biological understanding from both large and small data sets now requires the use and design of novel algorithms, developed in the field of computational biology. This gateway course is intended as a first exposure to computational biology for first-year undergraduates in the School of Computer Science, although it is open to other computationally minded 6students who are interested in exploring the field. Students will learn fundamental algorithmic and machine learning techniques that are used in modern biological investigations, including algorithms to process string, graph, and image data. They will use these techniques to answer questions such as "How do we reconstruct the sequence of a genome?", "How do we infer evolutionary relationships among many species?", and "How can we predict each gene's biological role?" on biological data. Previous exposure to molecular biology is not required, as the instructors will provide introductory materials as needed. After completion of the course, students will be well equipped to tackle advanced computational challenges in biology.	U	4, 15, 9	focused
2261	Computational Biology	Quantitative Cell and Molecular Biology Laboratory	This is an introductory laboratory-based course designed to teach basic biological laboratory skills used in exploring the quantitative nature of biological systems and the computational reasoning required for performing research in computational biology. Over the course of the semester, students will perform various experiments and computationally analyze the results of these experiments. Students will also use computation to design experiments based on the data they collect. During this course students will be using traditional, well-developed techniques as well as automated lab equipment to answer scientific questions: How should different sources of DNA in a specimen be identified? What changes do cells undergo during apoptosis? Understanding the results of these experiments will require students to think critically about the data they generate, the appropriate controls required to support their conclusions, and the biological context within which these results were obtained. During this course students will gain experience in many aspects of scientific research, including: designing and executing protocols for traditional and automated experiments, computational processing and analysis of collected results and communicating results to peers and colleagues. Course Outline: (1) 3-hour lab per week (1) 1-hour lecture per week. 9 units (12 units for CB majors). This course counts as a CSD Science and Engineering requirement as well as the lab requirement, and Dietrich College's Modeling/Science Gen Ed requirement.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
2331	Computational Biology	Modeling Evolution	Some of the most serious public health problems we face today, from drug-resistant bacteria, to cancer, all arise from a fundamental property of living systems -- their ability to evolve. Since Darwin's theory of natural selection was first proposed, we have begun to understand how heritable differences in reproductive success drive the adaptation of living systems. This makes it intuitive and tempting to view evolution from an optimization perspective. However, genetic drift, phenotypic trade-offs, constraints, and changing environments, are among the many factors that may limit the optimizing force of natural selection. This tug-of-war between selection and drift, between the forces that produce variation in a population, and the forces suppressing this variation, make evolutionary processes much more complex to model and understand than previously thought. The aim of this class is to provide an introduction into the theoretical formalism necessary to understand how biological systems are shaped by the forces and constraints driving evolutionary dynamics.	U	3, 10, 6	focused
2425	Computational Biology	Computational Methods for Proteogenomics and Metabolomics	Proteomics and metabolomics are the large scale study of proteins and metabolites, respectively. In contrast to genomes, proteomes and metabolomes vary with time and the specific stress or conditions an organism is under. Applications of proteomics and metabolomics include determination of protein and metabolite functions (including in immunology and neurobiology) and discovery of biomarkers for disease. These applications require advanced computational methods to analyze experimental measurements, create models from them, and integrate with information from diverse sources. This course specifically covers computational mass spectrometry, structural proteomics, proteogenomics, metabolomics, genome mining and metagenomics.	U	3, 17, 9	focused
2450	Computational Biology	Automation of Scientific Research	Automated scientific instruments are used widely in research and engineering. Robots dramatically increase the reproducibility of scientific experiments, and are often cheaper and faster than humans, but are most often used to execute brute-force sweeps over experimental conditions. The result is that many experiments are "wasted" on conditions where the effect could have been predicted. Thus, there is a need for computational techniques capable of selecting the most informative experiments. This course will introduce students to techniques from Artificial Intelligence and Machine Learning for automatically selecting experiments to accelerate the pace of discovery and to reduce the overall cost of research. Real-world applications from Biology, Bioengineering, and Medicine will be studied. Grading will be based on homeworks and two exams. The course is intended to be self-contained, but students should have a basic knowledge of biology, programming, statistics, and machine learning.	U	4, 9, 17	focused
2500	Computational Biology	Undergraduate Research in Computational Biology	This course is for undergraduate students who wish to do supervised research for academic credit with a Computational Biology faculty member. Interested students should first contact the Professor with whom they would like to work. If there is mutual interest, the Professor will direct you to the Academic Programs Coordinator and Asst Dept Head for Education.	U	4, 8, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
2510	Computational Biology	Computational Genomics	Dramatic advances in experimental technology and computational analysis are fundamentally transforming the basic nature and goal of biological research. The emergence of new frontiers in biology, such as evolutionary genomics and systems biology is demanding new methodologies that can confront quantitative issues of substantial computational and mathematical sophistication. In this course we will discuss classical approaches and latest methodological advances in the context of the following biological problems: 1) sequence analysis, focusing on gene finding and motifs detection, 2) analysis of high throughput molecular data, such as gene expression data, including normalization, clustering, pattern recognition and classification, 3) molecular and regulatory evolution, focusing on phylogenetic inference and regulatory network evolution, 4) population genetics, focusing on how genomes within a population evolve through recombination, mutation, and selection to create various structures in modern genomes and 5) systems biology, concerning how to combine diverse data types to make mechanistic inferences about biological processes. From the computational side this course focuses on modern machine learning methodologies for computational problems in molecular biology and genetics, including probabilistic modeling, inference and learning algorithms, data integration, time series analysis, active learning, etc. This course may be taken for 12 units, which requires completion of a course project, or for 9 units, which does not.	U	4, 9, 17	focused
2512	Computational Biology	Computational Methods for Biological Modeling and Simulation	This course covers a variety of computational methods important for modeling and simulation of biological systems. It is intended for graduates and advanced undergraduates with either biological or computational backgrounds who are interested in developing computer models and simulations of biological systems. The course will emphasize practical algorithms and algorithm design methods drawn from various disciplines of computer science and applied mathematics that are useful in biological applications. The general topics covered will be models for optimization problems, simulation and sampling, and parameter tuning. Course work will include problem sets with significant programming components and independent or group final projects.	U	4, 9, 17	focused
2518	Computational Biology	Computational Medicine	Modern medical research increasingly relies on the analysis of large patient datasets to enhance our understanding of human diseases. This course will focus on the computational problems that arise from studies of human diseases and the translation of research to the bedside to improve human health. The topics to be covered include computational strategies for advancing personalized medicine, pharmacogenomics for predicting individual drug responses, metagenomics for learning the role of the microbiome in human health, mining electronic medical records to identify disease phenotypes, and case studies in complex human diseases such as cancer and asthma. We will discuss how machine learning methodologies such as regression, classification, clustering, semi-supervised learning, probabilistic modeling, and time-series modeling are being used to analyze a variety of datasets collected by clinicians. Class sessions will consist of lectures, discussions of papers from the literature, and guest presentations by clinicians and other domain experts. Grading will be based on homework assignments and a project. 02-250 is a suggested pre-requisite.	U	3, 4, 17	focused
2540	Computational Biology	Bioimage Informatics	With the rapid advance of bioimaging techniques and fast accumulation of bioimage data, computational bioimage analysis and modeling are playing an increasingly important role in understanding of complex biological systems. The goals of this course are to provide students with the ability to understand a broad set of practical and cutting-edge computational techniques to extract knowledge from bioimages.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
2601	Computational Biology	Programming for Scientists	Provides a practical introduction to programming for students with little or no prior programming experience who are interested in science. Fundamental scientific algorithms will be introduced, and extensive programming assignments will be based on analytical tasks that might be faced by scientists, such as parsing, simulation, and optimization. Principles of good software engineering will also be stressed, and students will have the opportunity to design their own programming project on a scientific topic of their choice. The course will introduce students to the Go programming language, an industry-supported, modern programming language, the syntax of which will be covered in depth. Other assignments will be given in other programming languages such as Python and Java to highlight the commonalities and differences between languages. No prior programming experience is assumed, and no biology background is needed. Analytical skills and mathematical maturity are required. Course not open to CS majors.	G	4, 9, 17	focused
2602	Computational Biology	Professional Issues for Computational and Automated Scientists	This course gives Master's in Computational Biology and Master's in Automated Science students the opportunity to develop the professional skills necessary for a successful career in either academia or industry. This course, required in the first semester of both programs, will include assistance with elevator pitches, interview preparation, resume and cover letter writing, networking, and presentation skills. The course will also include opportunities to connect with computational biology professionals as part of industry outreach. The course will meet once a week and is pass/fail only.	G	4, 9, 17	focused
2604	Computational Biology	Fundamentals of Bioinformatics	How do we find potentially harmful mutations in your genome? How can we reconstruct the Tree of Life? How do we compare similar genes from different species? These are just three of the many central questions of modern biology that can only be answered using computational approaches. This 12-unit course will delve into some of the fundamental computational ideas used in biology and let students apply existing resources that are used in practice every day by thousands of biologists. The course offers an opportunity for students who possess an introductory programming background to become more experienced coders within a biological setting. As such, it presents a natural next course for students who have completed 02-601.	G	4, 15, 14	focused
2605	Computational Biology	Professional Issues in Automated Science	This course gives MS in Automated Science students an opportunity to develop professional skills necessary for a successful career in computational biology. This course will include assistance with resume writing, interview preparation, presentation skills, and job search techniques. This course will also include opportunities to network with computational biology professionals and academic researchers.	G	4, 8, 17	focused
2613	Computational Biology	Algorithms and Advanced Data Structures	The objective of this course is to study algorithms for general computational problems, with a focus on the principles used to design those algorithms. Efficient data structures will be discussed to support these algorithmic concepts. Topics include: Run time analysis, divide-and-conquer algorithms, dynamic programming algorithms, network flow algorithms, linear and integer programming, large-scale search algorithms and heuristics, efficient data storage and query, and NP-completeness. Although this course may have a few programming assignments, it is primarily not a programming course. Instead, it will focus on the design and analysis of algorithms for general classes of problems. This course is not open to CS graduate students who should consider taking 15-651 instead. 02-250 is a suggested prerequisite for undergraduates.	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
2620	Computational Biology	Machine Learning for Scientists	With advances in scientific instruments and high-throughput technology, scientific discoveries are increasingly made from analyzing large-scale data generated from experiments or collected from observational studies. Machine learning methods that have been widely used to extract complex patterns from large speech, text, and image data are now being routinely applied to answer scientific questions in biology, bioengineering, and medicine. This course is intended for graduate students interested in learning machine learning methods for scientific data analysis and modeling. It will cover classification and regression techniques such a logistic regression, random forest regression, Gaussian process regression, decision trees, and support vector machines; unsupervised learning methods such as clustering algorithms, mixture models, and hidden Markov models; probabilistic graphical models and deep learning methods; and learning theories such as PAC learning and VC dimension. The course will focus on applications of these methods in genomics and medicine. Programming skills and basic knowledge of linear algebra, probability, statistics are assumed.	G	4, 15, 9	focused
2680	Computational Biology	Essential Mathematics and Statistics for Scientists	This course is for first year master's students looking for a rigorous introduction to mathematics and statistics as preparation for more advanced coursework in computational courses. Closed to enrollment for undergraduates.	G	4, 9, 17	focused
2700	Computational Biology	M.S. Thesis Research	This course is for M.S. students who wish to do supervised research for academic credit with a Computational Biology faculty member. Interested students should first contact the Professor with whom they would like to work. If there is mutual interest, the Professor will direct you to the Academic Programs Coordinator, who will enroll you in the course.	G	4, 17, 8	focused
2710	Computational Biology	Computational Genomics	Dramatic advances in experimental technology and computational analysis are fundamentally transforming the basic nature and goal of biological research. The emergence of new frontiers in biology, such as evolutionary genomics and systems biology is demanding new methodologies that can confront quantitative issues of substantial computational and mathematical sophistication. From the computational side this course focuses on modern machine learning methodologies for computational problems in molecular biology and genetics, including probabilistic modeling, inference and learning algorithms, data integration, time series analysis, active learning, etc. This course counts as a CSD Applications elective	G	4, 9, 17	focused
2712	Computational Biology	Computational Methods for Biological Modeling and Simulation	This course covers a variety of computational methods important for modeling and simulation of biological systems. It is intended for graduates and advanced undergraduates with either biological or computational backgrounds who are interested in developing computer models and simulations of biological systems. The course will emphasize practical algorithms and algorithm design methods drawn from various disciplines of computer science and applied mathematics that are useful in biological applications. The general topics covered will be models for optimization problems, simulation and sampling, and parameter tuning. Course work will include problem sets with significant programming components and independent or group final projects.	G	4, 9, 17	focused
2718	Computational Biology	Computational Medicine	Modern medical research increasingly relies on the analysis of large patient datasets to enhance our understanding of human diseases. This course will focus on the computational problems that arise from studies of human diseases and the translation of research to the bedside to improve human health. The topics to be covered include computational strategies for advancing personalized medicine, pharmacogenomics for predicting individual drug responses, metagenomics for learning the role of the microbiome in human health, mining electronic medical records to identify disease phenotypes, and case studies in complex human diseases such as cancer and asthma. We will discuss how machine learning methodologies such as regression, classification, clustering, semi-supervised learning, probabilistic modeling, and time-series modeling are being used to analyze a variety of datasets collected by clinicians. Class sessions will consist of lectures, discussions of papers from the literature, and guest presentations by clinicians and other domain experts. Grading will be based on homework assignments and a project. 02-250 is a suggested pre-requisite.	G	3, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
2725	Computational Biology	Computational Methods for Proteogenomics and Metabolomics	Proteomics and metabolomics are the large scale study of proteins and metabolites, respectively. In contrast to genomes, proteomes and metabolomes vary with time and the specific stress or conditions an organism is under. Applications of proteomics and metabolomics include determination of protein and metabolite functions (including in immunology and neurobiology) and discovery of biomarkers for disease. These applications require advanced computational methods to analyze experimental measurements, create models from them, and integrate with information from diverse sources. This course specifically covers computational mass spectrometry, structural proteomics, proteogenomics, metabolomics, genome mining and metagenomics.	G	3, 17, 9	focused
2730	Computational Biology	Cell and Systems Modeling	This course will introduce students to the theory and practice of modeling biological systems from the molecular to the organism level with an emphasis on intracellular processes. Topics covered include kinetic and equilibrium descriptions of biological processes, systematic approaches to model building and parameter estimation, analysis of biochemical circuits modeled as differential equations, modeling the effects of noise using stochastic methods, modeling spatial effects, and modeling at higher levels of abstraction or scale using logical or agent-based approaches. A range of biological models and applications will be considered including gene regulatory networks, cell signaling, and cell cycle regulation. Weekly lab sessions will provide students hands-on experience with methods and models presented in class. Course requirements include regular class participation, bi-weekly homework assignments, a take-home exam, and a final project. The course is designed for graduate and upper-level undergraduate students with a wide variety of backgrounds. The course is intended to be self-contained but students may need to do some additional work to gain fluency in core concepts. Students should have a basic knowledge of calculus, differential equations, and chemistry as well as some previous exposure to molecular biology and biochemistry. Experience with programming and numerical computation is useful but not mandatory. Laboratory exercises will use MATLAB as the primary modeling and computational tool augmented by additional software as needed. *THIS COURSE WILL BE AT PITT	G	4, 9, 17	focused
2731	Computational Biology	Modeling Evolution	Some of the most serious public health problems we face today, from drug-resistant bacteria, to cancer, all arise from a fundamental property of living systems -- their ability to evolve. Since Darwin's theory of natural selection was first proposed, we have begun to understand how heritable differences in reproductive success drive the adaptation of living systems. This makes it intuitive and tempting to view evolution from an optimization perspective. However, genetic drift, phenotypic trade-offs, constraints, and changing environments, are among the many factors that may limit the optimizing force of natural selection. This tug-of-war between selection and drift, between the forces that produce variation in a population, and the forces suppressing this variation, make evolutionary processes much more complex to model and understand than previously thought. The aim of this class is to provide an introduction into the theoretical formalism necessary to understand how biological systems are shaped by the forces and constraints driving evolutionary dynamics.	G	3, 10, 6	focused
2740	Computational Biology	Bioimage Informatics	With the rapid advance of bioimaging techniques and fast accumulation of bioimage data, computational bioimage analysis and modeling are playing an increasingly important role in understanding of complex biological systems. The goals of this course are to provide students with the ability to understand a broad set of practical and cutting-edge computational techniques to extract knowledge from bioimages.	G	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
2750	Computational Biology	Automation of Scientific Research	Automated scientific instruments are used widely in research and engineering. Robots dramatically increase the reproducibility of scientific experiments, and are often cheaper and faster than humans, but are most often used to execute brute-force sweeps over experimental conditions. The result is that many experiments are "wasted" on conditions where the effect could have been predicted. Thus, there is a need for computational techniques capable of selecting the most informative experiments. This course will introduce students to techniques from Artificial Intelligence and Machine Learning for automatically selecting experiments to accelerate the pace of discovery and to reduce the overall cost of research. Real-world applications from Biology, Bioengineering, and Medicine will be studied. Grading will be based on homeworks and two exams. The course is intended to be self-contained, but students should have a basic knowledge of biology, programming, statistics, and machine learning.	G	4, 9, 17	focused
2760	Computational Biology	Laboratory Methods for Computational Biologists	Computational biologists frequently focus on analyzing and modeling large amounts of biological data, often from high-throughput assays or diverse sources. It is therefore critical that students training in computational biology be familiar with the paradigms and methods of experimentation and measurement that lead to the production of these data. This one-semester laboratory course gives students a deeper appreciation of the principles and challenges of biological experimentation. Students learn a range of topics, including experimental design, structural biology, next generation sequencing, genomics, proteomics, bioimaging, and high-content screening. Class sessions are primarily devoted to designing and performing experiments in the lab using the above techniques. Students are required to keep a detailed laboratory notebook of their experiments and summarize their resulting data in written abstracts and oral presentations given in class-hosted lab meetings. With an emphasis on the basics of experimentation and broad views of multiple cutting-edge and high-throughput techniques, this course is appropriate for students who have never taken a traditional undergraduate biology lab course, as well as those who have and are looking for introductory training in more advanced approaches. Grading: Letter grade based on class participation, laboratory notebooks, experimental design assignments, and written and oral presentations. 02-250 is a suggested pre-requisite.	G	4, 9, 15	focused
2761	Computational Biology	Laboratory Methods for Automated Biology I	In order to rapidly generate reproducible experimental data, many modern biology labs leverage some form of laboratory automation to execute experiments. In the not so distant future, the use of laboratory automation will continue to increase in the biological lab to the point where many labs will be fully automated. Therefore, it is critical for automation scientists to be familiar with the principles, experimental paradigms, and techniques for automating biological experimentation with an eye toward the fully automated laboratory. In this laboratory course, students will learn about various automatable experimental methods, design of experiments, hardware for preparing samples and executing automated experiments, and software for controlling that hardware. These topics will be taught in lectures as well as through laboratory experience using multi-purpose laboratory robotics. During weekly laboratory time, students will complete and integrate parts of two larger projects. The first project will be focused on liquid handling, plate control, plate reading, and remote control of the automated system based on experimental data. The second project will be focused on the design, implementation, and analysis of a high content screening campaign using fluorescence microscopy, image analysis, and tissue culture methods.	G	4, 9, 17	focused
2762	Computational Biology	Laboratory Methods for Automated Biology II	This laboratory course provides a continuation and extension of experiences in 02-761. Instruction will consist of lectures and laboratory experience using multi-purpose laboratory robotics. During weekly laboratory time, students will complete and integrate parts of two larger projects. The first project will be focused on the execution of a molecular biology experiment requiring nucleic acid extraction, library preparation for sequencing, and quality control. The second project will be focused on the implementation and execution of automated methods using active learning techniques to direct the learning of a predictive model for a large experimental space (such as learning the effects of many possible drugs on many possible targets). Grading will be based on lab and project completion and quality.	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
2763	Computational Biology	Automated Science Capstone I	This course consists of small group projects on development, implementation and/or execution of automated science campaigns in collaboration with industry and/or academic partners. Projects will be either 4.5 months or 9 months in duration depending on whether 02-764 will also be taken. Enrollment is only open to M.S. in Automated Science students.	G	4, 9, 17	focused
2764	Computational Biology	Automated Science Capstone II	This course consists of small group projects on development, implementation and/or execution of automated science campaigns in collaboration with industry and/or academic partners. This course may only be taken as part of a continuous sequence with 02-763. Enrollment is only open to M.S. in Automated Science students.	G	4, 9, 17	focused
2801	Computational Biology	Computational Biology Internship	This course allows a student to gain computational biology experience in a real-world setting. Internships vary widely in scope, but common to all is the chance to practice computational biology skills acquired in the classroom. Typically, students seek and secure their own internships. Internships must be approved by CPCB Program Directors and will be in place of 02-900 for 1 semestser.	G	4, 17, 8	focused
2900	Computational Biology	Ph.D. Thesis Research	This course is for Ph.D students doing supervised research for academic credit.	G	4, 17, 8	focused
3116	Biological Sciences	Phage Genomics Research	Spring Semester: The DNA sequences will be analyzed with bioinformatic tools and compared with those of phages isolated at other locations to identify genes, their organization, the differences that may characterize different phage groups, and how these have arisen during evolution.	U	17, 4, 10	focused
3117	Biological Sciences	Frontiers, Analysis, and Discovery in Biological Sciences	In this hands-on laboratory class, students will investigate a current biology problem. Students will read literature articles, design hypotheses, plan and carry out experiments, analyze and interpret data, and design future questions as part of a collaborative research team. In addition, teams will work with faculty and fellow students to understand and explore the relevance of their projects in the field of biology and other disciplines. Finally, teams will communicate results in an oral presentation to peers and faculty. Students will gain research skills, analytical skills, communication skills (both written and oral), and project design skills.	U	4, 17, 9	focused
3118	Biological Sciences	Beer: A Yeast's Perspective	This is a combined lecture and laboratory course in which students will investigate the biochemistry of fermentation using strains of yeast commonly used in brewing science. Lectures and readings will cover all necessary information to succeed in the course, including topics like yeast metabolism, fermentation at the micro and industrial levels, and a history of fermentation's influence on society. Lab experiments will investigate yeast growth and fermentation processes in various strains used in brewing, and quantitative assessments of beer at the molecular level. The course puts a focus on microbiology lab techniques and yeast biochemistry; however, no previous lab experience or biology coursework is required, and anyone with an interest in the science behind brewing yeast can succeed in the class.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
3120	Biological Sciences	Biology for Life Special Topics Mini	Special Topics in Biological Sciences Mini Courses. Topics will vary depending on the semester and instructor. Courses offered under this course number will not require prior knowledge of or exposure to biological sciences and are open to students from any major and class year. Please read individual section descriptions for more information. Fall 2019 Section A1: "Germs": The Good, The Bad, and The Ugly Bacteria are a scourge to humankind, causing life-threatening infections like tuberculosis, meningitis, and pneumonia to the less severe ear infections and strep throats that plague many childhoods. On the other hand, the healthy human microbiota is a community of microorganisms dominated by trillions of bacteria that reside everywhere from our skin to nasal passages and gut. This "virtual organ" is estimated to weigh as much as the human brain and contributes to essential bodily functions like food metabolism and defense against infection, while also impacting memory, anxiety, and depression. Changes in the gut microbiota are also associated with diseases including autism, obesity, allergies, and inflammatory bowel disease. Why the incidence of these chronic diseases is increasing is unclear, but it may be the result of excessive antibiotic use, dietary changes that harm our gut microbes, or both. This century will be marked by both the challenge of antibiotic resistant infectious "bad" bacteria, and the possibilities to harness "good" bacteria to promote human health. In this course, we explore how bacteria make you healthy and what we can do to nurture our microbiota, and how bacteria make you sick and what we can do to stop them. Spring 2020 Section A1: "How Stuff Kills You"	U	3, 4, 2	focused
3121	Biological Sciences	Modern Biology	This is an introductory course that provides the basis for further studies in biochemistry, cell biology, genetics and molecular biology. This course emphasizes the chemical principles underlying biological processes and cell structures as well as the analysis of genetics and heredity from a molecular perspective. This is the introductory biology course for all science and non-science majors.	U	9, 4, 6	focused
3124	Biological Sciences	Modern Biology Laboratory	This laboratory is designed to introduce students to modern concepts in the biological sciences. The experiments illustrate many of the principles covered in 03-121 and 03-230. Experimentation using living organisms and/or their tissues, cells or molecules is an essential component of this course.	U	4, 9, 15	focused
3125	Biological Sciences	Evolution	Evolutionary theory is the unifying principle of biology. A good comprehension of the concepts that underlie this theory is therefore important to properly appreciate and understand any biological process. This course is designed for students intending to continue studies in biology so that they may gain an understanding of the evolutionary framework in their more advanced courses, and also non-biology majors who want to extend their knowledge of biology at an introductory level. The lectures will include (i) an examination of the history and development of evolutionary theory, (ii) consideration of some of the facts that have established the theory, (iii) an introduction to the concepts of phylogenetics, (iv) discussion of the patterns and mechanism that lead to the diversity and origins of the groups of life, (v) an introduction to genetics and population genetic theory, and (vi) discussion of and how this applies to natural selection and speciation. The course will also include some more specialist topics, including evolution of development, sexual selection, evolutionary applications to medicine and conservation biology, and genome evolution. Assessment will be based on several in-class exams and quizzes, homework assignments, a written term paper, and a final exam.	U	15, 4, 5	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
3128	Biological Sciences	Biology for Life Special Topics	Special Topics in Biological Sciences. Topics will vary depending on the semester and instructor. Courses offered under this course number will not require prior knowledge of or exposure to biological sciences and are open to students from any major and class year. Please read individual section descriptions for more information. Fall 2019 Section A: Environmental Science Environmental science is a highly interdisciplinary field that integrates knowledge and modes of inquiry from across the sciences to understand some of the most important challenges of 21st century. This course provides a foundational background in scientific method, critical thinking and problem solving strategies used to study and evaluate the environment. Modules include, principles of ecology and eco-systems, biological diversity, biogeochemical cycles, endangered species management, human population growth, atmosphere, climate and global warming. Assessment will include class attendance, quizzes, individual and small group projects, in class exams. Projects may involve visits to local sites. Spring 2020 Section A: Environmental Science Environmental science is a highly interdisciplinary field that integrates knowledge and modes of inquiry from across the sciences to understand some of the most important challenges of 21st century. This course provides a foundational background in scientific method, critical thinking and problem solving strategies used to study and evaluate the environment. Modules include, principles of ecology and eco-systems, biological diversity, biogeochemical cycles, endangered species management, human population growth, atmosphere, climate and global warming. Assessment will include class attendance, quizzes, individual and small group projects, in class exams. Projects may involve visits to local sites.	U	13, 15, 8	focused
3133	Biological Sciences	Neurobiology of Disease	This course will explore the biological basis of several neurological and neuropsychiatric diseases, with an emphasis on medical diagnostic tools and techniques. It will include discussions of the anatomical basis of neurological diseases as well as recent research into understanding the mechanisms of disease. This course is intended to broaden students' understanding of how diseases are diagnosed and studied. Students will also learn how basic neurological and psychiatric evaluations are conducted and gain proficiency in these evaluation techniques. We will discuss neurobiological research to serve as a basis for understanding brain structures and functional alterations in a variety of developmental, degenerative, neurological, and psychiatric disorders.	U	3, 4, 17	focused
3135	Biological Sciences	Structure and Function of the Human Body	Structure and Function of the Human Body is a non-majors course designed to explore fundamental relationships between form and function of the human body. The anatomy and physiology of major organ systems will be studied in the context of normal and disease states. Because no prerequisite knowledge is required, students will learn about critical biological processes such as the central dogma, membrane diffusion and transport, cell signaling, gas exchange, blood flow, nutrient absorption, blood pH balance, and action potential generation and propagation. Students will then apply this knowledge to understand how organs respond to various inputs in maintaining homeostasis. Hands-on demonstrations will be incorporated to provide a practical framework for the information presented in lectures. At the culmination of the semester, students will gain a broad understanding of how the body systems function at the cellular, tissue and organ levels and be able to relate simple physiological processes to better understand highly prevalent diseases in society.	U	3, 4, 11	focused
3140	Biological Sciences	Ecology and Environmental Science	Environmental science is a highly interdisciplinary field that integrates knowledge and modes of inquiry from across the sciences to understand some of the most important challenges of the 21st century. This course provides a foundational background in scientific method, critical thinking and problem solving strategies used to study and evaluate the environment. Modules include: principles of ecology and eco-systems, biological diversity, biogeochemical cycles, endangered species management, human population growth, atmosphere, climate and global warming. Assessment will include class attendance, quizzes, individual and small group projects, in class exams. Projects may involve visits to local sites.	U	13, 15, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
3151	Biological Sciences	Honors Modern Biology	This course will cover in some depth, the basics of the structure and function of the major biomolecules in the cell, cellular structure and function, genetic replication, transmission and expression of biological information, and cell-cell interactions. While similar core topics will be covered in all sections of Modern Biology, this section will be offered at an accelerated pace, requiring more independent learning. The extra class time this pacing provides will allow the exploration of the molecular basis of life to help students integrate and apply the core principles of biology covered in the course. THIS SECTION IS RESERVED FOR INCOMING FIRST-YEAR MCS STUDENTS.	U	4, 17, 9	focused
3161	Biological Sciences	Molecules to Mind	This course provides a depth-first approach to understanding neuroscience. We will begin with a clinical focus on neuroanatomy, introducing students to some basic neurological diagnostic techniques. We will then explore the biological basis of neuronal function and link the function of individual neurons to a broader context of neural systems. This will be done in the context of primary literature. Students who complete this course will therefore have an understanding of research methods and be prepared to evaluate scientific literature. The course will have a strong focus on the biological and cellular basis of neuronal excitability and also give students significant, in depth exposure to the function of synapses and their plasticity. Finally, the course will give students an in depth look at sensory and/or motor systems by focusing on one system in particular.	U	4, 17, 9	focused
3201	Biological Sciences	Undergraduate Colloquium for Sophomores	The purpose of this seminar series is to update biology undergraduates about university and departmental functions, seminars, etc. that are pertinent or useful. In addition, research talks by faculty and undergraduates will be used to introduce students to the research being conducted in faculty laboratories. Additional topics may include graduate and medical school applications, career options, topics in the press, and important scientific discoveries.	U	4, 17, 8	focused
3206	Biological Sciences	Biomedical Engineering Laboratory	This laboratory course is designed to provide students with the ability to make measurements on and interpret data from living systems. The experimental modules reinforce concepts from 42-101 Introduction to Biomedical Engineering and expose students to four areas of biomedical engineering: biomedical signal and image processing, biomaterials, biomechanics, and cellular and molecular biotechnology. Several cross-cutting modules are included as well. The course includes weekly lectures to complement the experimental component. Priority for enrollment will be given to students who have declared the Additional Major in Biomedical Engineering. Notes: This course number is reserved for students who are CIT majors and registered with the HPP program. If you require a biology lab for pre-health admissions requirements, please contact Dr. Conrad Zapanta and Dr. Maggie Braun (in the same email) for permission to register for 03-206 instead of 42-203. Priority for enrollment will be given to students who have declared the Additional Major in Biomedical Engineering.	U	4, 9, 2	focused
3220	Biological Sciences	Genetics	The mechanisms of transmission of inherited traits in viruses, bacteria, fungi, plants and animals are discussed. Molecular mechanisms of gene expression and gene regulation are analyzed. Recombinant DNA and its applications in genetic analysis, biotechnology, forensics, agriculture, medicine, and the pharmaceutical industry are presented. Special topics in human genetics are considered, such as the genetics of cancer. Principles and methods for the study of developmental genetics, population genetics and complex traits are also introduced.	U	3, 2, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
3221	Biological Sciences	Genomes, Evolution, and Disease: Introduction to Quantitative Genetic Analysis	Scientific and technical advances in genetics have accelerated dramatically since the draft human genome sequence was published in 2001. The development of massively parallel DNA sequencing and associated technologies has transformed the way we approach genetic questions. Contemporary genetics is increasingly concerned with generating, processing and analyzing vast amounts of data to extract information about genetic variation, expression, interactions and associations. At the same time, comparative genomics, bioinformatic and reverse genetic methods are transforming the way in which gene functions are investigated, while the development of powerful methods for precise modification of genomes is opening the way to cell- and gene-based therapies for disease. In parallel, the promise of precision or personalized medicine is predicated on advances in understanding of complex traits, genetic interactions and networks. These and other topics will be covered following a review of basic principles of gene structure and expression, the fundamental principles of Mendelian genetics, and their underpinnings in cellular mechanisms for the replication, recombination and transmission of genetic material. Although the topics overlap extensively with 03220 (Genetics), they will be presented at a more advanced level, with a greater emphasis on current methods of quantitative and statistical analysis. This course is recommended for students with a particular interest in emerging technologies for analysis of human genetics, genomics, gene therapy and precision medicine.	U	3, 4, 9	focused
3231	Biological Sciences	Honors Biochemistry	This course provides an introduction to molecules and processes found in living systems. Amino acids, sugars, lipids and nucleotides and their corresponding higher structures, proteins, polysaccharides, membranes and nucleic acids are studied. Kinetics and mechanisms of enzymes as well as elementary metabolic cycles and the energetics of biological systems are studied with a quantitative approach.	U	4, 9	focused
3232	Biological Sciences	Biochemistry I	This course provides an introduction to the application of biochemistry to biotechnology. The functional properties of amino acids, nucleotides, lipids, and sugars are presented. This is followed by a discussion of the structural and thermodynamic aspects of the organization of these molecules into higher-order structures, such as proteins, nucleic acids, and membranes. The kinetics and thermodynamics of protein-ligand interactions are discussed for non-cooperative, cooperative, and allosteric binding events. The use of mechanistic and kinetic information in enzyme characterization and drug discovery are discussed. Topics pertinent to biotechnology include: antibody production and use, energy production in biochemical systems, expression of recombinant proteins, and methods of protein purification and characterization. The course is an alternate to 03-231.	U	7, 9, 13	focused
3320	Biological Sciences	Cell Biology	This course provides descriptive information and mechanistic detail concerning key cellular processes in six areas: membrane function, protein targeting, signaling, cytoskeleton, cell division, and cell interaction. An attempt is made to introduce the methodology that was used to obtain this information and to discuss how our understanding of these processes relates to the treatment of human disease.	U	3, 4, 9	focused
3342	Biological Sciences	Introduction to Biological Laboratory Practices	This course is designed for students in the BS in Computational Biology degree program. It is a required co-requisite for 03-343, Experimental Genetics and Molecular Biology and is designed to be an introduction to basic laboratory practices. The course will introduce biological and chemical safety training and basic laboratory practices. Techniques of solution preparation and titration, pipetting, UV/VIS spectroscopy, and quantitation of biological compounds will be covered.	U	4, 6, 12	focused
3343	Biological Sciences	Experimental Techniques in Molecular Biology	This laboratory course is designed to teach experimental methods of modern biology. Experiments in microbial genetics, molecular biology and eukaryotic genetics are performed. Emphasis is placed on understanding and applying the biological principles of each experiment. This course is designed to be taken during the junior year and is intended to prepare students for undergraduate research. Experimentation using living organisms and/or their tissues, cells or molecules is an essential component of this course.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
3344	Biological Sciences	Experimental Biochemistry	This course is designed to be taken as a sequel to 03-343. Experiments cover a variety of methods for investigating the structure and function of biological molecules. Experimental methods with proteins, enzyme kinetics, lipids, spectroscopy, and isolation and quantization of biological molecules are covered. During several experiments, students design their own projects. Experimentation using living organisms and/or their tissues, cells or molecules is an essential component of this course.	U	4, 9, 15	focused
3346	Biological Sciences	Experimental Neuroscience	This laboratory is designed to teach concepts and experimental methods in neurobiology. Students work with a variety of organisms to study the anatomy, function, and development of the nervous system. Immunological, molecular, biochemical, and ballistic labeling techniques are used to examine the gene expression and structure in the mature and developing nervous system. Students study the function of neurons through neurophysiological techniques in invertebrates and computer simulation. This course makes extensive use of video microscopy and phase contrast, DIC, and fluorescence microscopes.	U	4, 17, 9	focused
3350	Biological Sciences	Developmental Biology	How does a complex, multicellular organism arise from a single cell? How do cells with identical genomes acquire distinctive properties? What are the medical consequences of abnormal embryonic development? How does regeneration occur? How has evolution modified developmental programs to produce different body plans? These are some of the central questions in the field of developmental biology. This course serves as an introduction to current concepts and experimental approaches in this rapidly advancing field. Topics in the course include genomics, differential gene expression, cell signaling, cell movements, tissue morphogenesis, stem cells, human development, and regeneration. The course examines the genes and signaling pathways that control development and the role that mis-regulation of these pathways plays in human disease.	U	3, 17, 4	focused
3360	Biological Sciences	Genomics and Epigenetics of the Brain	This course will provide an introduction to genomics, epigenetics, and their application to problems in neuroscience. The rapid advances in genomic technology are in the process of revolutionizing how we conduct molecular biology research. These new techniques have given us an appreciation for the role that epigenetics modifications of the genome play in gene regulation, development, and inheritance. In this course, we will cover the biological basis of genomics and epigenetics, the basic computational tools to analyze genomic data, and the application of those tools to neuroscience. Through programming assignments and reading primary literature, the material will also serve to demonstrate important concepts in neuroscience, including the diversity of neural cell types, neural plasticity, the role that epigenetics plays in behavior, and how the brain is influenced by neurological and psychiatric disorders. Although the course focuses on neuroscience, the material is accessible and applicable to a wide range of topics in biology.	U	9, 17, 10	focused
3362	Biological Sciences	Cellular Neuroscience	Modern neuroscience is an interdisciplinary field that seeks to understand the function of the brain and nervous system. This course provides a comprehensive survey of cellular and molecular neuroscience ranging from molecules to simple neural circuits. Topics covered will include the properties of biological membranes, the electrical properties of neurons, neural communication and synaptic transmission, mechanisms of brain plasticity and the analysis of simple neural circuits. In addition to providing information the lectures will describe how discoveries were made and will develop students' abilities to design experiments and interpret data.	U	4, 9	focused
3363	Biological Sciences	Systems Neuroscience	Modern neuroscience is an interdisciplinary field that seeks to understand the function of the brain and nervous system. This course provides a comprehensive survey of systems neuroscience, a rapidly growing scientific field that seeks to link the structure and function of brain circuitry to perception and behavior. This course will explore brain systems through a combination of classical, Nobel prize-winning data and cutting edge primary literature. Topics will include sensory systems, motor function, animal behavior and human behavior in health and disease. Lectures will provide fundamental information as well as a detailed understanding of experimental designs that enabled discoveries. Finally, students will learn to interpret and critique the diverse and multimodal data that drives systems neuroscience.	U	3, 4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
3365	Biological Sciences	Neural Correlates of Learning and Memory	This course will examine the biological substrates of learning, memory, and behavioral adaptation. The focus will be on addressing how neural circuits change during new skill acquisition and adapt to variations in the environment. An introduction to experience-dependent changes in neural structure and function, in addition to behavioral learning paradigms, will be provided. Then we will consider the ways in which specific changes in biological substrates give rise to the emergent properties that drive behavioral adaptation, followed by in depth coverage of deciphering which biological substrates constitute a lasting memory trace. Finally, the concept of age-dependent learning will be examined. Concepts and specific examples will come through reading of primary literature and selected readings from advanced texts.	U	4, 12, 9	focused
3366	Biological Sciences	Biochemistry of the Brain	This course is designed to give students a comprehensive understanding of the major neurotransmitter systems in the brain. Students will explore qualitative and quantitative approaches to understanding how various neurotransmitters function as well as how they are modulated by endogenous and exogenous agents. The qualitative exploration will include basic principles of neural communication, signal transduction and second messenger systems, main classes of neurotransmitters, and the effects of medications and drugs of abuse. Quantitatively, we will explore the kinetics of neurotransmitter binding, affinity of different receptors for their neurotransmitters, and apply concepts of competitive, uncompetitive, and mixed inhibition to understanding the effects of exogenous agonists and antagonists on these receptors. Students will learn how these qualitative and quantitative biochemical processes affect the endocrine system, neuroinflammatory responses, addictive behaviors, and neurotoxic or degenerative conditions.	U	16, 4, 9	focused
3390	Biological Sciences	Molecular and Cellular Immunology	This is a course that covers the fundamentals of cellular and molecular immunology in a comprehensive manner. The objective of this course is to introduce the students to the immune system, the cells that constitute it, their ontogeny, their structure, activities and responses to stimuli and the systems/signals that integrate these cells into a coherent functional entity. Additionally, the course will demonstrate where, when, and how, the immune system responds in pathologic states, how its cells can themselves become the causes of pathologies, and how medical science targets and uses the immune system to prevent and treat a wide range of diseases.	U	4, 3, 9	focused
3391	Biological Sciences	Microbiology	The course provides introductory level microbial science and molecular biology that is aimed for students from all disciplines of natural science. It covers microbiology, genetics, genomics, as well as bacterial, fungal, and protozoan pathogenesis. Topics include: the human microbiome, genome sequencing, gene transfer across species, virulence, and drug resistance.	U	4, 15, 14	focused
3409	Biological Sciences	Applied Cell Biology	The course provides a hands-on experience in biology lab to conduct experiments, collect and analyze scientific data with the purpose of using the data to infer biological principals. Students will learn the details of western blot technique, commonly used in biology labs. In addition, they will apply the technique to study how insulin triggers specific signaling in target cells. This lab module will reinforce the students' understanding of material seen in Cell Biology lecture course (co-requisite 03-240) and will prepare them for future lab courses.	U	4, 17, 9	focused
3410	Biological Sciences	Special Topics in Biological Sciences TECH Technical Skills at the Bench	This course is designed to complement the Laboratory Course Experimental Techniuqes in Molecular Biology TECH. This course will help you build the literature, data analysis, and written communication skills necessary for the 300 - level biology laboratory courses. Emphasis is placed on understanding and applying the biological principles of each experiment. This course is designed to be taken during the junior year and is intended to prepare students for undergraduate research.	U	4, 9, 17	focused
3411	Biological Sciences	Topics in Research	During the year students attend and submit brief summaries of weekly seminars given by outside speakers or members of the Biology Department on current research topics in modern biology; some seminars outside of the department may be substituted.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
3435	Biological Sciences	Cancer Biology	Cancer affects roughly 1 in 3 people worldwide, and originates from both hereditary as well as environmental causes. Its prevalence makes it practically inescapable. Its of great relevance from both scientific and sociocultural perspectives. This course aims to examine various hallmarks of the biology of cancer while exploring novel concepts that challenge our understanding of cell biology. From the perspective of a cancer cell, we will learn about basic concepts of cell division, DNA replication, cell signaling, cell cycle control, cell metabolism, the regulation of gene expression in human cells, oncogenes, tumor suppressor genes, mutations, the process of metastasis, cancer diagnosis, cancer treatments and ethical questions surrounding treating patients, the epidemiology of cancer including prevalence and historical trends in diagnosis, as well as social impacts of a cancer diagnosis. Students will also explore the primary literature and scientific review articles to better understand research and methods of investigation into the cellular and molecular processes of tumorigenesis. This course will include interactive lectures, guest speakers, and in class discussion exercises aimed at building class participation and association, as well as confidence in public speaking about the sciences. Given the well-documented link between stress and cancer, there will also be a small component aimed at making students aware of health and wellness, such as reducing stress and anxiety.	U	3, 4, 12	focused
3439	Biological Sciences	Introduction to Biophysics	This intermediate level course is primarily offered to Physics and Biology undergrads (junior/senior) and provides a modern view of molecular and cellular biology as seen from the perspective of physics, and quantified through the analytical tools of physics. This course will not review experimental biophysical techniques (which are covered, e.g., in 03-871). Rather, physicists will learn what sets "bio" apart from the remainder of the physics world and how the apparent dilemma that the existence of life represents to classical thermodynamics is reconciled. They also will learn the nomenclature used in molecular biology. In turn, biologists will obtain (a glimpse of) what quantitative tools can achieve beyond the mere collecting and archiving of facts in a universe of observations: By devising models, non-obvious quantitative predictions are derived which can be experimentally tested and may lead to threads that connect vastly different, apparently unrelated phenomena. One major goal is then to merge the two areas, physics and biology, in a unified perspective.	U	9, 4, 7	focused
3442	Biological Sciences	Molecular Biology	The structure and expression of eukaryotic genes are discussed, focusing on model systems from a variety of organisms including yeast, flies, worms, mice, humans, and plants. Topics discussed include (1) genomics, proteomics, and functional proteomics and (2) control of gene expression at the level of transcription of mRNA from DNA, splicing of pre-mRNA, export of spliced mRNA from the nucleus to the cytoplasm, and translation of mRNA.	U	9, 15, 8	focused
3451	Biological Sciences	Advanced Developmental Biology and Human Health	This course will examine current research in developmental biology, focusing on areas that have important biomedical implications. The course will examine stem cell biology, cellular reprogramming, cell signaling pathways, tissue morphogenesis, and genetic/developmental mechanisms of birth defects and human diseases. Emphasis will be placed on the critical reading of recent, original research papers and classroom discussion, with supporting lectures by faculty.	U	4, 3, 17	focused
3511	Biological Sciences	Computational Molecular Biology and Genomics	An advanced introduction to computational molecular biology, using an applied algorithms approach. The first part of the course will cover established algorithmic methods, including pairwise sequence alignment and dynamic programming, multiple sequence alignment, fast database search heuristics, hidden Markov models for molecular motifs and phylogeny reconstruction. The second part of the course will explore emerging computational problems driven by the newest genomic research. Course work includes four to six problem sets, one midterm and final exam.	U	4, 17, 9	focused
3601	Biological Sciences	Computational Biology Internship	This course allows a student to gain computational biology experience in a "real-world" setting. Internships vary widely in scope, but common to all is the chance to practice computational biology skills acquired in the classroom. Typically, students seek and secure their own internships.	G	4, 17, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
3603	Biological Sciences	Applied Professional Skills for Computational Biologists	This course gives Masters in Computational Biology students the opportunity to refine the professional skills necessary for a successful career in industry. This course, required for students completing the "Applied Study" option in the MS in Computational Biology program, provides opportunities to connect with computational biology professionals as part of industry outreach. The course will also include additional, customized review of application materials.	G	4, 9, 17	focused
3709	Biological Sciences	Applied Cell and Molecular Biology	The purpose of this course is to review key cellular and molecular phenomenon in biological pathways with strong emphasis on latest experimental techniques used in applications including but not limited to disease diagnosis, therapeutics, large-scale genomic and proteomic analysis. Knowledge gained from this course will be both conceptual and analytical. Students will periodically write extensive research reports on select topics and give oral presentations on a select few, while critically analyzing primary literature.	G	3, 4, 17	focused
3711	Biological Sciences	Computational Molecular Biology and Genomics	An advanced introduction to computational molecular biology, using an applied algorithms approach. The first part of the course will cover established algorithmic methods, including pairwise sequence alignment and dynamic programming, multiple sequence alignment, fast database search heuristics, hidden Markov models for molecular motifs and phylogeny reconstruction. The second part of the course will explore emerging computational problems driven by the newest genomic research. Course work includes four to six problem sets, one midterm and final exam.	G	4, 17, 9	focused
3713	Biological Sciences	Bioinformatics Data Integration Practicum	This course provides a hands-on, self-directed experience dealing with biological data and integrating it to produce software and analyses that are of use to biologists. Data are taken from a variety of sources, including academic research labs, large scale public genomics projects and data from private industry partners. Students will be given a project and asked to design a solution using a combination of existing tools and their own developed software.	G	4, 9, 17	focused
3728	Biological Sciences	Genome Editing Biotechnology	How can we create genetically engineered cells, animals, plants, and even humans? This course will focus on the technologies that enable genome modification, with an emphasis on the recently developed CRISPR-Cas9 system. Specific topics will include an introduction to CRISPR technology and its history; DNA double strand break repair; Off target effects; Gene regulator CRISPRs; Alternate technologies; Ethics of modifying our genomes; Applications - cell screening; Applications - organism engineering; Applications - anti-HIV and immunotherapy; Overview of Gene therapy. Student in-class presentations will cover late-breaking topics and specific areas of student interest.	G	9, 3, 15	focused
3730	Biological Sciences	Advanced Genetics	This course considers selected current topics in genetics at an advanced level. Emphasis is on classroom discussion of research papers. Topics change yearly. Recent topics have included nucleocytoplasmic trafficking of RNA in yeast, genome imprinting in mammals, genetics of learning and memory in Drosophila, and viral genomics.	G	4, 16, 17	focused
3741	Biological Sciences	Advanced Cell Biology	This course covers fourteen topics in which significant recent advances or controversies have been reported. For each topic there is a background lecture by the instructor, student presentations of the relevant primary research articles and a general class discussion. Example topics are: extracellular matrix control of normal and cancer cell cycles, force generating mechanisms in trans-membrane protein translocation, signal transduction control of cell motility, and a molecular mechanism for membrane fusion.	G	3, 4, 17	focused
3742	Biological Sciences	Advanced Molecular Biology	The structure and expression of eukaryotic genes are discussed, focusing on model systems from a variety of organisms including yeast, flies, worms, mice, humans, and plants. Topics discussed include (1) genomics, proteomics, and functional proteomics and (2) control of gene expression at the level of transcription of mRNA from DNA, splicing of pre-mRNA, export of spliced mRNA from the nucleus to the cytoplasm, and translation of mRNA.	G	9, 15, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
3744	Biological Sciences	Membrane Trafficking	While the focus of this course is to analyze membrane/protein traffic along both the biosynthetic and endocyctic pathways, our general goal is to teach students how to read and interpret the literature. In particular, we emphasize the conclusions and discuss their validity. The course is updated each year to include topics in which new and interesting developments have occurred. Emphasis is placed on how membrane traffic is regulated and where applicable how it is disrupted or subverted during disease processes. The course is of general interest to students, fellows, and faculty interested in cell biology, immunology, neurobiology, pharmacology and virology.	G	4, 3, 11	focused
3750	Biological Sciences	Graduate Seminar	Each semester, all Department of Biological Sciences graduate students are required to register for and attend the weekly departmental Research Seminar (03-750; 1 unit). Graduate students are strongly urged to meet the speakers to broaden their knowledge of cutting-edge biological science, to discuss career paths and strategies and to make useful contacts; the faculty host can arrange group meetings for interested students.	G	4, 17, 8	focused
3751	Biological Sciences	Advanced Developmental Biology and Human Health	This course will examine current research in developmental biology, focusing on areas that have important biomedical implications. The course will examine stem cell biology, cellular reprogramming, cell signaling pathways, tissue morphogenesis, and genetic/developmental mechanisms of birth defects and human diseases. Emphasis will be placed on the critical reading of recent, original research papers and classroom discussion, with supporting lectures by faculty.	G	4, 3, 17	focused
3758	Biological Sciences	Special Topics	Special topics course for graduate students. 03-758-A1: Biosensors Biological systems are essentially 3D, highly-linked networks that sense, compute and respond to internal or external stimuli via widely distributed and diversified cells interacting over various timescales. To understand such complex biological systems, ideally, it would require observation of the activity of numerous populations of cells with a high degree of precision and resolution down to molecular building block. In this way, we can understand the functions and dynamics that are produced by the interactions between different cells as well as subcellular signaling events within individual cells. This course explores up-to-date tools that enable insight into how biological components work together to implement physiological functions, and how these interactions go awry in disease states. 03-758-A2: Synthetic Biology This course explores the following: Structure of, expression and regulation in prokaryotic and eukaryotic systems, including their viruses. Advanced biotechnological methods comprising cloning, mutagenesis, polymerase chain reaction, synthesis of nucleic acids, DNA sequence determination, synthetic genomics, CRISPR-Cas9, directed evolution, alternative splicing and computational modeling. Experimental characterization of structural and functional properties of biomolecules. Bioinformatic analysis and characterization of genes and biomolecules.	G	4, 9, 17	focused
3762	Biological Sciences	Advanced Cellular Neuroscience	This course is an introductory graduate course in cellular neuroscience. As such it will assume little or no background but will rapidly progress to discussions of papers from the primarily literature. The structure of the course will be about half lectures and half discussions of new and classic papers from the primary literature. These discussions will be substantially led by students in the course. Topics covered will include ion channels and excitability, synaptic transmission and plasticity, molecular understanding of brain disease and cell biology of neurons. Assessment will be based on class participation, including performance on in-class presentations and a writing assignment.	G	4, 3, 17	focused
3763	Biological Sciences	Advanced Systems Neuroscience	This course is a graduate version of 03-363. Students will attend the same lectures as the students in 03-363, plus an additional once weekly meeting. In this meeting, topics covered in the lectures will be addressed in greater depth, often through discussions of papers from the primary literature. Students will read and be expected to have an in depth understanding of several classic papers from the literature as well as current papers that illustrate cutting edge approaches to systems neuroscience or important new concepts. Use of animals as research model systems will also be discussed. Performance in this portion of the class will be assessed by supplemental exam questions as well as by additional homework assignments.	G	4, 9, 15	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
3791	Biological Sciences	Advanced Microbiology	This course will use both lectures and current research literature in the area of Microbiology and Infectious Diseases to introduce such topics as prokaryotic cytoskeletal functions, the human microbiome and its impact, metabolic engineering, transposon mutagenesis for gene function elucidation, synthetic genome construction and applications, pathogenicity islands, functional and expression-based identification of pathogenicity determinants, horizontal gene transfer, regulatory RNAs, biofilm formation quorum sensing, and antimicrobial drug development.	G	3, 17, 9	focused
3871	Biological Sciences	Structural Biophysics	The physical properties of biological macromolecules and the methods used to analyze their structure and function are discussed. Topics covered include: protein architecture and folding; nucleic acid structures and energetics; structure determination by X-ray crystallography and NMR; biological spectroscopy with emphasis on absorption, fluorescence, and NMR spectroscopies; other methods to characterize proteins and protein-ligand interactions, such as mass spectrometry, calorimetry, and surface plasmon resonance. Sufficient detail is given to allow the student to critically evaluate the current literature.	G	4, 9	focused
4330	Information & Communication Technology	Fundamentals of Software Development and Problem Solving	This course explores the discipline of computer science through a hands-on focus on practical programming skills. Topics include algorithm development, problem solving (decomposition and synthesis), program design, data representation, arithmetic and logical expressions, input/output operations, basic user interfaces, and object-oriented programming and design, with an emphasis on developing good programming habits. Intensive programing assignments are required. The programming will involve understanding and analyzing a set of requirements for a problem, formulating a solution, and implementing that solution on the computer along with tests that show that the program achieves its goals. These programs can be intensive and fun, and are designed to provide the student with a clear understanding of principals needed to work with the computer in the future http://public.rwanda.cmu.edu/cbishop/pfun/syllabus.html	U	4, 9, 8	focused
4621	Information & Communication Technology	Blockchain and Cryptocurrencies	This course enables students to understand the complete blockchain and cryptocurrency ecosystem from users, to miners, to merchants, to industries. Students will understand the underlying distributed ledger technology, cryptography applications, distributed computing, and how they can apply them to other domains. They will understand the future trends in blockchain and cryptocurrencies from a business and policy perspective. Through an understanding of blockchain, students will learn about cryptography and best practices for cryptographic applications.	G	9, 4, 15	focused
4705	Information & Communication Technology	Academic Writing: Linguistic Foundations	This course aims to raise awareness of basic conventions in academic writing, such as referencing and use of sources, supporting assertions and linking them to previous research, and writing using an impersonal style. During the course, students review basics of English grammar and complex sentence structure. It enables students to produce short pieces of academic writing which are broadly accurate and clear, and which follow the basic conventions of the genre. In addition, the course aims to develop student autonomy in noticing and correcting common writing errors. It is expected that successful completion of this course will improve students abilities to more effectively and accurately complete written tasks and assignments as part of their other courses. Note that this course is intended to only be offered & taken PASS/NO PASS.	G	4, 17, 2	focused
4706	Information & Communication Technology	Academic Writing: Analytical Writing	This course aims to support learners to develop the linguistic and critical skills necessary to compose an extended piece of academic writing that is accurate, cohesive and analytical. During the course, students will improve their process writing proficiencies through the planning, drafting, and editing of writing assignments. They will also develop the skills necessary to develop sound paragraphs and compose an appropriate thesis statement and topic sentences within a literature review. In addition, this course will aim to raise awareness and use of cohesive devices within and across paragraphs, as well as review patterns of academic vocabulary usage, source summarization, analysis and synthesis, hedging language, and referencing. It is expected that successful completion of the course will enable students to convey complex and technical information with greater clarity and precision. Note that this course is intended to only be offered & taken PASS/NO PASS.	G	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
4800	Information & Communication Technology	Special Topics in ICT	Sec H Advanced Database Systems: This course aims at describing the databases in a way suitable for applications and computer systems designers. First, the course describes the fundamental characteristics of current architectures.Then, it illustrates the main lines of system evolution, presenting the models that go beyond the relational systems, such as active databases, object-oriented systems and the management of XML data. Sec K Vulnerability Assessment and Testing: This course will introduce students to professional penetration testing by teaching offensive tactics along with the appropriate methodologies and responsibilities it takes to ethically attack systems. The majority of time will be spent in hands-on labs performing reconnaissance, discovering vulnerabilities, developing exploits, and carefully penetrating targets. Students will be required have a basic understanding of networking concepts (TCP/IP), Linux/Unix operating systems and shell scripting. Additionally, students will also be expected to put in the additional time to research solutions on their own.	G	9, 4, 17	focused
4802	Information & Communication Technology	Special Topics in ICT	Recent advances in machine learning and an increase in the availability and collection of massive data sources, such as satellite images, social media data, and call detail records from mobile phone operators, have begun to transform our understanding of critical challenges facing the developing world, especially within the African continent. In particular, these data sources can offer a more timely, complete, and cost-efficient alternative that has the potential to guide more effective decision-making. However, in order to maximize the value of alternative data, users need to have an awareness of their sources and value, knowledge of how and when to use alternative data to obtain meaningful insights, and a deep appreciation of a range of ethical issues, such as privacy. In this course, students will become conversant with current research that uses alternative data to better understand the social and economic realities of people and communities in African countries. Through readings of recent work, students will also analyze the opportunities and challenges presented by the use of alternative data. Upon successful completion of this course, students will be more familiar with the use of current alternative data approaches in research. In addition, students will be able to formulate research questions that are grounded in a review of relevant literature and answerable through an analysis of alternative data, and identify existing data sources and relevant machine learning approaches that can be used to answer these questions. This course is designed as a seminar. Therefore, it is based on interactions between the students and the instructor, grounded on readings of current research as well as students' own writing.	G	4, 8, 17	focused
4990	Information & Communication Technology	Research Project	This Research Project is for students selecting the academic focus for their MSIT. When selecting this course, the student will replace the 24 units MSIT practicum by 36 units of research project. The research project is conducted under the supervision of a faculty research adviser who first approves it based on the student's skills and mutual interest. This project can only be performed in 3rd and/or 4th semester of MSIT. Students will be required to present and defend their research thesis in front of a research committee (public invited). The research committee consists of 3 members including the adviser, and may include one external member. Students can contact a faculty research adviser at any time during their MSIT to discuss the option of taking this "course". The faculty research adviser may recommend pre-requisite courses based on the student's skills or the subject of the research project. Students selecting this course (and the MSIT academic focus) cannot take 04-980 Independent study.	G	4, 17, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
5200	Human-Computer Interaction	Ethics and Policy Issues in Computing	Should autonomous robots make life and death decisions on their own? Should we allow them to select a target and launch weapons? To diagnose injuries and perform surgery when human doctors are not around? Who should be permitted to observe you, find out who your friends are, what you do and say with them, what you buy, and where you go? Do social media and personalized search restrict our intellectual horizons? Do we live in polarizing information bubbles, just hearing echoes of what we already know and believe? As computing technology becomes ever more pervasive and sophisticated, we are presented with an escalating barrage of decisions about who, how, when, and for what purposes technology should be used. This course will provide an intellectual framework for discussing these pressing issues of our time, as we shape the technologies that in turn shape us. We will seek insight through reading, discussion, guest lectures, and debates. Students will also undertake an analysis of a relevant issue of their choice, developing their own position, and acquiring the research skills needed to lend depth to their thinking. The course will enhance students' ability to think clearly about contentious technology choices, formulate smart positions, and support their views with winning arguments.	U	4, 9, 1	focused
5292	Human-Computer Interaction	IDeATe: Learning in Museums	Learning in Museums brings together students from across the disciplines to consider the design of mediated learning experiences though a project-based inquiry course. Students will be introduced to a range of design research methods and associated frameworks that explore the cognitive, social and affective dimensions of learning in everyday contexts through readings, invited lectures, in-class activities and assignments. Students will conduct a series of short design research studies to define learning goals and develop supporting design concepts that improve learning outcomes for diverse participants in informal learning settings (e.g. museums, after school programs, maker spaces or online). In concept development, we will look at how to position technology and question its role in the setting to engage and foster positive learning interactions. This course will culminate in a media-rich presentation of design concepts and a prototype to a stakeholder audience, and include an evaluation plan describing how learning outcomes for the project would be assessed.	U	4, 9, 17	focused
5300	Human-Computer Interaction	HCI Undergraduate Pro Seminar	HCI is a broad field that brings together approaches from design, computer science, and psychology. This course provides an introduction to the field of HCI and to the HCI community at CMU. Guest speakers from around campus will provide a general introduction to these approaches and how they are pursued at CMU, and will describe research opportunities that are available to undergraduates. The course will also discuss career options in both industry and academia for students of HCI, and will include presentations from HCI alumni and sessions on preparing resumes, creating portfolios, and interviewing for jobs. The course is designed for current or potential HCI majors and minors but is open to anyone with an interest in applying for the HCI major/minor. Note that class will begin 5 minutes after the scheduled start to accommodate students arriving to Craig street from the main campus.	U	4, 9, 17	focused
5317	Human-Computer Interaction	Design of Artificial Intelligence Products	This course teaches students how to design new products and services that leverage the capabilities of AI and machine learning to improve the quality of peoples lives. Students will learn to follow a matchmaking design, user-centered design, and service design process. Students will learn to ideate; reframing problematic situations by envisioning many possible products and services. Students will learn to iteratively refine and assess their ideas with real users/customers. Class projects will focus on the challenges of deploying systems that generate errors and the challenges of situating intelligent systems such that they harmonize the best qualities of human and machine intelligence.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
5318	Human-Computer Interaction	Human AI Interaction	Artificial Intelligence is inspired by human intelligence, made powerful by human data, and ultimately only useful in how it positively affects the human experience. This course is an introduction to harnessing the power of AI so that it is beneficial and useful to people. We will cover a number of general topics: agency and initiative, AI and ethics, bias and transparency, confidence and errors, human augmentation and amplification, trust and explainability, mixed-initiative systems, and programming by example. These topics will be explored via projects in dialog and speech-controlled systems, automatic speech recognition, computer vision, data science, recommender systems, text summarization, learning science, UI personalization, and visualization. Students will complete individual weekly mini-projects in which they will design and build AI systems across a wide variety of domains. Students should be comfortable with programming; assignments will be primarily in Python and Javascript. Prior experience with AI/machine learning will be useful but is not required. Students will also be responsible for weekly readings and occasional presentations to the class.	U	4, 9, 5	focused
5320	Human-Computer Interaction	Social Web	With the growth of online environments like MySpace, Second Life, World of Warcraft, Wikipedia, blogs, online support groups, and open source development communities, the web is no longer just about information. This course, jointly taught by a computer scientist and a behavioral scientist, will examine a sampling of the social, technical and business challenges social web sites must solve to be successful, teach students how to use high-level tools to analyze, design or build online communities, and help them understand the social impact of spending at least part of their lives online. This class is open to advanced undergraduates and graduate students with either technical or non-technical backgrounds. Course work will include lectures and class discussion, homework, class presentations, and a group research or design project.	U	4, 17, 9	focused
5333	Human-Computer Interaction	Gadgets, Sensors and Activity Recognition in HCI	Recent advances in HCI have been driven by new capabilities to deliver inexpensive devices to users, to display information in mobile and other contexts, to sense the user and their environment, and use these sensors to create models of a user's context and actions. This course will consider both concepts surrounding these new technological opportunities through discussion of current literature - and practical considerations the skills needed to actually build devices. About 1/3 of this class will review current advances in this area. The remainder will be devoted to development of individual skills so that students leaving the class will have an ability to actually build small devices for human interaction (in short: "HCI gadgets"). In particular, the course will concentrate on the basics of building simple microcontroller-based devices and will also provide very basic coverage of the machine learning techniques needed for simple sensor-driven statistical models. The course is designed to be accessible to students with a wide range of backgrounds including both technically-oriented and non-technical students (especially Designers) interested in HCI. The class will be project oriented with 4-5 electronic prototype building projects during the semester. At least two of these projects will be self-defined in nature and can be adapted to the existing skills and interests of each student. There are no formal prerequisites for this class. However, the class will involve programming and debugging of micro-controllers. Some coverage of the language used to do this will be provided, and if required by your background, the programming component of the projects can be made comparatively small (but, in that case some other aspect of the projects will need to be expanded). However, you should not take this course if you have no programming background. This course assumes no background in electronics.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
5391	Human-Computer Interaction	Designing Human Centered Software	Why are things so hard to use these days? Why doesn't this thing I just bought work? Why is this web site so hard to use? These are frustrations that we have all faced from systems not designed with people in mind. The question this course will focus on is: how can we design human-centered systems that people find useful and usable? This course is an introduction to designing, prototyping, and evaluating user interfaces. If you take only one course in Human-Computer Interaction, this is the course for you. This class is open to all undergrads and grad students, with either technical or non-technical backgrounds. We will cover theory as well as practical application of ideas from Human-Computer Interaction. Course work includes lectures, class discussion, homework, class presentations, and group project.	U	4, 9, 17	focused
5392	Human-Computer Interaction	Interaction Design Overview	This studio course offers a broad overview of communication and interaction design. Students will learn design methodologies such as brainstorming, sketching, storyboarding, wire framing, and prototyping. Students learn to take a human-centered design approach to their work. Assignments include short in-class exercises as well as individual and team-based projects. Students take part in studio critiques, engaging in critical discussions about the strengths and weaknesses of their own work and the work of others. No coding is required.	U	4, 9	focused
5395	Human-Computer Interaction	Applications of Cognitive Science	The goal of this course is to examine cases where basic research on cognitive science, including cognitive neuroscience, has made its way into application, in order to understand how science gets applied more generally. The course focuses on applications that are sufficiently advanced as to have made an impact outside of the research field per se; for example, as a product, a change in practice, or a legal statute. Examples are virtual reality (in vision, hearing, and touch), cognitive tutors, phonologically based reading programs, latent semantic analysis applications to writing assessment, and measures of consumers' implicit attitudes. The course will use a case-study approach that considers a set of applications in detail, while building a general understanding of what it means to move research into the applied setting. The questions to be considered include: What makes a body of theoretically based research applicable? What is the pathway from laboratory to practice? What are the barriers - economic, legal, entrenched belief or practice? The format will emphasize analysis and discussion by students. They should bring to the course an interest in application; extensive prior experience in cognitive science is not necessary. The course will include tutorials on basic topics in cognitive science such as perception, memory, and spatial cognition. These should provide sufficient grounding to discuss the applications.	U	4, 8, 17	focused
5410	Human-Computer Interaction	User-Centered Research and Evaluation	This course provides and overview and introduction to the field of human-computer interaction (HCI). It introduces students to tools, techniques, and sources of information about HCI and provides a systematic approach to design. The course increases awareness of good and bad design through observation of existing technology, and teaches the basic skills of task analysis, and analytic and empirical evaluation methods. This is a companion course to courses in visual design (51-422) and software implementation (05-430, 05-431). When registering for this course, undergraduate students are automatically placed the wait list. Students will be then moved into the class, based on if they are in the BHCI second major and year in school e.g. seniors, juniors, etc This course is NOT open to students outside the HCI major. When registering for this course, undergraduate students are automatically placed the wait list. Students will be then moved into the class, based on if they are in the BHCI second major and year in school. This course is a core requirement for students in the HCI additional major.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
5413	Human-Computer Interaction	Human Factors	This course uses theory and research from human factors, cognitive science, and social science to understand and design the interactions of humans with the built world, tools, and technology. The course emphasizes current work in applied domains such as automotive design, house construction, medical human factors, and design of information devices. The course also will emphasize not only individual human factors (e.g., visual response, anthropometry) but also the organizational arrangements that can amplify or correct human factors problems. Through reading, discussion, and projects, you will learn about human perceptual, cognitive, and physical processes that affect how people interact with, and use, technology and tools. You will learn why we have so many automobile accidents, voting irregularities, and injuries from prescription medication. You will learn some tried and true solutions for human factors problems, and some of the many problems in human factors that remain. You will also have gained experience in research in this field.	U	9, 17, 1	focused
5418	Human-Computer Interaction	Design Educational Games	The potential of digital games to improve education is enormous. However, it is a significant challenge to create a game that is both fun and educational. In this course, students will learn to meet this challenge by combining processes and principles from game design and instructional design. Students will also learn to evaluate their games for fun, learning, and the integration of the two. They will be guided by the EDGE framework for the analysis and design educational games. The course will involve a significant hands-on portion, in which students learn a design process to create educational games digital or non-digital. They will also read about existing educational games and discuss game design, instructional design, learning and transfer, and the educational effectiveness of digital games. They will analyze an educational game and present their analysis to the class.	U	4, 9, 1	focused
5430	Human-Computer Interaction	Programming Usable Interfaces	This course is combines lecture, and an intensive programming lab and design studio. It is for those who want to express their interactive ideas in working prototypes. It will cover the importance of human-computer interaction/interface design, iterative design, input/output techniques, how to design and evaluate interfaces, and research topics that will impact user interfaces in the future. In lab, you will learn how to design and program effective graphical user interfaces, and how to perform user tests. We will cover a number of prototyping tools and require prototypes to be constructed in each, ranging from animated mock-ups to fully functional programs. Assignments will require implementing UIs, testing that interface with users, and then modifying the interface based on findings. Some class sessions will feature design reviews of student work. This course is for HCII Masters students and HCI dual majors with a minimal programming background. Students will often not be professional programmers, but will need to interact with programmers. RECITATION SELECTION: Students taking this course can sign up for either Prototyping Lab recitation. PREREQUISITES: Proficiency in a programming language, program structure, algorithm analysis, and data abstraction. Normally met through an introductory programming course using C, C++, Pascal or Java, such as 15100, 15112, 15127 or equivalent. Students entering this course should be able to independently write a 300-line program in 48 hours. This course is NOT open to students outside of the BHCI program.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
5431	Human-Computer Interaction	Software Structures for User Interfaces	This course considers the basic and detailed concepts for building software to implement user interfaces (UIs). It considers factors of input, output, application interface, and related infrastructure as well as the typical patterns used to implement them. It considers how these aspects are organized and managed within a well-structured object oriented system. We will cover a variety of "front-end" programming contexts, including conventional graphical user interface (GUI) programming for mobile apps (phones, watches), web apps, and regular desktop applications, across a variety of frameworks. We will also cover programming for data-driven and conversational (AI) user interfaces. We will briefly touch on front-end programming for visualizations, games, 3D, and virtual and artificial reality (VR and AR), along with interactive UI tools such as prototypers and resource editors. The homeworks and project in this course will involve extensive object-oriented programming, likely in both Java and JavaScript, so this course is only appropriate for students with a strong programming background. Note that this is not an HCI methods course -- we do not cover user-centered design or evaluation methods. This course is designed for students in the SCS HCI undergrad Major, but it also available to any undergrad or graduate student with an interest in the topic and solid prior programming experience who wish to understand the structures needed for professional development of interactive systems. Note that all students who register for this class will initially be placed on a waitlist. Priority for getting into the class are students in the HCII programs (more senior students first), and then others. The graduate (05-631) and undergraduate (05-431) numbers are for the same course with the same work. For more information, please refer to the class website: https://www.cs.cmu.edu/~bam/uicourse/05631fall2020/	U	9, 4, 17	focused
5432	Human-Computer Interaction	Personalized Online Learning	Online learning has become widespread (e.g., MOOCs, online and blended courses, and Khan Academy) and many claim it will revolutionize higher education and K-12. How can we make sure online learning is maximally effective? Learners differ along many dimensions and they change over time. Therefore, advanced learning technologies must adapt to learners to provide individualized learning experiences. This course covers a number of proven personalization techniques used in advanced learning technologies. One of the techniques is the use of cognitive modeling to personalize practice of complex cognitive skills in intelligent tutoring systems. This approach, developed at CMU, may well be the most significant application of cognitive science in education and is commercially successful. We will also survey newer techniques, such as personalizing based on student meta-cognition, affect, and motivation. Finally, we will look at personalization approaches that are widely believed to be effective but have not proven to be so. The course involves readings and discussion of different ways of personalizing instruction, with an emphasis on cognitive modeling approaches. Students will learn to use the Cognitive Tutor Authoring Tools (CTAT) to implement tutor prototypes that rely on computer-executable models of human problem solving to personalize instruction. The course is meant for graduate or advanced undergraduate students in Human-Computer Interaction, Psychology, Computer Science, Design, or related fields, who are interested in educational applications. Students should either have some programming skills or experience in the cognitive psychology of human problem solving, or experience with instructional design.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
5434	Human-Computer Interaction	Machine Learning in Practice	Machine Learning is concerned with computer programs that enable the behavior of a computer to be learned from examples or experience rather than dictated through rules written by hand. It has practical value in many application areas of computer science such as on-line communities and digital libraries. This class is meant to teach the practical side of machine learning for applications, such as mining newsgroup data or building adaptive user interfaces. The emphasis will be on learning the process of applying machine learning effectively to a variety of problems rather than emphasizing an understanding of the theory behind what makes machine learning work. This course does not assume any prior exposure to machine learning theory or practice. In the first 2/3 of the course, we will cover a wide range of learning algorithms that can be applied to a variety of problems. In particular, we will cover topics such as decision trees, rule based classification, support vector machines, Bayesian networks, and clustering. In the final third of the class, we will go into more depth on one application area, namely the application of machine learning to problems involving text processing, such as information retrieval or text categorization. 05-834 is the HCII graduate section. If you are an LTI student, please sign up for the LTI graduate course number (11-663) ONLY to count properly towards your degree requirements. 05-434 is the HCII undergraduate section. If you are an LTI student, please sign up for the LTI undergraduate course number (11-344) ONLY to count properly towards your degree requirements.	U	4, 9, 15	focused
5435	Human-Computer Interaction	Applied Fabrication for HCI	This course will consider how new fabrication techniques such as 3D printing, laser cutting, CNC machining and related computer controlled technologies can be applied to problems in Human-Computer Interaction. Each offering will concentrate on a particular application domain for its projects. This year the course will consider assistive technology. This course will be very hands-on and skills-oriented, with the goal of teaching students the skills necessary to apply these technologies to HCI problems such as rapid prototyping of new device concepts. To this end? Every student in this course will build and take home a 3D printer. (There will be $400-$500 cost associated with this course to make that possible. Details on this are still to be determined.)	U	4, 9, 8	focused
5436	Human-Computer Interaction	Usable Privacy and Security	There is growing recognition that technology alone will not provide all of the solutions to security and privacy problems. Human factors play an important role in these areas, and it is important for security and privacy experts to have an understanding of how people will interact with the systems they develop. This course is designed to introduce students to a variety of usability and user interface problems related to privacy and security and to give them experience in designing studies aimed at helping to evaluate usability issues in security and privacy systems. The course is suitable both for students interested in privacy and security who would like to learn more about usability, as well as for students interested in usability who would like to learn more about security and privacy. Much of the course will be taught in a graduate seminar style in which all students will be expected to do a weekly reading assignment and each week different students will prepare a presentation for the class. Students will also work on a group project throughout the semester. The course is open to all graduate students who have technical backgrounds. The 12-unit course numbers (08-734 and 5-836) are for PhD students and masters students. Students enrolled in these course numbers will be expected to play a leadership role in a group project that produces a paper suitable for publication. The 9-unit 500-level course numbers (08-534 and 05-436) are for juniors, seniors, and masters students. Students enrolled in these course numbers will have less demanding project and presentation requirements.	U	4, 9, 17	focused
5452	Human-Computer Interaction	Service Design	In this course, we will collectively define and study services and product service systems, and learn the basics of designing them. We will do this through lectures, studio projects, and verbal and written exposition. Classwork will be done individually and in teams.	U	9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
5470	Human-Computer Interaction	Digital Service Innovation	Attention entrepreneurs, designers, and engineers! This course teaches you to invent digital services. You will learn about value-creation in the service sector and a human-centered design process including brainstorming, story-boarding, interviewing, video sketches, and pitching. Students work in small, interdisciplinary teams to discover unmet needs of users. They conceive of a digital service and assess its technical feasibility, financial viability, and desirability. Then they produce a plan with a business model and a video sketch and pitch it to industry professionals. Grades will be determined primarily by the quality of the team's products.	U	9, 4, 8	focused
5499	Human-Computer Interaction	Special Topics in HCI	Special Topics in HCI is an opportunity for students interested in HCI to gain a deeper understanding of a specific area in this field. Each class is designed to cover an emerging research area within HCI, from designing large-scale peer learning systems to designing games around audience agency. All sections will help students: (1) build a more comprehensive understanding of an area of study within HCI, (2) work closely with faculty and peers to create mini-projects or team assignments that help students master the course material, (3) explore evidence-based research methods and techniques in HCI. Sections will vary in topic and often change from semester to semester. Because of this, students can take multiple sections, as they are individual classes. Undergraduate sections are listed as 499 and graduate sections are listed as 899. For descriptions of specific sections for this academic year, visit the "Courses" section on the Human-Computer Interaction Institute website.	U	4, 17, 9	focused
5540	Human-Computer Interaction	Rapid Prototyping of Computer Systems	This is a project-oriented course, which will deal with all four aspects of project development: the application, the artifact, the computer-aided design environment, and the physical prototyping facilities. The class consists of students from different disciplines who must synthesize and implement a system in a short period of time. Upon completion of this course the student will be able to: generate systems specifications from a perceived need; partition functionality between hardware and software; produce interface specifications for a system composed of numerous subsystems; use computer-aided development tools; fabricate, integrate, and debug a hardware/software system; and evaluate the system in the context of an end user application. The class consists of students from different disciplines who must synthesize and implement a system in a short period of time.	U	4, 9, 17	focused
5571	Human-Computer Interaction	Undergraduate Project in HCI	Experiential learning is a key component of the MHCI program. Through a substantial team project, students apply classroom knowledge in analysis and evaluation, implementation and design, and develop skills working in multidisciplinary teams. Student teams work with Carnegie Mellon University-based clients or external clients to iteratively design, build and test a software application which people directly use.	U	4, 17, 9	focused
5600	Human-Computer Interaction	HCI Pro Seminar	Students will attend weekly HCII Seminar Series of talks given by national leaders in the field of Human-Computer Interaction, attend communication workshops and conflict management workshops. This course is for MHCI students only.	G	4, 9, 8	focused
5602	Human-Computer Interaction	IDeATe: Learning in Museums	Learning in Museums brings together students from across the disciplines to consider the design of mediated learning experiences in a project-based inquiry course. Students will be introduced to a range of design research methods and associated frameworks that explore the cognitive, social and affective dimensions of learning in everyday contexts through readings, invited lectures, in-class activities and assignments. Students will conduct a series of short design research studies to define learning goals and develop supporting design concepts intended to improve learning outcomes for diverse participants in informal learning settings (e.g. museums, after-school programs, maker spaces or online). In concept development, we will look at how to position technology and question its role in the setting to engage and foster positive learning interactions and conversation. This semester we will be working with the Carnegie Museum of Natural History as our primary stakeholder. The course will culminate in a media-rich presentation of design concepts and a fielded prototype to a review panel and include a piloted evaluation plan describing how learning outcomes for the project would be assessed. In consultation with the instructor, students in the graduate section of the course will be assigned an HCI/learning research literature review and presentation related to their project topic.	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
5610	Human-Computer Interaction	User-Centered Research and Evaluation	This course provides and overview and introduction to the field of human-computer interaction (HCI). It introduces students to tools, techniques, and sources of information about HCI and provides a systematic approach to design. The course increases awareness of good and bad design through observation of existing technology, and teaches the basic skills of task analysis, and analytic and empirical evaluation methods. This is a companion course to courses in visual design (05-650) and software implementation (05-630, 05-631). This course is NOT open to students outside of the MHCI program.	G	4, 9, 17	focused
5618	Human-Computer Interaction	Human AI Interaction	Artificial Intelligence is inspired by human intelligence, made powerful by human data, and ultimately only useful in how it positively affects the human experience. This course is an introduction to harnessing the power of AI so that it is beneficial and useful to people. We will cover a number of general topics: agency and initiative, AI and ethics, bias and transparency, confidence and errors, human augmentation and amplification, trust and explainability, mixed-initiative systems, and programming by example. These topics will be explored via projects in dialog and speech-controlled systems, automatic speech recognition, computer vision, data science, recommender systems, text summarization, learning science, UI personalization, and visualization. Students will complete individual weekly mini-projects in which they will design and build AI systems across a wide variety of domains. Students should be comfortable with programming; assignments will be primarily in Python and Javascript. Prior experience with AI/machine learning will be useful but is not required. Students will also be responsible for weekly readings and occasional presentations to the class.	G	4, 9, 5	focused
5650	Human-Computer Interaction	Interaction Design Studio II	This course follows Interaction Design Fundamentals (05-651). Students are expected to apply what they have learned about design thinking and methodologies as a starting point for all assignments. Students will work in teams to perform guerrilla research, synthesize data, and consider the needs of multiple stakeholders in their design of mobile services and other intelligent systems. Design concepts go beyond user interfaces to include sensors, controls, and ubiquitous computing. Emphasis is placed on the quality of the students ideas and their ability to give form to their design concepts. By completing and presenting their work, students will gain skills related to professional UX design practice.	G	4, 9, 17	focused
5651	Human-Computer Interaction	Interaction Design Studio 1	This studio course introduces students to design thinking and the basic practices of interaction design. We follow a human-centered design process that includes research, concept generation, prototyping, and refinement. Students must work effectively as individuals and in small teams to design mobile information systems and other interactive experiences. Assignments approach design on three levels: specific user interactions, contexts of use, and larger systems. Students will become familiar with design methodologies such as sketching, storyboarding, wire framing, prototyping, etc. No coding is required. This course serves as a prerequisite for Interaction Design Studio (05-650). Students who are required to take this course have priority and will be enrolled first.	G	4, 9, 17	focused
5670	Human-Computer Interaction	Digital Service Innovation	Attention entrepreneurs, designers, and engineers! This course teaches you to invent digital services. You will learn about value-creation in the service sector and a human-centered design process including brainstorming, story-boarding, interviewing, video sketches, and pitching. Students work in small, interdisciplinary teams to discover unmet needs of users. They conceive of a digital service and assess its technical feasibility, financial viability, and desirability. Then they produce a plan with a business model and a video sketch and pitch it to industry professionals. Grades will be determined primarily by the quality of the team's products.	G	9, 4, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
5674	Human-Computer Interaction	Ethics and Policy Issues in Computing	Should autonomous robots make life and death decisions on their own? Should we allow them to select a target and launch weapons? To diagnose injuries and perform surgery when human doctors are not around? Who should be permitted to observe you, find out who your friends are, what you do and say with them, what you buy, and where you go? Do social media and personalized search restrict our intellectual horizons? Do we live in polarizing information bubbles, just hearing echoes of what we already know and believe? As computing technology becomes ever more pervasive and sophisticated, we are presented with an escalating barrage of decisions about who, how, when, and for what purposes technology should be used. This course will provide an intellectual framework for discussing these pressing issues of our time, as we shape the technologies that in turn shape us. We will seek insight through reading, discussion, guest lectures, and debates. Students will also undertake an analysis of a relevant issue of their choice, developing their own position, and acquiring the research skills needed to lend depth to their thinking. The course will enhance students' ability to think clearly about contentious technology choices, formulate smart positions, and support their views with winning arguments.	G	4, 9, 1	focused
5823	Human-Computer Interaction	E-Learning Design Principles and Methods	This course is about e-learning design principles, the evidence and theory behind them, and how to apply these principles to develop effective educational technologies. It is organized around the book "e-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning" by Clark & Mayer with further readings drawn from cognitive science, educational psychology, and human-computer interaction. You will learn design principles 1) for combining words, audio, and graphics in multimedia instruction, 2) for combining examples, explanations, practice and feedback in online support for learning by doing, and 3) for balancing learner versus system control and supporting student metacognition. You will read about the experiments that support these design principles, see examples of how to design such experiments, and practice applying the principles in educational technology development.	G	4, 9, 17	focused
5839	Human-Computer Interaction	Interactive Data Science	This course covers techniques and technologies for creating data driven interfaces. You will learn about the entire data pipeline from sensing to cleaning data to different forms of analysis and computation.	G	9, 12, 4	focused
5840	Human-Computer Interaction	Tools for Online Learning	In this course, we will explore issues that pertain to interaction and interface design. The class will focus on elements of the larger interaction design process including basic design principles, information architecture and navigation, planning and brainstorming methods, and techniques for developing rapid sketches and prototypes. Course Requirements: This class will not focus on learning specific software tools. Students are expected to have prior experience using a variety of design and programming tools. Please speak with the instructor if you have questions regarding these prerequisites. This course was design for students in the METALS program.	G	4, 9	focused
6100	Chemical Engineering	Introduction to Chemical Engineering	We equip students with creative engineering problem-solving techniques and fundamental chemical engineering material balance skills. Lectures, laboratory experiments, and recitation sessions are designed to provide coordinated training and experience in data analysis, material property estimation for single- and multi-phase systems, basic process flowsheet, reactive and non-reactive mass balances, problem solving strategies and tools, and team dynamics. The course is targeted for CIT First Year students.	U	4, 9, 6	focused
6200	Chemical Engineering	Sophomore Research Project	Research projects under the direction of the Chemical Engineering faculty. The nature of the project, the number of units, and the criteria for grading are to be determined between the student and the faculty supervisor. The agreement should then be summarized in a one-page project description for review by the faculty advisor of the student. A final written report or an oral presentation of the results is required.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
6221	Chemical Engineering	Thermodynamics	This course introduces students to the process thermodynamics of single component systems. Topics include equilibrium and thermodynamic state variables; heat and work; conservation of energy and the first law of thermodynamics; entropy balances and the second law of thermodynamics; reversibility; free energies; interconversion of heat and work via engines, refrigeration and power cycles; absolute temperature and the third law of thermodynamics; equations of state; principle of corresponding states; thermodynamic property relationships; changes of state; phase equilibrium and stability in single component systems; vapor pressure and phase transition.	U	15, 7, 4	focused
6222	Chemical Engineering	Sophomore Chemical Engineering Seminar	This course provides an overview of the chemical engineering profession. It discusses the rationale for the curriculum, career paths, resume writing, written communication skills, and ethics, and also involves a project on the use and manufacture of chemicals.	U	4, 9, 17	focused
6261	Chemical Engineering	Fluid Mechanics	The principles of fluid mechanics as applied to engineering, including unit operations, are discussed; examples include flow in conduits, process equipment, and commercial pipes, flow around submerged objects, and flow measurement. Microscopic mass and momentum balances are described, including the continuity and Navier-Stokes equations, and modern solution techniques will be explored. Microscopic flow structures will be determined for flow visualization. Boundary layer theory, turbulence, and non-Newtonian fluids are also discussed. A case-study project based on new technological advancements is also required.	U	9, 17, 8	focused
6262	Chemical Engineering	Mathematical Methods of Chemical Engineering	Mathematical techniques are presented as tools for modeling and solving engineering problems. Modeling of steady-state mass and energy balance problems using linear and matrix algebra, including Gaussian elimination, decomposition, and iterative techniques. Modeling of unsteady-state engineering problems using linear and nonlinear differential equations. Analytical techniques, including Laplace transforms, and numerical techniques for the solution of first-and higher-order differential equations and systems of differential equations arising in engineering models. Finally, the modeling of processes affected by chance and subject to experimental error; statistical and regression techniques within the context of experimental design and analysis of experimental data.	U	7, 9, 13	focused
6321	Chemical Engineering	Chemical Engineering Thermodynamics	The objective of this course is to cover principles and solution techniques for phase and chemical equilibria in multicomponent systems. Topics include thermodynamic properties of ideal and non-ideal mixtures; criteria for equilibrium; chemical potential, fugacity and activity coefficients; flash calculations; Gibbs energy minimization; thermodynamics of chemical reactions including equilibrium conversions.	U	7, 13, 9	focused
6322	Chemical Engineering	Junior Chemical Engineering Seminar	This course discusses career choices for chemical engineers, professional practice, including alternate career paths, global industry, and graduate studies. It also emphasizes writing, interview skills, and oral presentations. Safety, environmental and ethical issues are illustrated in projects and via invited lectures.	U	4, 9, 12	focused
6323	Chemical Engineering	Heat and Mass Transfer	This course presents the fundamentals of heat and mass transfer, including steady-state and transient heat conduction and molecular diffusion, convection of heat and mass, and thermal radiation, with application to heat and mass transfer processes. Development of dimensionless quantities for engineering analysis is emphasized.	U	9, 17, 8	focused
6361	Chemical Engineering	Unit Operations of Chemical Engineering	This course comprises many of the standard operations in chemical plants such as gas absorption, heat exchange, distillation and extraction. The design and operation of these devices is emphasized. A project dealing with a novel unit operation is also investigated.	U	9, 17, 6	focused
6363	Chemical Engineering	Transport Process Laboratory	Develop skills for proposing, designing, planning, implementing, interpreting, and communicating the results of experiments in fluid flow and heat and mass transfer. Oral and written reports are required.	U	4, 11, 8	focused
6364	Chemical Engineering	Chemical Reaction Engineering	Fundamental concepts in the kinetic modeling of chemical reactions, the treatment and analysis of rate data. Multiple reactions and reaction mechanisms. Analysis and design of ideal and non-ideal reactor systems. Energy effects and mass transfer in reactor systems. Introductory principles in heterogeneous catalysis.	U	7, 9, 13	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
6421	Chemical Engineering	Chemical Process Systems Design	Screening of processing alternatives. Computational strategies for preliminary material and energy balances in large chemical processes. Preliminary sizing of process equipment. Cost estimation, economics, and evaluation for chemical plants. Strategies for synthesizing energy networks and separation sequences. Preliminary design of a large industrial project.	U	9, 7, 13	focused
6423	Chemical Engineering	Unit Operations Laboratory	Open-ended laboratory projects illustrate the principles of unit operations in Chemical Engineering. In this course students select, with course staff review, current societal problems to which chemical engineering subject knowledge can be applied. Students work in teams to design and implement an experimental plan to evaluate proposed solutions. Teams must work together to identify constraints and relationships between the unit operations they work on. Students must document implementation feasibility (cost, scheduling, analytic capability, etc.) and clearly identify the criteria and methods for assessing experimental results. Oral and written reports are required.	U	4, 9, 6	focused
6426	Chemical Engineering	Experimental Colloid Surface Science	Laboratory exercises will deal with preparation and stabilization of colloids, flocculation, micellar aggregates, surface tension, contact angle, spreading and adsorption. Basic concepts will be related to practical problems of wetting, lubrication, foaming, adhesion, coatings and corrosion.	U	9, 4	focused
6463	Chemical Engineering	Chemical Product Design	Computer-aided design of a chemical product. Course involves design of molecular structure, microstructure, or devices/processes that effect chemical change. This is a project-based course, for which an extensive report must be submitted.	U	9, 17, 6	focused
6464	Chemical Engineering	Chemical Engineering Process Control	This course presents basic concepts of process dynamics and feedback control. Included are selection of measurements and manipulated variables, definition of transfer functions, creation of block diagrams and closed loop configurations. The course also covers concepts of open loop and closed loop stability, and tuning of PID controllers.	U	9, 6, 12	focused
6466	Chemical Engineering	Experimental Polymer Science	Macromolecular behavior in bulk and in solution will be explored in experiments on tensile strength, elasticity, swelling of networks, solution viscosity, melt flow, and polymerization reactions. Particular reference will be made to aspects affecting production and fabrication of polymeric materials.	U	9, 12, 4	focused
6607	Chemical Engineering	Physical Chemistry of Colloids and Surfaces	Thermodynamics of surfaces; adsorption at gas, liquid, and solid interfaces; capillarity; wetting, spreading, lubrication and adhesion; properties of monolayers and thin films; preparation and characterization of colloids; colloidal stability, flocculation kinetics, micelles, electrokinetic phenomena and emulsions.	G	7, 13, 6	focused
6608	Chemical Engineering	Graduate Professional Development Seminar	This course will also expose the students to personal safety issues encountered in normal science and engineering practice. Safety topics covered include mechanical, electrical, chemical, radiation, and biological hazards, to provide an awareness of these hazards and appropriate action to be taken in the event of an accident.	G	4, 17, 9	focused
6609	Chemical Engineering	Physical Chemistry of Macromolecules	This course develops fundamental principles of polymer science. Emphasis is placed on physio-chemical concepts associated with the macromolecular nature of polymeric materials. Engineering aspects of the physical, mechanical and chemical properties of these materials are discussed in relation to molecular structure. Topics include an introduction to polymer science and a general discussion of commercially important polymers; molecular weight; condensation and addition synthesis mechanisms with emphasis on molecular weight distribution; solution thermodynamics and molecular conformation; rubber elasticity; and the rheological and mechanical properties of polymeric systems. Students not having the prerequisite listed may seek permission of the instructor.	G	4, 9, 12	focused
6622	Chemical Engineering	Bioprocess Design	This course is designed to link concepts of cell culture, bioseparations, formulation and delivery together for the commercial production and use of biologically-based pharmaceuticals; products considered include proteins, nucleic acids, and fermentation-derived fine chemicals. Associated regulatory issues and biotech industry case studies are also included. A fair knowledge of cell culture and fermentation operations is assumed.	G	9, 6, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
6623	Chemical Engineering	Mathematical Modeling of Chemical Engineering Processes	Numerical approaches to solving problems relevant to chemical engineering applications. In this course, advanced mathematical topics relevant to chemical engineering will be used to solve complex problems. Topics include linear algebra, nonlinear equation solving, initial value and boundary value problems for solution of differential equations, numerical optimization, probability and stochastic methods. Significant focus will be placed on numerical rather than analytical solution to problems. Primary Software Package(s): Mathematical programming environment.	G	9, 4, 12	focused
6625	Chemical Engineering	Chemical and Reactive Systems	In this course process simulation software will be used to develop models of chemical and reactive systems. The models will be used to predict the performance of the system, as well as to probe how process modifications, e.g. process conditions, reactor types or sequences, etc affect system performance. The effects of the underlying thermodynamic and kinetic databases of chemical properties on the performance predictions will be explored. Methods to incorporate new thermodynamic and kinetic data into chemical and reactive system simulations will be examined. Thermochemical and kinetic data for reactions will be estimated for use in process simulation software. Primary Software Package(s): Molecular modeling and process simulation software.	G	9, 6, 12	focused
6663	Chemical Engineering	Analysis and Modeling of Transport Phenomena	Students will learn the basic differential equations and boundary conditions governing momentum, heat, and mass transfer. Students will learn how to think about these equations in dimensionless terms and will apply them to model physical and chemical processes. The primary mode for solving them will be numerical. Analytical results for classical problems of high symmetry also will be presented to serve as a basis for comparison and validation. Software: A finite element and computational transport tool.	G	4, 11, 9	focused
6681	Chemical Engineering	Special Topics: Data Science and Machine Learning in Chemical Engineering	This class will examine topics related to data science and machine learning in chemical engineering. This may include topics in data visualization and modeling, differentiable programming, and the use of data and models to design experiments. The course will emphasize computational implementations of these topics using Python, with applications in chemical engineering. Students will need to be comfortable with scientific programming using Python. Students who have take 06-623 and/or 06-625 should have the skills needed in this class.	G	4, 9, 6	focused
6714	Chemical Engineering	Surfaces and Adsorption	A survey of solid surfaces and gas-solid interactions. Topics include the structure and electronic properties of metal surfaces, the kinetics and thermodynamics of adsorption and desorption processes, and concepts in heterogeneous catalysis. The course emphasizes the application of recent experimental techniques in studying these problems.	G	7, 9, 13	focused
6722	Chemical Engineering	Bioprocess Design	This course is designed to link concepts of cell culture, bioseparations, formulation, and delivery together for the commercial production and use of biologically-based pharmaceuticals; products considered include proteins, nucleic acids, and fermentation-derived fine chemicals. Associated regulatory issues and biotech industry case studies are also included. A fair knowledge of cell culture and fermentation operations is assumed.	G	9, 6, 11	focused
7090	Computer Science	Artificial Intelligence Practicum	This course is for Artificial Intelligence students who wish to have an internship experience as part of their curriculum. Students are required to write a one-page summary statement prior to registration that explains how their internship connects with their AI curriculum, specifically on how it uses material they have learned as well as prepares them for future courses. Near the end of the internship, students will be required to submit a reflection paper that describes the work they did in more detail, including lessons learned about the work experience and how they utilized their AI education to work effectively. International students should consult with the Office of International Education for appropriate paperwork and additional requirements before registration. Units earned count toward the total required units necessary for degree completion; students should speak with an academic advisor for details. This course may be taken at most 3 times for a total of 9 units maximum. Students normally register for this course for use during the summer semester.	U	4, 17, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
7131	Computer Science	Great Practical Ideas for Computer Scientists	THIS COURSE IS OPEN TO CS FIRST YEAR ONLY. Throughout your education as a Computer Scientist at Carnegie Mellon, you will take courses on programming, theoretical ideas, logic, systems, etc. As you progress, you will be expected to pick up the so-called "tools of the trade." This course is intended to help you learn what you need to know in a friendly, low-stress, high-support way. We will discuss UNIX, LaTeX, debugging and many other essential tools. Laptop required. (Laptops will be available for those without their own laptops.)	U	4, 9, 1	focused
7180	Computer Science	Concepts in Artificial Intelligence	The course will introduce students to the main foundational concepts and techniques used in Artificial Intelligence (AI), including heuristic search, machine learning, automated decision making, and interaction with the physical world. The course will present a range of real-world applications in which AI is currently used. Students will be introduced to the history of AI, as well as the potential future of a world in which AI is commonplace. Programming-based assignments will enable students to get a feel for AI techniques. **FOR UNDERGRADUATES ONLY**	U	4, 9, 11	focused
9101	Chemistry	Introduction to Experimental Chemistry	This is a seven week chemistry laboratory course that is designed to introduce students to some basic laboratory skills, techniques, and equipment commonly used in experimental chemical investigations. The experiments will apply concepts in organic synthesis, quantitative analysis using visible spectrophotometry, kinetics, acid-base chemistry, thermochemistry, transition metal chemistry, chromatography, and protein biochemistry. 1 hr. lec., 3 hrs. lab.	U	4, 2, 9	focused
9103	Chemistry	Atoms, Molecules and Chemical Change	This is a one-semester introductory college level course designed for non-science and engineering majors who have had a high school course in chemistry. Students with primary or additional majors in MCS, CIT or SCS will not be allowed to enroll. Chemistry topics will be introduced on an as needed basis in the contexts of air pollution, the ozone layer, global warming, acid rain, safe drinking water, alternative energy sources, plastics, and drug design. Students will apply concepts in topics such as the classification of matter, the relationship between matter and energy, atomic theory and the Periodic Table, chemical bonding, molecular shapes, molecular polarity, interparticle forces, chemical reactions, stoichiometry, properties of aqueous solutions, acid-base chemistry, redox chemistry, and organic chemistry. Students will gain an understanding of how chemistry impacts major environmental, social, political, and economic issues that we encounter daily. They will also learn to apply chemical concepts to new situations or contexts. Students with credit for 09-105 or more advanced chemistry courses will not be allowed to enroll in this course. 3 hrs. lec., 1 hr. rec.	U	13, 6, 4	focused
9105	Chemistry	Introduction to Modern Chemistry I	This course begins with a very brief survey of some fundamental principles of chemistry and a presentation of chemically interesting applications and sophisticated problems. These will form the basis for introducing the relationships between the structure of molecules and their chemical properties and behavior. The subject matter will include principles of atomic structure, chemical bonding, intermolecular interactions and molecular structures of organic and inorganic compounds including some transition metal complexes. Relevant examples will be drawn from such areas as environmental, materials, and biological chemistry. 3 hrs. lec, 2 hrs. rec.	U	12, 13, 2	focused
9106	Chemistry	Modern Chemistry II	This course provides an overview of thermodynamics, kinetics and chemical equilibrium. Topics include the flow of energy in chemical systems; the spontaneity of chemical processes, i.e. entropy and free energy; the mechanisms and rates of chemical reactions; and the use of chemical equilibrium to reason about acid-base chemistry, solubility and electrochemistry. Applications include the energy economy, biological systems and environmental chemistry. 3 hrs. lec., 2 hrs. rec.	U	7, 13, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
9107	Chemistry	Honors Chemistry: Fundamentals, Concepts and Applications	This is an honors introductory course designed to provide students with a rigorous coverage of general chemistry in the context of grand challenges in the field. Traditional topics, such as equilibrium, kinetics, acid-base chemistry, and quantum chemistry, will be discussed through current research on nucleic acid-based therapeutics, atmospheric chemistry of pollutants, and catalysts for the production of solar fuels. The approach will integrate traditional lectures and readings from the textbook with discussions of journal articles, on-line content on research methods, and guest lectures from CMU faculty in these areas. This course assumes strong preparation in chemistry (AP Chemistry score of 3 or greater; IB Chemistry score of 5 or greater; SAT II Chemistry exam with a score of 700 or greater) and will be offered at an accelerated pace. The goal is to teach core principles of chemistry while exposing students to the diversity of modern chemical research and how it is addressing grand challenges facing society. 3 hrs. lec., 2 hrs. rec.	U	7, 4, 13	focused
9108	Chemistry	The Illusion and Magic of Food	Have you ever wondered how your morning orange juice when squeezed fresh from the fruit spoils after few hours while the one from the market lasts much longer without apparent alteration? How is that ground meat looks so red on the outside and unpleasantly brown in the inside? What is the nutritional value of milk and honey? Want to know how fruit flies helped to discover ways to make better-smelling beer? Why is wine normally stored in a dark glass bottle? These and many more questions will be answered in this course, not only by the instructor but also through the students research and curiosity. This course will introduce chemistry concepts on an as-needed basis but it will remain at the level of high school chemistry. We expect to help the student understand what food is made of, its nutritional value, how it is processed to offer longer shelf life, and how this may affect critical components. The topics will vary depending of the students motivation in learning about different concepts related to the food industry, from processing to analysis to packaging and appearance, we plan to discuss interesting things in every class and finish the course with a broad knowledge of what is on our table and better criteria to select our food. 3 hrs. lec.	U	4, 9, 2	focused
9110	Chemistry	The Design and Making of Skin and Hair Products	This hands-on course targets students from across the CMU community who are interested in learning how chemistry applies to their everyday life. We will focus on students gaining knowledge of the chemical components in cosmetics and on the methods for preparing them (from shampoos and conditioners to lotions, soaps and creams). We will emphasize good laboratory practices and safety in terms of the production of the cosmetic product as well as the fundamental chemical and physical concepts that govern the product behavior and use. The overarching goal is that the students have a hands-on laboratory experience and develop a full understanding of the science behind the products that they use every day. No human or animal testing will take place as part of the curriculum.	U	4, 9, 6	focused
9111	Chemistry	Nanolegos: Chemical Building Blocks	This course introduces fundamental chemical concepts and how they are used in various disciplines of scientific and engineering research, explaining everyday phenomena, in understanding technology, and in explaining and solving environmental problems. The course progresses through the major principles of atomic structure, interaction of energy and matter, chemical bonding, intermolecular/interparticle forces, molecular structures of organic and inorganic compounds, multiphase reaction stoichiometry, thermodynamics, kinetics, electrochemistry, equilibrium, and acid-base chemistry.	U	7, 13, 12	focused
9115	Chemistry	Introduction to Undergraduate Research in Chemistry	Undergraduate research is an important activity in the training of undergraduate chemistry majors. This course is intended for students who are planning to declare a major in chemistry who are novices to research at the university level and have an interest in being better informed about strategies and skills that contribute to success. It is intended that this course will lead to an opportunity to participate in a series of shadowing opportunities through a second course in the spring semester where students will be mentored by upperclass students or PhD candidates in faculty laboratories. Spaces will be reserved for MCS students. Students from other colleges with a strong interest in a chemistry major or additional major should contact the Director of Undergraduate Studies in the Chemistry Department.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
9116	Chemistry	Undergraduate Research Shadowing in Chemistry	This is a follow-up course to 09-115, Introduction to Undergraduate Research in Chemistry, which is intended to provide laboratory training for first-year MCS students who want to participate in research in chemistry as soon as their first year, but have not been through the teaching labs yet. Near the end of the fall mini for 09-115, students will be asked to rank their faculty/group interests for possible shadowing. Based on those rankings and faculty/mentor availability, in 09-116, students will be paired with mentors from research labs for seven-week shadowing experiences. Mentors may be graduate students or advanced undergraduate students carrying out research. At the beginning of each mini, the students and mentors will identify blocks of time each week for shadowing based on their schedules. If scheduling allows, students will also be encouraged to attend group meetings (this would count toward lab time). Shadowing will continue for seven weeks, at which time the students may rotate to a second group for another shadowing experience. We request a dedicated lecture room to ensure there is adequate space for the initial pairing and for an overview on assessments, and to allow for possible additional meetings as the course develops.	U	4, 17, 9	focused
9201	Chemistry	Undergraduate Seminar I	Issues and topics of importance to beginning chemistry majors are discussed in this course. It provides a general introduction to the facilities, faculty and programs of the Department of Chemistry and introduces students to career and research opportunities in the field of chemistry. Enrollment limited to students majoring in chemistry. 1 hr.	U	4, 17, 8	focused
9202	Chemistry	Undergraduate Seminar II: Safety and Environmental Issues for Chemists	Issues and topics focused on laboratory safety are discussed in this class. The topics are selected to supplement information covered in 09-221, Laboratory I. This course is intended to provide the necessary safety training for students wishing to undertake undergraduate research projects in the laboratory and is taught in collaboration with the Office of Environmental Health and Safety. Enrollment is limited to chemistry majors. 1 hr.	U	4, 12, 13	focused
9204	Chemistry	Professional Communication Skills in Chemistry	This required course for chemistry majors promotes development of written and oral communication skills in various formats within the discipline. Students are expected to develop these skills by becoming more familiar with the style and format of the chemical literature, current topics in chemistry, and research projects in the Department. Other learning outcomes include developing critical reading skills, providing effective feedback to peers' written and oral communication, demonstrating the ability to revise written work, and using chemical structure drawing software. 1 hr. lec.	U	4, 17, 9	focused
9207	Chemistry	Techniques in Quantitative Analysis	09-207 is the first of two chemistry lab courses required for the BS and BA degrees in biological sciences and the intercollege major in biological sciences and psychology. It is also suitable for fulfilling the requirement for two general chemistry labs for admission to programs in the health professions. The experimental work emphasizes the techniques of quantitative chemical analysis. Included are projects dealing with a variety of instrumental and wet chemical techniques. A mixture of individual and partner experiments concluding with one team experiment is conducted during the semester. In addition to laboratory techniques, safety, and written communication skills are emphasized.	U	4, 9, 6	focused
9217	Chemistry	Organic Chemistry I	This course presents an overview of structure and bonding as it pertains to organic molecules. Selected topics include: introduction to functional group chemistry, stereochemistry, conformational analysis, reaction mechanisms and use of retrosynthetic analysis in the development of multistep syntheses. Methods for structure determination of organic compounds by modern spectroscopic techniques are introduced. 3 hrs. lec., 1 hr. rec.	U	2, 17, 12	focused
9218	Chemistry	Organic Chemistry II	This course further develops many of the concepts introduced in Organic Chemistry I, 09-217. Emphasis is placed on the utilization of reaction mechanisms for understanding the outcome of chemical transformations, and the employment of a wide variety of functional groups and reaction types in the synthesis of organic molecules. Also included in the course will be special topics selected from the following; polymers and advanced materials, biomolecules such as carbohydrates, proteins and nucleic acids, and drug design. 3 hrs. lec., 1 hr. rec.	U	8, 9, 2	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
9219	Chemistry	Modern Organic Chemistry	Traditional introductory organic chemistry courses present structure, reactivity, mechanisms and synthesis of organic compounds. Students taking 09-219 will be exposed to the same topics, but presented in greater depth and broader context, with applications to allied fields such as (1) polymer and materials science, (2) environmental science and (3) biological sciences and medicine. This will be accomplished through an extra 50 minute lecture period, where more advanced topics and applications will be discussed. Topics will include computational chemistry, green chemistry, chiral separations, photochemistry, reaction kinetics, controlled radical polymerizations and petroleum cracking. Students who complete 09-219 will have a strong foundation in organic chemistry as well as a sophisticated understanding of how organic chemistry is currently practiced. 4 hrs. lec., 1 hr. rec.	U	4, 12, 13	focused
9220	Chemistry	Modern Organic Chemistry II	This course builds on 09-219 by introducing students to additional functional groups, chemical reaction mechanisms and synthetic strategies commonly used in the practice of organic chemistry. Advanced topics to be presented during the extra lecture will include multidimensional NMR spectroscopy, enantioselective synthesis, ionic polymerization, bioorganic and medicinal chemistry, natural products chemistry and toxicology. Students who complete 09-220 will have a strong foundation in synthetic, mechanistic and structural organic chemistry and will understand how this applies to human health and the environment. 4 hrs. lec, 1 hr. rec.	U	4, 2, 9	focused
9222	Chemistry	Laboratory II: Organic Synthesis and Analysis	In this second course in the laboratory sequence, students acquire laboratory skills relevant to synthesis and purification of organic compounds, as well as the practical use of chromatography and spectroscopy. Students will also further develop technical writing skills through preparation of lab reports. 2 hrs. lec., 6 hrs. lab.	U	4, 2, 17	focused
9224	Chemistry	Supramolecular Chemistry	Supramolecular chemistry involves the use of noncovalent bonding interactions to assemble molecules into stable, well-defined structures. This course will provide students with an introduction to this exciting field of research, which is finding increasing applications in the biological and materials sciences, nanotechnology and medicine. Students will be introduced to essential background concepts such as types of noncovalent bonding and strategies for the design of supramolecular assemblies. Readings from monographs and classroom lectures by the instructor will cover this material. Students will then begin to read about applications of supramolecular chemistry from the scientific literature, learning to compare articles, to evaluate the quality of the data and interpretations reached by the authors, to use the knowledge gained from these readings and discussions to predict the outcomes of related experiments, and to ultimately be able to design their own experiments to answer research questions. Meeting hours set by instructor, enrollment limited with priority given to sophomore chemistry majors.	U	4, 9, 7	focused
9225	Chemistry	Climate Change: Chemistry, Physics and Planetary Science	Understanding the essential features of climate and climate change is a critical tool for modern citizens and modern scientists. In addition, the prevalence of climate skepticism in modern political discourse requires of citizens that they be able to think critically about a technical subject and also be able to distinguish reliable scientific experts from advocates. In this course we shall examine the climate of terrestrial planets (specifically Earth and Venus) through geological time and to the present, considering geochemical methods used to determine atmospheric composition over Earths history (specifically the onset of oxygen in the atmosphere as well as the relationship between carbon dioxide and global temperature over geological timescales. The shorter climate history of Venus will be considered as a counter example, where the brightening dim young sun overwhelmed negative feedbacks in the weathering cycle, leading to a runaway greenhouse amplified by complete evaporation of the onetime Venus ocean. Throughout the course, we will consider climate change driven by human activity since the industrial revolution as a unifying theme.	U	13, 8, 9	focused
9231	Chemistry	Mathematical Methods for Chemists	This course covers mathematical techniques that are important in the chemical sciences. The techniques will be covered in the context of chemical phenomena, and combine topics from 3-dimensional calculus, differential equations, linear algebra and statistics. This course does not count towards the minor in chemistry. 3 hrs. lec.	U	4, 6, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
9303	Chemistry	Hooked: The Molecular Basis of Addiction	This course will introduce students to the topic of addiction through the framework of opioids, which are drugs that can trace their lineage back to the opium plant. (The term opiates is also commonly used and, while different, the two terms are often used interchangeably.) Opioids are among the most useful drugs ever developed, but they have also had devastating effects on society through their highly addictive properties. The scientific foundation of the course will be formed by the organic chemistry of opioid drug development and the biochemistry of opioid function in the brain. These scientific topics will be linked to the broader context through which opioid treatment and addiction are increasingly affecting our daily lives. The course will be organized in units that begin with a historical/societal "big picture" overview, followed by technical discussions of the underlying chemistry and biochemistry. Topics will include but are not limited to (1) biochemistry of endogenous opioid peptides; (2) morphine as a medicinal agent; (3) morphine derivatives: the good, the bad and the ugly; and (4) the fentanyl scourge. In the latter half of the semester, other addictive substances such as alcohol, marijuana, cocaine, nicotine and amphetamines will be introduced.	U	4, 2, 9	focused
9321	Chemistry	Laboratory III: Molecular Design and Synthesis	In this third course in the laboratory sequence, students will learn a variety of more advanced techniques for organic synthesis and characterization, and will gain experience with developing and designing synthetic procedures. Student writing skills are further reinforced through preparation of detailed lab reports. 2 hrs. lec., 6 hrs. lab.	U	4, 2, 9	focused
9322	Chemistry	Laboratory IV: Molecular Spectroscopy and Dynamics	This laboratory course is devoted to physical chemistry experiments, which involve the use of modern spectroscopic instrumentation to probe the optical and magnetic properties of molecules. The experiments include the use of high-resolution infrared, laser Raman, NMR, EPR, fluorescence, and UV-visible spectroscopies. Additional experiments demonstrate methods for measuring enzyme-catalyzed reaction rate constants, and the use of scanning probe microscopy for imaging and characterization of biological macromolecules.Throughout the course the students will learn how to use computer algebra packages for rigorous data analysis and modeling and will develop the skills in basic electronics, and vacuum techniques. 2 hrs. lec., 6 hrs. lab.	U	4, 9, 8	focused
9323	Chemistry	Bioorganic Chemistry Laboratory	Bioorganic chemistry is concerned with the action of synthesized compounds on biological systems. In order to maximize the likelihood of identifying a biologically active compound, synthetic libraries are often employed, requiring extensive familiarity with simple, efficient chemical coupling steps and protecting group chemistry. In this inquiry based laboratory course, using a process that mimics the current practice in drug discovery by pharmaceutical companies, students will rationally design a compound library in hopes of finding a compound active against a selected biological target, search for active compounds in the library, and then quantitatively characterize any identified compounds for activity. Working in small groups, students will develop proposals for and execute the target assay selected, the library synthesis, and the screening approach. Students will write reports summarizing the results in each phase of the course. Throughout the course, students will be introduced to concepts relevant to industrial scientific research, including regulatory compliance, quality control and assurance, and intellectual property.	U	9, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
9325	Chemistry	Special Topics in Chemistry: Environmental Systems on A Changing Planet	This course introduces the interconnected Earth systems that regulate our climate and ecosystems, providing the resources required to sustain all life, including human societies. Environmental systems are the fascinating connections between the oceans, atmosphere, continents, ecosystems, and people that provide our planet with resources that all life depends on. Human activities disrupt these natural systems, posing critical threats to the sustainable functioning of environmental systems. The course will explore how solar and biochemical energy moves through the Earth's interconnected systems, recycling nutrients; how complex environmental systems function to produce critical resources such as food and water; and how human activities interfere with environmental systems. Case studies include the interplay between climate change feedbacks, wildfires, and forest ecosystems; the hazards that everyday chemical toxins pose to ecosystems and human health and reproduction; and growing threats to ecosystem health and biodiversity. We will also develop the environmental, scientific, and information literacy required to understand current environmental issues that are frequently debated in the public sphere. This course draws on principles learned in high school science and satisfies the science requirement for the interdisciplinary Minor in Environmental and Sustainability Studies.	U	12, 13, 7	focused
9331	Chemistry	Modern Analytical Instrumentation	This course will cover all aspects of analytical instrumentation and its application to problems in materials, environmental, and biological chemistry. Topics covered will include mass spectrometry, optical spectroscopies and NMR. In addition, the course will emphasize how to select an analytical method appropriate to the problem at hand, how to optimize the signal to noise obtained by a measurement, and the quantitative analysis of experimental data. Some basic electronics will be covered as well. 3 hrs. lec.	U	12, 13, 9	focused
9344	Chemistry	Physical Chemistry (Quantum): Microscopic Principles of Physical Chemistry	The measurement and theoretical description of the properties of atoms and molecules are presented. The elementary principles of quantum chemistry are developed. The many types of spectroscopy used to study atoms and molecules are described. Methods of atomic structure determination are discussed. The structure and properties of solids are also presented. The basic results of statistical chemistry are outlined and a brief connection to thermodynamics is made. 3 hrs. lec., 1 hr. rec.	U	4, 17, 6	focused
9345	Chemistry	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	The measurement and theoretical descriptions of the equilibrium properties of chemical systems are presented. Chemical thermodynamics is introduced at the upper division level. The phases of matter are discussed. The quantitative treatment of mixtures is developed. The detailed description of chemical equilibrium is elaborated. The measurement and theoretical description of the nonequilibrium properties of chemical systems are presented. Elementary transport properties are introduced. The principles of classical chemical kinetics are developed in great detail. 3 hrs. lec., 1 hr. rec.	U	4, 11, 9	focused
9347	Chemistry	Advanced Physical Chemistry	09-347 Advanced Physical Chemistry Fall: 12 units A course of study designed to provide the microscopic basis of concepts encountered in the field of chemical engineering. The properties of macroscopic materials are calculated in terms of the microscopic properties of atoms and molecules. Both classical and quantum approaches are employed. The thermodynamic properties are developed in terms of the chemical potentials of the constituent particles. The transport properties are calculated using molecular dynamics and Brownian dynamics. Classical chemical kinetics is fully developed and applied to complex reactions. Rate constants are calculated for simple reactions in gases and solutions. The course enrollment is limited to chemical engineering majors. 4 hrs. lec.	U	9, 13, 12	focused
9348	Chemistry	Inorganic Chemistry	The focus of this class is understanding the properties of the elements and of the inorganic compounds. The electronic structure of elements is discussed as the basis for the element's organization in the Periodic Table and for their properties. The systematic chemistry of main group elements and of transition metals is presented. The number of inorganic compounds is extremely large and their properties are extremely diverse. Therefore in this course, the presentation of physical and chemical properties of inorganic compounds is based upon the observation of the trends in the respective properties and the relation between these trends and the place of the elements in the Periodic Table. 3 hrs. lec., 1 hr. rec.	U	6, 9, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
9402	Chemistry	Undergraduate Seminar VI	Students enrolled in this course present a 20 - 30 minute oral report on a current topic in chemistry. This may be from the student's research work or a special chemistry topic of general interest. Presentations or papers prepared for other courses are not acceptable for this purpose. Thoroughness in the use of the chemical literature is emphasized. The use of presentation aids such as PowerPoint is required. Other students in the class submit written evaluations of the presentation. Talks are recorded for viewing by the student and instructor as a means of providing individualized feedback about presentation skills. A seminar presentation is required of all chemistry majors. No exceptions possible. Enrollment is limited to students majoring in chemistry. 1 hr.	U	4, 3, 17	focused
9403	Chemistry	Hooked: The Chemical Basis of Drug Addiction	What makes us need something so much that it eclipses other important aspects of our lives, such as family, friends, work, hobbies, health and wellness? There are many different types of addiction; this course will focus on molecular addictions, specifically those involving members of the opiate class of narcotics. The ongoing epidemic of opiate addiction, arising both from over-prescription of pain killers and recreational use of heroin, has been widely reported and continues to rise at alarming rates, ravaging our urban and rural communities. In this course, we will explore the complicated role of chemistry in this epidemic, including the good (elucidating mechanisms of action, development of clinically useful and safe opiates and non-opiate pain killers) and the bad (design and synthesis of increasingly addictive opiates). We will also discuss ethical questions faced by the pharmaceutical industry that develops, markets and sells opiates, the medical community that prescribes opiates, and the government agencies charged with regulating these activities. Students who complete this course will emerge with a broad understanding and perspective on an issue that is of great scientific and societal importance. 3 hrs. lec.	U	9, 4, 11	focused
9445	Chemistry	Undergraduate Research	Properly qualified students may undertake research projects under the direction of members of the faculty, normally 6 to 12 hrs/week. A written, detailed report describing the project and results is required. Course may be taken only with the consent of a faculty research advisor in chemistry or on occasion in another department provided that the project is chemical in nature and with permission of the Director of Undergraduate Studies. The number of units taken generally corresponds to the actual number of hours the student actually spends in the lab doing research during the week. Maximum number of units taken per semester is 18.	U	4, 17, 9	focused
9502	Chemistry	Organic Chemistry of Polymers	A study of the synthesis and reactions of high polymers. Emphasis is on practical polymer preparation and on the fundamental kinetics and mechanisms of polymerization reactions. Topics include: relationship of synthesis and structure, step-growth polymerization, chain-growth polymerization via radical, ionic and coordination intermediates, copolymerization, discussions of specialty polymers and reactions of polymers. 09-509, Physical Chemistry of Macromolecules, is excellent preparation for this course but is not required. 3-6 hrs. lec. (Graduate Course: 12 units, 09-741)	U	2, 8, 4	focused
9507	Chemistry	Nanoparticles	This course discusses the chemistry, physics, and biology aspects of several major types of nanoparticles, including metal, semiconductor, magnetic, carbon, and polymer nanostructures. For each type of nanoparticles, we select pedagogical examples (e.g. Au, Ag, CdSe, etc.) and introduce their synthetic methods, physical and chemical properties, self assembly, and various applications. Apart from the nanoparticle materials, other topics to be briefly covered include microscopy and spectroscopy techniques for nanoparticle characterization, and nanolithography techniques for fabricating nano-arrays. The course is primarily descriptive with a focus on understanding major concepts (such as plasmon, exciton, polaron, etc.). The lectures are power point presentation style with sufficient graphical materials to aid students to better understand the course materials. Overall, this course is intended to provide an introduction to the new frontiers of nanoscience and nanotechnology. Students will gain an understanding of the important concepts and research themes of nanoscience and nanotechnology, and develop their abilities to pursue highly disciplinary nanoscience research. The course should be of interest and accessible to advanced undergraduates and graduate students in fields of chemistry, materials science, and biology. 3 hrs. lec.	U	4, 13, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
9509	Chemistry	Physical Chemistry of Macromolecules	This course develops fundamental principles of polymer science. Emphasis is placed on physio-chemical concepts associated with the macromolecular nature of polymeric materials. Engineering aspects of the physical, mechanical and chemical properties of these materials are discussed in relation to chain microstructure. Topics include an introduction to polymer science and a general discussion of commercially important polymers; molecular weight; condensation and addition synthesis mechanisms with emphasis on molecular weight distribution; solution thermodynamics and molecular conformation; rubber elasticity; and the rheological and mechanical properties of polymeric systems. (This course is also listed as 06-609. Graduate Course: 12 units, 09-715) 3 hrs. lec.	U	9, 4, 12	focused
9510	Chemistry	Chemistry and Sustainability	This course aims to educate students in the foundations of systematic leadership for building a sustainable world. Many sustainability challenges are associated with commercial chemicals and with operational modes of the chemical enterprise. For scientists, effectiveness in solving the technical challenges and redirecting cultural behavior is the defining substance of sustainability leadership. The course aims to challenge students to analyze and understand the root causes of unsustainability, especially in the technological dimension, to imagine a more sustainable world and to begin to define personal leadership missions. Students will be introduced to sustainability ethics as the foundation stone of transformative sustainability leadership, to the Collins ?Sustainability Compass? and ?Code of Sustainability Ethics? and to the Robért/Broman ?Framework for Strategic Sustainable Development (FSSD)?as powerful guiding tools. The Collins ?Bookcase of Green Science Challenges? organizes the technical content. It systematizes the major chemical sustainability challenges of our time: clean synthesis, renewable feed-stocks, safe energy, elemental pollutants, persistent molecular toxicants and endocrine disruptors. Focal areas will be the technical, toxicological and cultural histories of elemental and molecular pollutants and endocrine disruptor (ED) science?EDs represent the single greatest sustainability challenge of everyday chemicals. The graded substance will take the form of take-home work. Students will primarily read key books and articles and will summarize and personally evaluate the material in essay assignments. The course is intended for upper level undergraduates and graduates. There are no other prerequisites. The class is limited to 25 students. The 09-510 assignments are common to both undergraduate and graduate classes offerings. (Graduate course 12 units 09-710) 3 hrs. lec.	U	7, 12, 4	focused
9519	Chemistry	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	This course will introduce students to new developments in chemistry and biology, with emphasis on the synthesis, structural and functional aspects of peptides, proteins and small molecules. Basic concepts of bioorganic chemistry will be presented in the context of the current literature and students will have the opportunity to learn about the experimental methods used in various research labs. An introduction to combinatorial chemistry in the context of drug design and drug discovery will also be presented. Students will be required to keep abreast of the current literature. Homeworks and team projects will be assigned on a regular basis. The homework assignments will require data interpretation and experimental design; and team projects will give students the opportunity to work in teams to tackle contemporary problems at the interface of chemistry and biology. Students enrolled in the graduate level course (09-719) will be required to turn in an original research proposal at the end of the course, in addition to the homework assignments, midterm, and final exam that are required for the undergraduate course. (Graduate Course: 12 units 09-719) 3 hrs. lec.	U	4, 9, 17	focused
9522	Chemistry	Kinetics and Mechanisms of Enzymatic Reactions	Major attention is devoted to kinetic methods of investigation of mechanisms of homogeneous chemical and enzymatic reactions. A mini course on kinetics and mechanisms of chemical reactions in solution is integrated followed by basics of kinetics of enzymatic reactions. The relationships between electronic structures, catalytic properties, and oxidation reactivity of biologically relevant metal complexes will be provided. Multiple roles of metal complexes in chemical and biochemical oxidations will be presented. Electrochemical and redox properties, electronic structures of metal complexes will be reviewed. Mechanistic pathways of action of hydrolases, kinases, hydrogenases, oxidases, peroxidases, cytochrome P-450, and other metalloenzymes will be described. (Graduate course: 09-722, 12-units) 3 hrs. lec.	U	9, 4, 6	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
9529	Chemistry	Introduction to Sustainable Energy Science	This course focuses on the chemistry aspects of sustainable energy science. It introduces the major types of inorganic and molecular materials for various important processes of energy conversion and storage, such as photovoltaics, fuel cells, water splitting, solar fuels, batteries, and CO2 reduction. All the energy processes heavily rely on innovations in materials. This course is intended to offer perspectives on the materials/physical chemistry that are of importance in energy processes, in particular, how the atomic and electronic structures of materials impact the energy harvesting and conversion. In current energy research, intense efforts are focused on developing new strategies for achieving sustainable energy through renewable resources as opposed to the traditional oil/coal/gas compositions. This course offers students an introduction to the current energy research frontiers with a focus on solar energy conversion/storage, electrocatalysis and artificial photosynthesis. The major types of materials to be covered include metals, semiconductors, two-dimensional materials, and hybrid perovskites, etc. The material functions in catalysis, solar cells, fuel cells, batteries, supercapacitors, hydrogen production and storage are also discussed in the course. The lectures are power-point presentation style with sufficient graphical materials to aid students to better understand the course materials. Demo experiments are designed to facilitate student learning.	U	7, 13, 6	focused
9563	Chemistry	Molecular Modeling and Computational Chemistry	Computer modeling is playing an increasingly important role in chemical, biological and materials research. This course provides an overview of computational chemistry techniques including molecular mechanics, molecular dynamics, electronic structure theory and continuum medium approaches. Sufficient theoretical background is provided for students to understand the uses and limitations of each technique. An integral part of the course is hands on experience with state-of-the-art computational chemistry tools running on graphics workstations. This course I can count towards coursework requirements for chemistry PhD candidates. 3 hrs. lec.	U	4, 9, 17	focused
9611	Chemistry	Chemical Thermodynamics	A focused course on chemical thermodynamics. The basic thermodynamic functions will be introduced and discussed. The formal basis for thermochemistry will be presented. Single component phase equilibrium will be considered. The thermodynamic basis of solutions will be developed and applied to separation methods. The fundamental basis of chemical equilibrium will be developed and applied to a wide variety of reactions. Finally, a few special topics such as self-assembled systems will be presented. This is a graduate level course in chemistry and presumes the appropriate undergraduate preparation.	G	9, 4, 6	focused
9707	Chemistry	Nanoparticles	This course discusses the chemistry, physics, and biology aspects of several major types of nanoparticles, including metal, semiconductor, magnetic, carbon, and polymer nanostructures. For each type of nanoparticles, we select pedagogical examples (e.g. Au, Ag, CdSe, etc.) and introduce their synthetic methods, physical and chemical properties, self assembly, and various applications. Apart from the nanoparticle materials, other topics to be briefly covered include microscopy and spectroscopy techniques for nanoparticle characterization, and nanolithography techniques for fabricating nano-arrays. The course is primarily descriptive with a focus on understanding major concepts (such as plasmon, exciton, polaron, etc.). The lectures are power point presentation style with sufficient graphical materials to aid students to better understand the course materials. Overall, this course is intended to provide an introduction to the new frontiers of nanoscience and nanotechnology. Students will gain an understanding of the important concepts and research themes of nanoscience and nanotechnology, and develop their abilities to pursue highly disciplinary nanoscience research. 3 hrs. lec.	G	13, 4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
9710	Chemistry	Chemistry and Sustainability	This course aims to educate students in the foundations of systematic leadership for building a sustainable world. Many sustainability challenges are associated with commercial chemicals and with operational modes of the chemical enterprise. For scientists, effectiveness in solving the technical challenges and redirecting cultural behavior is the defining substance of sustainability leadership. The course aims to challenge students to analyze and understand the root causes of unsustainability, especially in the technological dimension, to imagine a more sustainable world and to begin to define personal leadership missions. Students will be introduced to sustainability ethics as the foundation stone of transformative sustainability leadership, to the Collins ?Sustainability Compass? and ?Code of Sustainability Ethics? and to the Robért/Broman ?Framework for Strategic Sustainable Development (FSSD)?as powerful guiding tools. The Collins ?Bookcase of Green Science Challenges? organizes the technical content. It systematizes the major chemical sustainability challenges of our time: clean synthesis, renewable feed-stocks, safe energy, elemental pollutants, persistent molecular toxicants and endocrine disruptors. Focal areas will be the technical, toxicological and cultural histories of elemental and molecular pollutants and endocrine disruptor (ED) science?EDs represent the single greatest sustainability challenge of everyday chemicals. The graded substance will take the form of take-home work. Students will primarily read key books and articles and will summarize and personally evaluate the material in essay assignments. The course is intended for upper level undergraduates and graduates. There are no other prerequisites. The class is limited to 25 students. The 09-510 assignments are common to both undergraduate and graduate classes offerings and 09-710 students will engage in additional projects. 3 hrs. lec.	G	7, 12, 4	focused
9714	Chemistry	Advanced Organic Chemistry	This course will expose the students to modern methods of organic synthesis including insights into the basis and mechanisms of chemical reactions. Topics include but are not limited to: modern spectroscopic analysis and structure determination, synthetic methods, retrosynthesis, organic reaction mechanisms, and references to separation techniques and some analytical methods. Upon completion of the course students should be able to design reaction schemes using scientific literature sources, evaluate their suitability for use in the lab and develop an aptitude in identifying the use of modern reagents that are more efficient, specific, safer and environmentally friendly. It is assumed that at minimum students will have completed at least two semesters of undergraduate coursework in organic chemistry and suggested that they have completed 09-222 and 09-321, the organic laboratory courses. 3 hrs. lec	G	4, 12, 2	focused
9715	Chemistry	Physical Chemistry of Macromolecules	This course addresses the fundamentals of polymer science with the emphasis on physicochemical consequences of chain nature of macromolecules and on the behavior of polymers in condensed state (polymers as soft condense matter). The topics to be covered include: chain structure and molecular weight; molecular weight distribution; step growth and addition polymerization mechanisms; chain conformation and behavior of polymers in solution; concentrated solutions and phase separation behavior; rubber elasticity; introduction to polymer viscoelasticity and rheology; mechanical behavior of polymers; glass transition and crystallization; multicomponent polymeric materials; liquid crystalline polymers; polymers at surfaces and interfaces; self-assembly and nanostructure formation in synthetic and biological systems; conducting and semiconducting polymers. Graduate students taking the course for 12 units will be required to write a term paper on a selected topic. 3 hrs. lec.	G	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
9719	Chemistry	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	This course will introduce students to new developments in chemistry and biology, with emphasis on the synthesis, structural and functional aspects of peptides, proteins and small molecules. Basic concepts of bioorganic chemistry will be presented in the context of the current literature and students will have the opportunity to learn about the experimental methods used in various research labs. An introduction to combinatorial chemistry in the context of drug design and drug discovery will also be presented. Students will be required to keep abreast of the current literature. Homeworks and team projects will be assigned on a regular basis. The homework assignments will require data interpretation and experimental design; and team projects will give students the opportunity to work in teams to tackle contemporary problems at the interface of chemistry and biology. Students enrolled in the graduate level course (09-719) will be required to turn in an original research proposal at the end of the course, in addition to the homework assignments, midterm, and final exam that are required for the undergraduate course.	G	4, 9, 17	focused
9729	Chemistry	Introduction to Sustainable Energy Science	This course focuses on the chemistry aspects of sustainable energy science. It introduces the major types of inorganic and molecular materials for various important processes of energy conversion and storage, such as photovoltaics, fuel cells, water splitting, solar fuels, batteries, and CO2 reduction. All the energy processes heavily rely on innovations in materials. This course is intended to offer perspectives on the materials/physical chemistry that are of importance in energy processes, in particular, how the atomic and electronic structures of materials impact the energy harvesting and conversion. In current energy research, intense efforts are focused on developing new strategies for achieving sustainable energy through renewable resources as opposed to the traditional oil/coal/gas compositions. This course offers students an introduction to the current energy research frontiers with a focus on solar energy conversion/storage, electrocatalysis and artificial photosynthesis. The major types of materials to be covered include metals, semiconductors, two-dimensional materials, and hybrid perovskites, etc. The material functions in catalysis, solar cells, fuel cells, batteries, supercapacitors, hydrogen production and storage are also discussed in the course. The lectures are power-point presentation style with sufficient graphical materials to aid students to better understand the course materials. Demo experiments are designed to facilitate student learning.	G	7, 13, 6	focused
9736	Chemistry	Transition Metal Catalysis for Organic and Polymer Synthesis	Transition metal catalysts are invaluable in small molecule and polymer synthesis. The course will begin with a brief overview of organometallic chemistry and a discussion of fundamental organometallic reactions. Following this, a survey of some selected topics for the formation of small molecules and polymers will be presented. Some topics to be highlighted include: (1) Hydrogenation (2) Palladium Catalyzed Cross-Coupling (3) Epoxidation (4) Olefin Metathesis (5) Olefin Polymerization	G	2, 9, 12	focused
9737	Chemistry	Medicinal Chemistry and Drug Development	Organic chemistry is an intimate part of the drug discovery and design processes in areas that include structure determination (NMR, mass spectrometry), synthesis, and determination of mechanisms of action. Once a promising compound (i.e. a ?lead?) has been identified in the laboratory, it is rarely ready to be used in the clinic. Complications include poor bioavailability, rapid degradation, and off-target effects. Students will learn about lead compound optimization through structural variations, cell-specific targeting and pro-drug strategies. Several examples will be presented to illustrate the role played by organic chemistry in the development of drugs used to treat a range of diseases, including cancer, HIV-AIDS, bacterial infections and heart disease.	G	3, 4, 2	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
9741	Chemistry	Organic Chemistry of Polymers	A study of the synthesis and reactions of high polymers. Emphasis is on practical polymer preparation and on the fundamental kinetics and mechanisms of polymerization reactions. Topics include: relationship of synthesis and structure, step-growth polymerization, chain-growth polymerization via radical, ionic and coordination intermediates, copolymerization, discussions of specialty polymers and reactions of polymers. Students in 09-741 will take the same lectures and the same exams as those enrolled in 09-502 but, in addition, will prepare a term paper on the topic of advanced polymeric materials, to be approved by the instructor. 09-509 or 09-715, Physical Chemistry of Macromolecules, is excellent preparation for this course but is not required. 3-6 hrs. lec.	G	4, 2, 9	focused
9763	Chemistry	Molecular Modeling and Computational Chemistry	Computer modeling is playing an increasingly important role in chemical, biological and materials research. This course provides an overview of computational chemistry techniques including molecular mechanics, molecular dynamics, electronic structure theory and continuum medium approaches. Sufficient theoretical background is provided for students to understand the uses and limitations of each technique. An integral part of the course is hands on experience with state-of-the-art computational chemistry tools running on graphics workstations. This is the graduate equivalent of 09-563. Students enrolled in the graduate level course will complete an additional independent project. 3 hrs. lec.	G	4, 17, 9	focused
9768	Chemistry	Machine Learning for Molecular Sciences	The emergence of contemporary artificial intelligence (AI) and machine learning (ML) methods has the potential to substantially alter and enhance the role of computers in science. At the heart of ML applications, lie statistical algorithms whose performance, much like that of a scholar, improves with training. There is a growing infrastructure of machine learning tools for generating, testing and refining scientific models. Such techniques are suitable for addressing complex problems that involve vast combinatorial spaces or complex processes, which conventional procedures either cannot solve or can tackle only at great computational cost. The purpose of this course is to provide a practical introduction to the core concepts and tools of machine learning in a manner easily understood and intuitive to STEM students. The course begins by covering fundamental concepts in ML, data science, and modern statistics such as the bias-variance tradeoff, overfitting, regularization, and generalization, before moving on to more advanced topics in both supervised and unsupervised learning. Topics covered in the course also include ensemble models, neural networks, modern deep learning, embedding, clustering and data visualization. Throughout the course, we emphasize application of ML methods to chemical, physical and biological data. A notable aspect of the course is the hands-on use of Python Jupyter notebooks to introduce modern ML/statistical packages.	G	4, 9, 5	focused
10301	Machine Learning	Introduction to Machine Learning	Machine Learning (ML) develops computer programs that automatically improve their performance through experience. This includes learning many types of tasks based on many types of experience, e.g. spotting high-risk medical patients, recognizing speech, classifying text documents, detecting credit card fraud, or driving autonomous vehicles. 10301 covers all or most of: concept learning, decision trees, neural networks, linear learning, active learning, estimation & the bias-variance tradeoff, hypothesis testing, Bayesian learning, the MDL principle, the Gibbs classifier, Naive Bayes, Bayes Nets & Graphical Models, the EM algorithm, Hidden Markov Models, K-Nearest-Neighbors and nonparametric learning, reinforcement learning, bagging, boosting and discriminative training. Grading will be based on weekly or biweekly assignments (written and/or programming), a midterm, a final exam. 10301 is recommended for undergraduates who are not SCS majors. (SCS majors should instead take 10315.) Prerequisites (strictly enforced): strong quantitative aptitude, college probability & statistics course, and programming proficiency. For learning to apply ML practically & effectively, without the above prerequisites, consider 11344/05834 instead. You can evaluate your ability to take the course via a self-assessment exam (http://bit.ly/2fkddDN). Also, be sure to read the ML course comparison (http://bit.ly/2eV3UaD).	U	4, 8, 5	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
10315	Machine Learning	Introduction to Machine Learning (SCS Majors)	Machine learning is subfield of computer science with the goal of exploring, studying, and developing learning systems, methods, and algorithms that can improve their performance with learning from data. This course is designed to give undergraduate students a one-semester-long introduction to the main principles, algorithms, and applications of machine learning and is specifically designed for the SCS undergrad majors. The topics of this course will be in part parallel with those covered in the graduate machine learning courses (10-715, 10-701, 10-601), but with a greater emphasis on applications and case studies in machine learning. After completing the course, students will be able to: *select and apply an appropriate supervised learning algorithm for classification problems (e.g., naive Bayes, perceptron, support vector machine, logistic regression). *select and apply an appropriate supervised learning algorithm for regression problems (e.g., linear regression, ridge regression). *recognize different types of unsupervised learning problems, and select and apply appropriate algorithms (e.g., clustering, linear and nonlinear dimensionality reduction). *work with probabilities (Bayes rule, conditioning, expectations, independence), linear algebra (vector and matrix operations, eigenvectors, SVD), and calculus (gradients, Jacobians) to derive machine learning methods such as linear regression, naive Bayes, and principal components analysis. *understand machine learning principles such as model selection, overfitting, and underfitting, and techniques such as cross-validation and regularization. *implement machine learning algorithms such as logistic regression via stochastic gradient descent, linear regression (using a linear algebra toolbox), perceptron, or k-means clustering. *run appropriate supervised and unsupervised learning algorithms on real and synthetic data sets and interpret the results.	U	4, 9, 1	focused
10403	Machine Learning	Deep Reinforcement Learning & Control	This course brings together many disciplines of Artificial Intelligence (including computer vision, robot control, reinforcement learning, language understanding) to show how to develop intelligent agents that can learn to sense the world and learn to act by imitating others, maximizing sparse rewards, and/or satisfying their curiosity.	U	4, 9	focused
10405	Machine Learning	Machine Learning with Large Datasets (Undergraduate)	Large datasets are difficult to work with for several reasons. They are difficult to visualize, and it is difficult to understand what sort of errors and biases are present in them. They are computationally expensive to process, and often the cost of learning is hard to predict - for instance, and algorithm that runs quickly in a dataset that fits in memory may be exorbitantly expensive when the dataset is too large for memory. Large datasets may also display qualitatively different behavior in terms of which learning methods produce the most accurate predictions. This course is intended to provide a student practical knowledge of, and experience with, the issues involving large datasets. Among the issues considered are: scalable learning techniques, such as streaming machine learning techniques; parallel infrastructures such as map-reduce; practical techniques for reducing the memory requirements for learning methods, such as feature hashing and Bloom filters; and techniques for analysis of programs in terms of memory, disk usage, and (for parallel methods) communication complexity. The class will include programming assignments, and a one-month short project chosen by the student. The project will be designed to compare the scalability of variant learning algorithms on datasets. An introductory course in machine learning, like 10-301, 10-315, or 10-701, is a prerequisite or a co-requisite. If you plan to take this course and the introductory machine learning course concurrently please tell the instructor. The course will include several substantial programming assignments, so an additional prerequisite is 15-211, or 15-214, or comparable familiarity with Java and good programming skills.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
10417	Machine Learning	Intermediate Deep Learning	Building intelligent machines that are capable of extracting meaningful representations from data lies at the core of solving many AI related tasks. In the past decade, researchers across many communities, from applied statistics to engineering, computer science and neuroscience, have developed deep models that are composed of several layers of nonlinear processing. An important property of these models is that they can learn useful representations by re-using and combining intermediate concepts, allowing these models to be successfully applied in a wide variety of domains, including visual object recognition, information retrieval, natural language processing, and speech perception. The goal of this course is to introduce students to both the foundational ideas and the recent advances in deep learning. The first part of the course will focus on supervised learning, including neural networks, back-propagation algorithm, convolutional models, recurrent neural networks, and their extensions with applications to image recognition, video analysis, and language modelling. The second part of the course will cover unsupervised learning, including variational autoencoders, sparse-coding, Boltzmann machines, and generative adversarial networks. This course will assume a reasonable degree of mathematical maturity and will require strong programming skills.	U	4, 9, 8	focused
10601	Machine Learning	Introduction to Machine Learning (Master's)	Machine Learning (ML) develops computer programs that automatically improve their performance through experience. This includes learning many types of tasks based on many types of experience, e.g. spotting high-risk medical patients, recognizing speech, classifying text documents, detecting credit card fraud, or driving autonomous vehicles. 10601 covers all or most of: concept learning, decision trees, neural networks, linear learning, active learning, estimation & the bias-variance tradeoff, hypothesis testing, Bayesian learning, the MDL principle, the Gibbs classifier, Naive Bayes, Bayes Nets & Graphical Models, the EM algorithm, Hidden Markov Models, K-Nearest-Neighbors and nonparametric learning, reinforcement learning, bagging, boosting and discriminative training. Grading will be based on weekly or biweekly assignments (written and/or programming), a midterm, a final exam, and possibly a project (details may vary depending on the section). 10601 is recommended for quantitative Masters students & non-MLD PhD students. Prerequisites (strictly enforced): strong quantitative aptitude, college prob&stats course, and programming proficiency. For learning to apply ML practically & effectively, without the above prerequisites, consider 11344/05834 instead. If you are unsure whether you have sufficient mathematical background to do well in this course, you should consider taking the minis 10-606/10-607 Mathematical Background for Machine Learning. You can evaluate your ability to take the course via a self-assessment exam at: https://qna-app.appspot.com/view.html?aglzfnFuYS1hcHByGQsSDFF1ZXN0aW9uTGlzdBiAgICgpO-KCgw ML course comparison: https://goo.gl/mmR2eL	G	4, 8, 5	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
10605	Machine Learning	Machine Learning with Large Datasets	Large datasets are difficult to work with for several reasons. They are difficult to visualize, and it is difficult to understand what sort of errors and biases are present in them. They are computationally expensive to process, and often the cost of learning is hard to predict - for instance, and algorithm that runs quickly in a dataset that fits in memory may be exorbitantly expensive when the dataset is too large for memory. Large datasets may also display qualitatively different behavior in terms of which learning methods produce the most accurate predictions. This course is intended to provide a student practical knowledge of, and experience with, the issues involving large datasets. Among the issues considered are: scalable learning techniques, such as streaming machine learning techniques; parallel infrastructures such as map-reduce; practical techniques for reducing the memory requirements for learning methods, such as feature hashing and Bloom filters; and techniques for analysis of programs in terms of memory, disk usage, and (for parallel methods) communication complexity. The class will include programming assignments, and a one-month short project chosen by the student. The project will be designed to compare the scalability of variant learning algorithms on datasets. An introductory course in machine learning, like 10-601 or 10-701, is a prerequisite or a co-requisite. If you plan to take this course and 10-601 concurrently please tell the instructor. The course will include several substantial programming assignments, so an additional prerequisite is 15-211, or 15-214, or comparable familiarity with Java and good programming skills.	G	4, 9, 17	focused
10617	Machine Learning	Intermediate Deep Learning	Building intelligent machines that are capable of extracting meaningful representations from data lies at the core of solving many AI related tasks. In the past decade, researchers across many communities, from applied statistics to engineering, computer science and neuroscience, have developed deep models that are composed of several layers of nonlinear processing. An important property of these models is that they can learn useful representations by re-using and combining intermediate concepts, allowing these models to be successfully applied in a wide variety of domains, including visual object recognition, information retrieval, natural language processing, and speech perception. The goal of this course is to introduce students to both the foundational ideas and the recent advances in deep learning. The first part of the course will focus on supervised learning, including neural networks, back-propagation algorithm, convolutional models, recurrent neural networks, and their extensions with applications to image recognition, video analysis, and language modelling. The second part of the course will cover unsupervised learning, including variational autoencoders, sparse-coding, Boltzmann machines, and generative adversarial networks. This course will assume a reasonable degree of mathematical maturity and will require strong programming skills.	G	4, 9, 8	focused
10701	Machine Learning	Introduction to Machine Learning (PhD)	Machine learning studies the question "How can we build computer programs that automatically improve their performance through experience?" This includes learning to perform many types of tasks based on many types of experience. For example, it includes robots learning to better navigate based on experience gained by roaming their environments, medical decision aids that learn to predict which therapies work best for which diseases based on data mining of historical health records, and speech recognition systems that learn to better understand your speech based on experience listening to you. This course is designed to give PhD students a thorough grounding in the methods, mathematics and algorithms needed to do research and applications in machine learning. Students entering the class with a pre-existing working knowledge of probability, statistics and algorithms will be at an advantage, but the class has been designed so that anyone with a strong numerate background can catch up and fully participate. You can evaluate your ability to take the course via a self-assessment exam that will be made available to you after you register. If you are interested in this topic, but are not a PhD student, or are a PhD student not specializing in machine learning, you might consider the master's level course on Machine Learning, 10-601." This class may be appropriate for MS and undergrad students who are interested in the theory and algorithms behind ML. If you are unsure whether you have sufficient mathematical background to do well in this course, you should consider taking the minis 10-606/10-607 Mathematical Background for Machine Learning. You can evaluate your ability to take the course via a self-assessment exam at: https://goo.gl/mmR2eL	G	4, 3, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
10703	Machine Learning	Deep Reinforcement Learning & Control	This course will cover latest advances in Reinforcement Learning and Imitation learning. This is a fast developing research field and an official textbook is available only for about one forth of the course material. The rest will be taught from recent research papers. This course brings together many disciplines of Artificial Intelligence to show how to develop intelligent agent that can learn to sense the world and learn to act imitating others or maximizing sparse rewards Particular focus will be given in incorporating visual sensory input and learning suitable visual state representations.	G	4, 17, 9	focused
10707	Machine Learning	Advanced Deep Learning	Building intelligent machines that are capable of extracting meaningful representations from high-dimensional data lies at the core of solving many AI related tasks. In the past few years, researchers across many different communities, from applied statistics to engineering, computer science and neuroscience, have developed deep (hierarchical) models -- models that are composed of several layers of nonlinear processing. An important property of these models is that they can learn useful representations by re-using and combining intermediate concepts, allowing these models to be successfully applied in a wide variety of domains, including visual object recognition, information retrieval, natural language processing, and speech perception. This is an advanced graduate course, designed for Master's and Ph.D. level students, and will assume a reasonable degree of mathematical maturity. The goal of this course is to introduce students to the recent and exciting developments of various deep learning methods. Some topics to be covered include: restricted Boltzmann machines (RBMs) and their multi-layer extensions Deep Belief Networks and Deep Boltzmann machines; sparse coding, autoencoders, variational autoencoders, convolutional neural networks, recurrent neural networks, generative adversarial networks, and attention-based models with applications in vision, NLP, and multimodal learning. We will also address mathematical issues, focusing on efficient large-scale optimization methods for inference and learning, as well as training density models with intractable partition functions. Prerequisite: ML: 10-701 or 10-715, and strong programming skills.	G	4, 9, 8	focused
10708	Machine Learning	Probabilistic Graphical Models	Many of the problems in artificial intelligence, statistics, computer systems, computer vision, natural language processing, and computational biology, among many other fields, can be viewed as the search for a coherent global conclusion from local information. The probabilistic graphical models framework provides an unified view for this wide range of problems, enabling efficient inference, decision-making and learning in problems with a very large number of attributes and huge datasets. This graduate-level course will provide you with a strong foundation for both applying graphical models to complex problems and for addressing core research topics in graphical models. The class will cover three aspects: The core representation, including Bayesian and Markov networks, and dynamic Bayesian networks; probabilistic inference algorithms, both exact and approximate; and, learning methods for both the parameters and the structure of graphical models. Students entering the class should have a pre-existing working knowledge of probability, statistics, and algorithms, though the class has been designed to allow students with a strong numerate background to catch up and fully participate. It is expected that after taking this class, the students should have obtain sufficient working knowledge of multi-variate probabilistic modeling and inference for practical applications, should be able to formulate and solve a wide range of problems in their own domain using GM, and can advance into more specialized technical literature by themselves. Students are required to have successfully completed 10701 or 10715, or an equivalent class.	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
10715	Machine Learning	Advanced Introduction to Machine Learning	The rapid improvement of sensory techniques and processor speed, and the availability of inexpensive massive digital storage, have led to a growing demand for systems that can automatically comprehend and mine massive and complex data from diverse sources. Machine Learning is becoming the primary mechanism by which information is extracted from Big Data, and a primary pillar that Artificial Intelligence is built upon. This course is designed for Ph.D. students whose primary field of study is machine learning, and who intend to make machine learning methodological research a main focus of their thesis. It will give students a thorough grounding in the algorithms, mathematics, theories, and insights needed to do in-depth research and applications in machine learning. The topics of this course will in part parallel those covered in the general PhD-level machine learning course (10-701), but with a greater emphasis on depth in theory and algorithms. The course will also include additional advanced topics such as fairness in machine learning. Students entering the class are expected to have a pre-existing strong working knowledge of algorithms, linear algebra, probability, and statistics. If you are interested in this topic, but do not have the required background or are not planning to work on a PhD thesis with machine learning as the main focus, you might consider the general PhD-level Machine Learning course (10-701) or the Masters-level Machine Learning course (10-601). ML course comparison: https://goo.gl/mmR2eL	G	4, 17, 9	focused
10716	Machine Learning	Advanced Machine Learning: Theory and Methods	Advanced Machine Learning: Theory and Methods is a graduate level course introducing the theoretical foundations of modern machine learning, as well as advanced methods and frameworks used in modern machine learning. The course assumes that students have taken graduate level introductory courses in machine learning (Introduction to Machine Learning, 10-701 or 10-715), as well as Statistics (Intermediate Statistics, 36-700 or 36-705). The course treats both the art of designing good learning algorithms, as well as the science of analyzing an algorithm's computational and statistical properties and performance guarantees. Theorems are presented together with practical aspects of methodology and intuition to help students develop tools for selecting appropriate methods and approaches to problems in their own research. We will cover theoretical foundation topics such as computational and statistical convergence rates, minimax estimation, and concentration of measure. We will also cover advanced machine learning methods such as nonparametric density estimation, nonparametric regression, and Bayesian estimation, as well as advanced frameworks such as privacy, causality, and stochastic learning algorithms.	G	4, 9, 17	focused
10725	Machine Learning	Convex Optimization	Nearly every problem in machine learning can be formulated as the optimization of some function, possibly under some set of constraints. This universal reduction may seem to suggest that such optimization tasks are intractable. Fortunately, many real world problems have special structure, such as convexity, smoothness, separability, etc., which allow us to formulate optimization problems that can often be solved efficiently. This course is designed to give a graduate-level student a thorough grounding in the formulation of optimization problems that exploit such structure, and in efficient solution methods for these problems. The main focus is on the formulation and solution of convex optimization problems, though we will discuss some recent advances in nonconvex optimization. These general concepts will also be illustrated through applications in machine learning and statistics. Students entering the class should have a pre-existing working knowledge of algorithms, though the class has been designed to allow students with a strong numerate background to catch up and fully participate. Though not required, having taken 10-701 or an equivalent machine learning or statistical modeling class is strongly encouraged, as we will use applications in machine learning and statistics to demonstrate the concepts we cover in class. Students will work on an extensive optimization-based project throughout the semester.	G	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
10805	Machine Learning	Machine Learning with Large Datasets	Large datasets pose difficulties across the machine learning pipeline. They are difficult to visualize and introduce computational, storage, and communication bottlenecks during data preprocessing and model training. Moreover, high capacity models often used in conjunction with large datasets introduce additional computational and storage hurdles during model training and inference. This course is intended to provide a student with the mathematical, algorithmic, and practical knowledge of issues involving learning with large datasets. Among the topics considered are: data cleaning, visualization, and pre-processing at scale; principles of parallel and distributed computing for machine learning; techniques for scalable deep learning; analysis of programs in terms of memory, computation, and (for parallel methods) communication complexity; and methods for low-latency inference. The class will include programming and written assignments to provide hands-on experience applying machine learning at scale. An introductory machine learning course (10-301, 10-315, 10-601, 10-701, or 10-715) is a prerequisite. A strong background in programming will also be necessary; suggested prerequisites include 15-210, 15-214, or equivalent. Students are expected to be familiar with Python or learn it during the course.	G	4, 9, 17	focused
11324	Language Technologies Institute	Human Language for Artificial Intelligence	An enduring aspect of the quest to build intelligent machines is the challenge of human language. This course introduces students with a background in computer science and a research interest in artificial intelligence fields to the structure of natural language, from sound to society. It covers phonetics (the physical aspects of speech), phonology (the sound-structure of language), morphology (the structure of words), morphosyntax (the use of word and phrase structure to encode meaning), syntactic formalisms (using finite sets of production rules to characterize infinite configurations of structure), discourse analysis and pragmatics (language in discourse and communicative context), and sociolinguistics (language in social context and social meaning). Evaluation is based on seven homework assignments, a midterm examination, and a final examination.	U	4, 9, 17	focused
11344	Language Technologies Institute	Machine Learning in Practice	Machine Learning is concerned with computer programs that enable the behavior of a computer to be learned from examples or experience rather than dictated through rules written by hand. It has practical value in many application areas of computer science such as on-line communities and digital libraries. This class is meant to teach the practical side of machine learning for applications, such as mining newsgroup data or building adaptive user interfaces. The emphasis will be on learning the process of applying machine learning effectively to a variety of problems rather than emphasizing an understanding of the theory behind what makes machine learning work. This course does not assume any prior exposure to machine learning theory or practice. In the first 2/3 of the course, we will cover a wide range of learning algorithms that can be applied to a variety of problems. In particular, we will cover topics such as decision trees, rule based classification, support vector machines, Bayesian networks, and clustering. In the final third of the class, we will go into more depth on one application area, namely the application of machine learning to problems involving text processing, such as information retrieval or text categorization.	U	4, 9, 15	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
11411	Language Technologies Institute	Natural Language Processing	This course is about a variety of ways to represent human languages (like English and Chinese) as computational systems, and how to exploit those representations to write programs that do neat stuff with text and speech data, like translation, summarization, extracting information, question answering, natural interfaces to databases, and conversational agents. This field is called Natural Language Processing or Computational Linguistics, and it is extremely multidisciplinary. This course will therefore include some ideas central to Machine Learning and to Linguistics. We'll cover computational treatments of words, sounds, sentences, meanings, and conversations. We'll see how probabilities and real-world text data can help. We'll see how different levels interact in state-of-the-art approaches to applications like translation and information extraction. From a software engineering perspective, there will be an emphasis on rapid prototyping, a useful skill in many other areas of Computer Science.	U	4, 9	focused
11423	Language Technologies Institute	ConLanging: Lrng. Ling. & Lang Tech via Constru Artif. Lang.	Students will work individually or in small groups to create artificial human(oid) languages for fictional human cultures or SciFi worlds. Students will implement language technologies for their languages. In the course of creating the languages, students will learn about the building blocks of human language such as phones, phonemes, morphemes, and morpho-syntactic constructions including their semantics and pragmatics. Class instruction will focus specifically on variation among human languages so that the students can make conlangs that are not just naively English-like. We will also touch on philosophical issues in philosophy of language and on real-world socio-political issues related to language policy. Students will be required to use at least one of the following technologies: language documentation tools that are used for field linguistics and corpus annotation, automatic speech recognition, speech synthesis, morphological analysis, parsing, or machine translation. Learning Objectives: 1. The building blocks (phonemes, morphemes, etc.) of language, how languages are built from them, and how they interact 2. Metalinguistic awareness and knowledge about variation in human language 3. Language, thought, and culture: how does language reflect thought and culture, and vice versa. Why wouldn't Elvish be a good language for Klingons? 4. Language policy in the real world: For students who want to manipulate real languages. 5. Historical linguistics and language change: for students who want to manipulate real languages or make families of related conlangs for fictional worlds. 6. Practical experience with a language technology. http://tts.speech.cs.cmu.edu/11-823/	U	4, 9, 11	focused
11441	Language Technologies Institute	Machine Learning for Text Mining	This course provides a comprehensive introduction to the theory and implementation of algorithms for organizing and searching large text collections. The first half of the course studies text search engines for enterprise and Web environments; the open-source Indri search engine is used as a working example. The second half studies text mining techniques such as clustering, categorization, and information extraction. Programming assignments give hands-on experience with document ranking algorithms, categorizing documents into browsing hierarchies, and related topics.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
11485	Language Technologies Institute	Introduction to Deep Learning	Neural networks have increasingly taken over various AI tasks, and currently produce the state of the art in many AI tasks ranging from computer vision and planning for self-driving cars to playing computer games. Basic knowledge of NNs, known currently in the popular literature as "deep learning", familiarity with various formalisms, and knowledge of tools, is now an essential requirement for any researcher or developer in most AI and NLP fields. This course is a broad introduction to the field of neural networks and their "deep" learning formalisms. The course traces some of the development of neural network theory and design through time, leading quickly to a discussion of various network formalisms, including simple feedforward, convolutional, recurrent, and probabilistic formalisms, the rationale behind their development, and challenges behind learning such networks and various proposed solutions. We subsequently cover various extensions and models that enable their application to various tasks such as computer vision, speech recognition, machine translation and playing games. Instruction Unlike prior editions of 11-785, the instruction will primarily be through instructor lectures, and the occasional guest lecture. Evaluation Students will be evaluated based on weekly continuous-evaluation tests, and their performance in assignments and a final course project. There will be six hands-on assignments, requiring both low-level coding and toolkit-based implementation of neural networks, covering basic MLP, convolutional and recurrent formalisms, as well as one or more advanced tasks, in addition to the final project.	U	4, 9, 17	focused
11488	Language Technologies Institute	Computational Forensics and AI	This course covers the use of computational methods in crime investigation (forensics) and prevention (intelligence). In almost all areas of forensics and intelligence, computational methods continue to aid, and sometimes entirely replace, human expertise in tracking crime. This is desirable since automation can address the problems associated with scale and global crime linkage through diverse data computational tools can potentially overcome and surpass human capabilities for crime investigation. This course is of a cross-disciplinary nature. It amalgamates knowledge from criminology, forensic sciences, computer science, statistics, signal processing, machine learning, AI, psychology, medicine and many other fields. Students from all departments and schools are welcome to take this course.	U	4, 16, 9	focused
11490	Language Technologies Institute	LTI Minor Project - Seniors	No course description provided.	U	17, 1	focused
11492	Language Technologies Institute	Speech Processing	Speech Processing offers a practical and theoretical understanding of how human speech can be processed by computers. It covers speech recognition, speech synthesis and spoken dialog systems. The course involves practicals where the student will build working speech recognition systems, build their own synthetic voice and build a complete telephone spoken dialog system. This work will be based on existing toolkits. Details of algorithms, techniques and limitations of state of the art speech systems will also be presented. This course is designed for students wishing understand how to process real data for real applications, applying statistical and machine learning techniques as well as working with limitations in the technology.	U	4, 9	focused
11624	Language Technologies Institute	Human Language for Artificial Intelligence	An enduring aspect of the quest to build intelligent machines is the challenge of human language. This course introduces students with a background in computer science and a research interest in artificial intelligence fields to the structure of natural language, from sound to society. It covers phonetics (the physical aspects of speech), phonology (the sound-structure of language), morphology (the structure of words), morphosyntax (the use of word and phrase structure to encode meaning), syntactic formalisms (using finite sets of production rules to characterize infinite configurations of structure), discourse analysis and pragmatics (language in discourse and communicative context), and sociolinguistics (language in social context and social meaning). Evaluation is based on seven homework assignments, a midterm examination, and a final examination.	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
11639	Language Technologies Institute	Designining Around Patents on Machine Learning and NLP Technology	This course uses Machine Learning and Natural Language Processing as vehicles to teach principles in designing software to avoid patents. After introducing students to the basics of patents, we investigate how to use students software skills to design around patents that is, create new technology that avoids a patent while maintaining some, or even all, of the performance and value of the patented technology. Designing around a patent can be viewed as a puzzle that requires technical skill, understanding the business value of technology, knowledge of patents, and creativity. Students will also be able to help design patents that cannot be easily designed-around. Not only does this add a valuable new dimension to the students skill set, the course material is organized as a vehicle for refining knowledge of ML and NLP techniques. We will practice by designing around patents on well-known ML and NLP algorithms. Students study the basic algorithm, learn the patents that cover those algorithms, and then experiment with software modifications that avoid the patent while preserving as much of the algorithms performance as possible. In essence, students will view the presence of particular patents as a design constraints, akin to designing for limited memory, bandwidth, or processor speed. Students must have already taken courses in Natural Language Processing (e.g., 11-411) and Machine Learning (e.g., 10-315). Law of Computer Technology 17-562, 17-662, 17-762 or Patents, Licensing, and Innovation 19-473, 19-673 are helpful but not required.	G	4, 9, 17	focused
11711	Language Technologies Institute	Algorithms for NLP	Algorithms for NLP is an introductory graduate-level course on the computational properties of natural languages and the fundamental algorithms for processing natural languages. The course will provide an in-depth presentation of the major algorithms used in NLP, including Lexical, Morphological, Syntactic and Semantic analysis, with the primary focus on parsing algorithms and their analysis.	G	4, 9	focused
11716	Language Technologies Institute	Graduate Seminar on Dialog Processing	Dialog systems and processes are becoming an increasingly vital area of interest both in research and in practical applications. The purpose of this course will be to examine, in a structured way, the literature in this area as well as learn about ongoing work. The course will cover traditional approaches to the problem, as exemplified by the work of Grosz and Sidner, as well as more recent work in dialog, discourse and evaluation, including statistical approaches to problems in the field. We will select several papers on a particular topic to read each week. While everyone will do all readings, a presenter will be assigned to overview the paper and lead the discussion. On occasion, a researcher may be invited to present their own work in detail and discuss it with the group. A student or researcher taking part in the seminar will come away with a solid knowledge of classic work on dialog, as well as familiarity with ongoing trends.	G	4, 17, 9	focused
11722	Language Technologies Institute	Grammar Formalisms	The goal of this course is to familiarize students with grammar formalisms that are commonly used for research in computational lingusitics, language technologies, and lingusitics. We hope to have students from a variety disciplines (linguistics, computer science, psychology, modern languages, philosophy) in order to cover a broad perspective in class discussions. Comparison of formalisms will lead to a deeper understanding of human language and natural language processing algorithms. The formalisms will include: Head Driven Phrase Structure Grammar, Lexical Functional Grammar, Tree Adjoining Grammar and Categorial Grammar. If time permits, we will cover Penn Treebank, dependency grammar, and Construction Grammar. We will cover the treatment of basic syntactic and semantic phenomena in each formalism, and will also discuss algorithms for parsing and generating sentences for each formalism. If time permits, we may discuss formal language theory and generative capacity. The course is taught jointly by the following faculty of the Language Technologies Institute: Alan Black Alon Lavie Lori Levin (main coordinator)	G	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
11724	Language Technologies Institute	Human Language for Artificial Intelligence	An enduring aspect of the quest to build intelligent machines is the challenge of human language. This course introduces students with a background in computer science and a research interest in artificial intelligence fields to the structure of natural language, from sound to society. It covers phonetics (the physical aspects of speech), phonology (the sound-structure of language), morphology (the structure of words), morphosyntax (the use of word and phrase structure to encode meaning), syntactic formalisms (using finite sets of production rules to characterize infinite configurations of structure), discourse analysis and pragmatics (language in discourse and communicative context), and sociolinguistics (language in social context and social meaning). Evaluation is based on seven homework assignments, a midterm examination, and a final examination.	G	4, 9, 17	focused
11739	Language Technologies Institute	Designing Around Patents on Machine Learning and NLP Technology	This course uses Machine Learning and Natural Language Processing as vehicles to teach principles in designing software to avoid patents. After introducing students to the basics of patents, we investigate how to use students software skills to design around patents that is, create new technology that avoids a patent while maintaining some, or even all, of the performance and value of the patented technology. Designing around a patent can be viewed as a puzzle that requires technical skill, understanding the business value of technology, knowledge of patents, and creativity. Students will also be able to help design patents that cannot be easily designed-around. Not only does this add a valuable new dimension to the student's skill set, the course material is organized as a vehicle for refining knowledge of ML and NLP techniques. We will practice by designing around patents on well-known ML and NLP algorithms. Students study the basic algorithm, learn the patents that cover those algorithms, and then experiment with software modifications that avoid the patent while preserving as much of the algorithm's performance as possible. In essence, students will view the presence of particular patents as a design constraints, akin to designing for limited memory, bandwidth, or processor speed. Students must have already taken courses in Natural Language Processing (e.g., 11-411) and Machine Learning (e.g., 10-315). Law of Computer Technology 17-562, 17-662, 17-762 or Patents, Licensing, and Innovation 19-473, 19-673 are helpful but not required.	G	4, 9, 17	focused
11741	Language Technologies Institute	Machine Learning for Text Mining	This course studies the theory, design, and implementation of text-based information systems. The Information Retrieval core components of the course include statistical characteristics of text, representation of information needs and documents, several important retrieval models (Boolean, vector space, probabilistic, inference net, language modeling), clustering algorithms, automatic text categorization, and experimental evaluation. The software architecture components include design and implementation of high-capacity text retrieval and text filtering systems. A variety of current research topics are also covered, including cross-lingual retrieval, document summarization, machine learning, topic detection and tracking, and multi-media retrieval. Prerequisites: Programming and data-structures at the level of 15-212 or higher. Algorithms comparable to the undergraduate CS algorithms course (15-451) or higher. Basic linear algebra (21-241 or 21-341). Basic statistics (36-202) or higher.	G	4, 9, 17	focused
11751	Language Technologies Institute	Speech Recognition and Understanding	The technology to allow humans to communicate by speech with machines or by which machines can understand when humans communicate with each other is rapidly maturing. This course provides an introduction to the theoretical tools as well as the experimental practice that has made the field what it is today. We will cover theoretical foundations, essential algorithms, major approaches, experimental strategies and current state-of-the-art systems and will introduce the participants to ongoing work in representation, algorithms and interface design. This course is suitable for graduate students with some background in computer science and electrical engineering, as well as for advanced undergraduates. Prerequisites: Sound mathematical background, knowledge of basic statistics, good computing skills. No prior experience with speech recognition is necessary. This course is primarily for graduate students in LTI, CS, Robotics, ECE, Psychology, or Computational Linguistics. Others by prior permission of instructor.	G	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
11755	Language Technologies Institute	Machine Learning for Signal Processing	Signal Processing is the science that deals with extraction of information from signals of various kinds. This has two distinct aspects -- characterization and categorization. Traditionally, signal characterization has been performed with mathematically-driven transforms, while categorization and classification are achieved using statistical tools. Machine learning aims to design algorithms that learn about the state of the world directly from data. A increasingly popular trend has been to develop and apply machine learning techniques to both aspects of signal processing, often blurring the distinction between the two. This course discusses the use of machine learning techniques to process signals. We cover a variety of topics, from data driven approaches for characterization of signals such as audio including speech, images and video, and machine learning methods for a variety of speech and image processing problems.	G	4, 9	focused
11777	Language Technologies Institute	Multimodal Machine Learning	Multimodal machine learning (MMML) is a vibrant multi-disciplinary research field which addresses some of the original goals of artificial intelligence by integrating and modeling multiple communicative modalities, including linguistic, acoustic and visual messages. With the initial research on audio-visual speech recognition and more recently with language vision projects such as image and video captioning, this research field brings some unique challenges for multimodal researchers given the heterogeneity of the data and the contingency often found between modalities. The course will present the fundamental mathematical concepts in machine learning and deep learning relevant to the five main challenges in multimodal machine learning: (1) multimodal representation learning, (2) translation & mapping, (3) modality alignment, (4) multimodal fusion and (5) co-learning. These include, but not limited to, multimodal auto-encoder, deep canonical correlation analysis, multi-kernel learning, attention models and multimodal recurrent neural networks. We will also review recent papers describing state-of-the-art probabilistic models and computational algorithms for MMML and discuss the current and upcoming challenges. The course will discuss many of the recent applications of MMML including multimodal affect recognition, image and video captioning and cross-modal multimedia retrieval. This is a graduate course designed primarily for PhD and research master students at LTI, MLD, CSD, HCII and RI; others, for example (undergraduate) students of CS or from professional master programs, are advised to seek prior permission of the instructor. It is required for students to have taken an introduction machine learning course such as 10-401, 10-601, 10-701, 11-663, 11-441, 11-641 or 11-741. Prior knowledge of deep learning is recommended."	G	4, 9, 17	focused
11927	Language Technologies Institute	MIIS Capstone Project	The capstone project course is a group-oriented demonstration of student skill in one or more areas covered by the degree. Typically the result of the capstone project is a major software application. The capstone project course consists of two components. The classroom component guides students in project planning, team management, development of requirements and design specifications, and software tools for managing group-oriented projects. The lab component provides project-specific technical guidance and expertise, for example in the development of a question answering system, dialog, or sentiment analysis application. Thus, each project receives two types of supervision, often from two separate members of the faculty.	G	4, 9, 17	focused
12100	Civil & Environmental Engineering	Exploring CEE: Infrastructure and Environment in a Changing World	Civil and Environmental Engineers (CEEs) engage in the planning, design, construction, operation, retrofit, demolition, and reuse of large-scale infrastructure that forms the backbone of all societies and economies. CEEs solve problems, innovate, start companies, and become global technology leaders. CEEs work at the dynamic interface of the built environment, information environment, and natural environment. Smart cities, sustainable energy and buildings, connected autonomous vehicles, resilient infrastructure, climate change adaptation, and global water management are just a few of the future domains that will rely on CEEs. Students will explore how sensing, data science, environmental science, systems analysis, and infrastructure design are integrated to create a built environment that meets the needs of smart and connected communities while enhancing sustainability. Team-based design-build projects introduce principles, ethics, design, and technologies for modern and future infrastructure.	U	13, 6, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
12200	Civil & Environmental Engineering	CEE Challenges: Design in a Changing World	Students will be challenged to solve problems related to conventional, cutting-edge, and emerging issues in Civil and Environmental Engineering and one or more of the areas of the built, natural and information environments, such as smart cities. Students will gain an understanding of the effects of uncertainty, such as changing climate conditions. Through several team projects, students will explore the impact and management of tradeoffs, like constructability, sustainability, cost, and maintenance on design. They will learn to apply mathematics and science, advanced technologies, and computing to solve open-ended problems. Students will learn communication and design skills and practice the design process, from problem definition to constructed work.	U	13, 4, 12	focused
12201	Civil & Environmental Engineering	Geology	Introduction to physical geology; common rocks and rock-forming minerals and their chemical compositions/structure, physical properties, origins, and uses; geologic processes: surface and ground-water flow, volcanism, mountain-building, tectonics, glaciation, sedimentation, seismicity, and atmospheric and oceanic circulation.	U	6, 14, 12	focused
12203	Civil & Environmental Engineering	Special Topics: Ecology	Ecology is the study of the distribution and abundance of organisms and the biotic and abiotic factors that affect ecosystems and their organisms. These factors include the traits of individual organisms that determine their performance within an ecosystem, interactions with other organisms of the same or different species, and their physical and chemical environment. Moreover, interactions of organisms (including humans) and their environments strongly influence large ecosystem patterns of energy flow and material cycling, transfer, transformation, and storage over the face of the Earth. The course presents the basic principles of ecology and their application to populations, communities, and ecosystems. Ecological processes in terrestrial and freshwater habitats are examined. An introduction to methods employed by ecologists to study natural systems is provided.	U	15, 7, 14	focused
12215	Civil & Environmental Engineering	Introduction to Professional Writing in CEE	The objective of the course is to prepare students for writing technical re-ports and essays assigned in CEE courses and laboratories, writing professional letters and reports for internships and pro-fessional positions, preparing documents in a team setting, delivering individual and team oral presentations, and transforming information for several types of audiences (scientific accommodation). The course focuses on document purpose, organization and style; basic editing techniques; scientific accommodation; plagiarism and proper par-aphrasing and summa-rizing; evaluating, citing and referencing sources; team communication strategies; oral presentations; and proper use of tables, graphics, and other visual aids in documents and presentations. Course ac-tivities include in-class exercises, peer workshops, and homework assignments to illustrate examples of good and poor communication and to practice technical communication skills. Concurrent with lectures and class activities, students draft and revise individual and team technical reports and will give individual and team oral presentations.	U	4, 3, 9	focused
12216	Civil & Environmental Engineering	Research Skills and Topics in Civil and Environmental Engineering	Civil Engineering undergraduates will learn and practice research skills relevant to both academic research and engineering practice. Exposure to a breadth of cutting-edge Civil Engineering research topics and projects will be achieved through expert presentations and practical exercises.	U	4, 12, 13	focused
12231	Civil & Environmental Engineering	Solid Mechanics	Analysis of deformable bodies incorporating concepts of stress, strain, mechanical properties of materials, and geometric compatibility. Response under axial loads, torsion, bending, transverse shear, and combined loadings. Stress and strain transformations and Mohr's circles, deflections of beams and shafts, buckling of columns.	U	4, 9, 8	focused
12232	Civil & Environmental Engineering	Solid Mechanics Lab	Analysis of stress-strain relationships, torsion of solid shafts, deformation due to bending, deformations in three dimensions, Mohr's circle representation of stress and strain, buckling of slender columns. Laboratory experiments and reports associated with theoretical concepts.	U	4, 9, 6	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
12271	Civil & Environmental Engineering	Computation and Data Science for Civil & Environmental Engineering	Computational science and computer applications play an important role in modern engineering practice and research. This course provides students with an introduction to the fundamentals of computation and data science using both deterministic and stochastic techniques. Topics include numerical methods for approximation, differentiation, integration, Monte Carlo simulation, quantifying error and uncertainty, regression, solving linear systems of equations and ordinary differential equations, root finding, and optimization; the use of several computing paradigms (numerical, symbolic, and spreadsheet) for enhancing engineering workflows with modeling and data, with an emphasis on identifying the appropriate tool for various engineering problems; the importance of and approaches for effective visual presentation of data; and the future of computer-based methods in engineering. Mathematical concepts from calculus, probability, and linear algebra are introduced as needed. Through application of these principles, students will develop the computational reasoning skills that are required to design and deploy computer-based solutions for a variety of problems in civil and environmental engineering.	U	4, 9, 12	focused
12301	Civil & Environmental Engineering	CEE Projects: Designing the Built, Natural and Information Environments	Students investigate the elements of civil and environmental engineering projects and advance their design, communication and teamwork skills through hands-on experiences. Students also advance their understanding of the professional and ethical aspects of engineering projects from conception through design, to implementation and operation. Students will design and build structures, use sensing to understand systems, and analyze sustainability as they work on open-ended projects.	U	4, 12, 9	focused
12335	Civil & Environmental Engineering	Soil Mechanics	Sampling, testing and identification of soils. Physical, chemical and hydraulic characteristics. Stress-strain-strength relationships for soils. Permeability, seepage, consolidation, and shear strength, with applications to deformation and stability problems, including earth dams, foundations, retaining walls, slopes and landfills.	U	6, 12, 2	focused
12336	Civil & Environmental Engineering	Soil Mechanics Laboratory	Examination of material properties and behavior of soils. Experiments include soil classification, permeability, compaction, consolidation and strength tests.	U	2, 6, 15	focused
12351	Civil & Environmental Engineering	Environmental Engineering	Provides a scientific and engineering basis for understanding environmental issues and problems. Introduces material and energy balances for tracking substances in the atmosphere, source and ground waters, and soil systems. Pertinent environmental laws are described, simple quantitative engineering models are developed, and qualitative descriptions of environmental engineering control technologies are presented.	U	6, 9, 12	focused
12352	Civil & Environmental Engineering	Environmental Engineering Lab	(Required for CEE students, not for others) Laboratory and field experiments that illustrate the basic principles of environmental engineering.	U	6, 4, 12	focused
12355	Civil & Environmental Engineering	Fluid Mechanics	Fluid characteristics; continuity, momentum and energy equations; dynamic similitude; laminar and turbulent boundary layers; flow in pipes; lift and drag on immersed bodies; open channel flow.	U	7, 13	focused
12356	Civil & Environmental Engineering	Fluid Mechanics Lab	Fluid properties: density, specific gravity, viscosity; fluid characteristics; continuity, conservation of energy; fluid behavior: center of pressure, pipe flow, open-channel flow. Laboratory experiments illustrating basic principles.	U	15, 7, 14	focused
12358	Civil & Environmental Engineering	Materials Lab	Examination of materials properties and behavior of concrete, masonry, and timber.	U	4, 12, 13	focused
12401	Civil & Environmental Engineering	CEE Design: Imagine, Build, Test	Students apply the design process and knowledge developed through the core curriculum to design engineering solutions for real engineering problems. Students work in teams in a pre-professional environment to meet the design challenges with which they are presented. Skills in oral, written, and graphic communications are essential to the projects. Students will imagine concepts to solve engineering problems and execute their designs, considering sustain-ability goals and uncertainty. Students build the final project and test it against the requirements and criteria established for the project.	U	4, 9, 17	focused
12411	Civil & Environmental Engineering	Project Management for Construction	Introduction to construction project management from owner's perspective in organizing planning, design, construction and operation as an integrated process. Examination of labor productivity, material management and equipment utilization. Cost estimation and financing of constructed facilities. Contracting, construction planning and fundamental scheduling procedures. Cost control, monitoring and accounting for construction.	U	8, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
12421	Civil & Environmental Engineering	Engineering Economics	Basic concepts of economic analysis and evaluation of alternative engineering projects for capital investment. Consideration of time value of money and common merit measures such as net present value and internal rate of return. Selection of independent projects and mutually exclusive proposals, using various methods of analysis. Capital budgeting and project financing. Influence of price level changes, depreciation and taxation on choice of alternatives. Uncertainty and risk in operation and financing. Important factors affecting investment decisions for private and public projects.	U	8, 9, 17	focused
12600	Civil & Environmental Engineering	AutoCAD	AutoCAD is mostly held online. The course provides an introduction to the fundamentals of computer-aided design (CAD)software. Students learn how to set up CAD projects using Autodesk's AutoCAD software. Topics include coordinates, lines, circles, arcs, zooms, snaps and grids, text, views, layers, plines, blocks, reference files, dimensioning, isometrics, 3D commands, surfaces, solids, and more. CAD standards for layers, plotting, and symbol libraries are also covered. The course includes development of a CAD project by each student.	G	4, 17, 9	focused
12606	Civil & Environmental Engineering	Traffic Engineering	Introduction to traffic engineering providing practical experience that can be used directly in the workforce. Course material will provide a solid foundation in preparing for the Transportation portion of the Professional Engineer exam. The course incorporates the initial planning side of transportation engineering with tasks such as traffic analyses, traffic studies and transportation/traffic engineering report writing.	G	11, 4, 17	focused
12612	Civil & Environmental Engineering	Intro to Sustainable Engineering	This course presents an overview of the concept of sustainability, including changing attitudes and values toward technology and the environment through the late twentieth and early twenty-first centuries. Relevant issues in sustainable engineering, including population growth, urbanization, energy, water, food and material resources are discussed. Tools for sustainable engineering are presented, including metrics of sustainability, principles of design for the environment, and use of material and energy balances in sustainable systems.	G	6, 12, 7	focused
12623	Civil & Environmental Engineering	Molecular Simulation of Materials	The purpose of this course is to expose engineering students to the theory and implementation of numerical techniques for modeling atomic-level behavior. The main focus is on molecular dynamics and Monte Carlo simulations. Students will write their own simulation computer codes, and learn how to perform calculations in different thermodynamic ensembles. Consideration will be given to heat transfer, mass transfer, fluid mechanics, mechanics, and materials science applications. The course assumes some knowledge of thermodynamics and computer programming. 4 hrs lec.	G	4, 9, 12	focused
12629	Civil & Environmental Engineering	Environmental Microbiology for Engineers	This class provides a general introduction to microorganisms in natural and engineered environments. Selected topics include: cellular architecture, energetics and energy conservation, growth and catabolism; evolution and genetics; population and community dynamics; water and soil microbiology; biogeochemical cycling; biofilms; and microorganisms in wastewater, pollution attenuation, and bioremediation.	G	6, 15, 12	focused
12635	Civil & Environmental Engineering	Structural Analysis	Classical and matrix-based methods of structural analysis; energy principles in structural mechanics. Basic concepts of force and displacement methods for analyzing redundant structural systems. Matrix methods utilizing the flexibility (force) and stiffness (displacement) concepts.	G	7, 13, 9	focused
12636	Civil & Environmental Engineering	Geotechnical Engineering	Behavior of geotechnical structures; engineering design of geotechnical structures considering failure modes; uncertainties; economic issues, required design formats and relevant code provisions; performance requirements for foundations, subsurface investigations; allowable stress and LRFD design approaches; reliability-based design; shallow foundations; deep foundations; retaining structures; reinforced concrete foundations.	G	8, 9, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
12645	Civil & Environmental Engineering	Smart Cities: Growth and Intelligent Transportation Systems	Cities all around the world are being built and re-invented as smart cities utilizing information systems and innovative applications of data analytics. One major smart cities component is transportation. The Intelligent Transportation Systems (ITS) industry is expected to grow at a rate of 19% per year and reach $5.5 Billion in annual investment by 2020. This shifting dynamic provides great opportunity for improved transportation safety and efficiency but also poses challenging information systems and public policy challenges. Furthermore, there are new opportunities for professional-school graduates outside of engineering schools for employment in transportation planning and policy. This course is supported by CMU's Traffic21 Initiative and Technologies for Safe and Efficient Transportation (T-SET) University Transportation Center. Classes will feature guest lectures provided by T-SET faculty and industry and government ITS professionals.	G	4, 9, 8	focused
12648	Civil & Environmental Engineering	CEE Senior Research Project	This course is designed to give students the opportunity to work on an open-ended project under the direction of a faculty member in the Civil & Environmental Engineering department. To register for this course, a student must have the approval of the faculty member for both the research topic and the number of units. A student in this course must write a proposal and submit progress reports to the advisor. The student must also make a formal presentation of the project results and submit a final report to the department. Senior standing in CEE and permission of the project advisor Units: 9-12	G	4, 12, 13	focused
12651	Civil & Environmental Engineering	Air Quality Engineering	The course provides a quantitative introduction to the processes that control atmospheric pollutants and the use of mass balance models to predict pollutant concentrations. We survey major processes including emission rates, atmospheric dispersion, chemistry, and deposition. The course includes discussion of basic atmospheric science and meteorology to support understanding air pollution behavior. Concepts in this area include vertical structure of the atmosphere, atmospheric general circulation, atmospheric stability, and boundary layer turbulence. The course also discusses briefly the negative impacts of air pollution on society and the regulatory framework for controlling pollution in the United States. The principles taught are applicable to a wide variety of air pollutants but special focus is given to tropospheric ozone and particulate matter. The course is intended for graduate students as well as advanced undergraduates. It assumes a knowledge of mass balances, fluid mechanics, chemistry, and statistics typical of an undergraduate engineer but is open to students from other scientific disciplines.	G	13, 4, 6	focused
12657	Civil & Environmental Engineering	Water Resource Systems Engineering	Water Resource Systems Engineering combines hydrology, engineering, economics, and operations research to create tools and analyses that support decisions about large-scale water resource systems. The emphasis in this course will be on optimization methods, which are a core element of water systems analysis. Both water quantity and water quality problems will be covered.	G	6, 9, 12	focused
12702	Civil & Environmental Engineering	Fundamentals of Water Quality Engineering	This course is a systematic overview of water quality engineering designed for students with no prior civil and environmental engineering background. Topics examined include physical, chemical, and biological characteristics of water; common water pollutants; basic water chemistry and micriobiology; mass and energy balances and their use in reactor analysis; physical, chemical and biological processes affecting natural water quality and the use of these processes in water supply and wastewater management systems; and selected problems in surface water and groundwater quality management. A background in college-level general chemistry, physics, calculus, and differential equations is assumed.	G	6, 12, 7	focused
12712	Civil & Environmental Engineering	Sustainable Engineering Principles	This course presents an overview of the concept of sustainability, including changing attitudes and values toward technology and the environment through the late twentieth and early twenty-first centuries. Relevant issues in sustainable engineering, including population growth, urbanization, energy, water, food and material resources are discussed. Tools for sustainable engineering are presented, including metrics of sustainability, principles of design for the environment, and use of material and energy balances in sustainable systems. Publicly available data sets and computational models will be explored to assess sustainability. A team-based project is required.	G	6, 12, 7	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
12714	Civil & Environmental Engineering	Environmental Life Cycle Assessment	Cradle-to-grave analysis of new products, processes and policies is important to avoid undue environmental harm and achieve extended product responsibility. This course provides an overview of approaches and methods for life cycle assessment and for green design of typical products and processes using the ISO 14040 family of standards. This includes goal and scoping definition, inventory analysis, life cycle impact assessment (LCIA), interpretation, and guidance for decision support. Process-based analysis models, input-output and hybrid approaches are presented for life cycle assessment. Example software such as MATLAB, Excel, and Simapro are introduced and used in assignments. A group life cycle assessment project consistent with the principles and tools of sustainability to solve real-world engineering problems is required.	G	12, 9, 13	focused
12719	Civil & Environmental Engineering	Special Topics: AIS/EESS Project	This course integrates and exercises students in a significant sustainable engineering and/or environmental project that is team-based and built upon the knowledge, skills, and technologies learned in the core and specialist courses in the EESS graduate curriculum.	G	4, 12, 9	focused
12720	Civil & Environmental Engineering	Water Resources Chemistry	This course provides a rigorous yet practical basis for applying the principles of physical chemistry to understanding the composition of natural waters and to the engineering of water and wastewater treatment processes. Topics covered include chemical equilibrium and kinetics; acid-base equilibria and buffering; solid precipitation and dissolution; oxidation and reduction reactions; adsorption on solids; and computer-aided problem solving. The primary objective of the course is to be able to formulate and solve chemical equilibrium models for complex aqueous systems. Knowledge of college-level general chemistry is assumed.	G	6, 12, 9	focused
12725	Civil & Environmental Engineering	Fate, Transport & Physicochemical Processes of Orgnc Contaminants in Aqua Systms	Examination of the major physical and chemical processes affecting the fate and treatment of organic compounds nanoparticles in aquatic systems. The emphasis is on anthropogenic organic compounds. The course will review some concepts from physical organic chemistry, and examine the relationships between chemical structure, properties, and environmental behavior of organic compounds. Chemical processes important to the fate, treatment, and biotransformation of specific organic compounds are addressed. Two laboratory sessions illustrate measurement techniques for organic compounds in water. 12-702 is a co- req for non environmental engineers or students who have not had and environmental engineering undergraduate course	G	6, 4, 12	focused
12726	Civil & Environmental Engineering	Mathematical Modeling of Environmental Quality Systems	Development and application of mathematical models for environmental systems. Material balance formulations and their solutions, computer implementation, model validation, uncertainty analysis, and use for projection and policy analysis. Applications to surface water, groundwater, atmospheric transport, indoor air pollution, and human exposure and risk. Prerequisite: 12-704 or equivalent.	G	6, 13, 12	focused
12740	Civil & Environmental Engineering	Data Acquisition	The intent of this course is to introduce students to the concepts, approaches and implementation issues associated with data acquisition for infrastructure systems. Students will be introduced to the types of data that is collected about infrastructure systems, excitation mechanisms, sensing technologies, data acquisition using sensors, signal pre-processing and post-processing techniques, and use of sensing in a variety of applications in construction and infrastructure management. Students will also gain experience with data acquisition hardware and software.	G	9, 4, 8	focused
12741	Civil & Environmental Engineering	Data Management	The intent of this course is to introduce students to database management systems and to knowledge discovery in database principles. Students will learn how to develop powerful tools for efficiently managing large amounts of civil engineering data so that it may persist safely over long periods of time. Students will be introduced to relational database systems and structured query languages. They will also be exposed to other existing data models. Students also will be introduced to data mining and analysis tools to discover patterns and knowledge from data.	G	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
12746	Civil & Environmental Engineering	Special Topics: Introduction to Python Prototyping for Infrastructure Systems	This course uses the Python programming language to introduce fundamental programming approaches to students from civil and environmental engineering. No prerequisite required and students with no programming experience are recommended to take this course. This course will cover fundamental programming approaches, object-oriented programming concepts, graphical user interface design in Python, and file and database operation. Real-world examples from infrastructure management will be used in the class for demonstration and term project. Students will work individually and in teams to develop a series of applications that are potentially be used in real-world applications.	G	9, 4, 12	focused
12747	Civil & Environmental Engineering	Sustainable Buildings	This course will cover the basics of the design, retrofit and monitoring of buildings to achieve energy efficiency. We will introduce energy simulation tools, the fundamentals of the most important building systems (i.e., heating, cooling, ventilation, insulation, etc.) and the technologies that can be used to monitor their performance. Graduate Standing, or approval of instructor	G	7, 9, 12	focused
12749	Civil & Environmental Engineering	Climate Change Adaptation	While the specific timing and magnitude of climate change impacts are uncertain, long-lived civil engineering infrastructure will need to be resilient to these potential impacts. Engineers designing for climate change adaptation require the tools to maximize resiliency and minimize cost for existing and proposed energy, transportation, water, urban and other types of infrastructure. Students successfully completing this course will understand how climate change affects civil infrastructure and how to quantitatively incorporate resilient designs and co-benefits under uncertainty. Students will use open data to examine current adaptation engineering challenges, quantify solutions, and communicate their technical recommendations through policy briefs. Prerequisites: Graduate standing or consent of instructor.	G	13, 6, 7	focused
12755	Civil & Environmental Engineering	Finite Elements in Mechanics I	The basic theory and applications of the finite element method in mechanics are presented. Development of the FEM as a Galerkin method for numerical solution of boundary value problems. Applications to second-order steady problems, including heat conduction, elasticity, convective transport, viscous flow, and others. Introduction to advanced topics, including fourth-order equations, time dependence, and nonlinear problems.Prerequisite: Graduate standing or consent of instructor. Prerequisites: Graduate standing or consent of instructor.	G	4, 17, 11	focused
12798	Civil & Environmental Engineering	Professional Communication for CEE Grad Students	The course reviews skills and techniques for preparing technical documents, professional letters, resumes, and presentations typically encountered in advanced degree programs and in research and development positions in the public and private sector. Class topics focus on document purpose and organization; researching technical sources; summarizing, paraphrasing, and citing sources; simplifying and revising techniques; and the proper use of tables, graphics, and other visual aids in documents and oral presentations. Course content emphasizes North American writing norms.	G	4, 3, 17	focused
15050	Computer Science	Study Abroad	Students who are interested in studying abroad should first contact the Office of International Education. More information on Study Abroad is available on OIE's Study Abroad page and at the CS Undergraduate Office.	U	4, 17, 1	focused
15075	Computer Science	Computer Science Co-Op	This course is meant for CS undergraduate students with a full-time internship that encompasses a summer and a contiguous semester, either Spring-Summer or Summer-Fall who wish to have this recorded on their academic transcript. Units posted for this course do not count toward any requirement for the CS undergraduate degree including free elective units. This course is not available to international students; consult with the Office for International Education for more information.	U	4, 17, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
15090	Computer Science	Computer Science Practicum	This course is for Computer Science students who wish to have an internship experience as part of their curriculum. Students are required to write a one-page summary statement prior to registration that explains how their internship connects with their CS curriculum, specifically on how it uses material they have learned as well as prepares them for future courses. Near the end of the internship, students will be required to submit a reflection paper that describes the work they did in more detail, including lessons learned about the work experience and how they utilized their CS education to work effectively. International students should consult with the Office of International Education for appropriate paperwork and additional requirements before registration. Units earned count toward the total required units necessary for degree completion; students should speak with an academic advisor for details. This course may be taken at most 3 times for a total of 9 units maximum. Students normally register for this course for use during the summer semester.	U	4, 17, 1	focused
15104	Computer Science	Introduction to Computing for Creative Practice	An introduction to fundamental computing principles and programming techniques for creative cultural practices, with special consideration to applications in music, design and the visual arts. Intended for students with little to no prior programming experience, the course develops skills and understanding of text-based programming in a procedural style, including idioms of sequencing, selection, iteration, and recursion. Topics include data organization (arrays, files, trees), interfaces and abstraction (modular software design, using sensor data and software libraries), basic algorithms (searching and sorting), and computational principles (randomness, concurrency, complexity). Intended for students participating in IDeATe courses or minors who have not taken 15-112.	U	4, 9, 11	focused
15106	Computer Science	Introduction to Computing for Data Analysis	[Course Pilot] An introductory course in programming for students in statistics-related disciplines using R. Fundamental data types and data structures: booleans, numbers, characters, vectors, matrices, data frames, and lists. Programming constructs: assignment, conditionals, loops, function calls. Processing data: vectorization, "apply" functions, text processing, plotting tools. Additional topics, time permitting: writing functions, using data files, random number generation and simulation. This course is not for credit for SCS majors.	U	4, 9, 8	focused
15110	Computer Science	Principles of Computing	A course in fundamental computing principles for students with minimal or no computing background. Programming constructs: sequencing, selection, iteration, and recursion. Data organization: arrays and lists. Use of abstraction in computing: data representation, computer organization, computer networks, functional decomposition, and application programming interfaces. Use of computational principles in problem-solving: divide and conquer, randomness, and concurrency. Classification of computational problems based on complexity, non-computable functions, and using heuristics to find reasonable solutions to complex problems. Social, ethical and legal issues associated with the development of new computational artifacts will also be discussed.	U	4, 9, 17	focused
15112	Computer Science	Fundamentals of Programming and Computer Science	A technical introduction to the fundamentals of programming with an emphasis on producing clear, robust, and reasonably efficient code using top-down design, informal analysis, and effective testing and debugging. Starting from first principles, we will cover a large subset of the Python programming language, including its standard libraries and programming paradigms. We will also target numerous deployment scenarios, including standalone programs, shell scripts, and web-based applications. This course assumes no prior programming experience. Even so, it is a fast-paced and rigorous preparation for 15-122. Students seeking a more gentle introduction to computer science should consider first taking 15-110. NOTE: students must achieve a C or better in order to use this course to satisfy the pre-requisite for any subsequent Computer Science course.	U	4, 9, 12	focused
15121	Computer Science	Introduction to Data Structures	A continuation of the process of program design and analysis for students with some prior programming experience (functions, loops, and arrays, not necessarily in Java). The course reinforces object-oriented programming techniques in Java and covers data aggregates, data structures (e.g., linked lists, stacks, queues, trees, and graphs), and an introduction to the analysis of algorithms that operate on those data structures.	U	4, 9, 15	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
15122	Computer Science	Principles of Imperative Computation	For students with a basic understanding of programming (variables, expressions, loops, arrays, functions). Teaches imperative programming and methods for ensuring the correctness of programs. Students will learn the process and concepts needed to go from high-level descriptions of algorithms to correct imperative implementations, with specific application to basic data structures and algorithms. Much of the course will be conducted in a subset of C amenable to verification, with a transition to full C near the end. This course prepares students for 15-213 and 15-210. NOTE: students must achieve a C or better in order to use this course to satisfy the pre-requisite for any subsequent Computer Science course.	U	4, 9	focused
15150	Computer Science	Principles of Functional Programming	An introduction to programming based on a "functional" model of computation. The functional model is a natural generalization of algebra in which programs are formulas that describe the output of a computation in terms of its inputs---that is, as a function. But instead of being confined to real- or complex-valued functions, the functional model extends the algebraic view to a very rich class of data types, including not only aggregates built up from other types, but also functions themselves as values. This course is an introduction to programming that is focused on the central concepts of function and type. One major theme is the interplay between inductive types, which are built up incrementally; recursive functions, which compute over inductive types by decomposition; and proof by structural induction, which is used to prove the correctness and time complexity of a recursive function. Another major theme is the role of types in structuring large programs into separate modules, and the integration of imperative programming through the introduction of data types whose values may be altered during computation. NOTE: students must achieve a C or better in order to use this course to satisfy the pre-requisite for any subsequent Computer Science course.	U	4, 9, 8	focused
15151	Computer Science	Mathematical Foundations for Computer Science	*CS majors only* This course is offered to incoming Computer Science freshmen and focuses on the fundamental concepts in Mathematics that are of particular interest to Computer Science such as logic, sets,induction, functions, and combinatorics. These topics are used as a context in which students learn to formalize arguments using the methods of mathematical proof. This course uses experimentation and collaboration as ways to gain better understanding of the material. Open to CS freshmen only. NOTE: students must achieve a C or better in order to use this course to satisfy the pre-requisite for any subsequent Computer Science course.	U	4, 9	focused
15182	Computer Science	Artificial Intelligence for Medicine	This course introduces Artificial Intelligence (AI) and its recent applications in medicine for students with no background in computer science. It starts by motivating and defining AI, before folding over to a survey of some of its newest applications to medicine, including diagnosis, prognosis, drug discovery, and recommendations of individualized treatments, to mention just a few. Afterwards, it provides a birds-eye view of some of the major AI techniques, including machine learning, deep neural networks, recommendation systems, ranked retrieval, and probabilistic graphical models. Finally, it concludes with a discussion on some of the concerns related to AI, including ethical issues, job security, society, and healthcare institutions, among others	U	4, 8, 9	focused
15210	Computer Science	Parallel and Sequential Data Structures and Algorithms	Teaches students about how to design, analyze, and program algorithms and data structures. The course emphasizes parallel algorithms and analysis, and how sequential algorithms can be considered a special case. The course goes into more theoretical content on algorithm analysis than 15-122 and 15-150 while still including a significant programming component and covering a variety of practical applications such as problems in data analysis, graphics, text processing, and the computational sciences. NOTE: students must achieve a C or better in order to use this course to satisfy the pre-requisite for any subsequent Computer Science course.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
15213	Computer Science	Introduction to Computer Systems	This course provides a programmer's view of how computer systems execute programs, store information, and communicate. It enables students to become more effective programmers, especially in dealing with issues of performance, portability and robustness. It also serves as a foundation for courses on compilers, networks, operating systems, and computer architecture, where a deeper understanding of systems-level issues is required. Topics covered include: machine-level code and its generation by optimizing compilers, performance evaluation and optimization, computer arithmetic, memory organization and management, networking technology and protocols, and supporting concurrent computation. NOTE FOR GRADUATE STUDENTS: This course is not open to graduate students beginning Spring 2015. Graduate students must register for 15-513 instead.	U	4, 9	focused
15236	Computer Science	Special Topics: Saving Humanity With Computational Models	We live in a complex society and on a complex planet; but we tend to think about the world through simplified models and assumptions. How do we know if our simplified mental models make sense? Computational modeling is an approach to understanding our understanding of the world wherein we write down our mental models as computer code, mix in a bit of real data, and run it to see what we can learn. Models can help us to understand ourselves, the world around us, and how to shape the future. This course will teach the basics of computational modeling through hands-on exercises investigating student-directed topics. We will cover the basics of computational modeling, finding and processing data, visualization, modularity, and interactivity. Students will build a series of models throughout the course, starting with smaller warm-ups and culminating in a final project in which students will work together to create a high-quality model and interactive web-based visualization with the goal of informing public discourse and policymaking. This course is designed for CS sophomores and most "seats" in the course will be reserved for CS sophomores.	U	4, 17, 9	focused
15251	Computer Science	Great Ideas in Theoretical Computer Science	This course is about how to use theoretical ideas to formulate and solve problems in computer science. It integrates mathematical material with general problem solving techniques and computer science applications. Examples are drawn from algorithms, complexity theory, game theory, probability theory, graph theory, automata theory, algebra, cryptography, and combinatorics. Assignments involve both mathematical proofs and programming. NOTE: students must achieve a C or better in order to use this course to satisfy the pre-requisite for any subsequent Computer Science course.	U	4, 9	focused
15259	Computer Science	Probability and Computing	Probability theory is indispensable in computer science today. In areas such as artificial intelligence and computer science theory, probabilistic reasoning and randomization are central. Within networks and systems, probability is used to model uncertainty and queuing latency. This course gives an introduction to probability as it is used in computer science theory and practice, drawing on applications and current research developments as motivation. The course has 3 parts: Part I is an introduction to probability, including discrete and continuous random variables, heavy tails, simulation, Laplace transforms, z-transforms, and applications of generating functions. Part II is an in-depth coverage of concentration inequalities, like the Chernoff bound and SLLN bounds, as well as their use in randomized algorithms. Part III covers Markov chains (both discrete-time and continuous-time) and stochastic processes and their application to queuing systems performance modeling. This is a fast-paced class which will cover more material than the other probability options and will cover it in greater depth.	U	10, 9, 17	focused
15260	Computer Science	Statistics and Computing	Statistics is essential for a wide range of fields including machine learning, artificial intelligence, bioinformatics, and finance. This mini course presents the fundamental concepts and methods in statistics in six lectures. The course covers key topics in statistical estimation, inference, and prediction.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
15281	Computer Science	Artificial Intelligence: Representation and Problem Solving	This course is about the theory and practice of Artificial Intelligence. We will study modern techniques for computers to represent task-relevant information and make intelligent (i.e. satisficing or optimal) decisions towards the achievement of goals. The search and problem solving methods are applicable throughout a large range of industrial, civil, medical, financial, robotic, and information systems. We will investigate questions about AI systems such as: how to represent knowledge, how to effectively generate appropriate sequences of actions and how to search among alternatives to find optimal or near-optimal solutions. We will also explore how to deal with uncertainty in the world, how to learn from experience, and how to learn decision rules from data. We expect that by the end of the course students will have a thorough understanding of the algorithmic foundations of AI, how probability and AI are closely interrelated, and how automated agents learn. We also expect students to acquire a strong appreciation of the big-picture aspects of developing fully autonomous intelligent agents. Other lectures will introduce additional aspects of AI, including natural language processing, web-based search engines, industrial applications, autonomous robotics, and economic/game-theoretic decision making.	U	9, 4, 8	focused
15282	Computer Science	Artificial Intelligence for Medicine	This course introduces Artificial Intelligence (AI) and its recent applications in medicine for students with only a little background in computer science. It starts by motivating and defining AI, before folding over to a survey of some of its newest applications to medicine, including diagnosis, prognosis, drug discovery, and recommendations of individualized treatments, to mention just a few. Afterwards, it provides a birds-eye view of some of the major AI techniques, including machine learning, deep neural networks, recommendation systems, ranked retrieval, and probabilistic graphical models. Finally, it concludes with a discussion on some of the concerns related to AI, including ethical issues, job security, society, and healthcare institutions, among others. The course comprises a balance of lectures, case studies, live demonstrations of some medical AI applications, problem-solving & programming assignments, and research tasks. The students will be exposed to industry- and research-based perspectives on AI for medicine. In addition, they will learn through a course project the nuances of working with medical data and applying AI models to solve concrete problems in healthcare.	U	4, 9, 17	focused
15294	Computer Science	Rapid Prototyping Technologies	This mini-course introduces students to rapid prototyping technologies with a focus on laser cutting and 3D printing. The course has three components: 1) A survey of rapid prototyping and additive manufacturing technologies, the maker and open source movements, and societal impacts of these technologies; 2) An introduction to the computer science behind these technologies: CAD tools, file formats, slicing algorithms; 3) Hands-on experience with SolidWorks, laser cutting, and 3D printing, culminating in student projects (e.g. artistic creations, functional objects, replicas of famous calculating machines, etc.). Please note that there will be a usage/materials fee for this course.	U	9, 4, 8	focused
15295	Computer Science	Competition Programming and Problem Solving	Each year, Carnegie Mellon fields two teams for participation in the ACM-ICPC Regional Programming Contest. During many recent years, one of those teams has earned the right to represent Carnegie Mellon at the ACM-ICPC World Finals. This course is a vehicle for those who consistently and rigorously train in preparation for the contests to earn course credit for their effort and achievement. Preparation involves the study of algorithms, the practice of programming and debugging, the development of test sets, and the growth of team, communication, and problem solving skills. Neither the course grade nor the number of units earned are dependent on ranking in any contest. Students are not required to earn course credit to participate in practices or to compete in ACM-ICPC events.	U	4, 8, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
15300	Computer Science	Research and Innovation in Computer Science	This Fall course is the first part of a two-course sequence that is designed to help prepare students to invent the future state-of-the-art in the field of computer science. Course topics will include the following: an overview of important things to know about how research and innovation works in the field of computer science; a survey of the current cutting- edge of computer science research, both here at Carnegie Mellon and elsewhere; critical thinking skills when reading research publications that disagree with each other; strategies for coping with open-ended problems; and technical communication skills for computer scientists. Students will also match up with a faculty mentor for a potential Technology Innovation Project (to be performed in the Spring), put together a detailed plan of attack for that project, and start to get up to speed (including background reading, etc.). This course can be used to satisfy the Technical Communications requirement for the CS major.	U	4, 9, 17	focused
15312	Computer Science	Foundations of Programming Languages	This course discusses in depth many of the concepts underlying the design, definition, implementation, and use of modern programming languages. Formal approaches to defining the syntax and semantics are used to describe the fundamental concepts underlying programming languages. A variety of programming paradigms are covered such as imperative, functional, logic, and concurrent programming. In addition to the formal studies, experience with programming in the languages is used to illustrate how different design goals can lead to radically different languages and models of computation.	U	9, 4	focused
15314	Computer Science	Programming Language Semantics	This course is designed for advanced undergraduates with interests in the mathematical and logical foundations of programming languages. The course introduces the foundational concepts and fundamental techniques of the most prominent and successful approaches to programming language semantics that have been developed. Broadly speaking, semantics is concerned with the provision of mathematical meanings to programs, at an appropriate level of abstraction, to allow formalization of program behavior and facilitate proofs of correctness. Our aim is to demonstrate the utility of a scientific approach to programming and languages. We focus on the most important and most general frameworks for semantic description: denotational and operational semantics. These frameworks are widely applicable and offer complementary approaches to language definition, with various advantages. We also discuss formal specifications, and logics of program correctness. We make extensive use of mathematical and structural induction, and computational induction. We use semantics to describe program behavior, guide the development of correct programs, specify and prove the correctness of a compiler, validate program logics, and derive laws of program equivalence. We discuss imperative and functional languages, sequential and parallel, high-level and low-level, as time permits.	U	4, 9, 17	focused
15316	Computer Science	Software Foundations of Security and Privacy	Security and privacy issues in computer systems continue to be a pervasive issue in technology and society. Understanding the security and privacy needs of software, and being able to rigorously demonstrate that those needs are met, is key to eliminating vulnerabilities that cause these issues. Students who take this course will learn the principles needed to make these assurances about software, and some of the key strategies used to make sure that they are correctly implemented in practice. Topics include: policy models and mechanisms for confidentiality, integrity, and availability, language-based techniques for detecting and preventing security threats, mechanisms for enforcing privacy guarantees, and the interaction between software and underlying systems that can give rise to practical security threats. Students will also gain experience applying many of these techniques to write code that is secure by construction.	U	4, 9, 1	focused
15317	Computer Science	Constructive Logic	This multidisciplinary junior-level course is designed to provide a thorough introduction to modern constructive logic, its roots in philosophy, its numerous applications in computer science, and its mathematical properties. Some of the topics to be covered are intuitionistic logic, inductive definitions, functional programming, type theory, realizability, connections between classical and constructive logic, decidable classes.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
15319	Computer Science	Cloud Computing	This course gives students an overview of Cloud Computing, which is the delivery of computing as a service over a network, whereby distributed resources are rented, rather than owned, by an end user as a utility. Students will study its enabling technologies, building blocks, and gain hands-on experience through projects utilizing public cloud infrastructures. Cloud computing services are widely adopted by many organizations across domains. The course will introduce the cloud and cover the topics of data centers, software stack, virtualization, software defined networks and storage, cloud storage, and programming models. We will start by discussing the clouds motivating factors, benefits, challenges, service models, SLAs and security. We will describe several concepts behind data center design and management, which enable the economic and technological benefits of the cloud paradigm. Next, we will study how CPU, memory and I/O resources, network (SDN) and storage (SDS) are virtualized, and the key role of virtualization to enable the cloud. Subsequently, students will study cloud storage concepts like data distribution, durability, consistency and redundancy. We will discuss distributed file systems, NoSQL databases and object storage using HDFS, CephFS, HBASE, MongoDB, Cassandra, DynamoDB, S3, and Swift as case studies. Finally, students will study the MapReduce, Spark and GraphLab programming models. Students will work with Amazon Web Services and Microsoft Azure, to rent and provision compute resources and then program and deploy applications using these resources. Students will develop and evaluate scaling and load balancing solutions, work with cloud storage systems, and develop applications in several programming paradigms. 15619 students must complete an extra team project which entails designing and implementing a cost- and performance-sensitive web-service for querying big data.	U	9, 8, 4	focused
15322	Computer Science	Introduction to Computer Music	Computers are used to synthesize sound, process signals, and compose music. Personal computers have replaced studios full of sound recording and processing equipment, completing a revolution that began with recording and electronics. In this course, students will learn the fundamentals of digital audio, basic sound synthesis algorithms, and techniques for digital audio effects and processing. Students will apply their knowledge in programming assignments using a very high-level programming language for sound synthesis and composition. In a final project, students will demonstrate their mastery of tools and techniques through music composition or by the implementation of a significant sound-processing technique.	U	4, 9, 17	focused
15330	Computer Science	Introduction to Computer Security	Security is becoming one of the core requirements in the design of critical systems. This course will introduce students to the intro-level fundamental knowledge of computer security and applied cryptography. Students will learn the basic concepts in computer security including software vulnerability analysis and defense, networking and wireless security, and applied cryptography. Students will also learn the fundamental methodology for how to design and analyze security critical systems.	U	4, 9, 1	focused
15346	Computer Science	Special Topics: Computer Architecture: Design and Simulation	This course will help students develop an understanding of basic microarchitectural principles and designs. Starting with creating benchmarks and simulators, students will learn the practice of computer architecture design. The emphasis will be on how processors exploit instruction-level parallelism for performance, as well as the supporting technologies such as caches and branch prediction that are required. Several frontiers of current research will be explored in energy efficiency and security threats.	U	7, 4, 9	focused
15351	Computer Science	Algorithms and Advanced Data Structures	The objective of this course is to study algorithms for general computational problems, with a focus on the principles used to design those algorithms. Efficient data structures will be discussed to support these algorithmic concepts. Topics include: Run time analysis, divide-and-conquer algorithms, dynamic programming algorithms, network flow algorithms, linear and integer programming, large-scale search algorithms and heuristics, efficient data storage and query, and NP-completeness. Although this course may have a few programming assignments, it is primarily not a programming course. Instead, it will focus on the design and analysis of algorithms for general classes of problems. This course is not open to CS graduate students who should consider taking 15-651 instead. THIS COURSE IS NOT OPEN TO COMPUTER SCIENCE MAJORS OR MINORS.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
15354	Computer Science	Computational Discrete Mathematics	This course is about the computational aspects of some of the standard concepts of discrete mathematics (relations, functions, logic, graphs, algebra, automata), with emphasis on efficient algorithms. We begin with a brief introduction to computability and computational complexity. Other topics include: iteration, orbits and fixed points, order and equivalence relations, propositional logic and satisfiability testing, finite fields and shift register sequences, finite state machines, and cellular automata. Computational support for some of the material is available in the form of a Mathematica package.	U	4, 9, 12	focused
15356	Computer Science	Introduction to Cryptography	This course is aimed as an introduction to modern cryptography. This course will be a mix of applied and theoretical cryptography. We will cover popular primitives such as: pseudorandom functions, encryption, signatures, zero-knowledge proofs, multi-party computation, and Blockchains. In addition, we will cover the necessary number-theoretic background. We will cover formal definitions of security, as well as constructions based on well established assumptions like factoring. Please see the course webpage for a detailed list of topics.	U	9, 1	focused
15386	Computer Science	Neural Computation	Computational neuroscience is an interdisciplinary science that seeks to understand how the brain computes to achieve natural intelligence. It seeks to understand the computational principles and mechanisms of intelligent behaviors and mental abilities -- such as perception, language, motor control, and learning -- by building artificial systems and computational models with the same capabilities. This course explores how neurons encode and process information, adapt and learn, communicate, cooperate, compete and compute at the individual level as well as at the levels of networks and systems. It will introduce basic concepts in computational modeling, information theory, signal processing, system analysis, statistical and probabilistic inference. Concrete examples will be drawn from the visual system and the motor systems, and studied from computational, psychological and biological perspectives. Students will learn to perform computational experiments using Matlab and quantitative studies of neurons and neuronal networks.	U	4, 9	focused
15387	Computer Science	Computational Perception	In this course, we will first cover the biological and psychological foundational knowledge of biological perceptual systems, and then apply computational thinking to investigate the principles and mechanisms underlying natural perception. The course will focus on vision this year, but will also touch upon other sensory modalities. You will learn how to reason scientifically and computationally about problems and issues in perception, how to extract the essential computational properties of those abstract ideas, and finally how to convert these into explicit mathematical models and computational algorithms. Topics include perceptual representation and inference, perceptual organization, perceptual constancy, object recognition, learning and scene analysis. Prerequisites: First year college calculus, some basic knowledge of linear algebra and probability and some programming experience are desirable.	U	4, 9	focused
15388	Computer Science	Practical Data Science	Data science is the study and practice of how we can extract insight and knowledge from large amounts of data. This course provides a practical introduction to the "full stack" of data science analysis, including data collection and processing, data visualization and presentation, statistical model building using machine learning, and big data techniques for scaling these methods. Topics covered include: collecting and processing data using relational methods, time series approaches, graph and network models, free text analysis, and spatial geographic methods; analyzing the data using a variety of statistical and machine learning methods include linear and non-linear regression and classification, unsupervised learning and anomaly detection, plus advanced machine learning methods like kernel approaches, boosting, or deep learning; visualizing and presenting data, particularly focusing the case of high-dimensional data; and applying these methods to big data settings, where multiple machines and distributed computation are needed to fully leverage the data.Students will complete weekly programming homework that emphasize practical understanding of the methods described in the course. In addition, students will develop a tutorial on an advanced topic, and will complete a group project that applies these data science techniques to a practical application chosen by the team; these two longer assignments will be done in lieu of a midterm or final.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
15394	Computer Science	Intermediate Rapid Prototyping	This course covers additional topics in rapid prototyping beyond the content of 15-294. Example topics include mechanism design, procedural shape generation using Grasshopper, 3D scanning and mesh manipulation, and advanced SolidWorks concepts. The only prerequisite is basic familiarity with SolidWorks, which can be obtained via 15-294, from other CMU courses, or from online tutorials.	U	9, 4	focused
15400	Computer Science	Research Practicum in Computer Science	This Spring course is the second part of a two-course sequence that is designed to help prepare students to invent the future state-of-the-art in the field of computer science. Building directly upon 15-300 (the prerequisite for this course), students will conduct a semester-long independent research project, under the guidance of both the course staff and a faculty project mentor. The course does not meet for lecture or recitations. Instead, the students will spend their time working on their research projects, and will also meet with course staff on a bi-weekly basis to discuss their progress. Students will prepare a written report and a poster presentation at the end of the semester to describe what they have accomplished.	U	4, 17, 9	focused
15410	Computer Science	Operating System Design and Implementation	Operating System Design and Implementation is a rigorous hands-on introduction to the principles and practice of operating systems. The core experience is writing a small Unix-inspired OS kernel, in C with some x86 assembly language, which runs on a PC hardware simulator (and on actual PC hardware if you wish). Work is done in two-person teams, and "team programming" skills (source control, modularity, documentation) are emphasized. The size and scope of the programming assignments typically result in students significantly developing their design, implementation, and debugging abilities. Core concepts include the process model, virtual memory, threads, synchronization, and deadlock; the course also surveys higher-level OS topics including file systems, interprocess communication, networking, and security. Students, especially graduate students, who have not satisfied the prerequisite at Carnegie Mellon are strongly cautioned - to enter the class you must be able to write a storage allocator in C, use a debugger, understand 2's-complement arithmetic, and translate between C and x86 assembly language. The instructor may require you to complete a skills assessment exercise before the first week of the semester in order to remain registered in the class. Auditing: this course is usually full, and we generally receive many more requests to audit than we can accept. If you wish to audit, please have your advisor contact us before the semester begins to discuss your educational goals.	U	4, 9, 17	focused
15411	Computer Science	Compiler Design	This course covers the design and implementation of compiler and run-time systems for high-level languages, and examines the interaction between language design, compiler design, and run-time organization. Topics covered include syntactic and lexical analysis, handling of user-defined types and type-checking, context analysis, code generation and optimization, and memory management and run-time organization.	U	9, 4	focused
15414	Computer Science	Bug Catching: Automated Program Verification	Many CS and ECE students will be developing software and hardware that must be ultra reliable at some point in their careers. Logical errors in such designs can be costly, even life threatening. There have already been a number of well publicized errors like the Intel Pentium floating point error and the Arian 5 crash. In this course we will study tools for finding and preventing logical errors. Three types of tools will be studied: automated theorem proving, state exploration techniques like model checking and tools based on static program analysis. Although students will learn the theoretical basis for such tools, the emphasis will be on actually using them on real examples. This course can be used to satisfy the Logic & Languages requirement for the Computer Science major.	U	4, 17, 9	focused
15418	Computer Science	Parallel Computer Architecture and Programming	The fundamental principles and engineering tradeoffs involved in designing modern parallel computers, as well as the programming techniques to effectively utilize these machines. Topics include naming shared data, synchronizing threads, and the latency and bandwidth associated with communication. Case studies on shared-memory, message-passing, data-parallel and dataflow machines will be used to illustrate these techniques and tradeoffs. Programming assignments will be performed on one or more commercial multiprocessors, and there will be a significant course project.	U	9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
15440	Computer Science	Distributed Systems	The goals of this course are twofold: First, for students to gain an understanding of the principles and techniques behind the design of distributed systems, such as locking, concurrency, scheduling, and communication across the network. Second, for students to gain practical experience designing, implementing, and debugging real distributed systems. The major themes this course will teach include scarcity, scheduling, concurrency and concurrent programming, naming, abstraction and modularity, imperfect communication and other types of failure, protection from accidental and malicious harm, optimism, and the use of instrumentation and monitoring and debugging tools in problem solving. As the creation and management of software systems is a fundamental goal of any undergraduate systems course, students will design, implement, and debug large programming projects. As a consequence, competency in both the C and Java programming languages is required.	U	4, 9	focused
15441	Computer Science	Computer Networks	The emphasis in this course will be on the basic performance and engineering trade-offs in the design and implementation of computer networks. To make the issues more concrete, the class includes several multi-week projects requiring significant design and implementation. The goal is for students to learn not only what computer networks are and how they work today, but also why they are designed the way they are and how they are likely to evolve in the future. We will draw examples primarily from the Internet. Topics to be covered include: network architecture, routing, congestion/flow/error control, naming and addressing, peer-to-peer and the web, internetworking, and network security.	U	4, 9, 11	focused
15445	Computer Science	Database Systems	This course is on the design and implementation of database management systems. Topics include data models (relational, document, key/value), storage models (n-ary, decomposition), query languages (SQL, stored procedures), storage architectures (heaps, log-structured), indexing (order preserving trees, hash tables), transaction processing (ACID, concurrency control), recovery (logging, checkpoints), query processing (joins, sorting, aggregation, optimization), and parallel architectures (multi-core, distributed). Case studies on open-source and commercial database systems will be used to illustrate these techniques and trade-offs. The course is appropriate for students with strong systems programming skills.	U	4, 9, 15	focused
15451	Computer Science	Algorithm Design and Analysis	This course is about the design and analysis of algorithms. We study specific algorithms for a variety of problems, as well as general design and analysis techniques. Specific topics include searching, sorting, algorithms for graph problems, efficient data structures, lower bounds and NP-completeness. A variety of other topics may be covered at the discretion of the instructor. These include parallel algorithms, randomized algorithms, geometric algorithms, low level techniques for efficient programming, cryptography, and cryptographic protocols.	U	9, 17, 12	focused
15455	Computer Science	Undergraduate Complexity Theory	Complexity theory is the study of how much of a resource (such as time, space, parallelism, or randomness) is required to perform some of the computations that interest us the most. In a standard algorithms course, one concentrates on giving resource efficient methods to solve interesting problems. In this course, we concentrate on techniques that prove or suggest that there are no efficient methods to solve many important problems. We will develop the theory of various complexity classes, such as P, NP, co-NP, PH, #P, PSPACE, NC, AC, L, NL, UP, RP, BPP, IP, and PCP. We will study techniques to classify problems according to our available taxonomy. By developing a subtle pattern of reductions between classes we will suggest an (as yet unproven!) picture of how by using limited amounts of various resources, we limit our computational power.	U	4, 17, 7	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
15458	Computer Science	Discrete Differential Geometry	Geometry plays a vital role in both engineering and scientific discovery, as well as in our everyday lives via emerging technologies like depth cameras and 3D printing. This course teaches students how to think about three-dimensional shape, both mathematically and computationally. Students will get a crash course in differential geometry, and will apply this knowledge to design and implement practical algorithms for 3D geometry processing. Basic geometric concepts (like curvature) are examined via complementary computational and mathematical points of view, with an emphasis on visual intution and real-world applications. In homework, students will derive and implement core geometry processing algorithms; they will also explore a topic of their choice in a final class project. MS and PhD students will complete additional written and coding exercises, and will perform a more comprehensive literature review for their final project. Topics include curves and surfaces, curvature, connections and parallel transport, exterior calculus, simplicial homology, conformal mapping, finite element methods, and numerical linear algebra; applications include approximation of curvature, curve and surface smoothing, surface parameterization, vector field design, and computation of geodesic distance.	U	4, 9, 17	focused
15459	Computer Science	Undergraduate Quantum Computation	This undergraduate course will be an introduction to quantum computation and quantum information theory, from the perspective of theoretical computer science. Topics include: Qubit operations, multi-qubit systems, p=artial measurements, entanglement, quantum teleportation and quantum money, quantum circuit model, Deutsch-Jozsa and Simon's algorithm, number theory and Shor's Algorithm, Grover's Algorithm, quantum complexity theory, limitations and current practical developments.	U	4, 9	focused
15463	Computer Science	Computational Photography	Computational photography is the convergence of computer graphics, computer vision and imaging. Its role is to overcome the limitations of the traditional camera, by combining imaging and computation to enable new and enhanced ways of capturing, representing, and interacting with the physical world. This advanced undergraduate course provides a comprehensive overview of the state of the art in computational photography. At the start of the course, we will study modern image processing pipelines, including those encountered on mobile phone and DSLR cameras, and advanced image and video editing algorithms. Then we will proceed to learn about the physical and computational aspects of tasks such as 3D scanning, coded photography, lightfield imaging, time-of-flight imaging, VR/AR displays, and computational light transport. Near the end of the course, we will discuss active research topics, such as creating cameras that capture video at the speed of light, cameras that look around walls, or cameras that can see through tissue. The course has a strong hands-on component, in the form of seven homework assignments and a final project. In the homework assignments, students will have the opportunity to implement many of the techniques covered in the class, by both acquiring their own images of indoor and outdoor scenes and developing the computational tools needed to extract information from them. For their final projects, students will have the choice to use modern sensors provided by the instructors (lightfield cameras, time-of-flight cameras, depth sensors, structured light systems, etc.). This course requires familarity with linear algebra, calculus, programming, and doing computations with images. The course does not require prior experience with photography or imaging.	U	4, 9, 17	focused
15464	Computer Science	Technical Animation	This course introduces techniques for computer animation such as keyframing, procedural methods, motion capture, and simulation. The course also includes a brief overview of story-boarding, scene composition, lighting and sound track generation. The second half of the course will explore current research topics in computer animation such as dynamic simulation of flexible and rigid objects,automatically generated control systems, and evolution of behaviors. The course should be appropriate for graduate students in all areas and for advanced undergraduates.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
15466	Computer Science	Computer Game Programming	The goal of this course is to acquaint students with the code required to turn ideas into games. This includes both runtime systems -- e.g., AI, sound, physics, rendering, and networking -- and the asset pipelines and creative tools that make it possible to author content that uses these systems. In the first part of the course, students will implement small games that focus on specific runtime systems, along with appropriate asset editors or exporters. In the second part, students will work in groups to build a larger, polished, open-ended game project. Students who have completed the course will have the skills required to extend -- or build from scratch -- a modern computer game. Students wishing to take this class should be familiar with the C++ language and have a basic understanding of the OpenGL API. If you meet these requirements but have not taken 15-462 (the formal prerequisite), please contact the instructor.	U	4, 9, 17	focused
15468	Computer Science	Special Topic: Physics-Based Rendering	This course is an introduction to physics-based rendering at the advanced undergraduate and introductory graduate level. During the course, we will cover fundamentals of light transport, including topics such as the rendering and radiative transfer equation, light transport operators, path integral formulations, and approximations such as diffusion and single scattering. Additionally, we will discuss state-of-the-art models for illumination, surface and volumetric scattering, and sensors. Finally, we will use these theoretical foundations to develop Monte Carlo algorithms and sampling techniques for efficiently simulating physically-accurate images. Towards the end of the course, we will look at advanced topics such as rendering wave optics, and differentiable rendering. The course has a strong programming component, during which students will develop their own working implementation of a physics-based rendering engine, including support for a variety of rendering algorithms (path tracing, bidirectional path tracing, Markov chain Monte Carlo), materials (diffuse, glossy, specular, translucent), illumination sources, and sensors. Students will learn common light transport and material models, and be able to write their own code to use these models to create physically-accurate images.	U	4, 9, 11	focused
15469	Computer Science	Special Topic: Algorithmic Textiles Design	Textile artifacts are -- quite literally -- all around us; from clothing to carpets to car seats. These items are often produced by sophisticated, computer-controlled fabrication machinery. In this course we will discuss everywhere code touches textiles fabrication, including design tools, simulators, and machine control languages. Students will work on a series of multi-week, open-ended projects, where they use code to create patterns for modern sewing/embroidery, weaving, and knitting machines; and then fabricate these patterns in the textiles lab. Students in the 800-level version of the course will additionally be required to create a final project that develops a new algorithm, device, or technique in textiles fabrication.	U	9, 4, 17	focused
15482	Computer Science	Autonomous Agents	Autonomous agents use perception, cognition, actuation, and learning to reliably achieve desired goals, where the agents can be smart homes, mobile robots, intelligent factories, self-driving cars, etc. The goal of this course is to provide students with the techniques needed for developing complete, integrated AI-based autonomous agents. Topics to be investigated include architectures for intelligent agents, task planning, reasoning under uncertainty, optimization, monitoring, execution, error detection and recovery, collaborative and adversarial multiagent interaction, machine learning, ethical behavior, and explanation. The course is project-oriented where, over the course of the semester, small teams of students will design, implement, and evaluate autonomous agents operating in a real-world environment.	U	4, 9, 17	focused
15494	Computer Science	Cognitive Robotics: The Future of Robot Toys	This course will explore the future of robot toys by analyzing and programming Anki Cozmo, a new robot with built-in artificial intelligence algorithms. Como is distinguished from earlier consumer robots by its reliance on vision as the primary sensing mode and its sophisticated use of A.I. Its capabilities include face and object recognition, map building, path planning, and object pushing and stacking. Although marketed as a pre-programmed children's toy, Cozmo's open source Python SDK allows anyone to develop new software for it, which means it can also be used for robotics education and research. The course will cover robot software architecture, human-robot interaction, perception, and planning algorithms for navigation and manipulation. Prior robotics experience is not required, just strong programming skills.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
15513	Computer Science	Introduction to Computer Systems	This course provides a programmer's view of how computer systems execute programs, store information, and communicate. It enables students to become more effective programmers, especially in dealing with issues of performance, portability and robustness. It also serves as a foundation for courses on compilers, networks, operating systems, and computer architecture, where a deeper understanding of systems-level issues is required. Topics covered include: machine-level code and its generation by optimizing compilers, performance evaluation and optimization, computer arithmetic, memory organization and management, networking technology and protocols, and supporting concurrent computation.	U	4, 9	focused
15539	Computer Science	Computer Science Pedagogy	The objective of this course is to build skills in the area of collaborative product design in an educational context. The first part of the course will focus on how to communicate with and engage an audience in an ever-growing virtual environment, using computer science education as the medium. The goal will be to learn how to present information in a creative yet intrinsically pedagogical way. Throughout the course, students will work both independently and in groups to create content for high school students using CMU CS Academy's computer programming curriculum. Contact ecawley@andrew.cmu.edu if you are interested in taking this class as it is special permission only.	U	4, 9, 8	focused
15619	Computer Science	Cloud Computing	This course gives students an overview of Cloud Computing, which is the delivery of computing as a service over a network, whereby distributed resources are rented, rather than owned, by an end user as a utility. Students will study its enabling technologies, building blocks, and gain hands-on experience through projects utilizing public cloud infrastructures. Cloud computing services are widely adopted by many organizations across domains. The course will introduce the cloud and cover the topics of data centers, software stack, virtualization, software defined networks and storage, cloud storage, and programming models. We will start by discussing the clouds motivating factors, benefits, challenges, service models, SLAs and security. We will describe several concepts behind data center design and management, which enable the economic and technological benefits of the cloud paradigm. Next, we will study how CPU, memory and I/O resources, network (SDN) and storage (SDS) are virtualized, and the key role of virtualization to enable the cloud. Subsequently, students will study cloud storage concepts like data distribution, durability, consistency and redundancy. We will discuss distributed file systems, NoSQL databases and object storage using HDFS, CephFS, HBASE, MongoDB, Cassandra, DynamoDB, S3, and Swift as case studies. Finally, students will study the MapReduce, Spark and GraphLab programming models. Students will work with Amazon Web Services and Microsoft Azure, to rent and provision compute resources and then program and deploy applications using these resources. Students will develop and evaluate scaling and load balancing solutions, work with cloud storage systems, and develop applications in several programming paradigms. 15619 students must complete an extra team project which entails designing and implementing a cost- and performance-sensitive web-service for querying big data.	G	9, 8, 4	focused
15668	Computer Science	Special Topic: Physics-Based Rendering	This course is an introduction to physics-based rendering at the advanced undergraduate and introductory graduate level. During the course, we will cover fundamentals of light transport, including topics such as the rendering and radiative transfer equation, light transport operators, path integral formulations, and approximations such as diffusion and single scattering. Additionally, we will discuss state-of-the-art models for illumination, surface and volumetric scattering, and sensors. Finally, we will use these theoretical foundations to develop Monte Carlo algorithms and sampling techniques for efficiently simulating physically-accurate images. Towards the end of the course, we will look at advanced topics such as rendering wave optics, and differentiable rendering. The course has a strong programming component, during which students will develop their own working implementation of a physics-based rendering engine, including support for a variety of rendering algorithms (path tracing, bidirectional path tracing, Markov chain Monte Carlo), materials (diffuse, glossy, specular, translucent), illumination sources, and sensors. Students will learn common light transport and material models, and be able to write their own code to use these models to create physically-accurate images.	G	4, 9, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
15719	Computer Science	Advanced Cloud Computing	Computing in the cloud has emerged as a leading paradigm for cost-effective, scalable, well-managed computing. Users pay for services provided in a broadly shared, power efficient datacenter, enabling dynamic computing needs to be met without paying for more than is needed. Actual machines may be virtualized into machine-like services, or more abstract programming platforms, or application-specific services, with the cloud computing infrastructure managing sharing, scheduling, reliability, availability, elasticity, privacy, provisioning and geographic replication This course will survey the aspects of cloud computing by reading about 30 papers and articles, executing cloud computing tasks on a state of the art cloud computing service, and implementing a change or feature in a state of the art cloud computing framework. There will be no final exam, but there will be two in class exams. Grades will be about 50% project work and about 50% examination results. Please refer to https://www.cs.cmu.edu/~csd-grad/courseschedules20.html for the most recent schedule updates.	G	9, 4, 7	focused
16223	Robotics	IDeATe Portal: Creative Kinetic Systems	The art and science of machines which evoke human delight through physical movement is founded on a balance of form and computation. This introductory physical computing course addresses the practical design and fabrication of robots, interactive gadgets, and kinetic sculptures. The emphasis is on creating experiences for human audiences through the physical behavior of devices which embody computation with mechanism, sensing, and actuation. Specific topics include basic electronics, elementary mechanical design, embedded programming, and parametric CAD. A key objective is gaining an intuitive understanding of how information and energy move between the physical, electronic, and computational domains to create a compelling behavior. The final projects are tested in the field on children and adults. This interdisciplinary course is an IDeATe Portal Course open to students from all colleges. For students choosing to follow an IDeATe program it is an entry into either Physical Computing or Intelligent Environments. The structure of the class revolves around collaborative exercises and projects which introduce core physical computing and system engineering techniques in a human-centric context. Students apply system and design thinking across multiple domains, work together to make and test several devices, and participate in wide-ranging critique which considers both technical and artistic success.	U	9, 4, 7	focused
16299	Robotics	Introduction to Feedback Control Systems	This course is designed as a first course in feedback control systems for computer science majors. Course topics include classical linear control theory (differential equations, Laplace transforms, feedback control), linear state-space methods (controllability/observability, pole placement, LQR), nonlinear systems theory, and an introduction to control using computer learning techniques. Priorities will be given to computer science majors with robotics minor.	U	4, 9	focused
16311	Robotics	Introduction to Robotics	This course presents an overview of robotics in practice and research with topics including vision, machine learning, motion planning, mobile mechanisms, kinematics, inverse kinematics, and sensors. In course projects, students construct LEGO robots which are driven by a microcontroller, with each project reinforcing the basic principles developed in lectures. Students usually work in teams of three: an electrical engineer, a mechanical engineer, and a computer scientist. Groups are typically self-formed except for the first lab. This course will also expose students to some of the contemporary happenings in robotics, including current robotics research, applications, robot contests and robots in the news.	U	4, 9, 17	focused
16350	Robotics	Planning Techniques for Robotics	Planning is one of the core components that enable robots to be autonomous. Robot planning is responsible for deciding in real-time what should the robot do next, how to do it, where should the robot move next and how to move there. This class does an in-depth study of popular planning techniques in robotics and examines their use in ground and aerial robots, humanoids, mobile manipulation platforms and multi-robot systems. The students learn the theory of these methods and also implement them in a series of programming-based projects. To take the class students should have taken an Intro to Robotics class and have a good knowledge of programming and data structures.	U	9, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
16362	Robotics	Mobile Robot Algorithms Laboratory	This course is a comprehensive hands-on introduction to the concepts and basic algorithms needed to make a mobile robot function reliably and effectively. We will work in small groups with small robots that are controlled over wireless from your laptop computers. The robots are custom-designed mini forktrucks that can move pallets from place to place just like commercial automated guided vehicles do today. The robots are programmed in the modern MATLAB programming environment. It is a pretty easy language to learn, and a very powerful one for prototyping robotics algorithms. You will get a lot of experience in this course in addition to some theory. Lectures are focused on the content of the next lab. There is a lab every week and they build on each other so that a complete robot software system results. The course will culminate with a class-wide robot competition that tests the performance of all of your code implemented in the semester. In order to succeed in the course, students must have a 1) 2nd year science/engineering level background in mathematics (matrices, vectors, coordinate systems) and 2) have already mastered at least one procedural programming language like C or Java, and 3) have enough experience to be reasonably prepared to write a 5000 line software system in 13 weeks with the help of one or two others. When the course is over, you will have written a single software system that has been incrementally extended in functionality and regularly debugged throughout the semester.	U	4, 9, 12	focused
16375	Robotics	IDeATe: Robotics for Creative Practice	Robots come in all shapes and sizes: it is the integration of software and hardware that can make any machine surprisingly animate. This project-oriented course brings art and engineering together to build performance systems using embodied behavior as a creative medium. Students learn skills for designing, constructing and programming automated systems for storytelling and human interaction, then explore the results through exhibition and performance. Technical topics include closed-loop motion control, expressive physical and computational behavior, machine choreography, and performance conceptualization. Discussion topics include both contemporary kinetic sculpture and robotics research. This interdisciplinary course is part of IDeATe Physical Computing but is open to any student.	U	4, 9, 17	focused
16376	Robotics	IDeATe: Kinetic Fabrics	Kinetic Fabrics brings together the fields of robotics and textiles to explore their unified creative and expressive potential. It is a wide-open frontier for kinetic art, wearable art, and architectural installation. In this course students will build a variety of performative systems combining fabrics and robotic technologies. Students will apply modular actuation and sensing to textile artworks, using software designed to facilitate fluid explorations, rapid iterations, and playful experimentation. Students will learn basic textile skills, such as hand and machine sewing, as well as gain facility and familiarity with the characteristics of multiple type of fabrics. Historical precedents as well as contemporary examples of works will support students creative growth and knowledge of the field. Students' course work will include short-term and long-term projects, sampling and prototyping, critique, and documentation. Additionally, students will organize an end-of-semester event where they will perform a developed kinetic fabric work for a public audience.	U	4, 9, 8	focused
16385	Robotics	Computer Vision	This course provides a comprehensive introduction to computer vision. Major topics include image processing, detection and recognition, geometry-based and physics-based vision, sensing and perception, and video analysis. Students will learn basic concepts of computer vision as well as hands on experience to solve real-life vision problems. This course is for undergraduate students only.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
16450	Robotics	Robotics Systems Engineering	Systems engineering examines methods of specifying, designing, analyzing and testing complex systems. In this course, principles and processes of systems engineering are introduced and applied to the development of robotic devices. The focus is on robotic system engineered to perform complex behavior. Such systems embed computing elements, integrate sensors and actuators, operate in a reliable and robust fashion, and demand rigorous engineering from conception through production. The course is organized as a progression through the systems engineering process of conceptualization, specification, design, and prototyping with consideration of verification and validation. Students completing this course will engineer a robotic system through its compete design and initial prototype. The project concept and teams can continue into the Spring-semester (16-474 Robotics Capstone) for system refinement, testing and demonstration.	U	9, 4, 17	focused
16467	Robotics	Human Robot Interaction	The field of human-robot interaction (HRI) is fast becoming a significant area of research in robotics. The basic objective is to create natural and effective interactions between people and robots. HRI is highly interdisciplinary, bringing together methodologies and techniques from robotics, artificial intelligence, human-computer interaction, psychology, education, and other fields. This course is primarily lecture-based, with in-class participatory mini-projects, homework assignments, a group term project that will enable students to put theory to practice, and a final. The topics covered will include technologies that enable human-robot interactions, the psychology of interaction between people and robots, how to design and conduct HRI studies, and real-world applications such as assistive robots. This course has no prerequisites, but some basic familiarity with robots is recommended (programming knowledge is not necessary, but is useful for the term project).	U	4, 9, 17	focused
16474	Robotics	Robotics Capstone	In this course students refine the design, build, integrate, test, and demonstrate the performance of the robot they designed in the pre-requisite Systems Engineering Course (16-450). The students are expected to continue to apply the process and methods of Systems Engineering to track requirements, evaluate alternatives, refine the cyberphysical architectures, plan and devise tests, verify the design, and validate system performance. In addition, the students learn and apply Project Management techniques to manage the technical scope, schedule, budget, and risks of their project. The course consists of lectures, class meetings, reviews, and a final demonstration. Lectures cover core topics in Project Management and special topics in Systems Engineering. During class meetings the students and instructor review progress on the project and discuss technical and project-execution challenges. There are three major reviews approximately at the end of each of the first three months of the semester. For each review, the students give a presentation and submit an updated version of the System Design and Development Document. The course culminates in a System Performance Validation Demonstration at the end of the semester. In addition to that the students hold a special demonstration of their robotic system for the broader Robotics community.	U	4, 9, 17	focused
16480	Robotics	IDeATe: Special Topics: Creative Robotics	This experimental course offers unique topics situated at the intersection of robotics research and the arts, with a specific research focus that varies each semester. In this course, students survey the state of an emerging research area, then design and fabricate experimental systems and artworks on the theme. Students are guided through literature search and technical paper analysis to identify opportunities and techniques. The textual study spans contemporary robotics and arts literature. The project component is research-focused and explores novel techniques in design, fabrication, programming, and control. The project sequence culminates in the collaborative design of expressive robotic systems which match technical innovation with a human need or artistic expression. The initial iteration of the course focuses on soft robotics, an emerging discipline centered on devices constructed from compliant materials that incorporate sensing and actuation. The literature survey spans soft robotics and kinetic sculpture. The projects center on fabricating forms that incorporate actuators and sensors using silicone rubber cast into 3D-printed and laser-cut molds. This course is offered by IDeATe and this iteration will satisfy minor requirements for IDeATe Soft Technologies or IDeATe Physical Computing.	U	9, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
16597	Robotics	Undergraduate Reading and Research	Undergraduate Reading and Research enables students to gain academic credits for conducing independent studies in robotics. Students must work with a robotics faculty advisor to devise a specific objective, activities (such as reading, evaluating, designing, coding, building, or testing robotic systems) and metrics for evaluation of their performance by their advisor.	U	4, 17, 9	focused
16621	Robotics	MSCV Project I	The MSCV capstone project course is designed to give project teams additional feedback on their capstone project from peers and faculty. Every week, capstone teams will present their project PPFs (Past-Present-Future) reports. For the presenting teams, the capstone course will help develop presentation and communication skills. For the students participating as peer-reviewers, it will help develop critical thinking and the ability to give constructive advice.	G	4, 17, 8	focused
16622	Robotics	MSCV Capstone	The MSCV capstone project course is designed to give project teams additional feedback on their capstone project from peers and faculty. Every week, capstone teams will present their project PPFs (Past-Present-Future) reports. For the presenting teams, the capstone course will help develop presentation and communication skills. For the students participating as peer-reviewers, it will help develop critical thinking and the ability to give constructive advice.	G	4, 17, 8	focused
16665	Robotics	Robot Mobility on Air, Land, & Sea	Many robots are designed to move through their environments. Three prevalent environments on earth are land, air, and water. This course will explore the modeling, control, and navigation of ground-based (wheeled and legged), air-based (rotorcraft such as quadcopters), and water-based robots.	G	6, 14, 9	focused
16682	Robotics	Robotic Systems Development Project Course II	This course is the second semester in a two-semester sequence intended to enable student teams to design and implement robot systems from the requirements development phase through implementation, verification, and demonstration of a working prototype. Teams of 4-5 students continue work on a project provided by industrial and academic partners, refine design requirements, refine or create new subsystems, and integrate and demonstrate the full system.	G	9, 4, 17	focused
16720	Robotics	Computer Vision	This course introduces the fundamental techniques used in computer vision, that is, the analysis of patterns in visual images to reconstruct and understand the objects and scenes that generated them. Topics covered include image formation and representation, camera geometry, and calibration, computational imaging, multi-view geometry, stereo, 3D reconstruction from images, motion analysis, physics-based vision, image segmentation and object recognition. The material is based on graduate-level texts augmented with research papers, as appropriate. Evaluation is based on homeworks and a final project. The homeworks involve considerable Matlab programming exercises. Texts recommended but not required: Title: "Computer Vision Algorithms and Applications" Author: Richard Szeliski Series: Texts in Computer Science Publisher: Springer ISBN: 978-1-84882-934-3 Title: "Computer Vision: A Modern Approach" Authors: David Forsyth and Jean Ponce Publisher: Prentice Hall ISBN: 0-13-085198-1	G	17, 4, 9	focused
16725	Robotics	(Bio)Medical Image Analysis	Students will gain theoretical and practical skills in 2D, 3D, and 4D biomedical image analysis, including skills relevant to general image analysis. The fundamentals of computational medical image analysis will be explored, leading to current research in applying geometry and statistics to segmentation, registration, visualization, and image understanding. Additional and related covered topics include de-noising/restoration, morphology, level sets, and shape/feature analysis. Students will develop practical experience through projects using the latest version of the National Library of Medicine Insight Toolkit (ITK) and SimpleITK, a popular open-source software library developed by a consortium of institutions including Carnegie Mellon University and the University of Pittsburgh. In addition to image analysis, the course will include interaction with radiologists and pathologist(s). *** Lectures are at CMU and students will visit clinicians at UPMC. Some or all of the class lectures may also be videoed for public distribution, but students may request to be excluded from distributed video. 16-725 is a graduate class, and 16-425 is a cross-listed undergraduate section. 16-425 is new this year, and has substantially reduced requirements for the final project and for the larger homework assignments, nor does it require shadowing the clinicians. Prerequisites: Knowledge of vector calculus, basic probability, and either C++ or python, including basic command-line familiarity and how to pass arguments to your own command-line programs. Extensive expertise with C++ and templates is not necessary, but some students may find it helpful.	G	4, 17, 15	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
16726	Robotics	Learning-based Image Synthesis	This course introduces machine learning methods for image and video synthesis. The objectives of synthesis research vary from modeling statistical distributions of visual data, through realistic picture-perfect recreations of the world in graphics, and all the way to providing interactive tools for artistic expression. Key machine learning algorithms will be presented, ranging from classical learning methods (e.g., nearest neighbor, PCA, Markov Random Fields) to deep learning models (e.g., ConvNets, deep generative models, such as GANs and VAEs). We will also introduce image and video forensics methods for detecting synthetic content. In this class, students will learn to build practical applications and create new visual effects using their own photos and videos.	G	4, 17, 9	focused
16730	Robotics	Robotics Business	This course introduces and develops business concepts that will be useful to new and existing companies, while focusing on robotic technology exemplars. The concepts begin with how to identify a new idea to for a business that can be effectively started. Initial ideas often start as a grandiose plan to change the world and these plans are legitimately the fuel that drive new businesses forward. However, when a company starts (e.g., builds a prototype or writes a first line of code), what is the least product a company can produce that customers still want and need? This kernel -- extracted from the "big plan"-- is a Minimal Viable Product (MVP). Once an MVP business kernel is formulated, we will learn and study how to understand customer needs, how to market a new idea and how raise and manage money for a new business entity. These steps abridge information that can be found in an MBA curriculum, but engineers and scientists focused on the technical side will need this information to participate in the process of building companies. In parallel, we will investigate the marketplace through the stock market. The stock market is a powerful window into the world of business. In other words, when a new business is built it has to live inside the competitive environment of every other business. To understand this eco-system, we will follow several companies in-situ as they go through their own ups-and-downs within the business world. The course is project based. Each student will either build their own business concept, or they will build an improvement plan that would be targeted to improve an existing business. Professor Bourne is a founding member of the Robotics Institute(1979) and has taught business concepts within the Tepper Business School and the Robotics Institute since 1988. In addition, he is the President of his own company Design One Software.	G	4, 9, 7	focused
16735	Robotics	Ethics and Robotics	This course contextualizes robotics, AI, and machine learning within cultural conversation, ethics, and power relationships in society. It will draw upon "AI and Humanity" as well as numerous other texts, including Mindless by Simon Head, Drone Theory by Grégoire Chamayou, and news articles. The course will culminate in an ethics module design project in collaboration with an instructor of another robotics course. Our target audience is students who will participate in computer science and robotics research and can use this course to inform future research and career decisions.	G	4, 17, 9	focused
16740	Robotics	Learning for Manipulation	Manipulation is the process of changing the state of objects through direct physical interactions. To perform manipulation tasks in unstructured environments, autonomous robots will need to learn about the objects in their surroundings as well as the skills required to manipulate and change the state of these objects. In this course, we explore the use of machine learning and data-driven algorithms for robot manipulation. The course introduces students to the wide variety of challenges posed by manipulation tasks, and how these challenges can be formulated as learning problems. Students are taught how these problems can be solved using machine learning techniques. The types of machine learning methods covered in this course include supervised, unsupervised, active, and reinforcement learning methods. The course includes both lectures and guided paper discussions.	G	4, 9, 8	focused
16741	Robotics	Mechanics of Manipulation	Kinematics, statics, and dynamics of robotic manipulator's interaction with a task, focusing on intelligent use of kinematic constraint, gravity, and frictional forces. Automatic planning based on mechanics. Application examples drawn from manufacturing and other domains.	G	9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
16745	Robotics	Optimal Control and Reinforcement Learning	This course surveys the use of optimization (especially optimal control) to design behavior. We will explore ways to represent policies including hand-designed parametric functions, basis functions, tables, and trajectory libraries. We will also explore algorithms to create policies including parameter optimization and trajectory optimization (first and second order gradient methods, sequential quadratic programming, random search methods, evolutionary algorithms, etc.). We will discuss how to handle the discrepancy between models used to create policies and the actual system being controlled (evaluation and robustness issues). The course will combine lectures, student-presented material, and projects.	G	4, 9, 8	focused
16748	Robotics	Underactuated Robots	People and animals move through and interact with the world in a fundamentally dynamic way. In the vast majority of cases the same cannot be said for robots. In fact, many conventional approaches to motion planning and robot control attempt to explicitly cancel out the dynamics associated with different tasks. This class will consider underactuated robots, systems that do not have full control over their state and therefore cannot be planned for or controlled via conventional methods. Our goal will be to make novel locomoting robots act more "naturally." This class will highlight the relationship between conventional ideas from deterministic motion planning and control design (e.g., dynamic programming and linear-quadratic regulators) and their contemporary counterparts, many of which help form the analytical basis for the probabilisitic reasoning that underlies contemporary AI systems (e.g., POMDPs). Note that this course is inspired by and, for the most part, will follow the format of "Underactuated Robotics: Learning, Planning, and Control for Efficient and Agile Machines" created by Prof. Russ Tedrake at MIT. We will take several tangents, but the course materials provided by Prof. Tedrake through MIT Open Courseware are an incredible resource for this course (and really just in general).	G	9, 4, 15	focused
16761	Robotics	Mobile Robots	The course is targeted to senior undergraduates and graduate level students. The lectures will develop the fundamentals of this emerging sub-field of robotics by calling on the experience of practitioners, the common themes of the literature, and relevant material from more basic fields such as computer vision, mathematics, and physics.	G	4, 9	focused
16778	Robotics	Mechatronic Design	Mechatronics is the synergistic integration of mechanism, electronics, and computer control to achieve a functional system. This course is a semester-long multidisciplinary capstone hardware project design experience in which small (typically four-person) teams of electrical and computer engineering, mechanical engineering and robotics students deliver an end-of-course demonstration of a final integrated system capable of performing a mechatronic task. Throughout the semester, the students design, configure, implement, test and evaluate in the laboratory devices and subsystems culminating in the final integrated mechatronic system. Lectures will complement the laboratory experience with comparative surveys, operational principles, and integrated design issues associated with the spectrum of mechanism, microcontroller, electronic, sensor, and control components.	G	9, 4, 17	focused
16782	Robotics	Planning and Decision-making in Robotics	Planning and Decision-making are critical components of autonomy in robotic systems. These components are responsible for making decisions that range from path planning and motion planning to coverage and task planning to taking actions that help robots understand the world around them better. This course studies underlying algorithmic techniques used for planning and decision-making in robotics and examines case studies in ground and aerial robots, humanoids, mobile manipulation platforms and multi-robot systems. The students will learn the algorithms and implement them in a series of programming-based projects.	G	9, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
16785	Robotics	Integrated Intelligence in Robotics: Vision Language Planning	This course is a project-oriented one that covers the topics on cognitive intelligence for robotic systems. Cognitive abilities constitute high-level, humanlike intelligence that exhibits reasoning or problem-solving skills. Such abilities as semantic perception, language understanding, and task planning can be built on top of low-level robot autonomy. The topics covered generally bridge across multiple technical areas, for example, vision-language intersection and language-action/plan grounding. This course is composed of 50% lectures and 50% seminar classes. Since this is a project-oriented course, we will put a special emphasis on learning research skills, e.g., problem formulation, literature review, ideation, evaluation planning, results analysis, and hypothesis verification. This course will be fully virtual. The course is still discussion intensive, and thus synchronous attendance is required.	G	4, 9, 17	focused
16791	Robotics	Applied Data Science	This course explores the rapidly developing field of data science in the context of its pragmatic applications. Applied Data Science strives to achieve three main goals. The first is to optimize the efficacy of decision making by human managers. The second is to maximize the utilization of available data, so that no important clue is ever missed. The third is to improve understanding of data and the underlying processes that produce it. This course aims at building skills required to systematically achieve those goals in practice. The students will gain and solidify awareness of the most prevalent contemporary methods of Data Science, and develop intuition needed for assessing practical utility of the studied topics in application scenarios. They will be able to learn how to formulate analytic tasks in support of project objectives, how to define successful analytic projects, and how to evaluate utility of existing and potential applications of the discussed technologies in practice.	G	4, 9, 17	focused
16831	Robotics	Statistical Techniques in Robotics	Probabilistic and learning techniques are now an essential part of building robots (or embedded systems) designed to operate in the real world. These systems must deal with uncertainty and adapt to changes in the environment by learning from experience. Uncertainty arises from many sources: the inherent limitations in our ability to model the world, noise and perceptual limitations in sensor measurements, and the approximate nature of algorithmic solutions. Building intelligent machines also requires that they adapt to their environment. Few things are more frustrating than machines that repeat the same mistake over and over again. We'll explore modern learning techniques that are effective at learning online: i.e. throughout the robots operation. We'll explore how the twin ideas of uncertainty and adaptation are closely tied in both theory and implementation.	G	4, 9, 12	focused
16833	Robotics	Robot Localization and Mapping	Robot localization and mapping are fundamental capabilities for mobile robots operating in the real world. Even more challenging than these individual problems is their combination: simultaneous localization and mapping (SLAM). Robust and scalable solutions are needed that can handle the uncertainty inherent in sensor measurements, while providing localization and map estimates in real-time. We will explore suitable efficient probabilistic inference algorithms at the intersection of linear algebra and probabilistic graphical models. We will also explore state-of-the-art systems.	G	9, 4, 12	focused
16845	Robotics	Insects and Robots	This course will cover all facets of modeling, design, fabrication, and analysis of robots operating on the insect scale, with a microrobotics perspective. Insects can perform different tasks, such as manipulation or locomotion, with their small scale bodies varying from 200¿m to 16cm length. Similarly, we can define a micro-robotic system as an autonomous or semi-autonomous device with features on the micron scale or that make use of micron-scale physics for mobility or manipulation of objects. Due to their small size scales, microrobots will encounter difficulties unlike their macro-scale counterparts, in terms of fabrication and autonomy. In this project-based course, our aim will be on learning the physics of scaling, fabrication paradigms, actuation and sensing strategies, with numerous case studies, and to build an insect-inspired robotic system. We will also discuss multiple applications such as surgical robotics, mobile microrobots, multi-agent systems, and micro/nano manipulation.	G	9, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
16880	Robotics	Special Topics: Engineering Haptic Interfaces	This course focuses on addressing challenges in the field of haptics from an engineer's perspective. We will begin by studying human haptic perception and an introduction into psychophysics. We will then study the design and control of haptic systems which provide touch feedback to a user. The class format will include lectures, discussion, paper presentations, laboratories and assignments using hardware that will be shipped to the students, and a class project. This class is designed to be a graduate/advanced undergraduate course and requires a background in dynamic systems, mechatronics, and basic programming. Mechanical prototyping, robotics, and feedback control knowledge are useful skills for this class but are not required.	G	4, 9, 17	focused
16881	Robotics	Special Topics: Deep Reinforcement Learning for Robotics	The format of the class will be: each class, 2 students will present (1 paper each); one paper will be an interesting new paper on deep RL; the other will be a paper on robotics, which will have an impressive robotics result, possibly using RL but not deep RL. The class will compare and contrast these papers and try to understand: - How did the robotics paper achieve its result without deep RL? - What are the strengths and limitations of the approach described in the robotics paper? - What insights can we take away from this paper? - What are the strengths and limitations of the method described in the deep RL paper? - How can the method described in each paper be improved? Students will also work on a class project related to deep RL, of their choosing. Grading will be based on the presentations and the class project. Prerequisites: Students are expected to have already have a basic understanding of reinforcement learning, such as from 10-703, 16-748, 16-831, or a similar course, prior to taking this course.	G	4, 17, 9	focused
16883	Robotics	Special Topics: Provably Safe Robotics	Safe autonomy has become increasingly critical in many application domains. It is important to ensure not only the safety of the ego robot, but also the safety of other agents (humans or robots) that directly interact with the autonomy. For example, robots should be safe to human workers in human-robot collaborative assembly; autonomous vehicles should be safe to other road participants. For complex autonomous systems with many degrees of freedom, safe operation depends on the correct functioning of all system components, i.e., accurate perception, optimal decision making, and safe control. This course deals with both the design and the verification of safe robotic systems. From the design perspective, we will talk about how to assure safety through planning, prediction, learning, and control. From the verification perspective, we will talk about verification of deep neural networks, safety or reachability analysis for closed loop systems, and analysis of multi-agent systems.	G	9, 4, 16	focused
16885	Robotics	Special Topics: Tactile Sensing and Haptics	Touch is an important perception modality for both humans and robots. This course aims at providing an overview of the touch perception system for both robots and humans, and provide students with some hands-on experience with the popular touch sensors and devices. On the side of robot sensing, the course will cover the topics on the working principles and designs of robot touch sensors, signal processing algorithms for tactile sensing, and the application of tactile sensing in different robotic tasks; on the side of haptics, the course will introduce the neurological and cognitive study in human haptic system, and the designs and applications of haptic devices that provide a human-machine interface. The human-machine interface is a core part of Virtual Reality (VR) and teleoperation of robots when touch is involved. The course includes lectures, research paper presentation and discussion, and course projects with tactile sensors or haptic devices.	G	9, 17, 15	focused
16888	Robotics	Special Topic: Foldable Robots: Origami-inspired design meets mechatronics	The way we make robots have changed dramatically since the limitations on the material space was removed. Instead of using "nuts-and-bolts" approach that helped us to make robust, rigid, industrial robots, we can make light-weight, compliant, conformable robots out of paper, fabric, and polymers. In this class, we will explore foldable robots with a multifaceted perspective: Kinematics, design, fabrication, control, and application. We will design and manufacture mechanisms for targeted applications, such as manipulation, bio-inspiration, medical, architecture, using laminates with integrated joints and limited number of actuators.	G	9, 7, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
16889	Robotics	Special Topics: Robotics & AI for Agriculture	Robotics and artificial intelligence technologies have the potential to increase the efficiency, long-term sustainability, and profitability of agricultural production methods. This class will introduce common aspects of agricultural systems, the AI/Robotics tools that are being used to address them, and key research challenges looking forward. Technical topics include IoT sensor networks, in-field computer vision, 3D crop mapping and modeling, mobile robot navigation, and robotic manipulation of plants. Course sessions will be split evenly between lectures by the instructor and student-led discussion of relevant papers from the contemporary research literature.	G	2, 9, 12	focused
16899	Robotics	Adaptive Control and Reinforcement Learning	Section C: Adaptive Control and Reinforcement Learning. This course will discuss algorithms that learn and adapt to the environment. This course is directed to studentsprimarily graduate although talented undergraduates are welcome as wellinterested in developing adaptive software that makes decisions that affect the world.	G	4, 12, 15	focused
17200	Software Engineering	Ethics and Policy Issues in Computing	Should autonomous robots make life and death decisions on their own? Should we allow them to select a target and launch weapons? To diagnose injuries and perform surgery when human doctors are not around? Who should be permitted to observe you, find out who your friends are, what you do and say with them, what you buy, and where you go? Do social media and personalized search restrict our intellectual horizons? Do we live in polarizing information bubbles, just hearing echoes of what we already know and believe? As computing technology becomes ever more pervasive and sophisticated, we are presented with an escalating barrage of decisions about who, how, when, and for what purposes technology should be used. This course will provide an intellectual framework for discussing these pressing issues of our time, as we shape the technologies that in turn shape us. We will seek insight through reading, discussion, guest lectures, and debates. Students will also undertake an analysis of a relevant issue of their choice, developing their own position, and acquiring the research skills needed to lend depth to their thinking. The course will enhance students' ability to think clearly about contentious technology choices, formulate smart positions, and support their views with winning arguments.	U	4, 9, 1	focused
17214	Software Engineering	Principles of Software Construction: Objects, Design, and Concurrency	Note: This course previously offered as 15-214. Software engineers today are less likely to design data structures and algorithms from scratch and more likely to build systems from library and framework components. In this course, students engage with concepts related to the construction of software systems at scale, building on their understanding of the basic building blocks of data structures, algorithms, and program and computer structures. The course covers technical topics in four areas: (1) concepts of design for complex systems, (2) object-oriented programming, (3) static and dynamic analysis for programs, and (4) concurrency. At the conclusion of this course, students will have substantial experience building medium-sized software systems in Java.	U	9, 4	focused
17313	Software Engineering	Foundations of Software Engineering	Note: This course previously offered as 15313.Students gain exposure to the fundamental principles of software engineering. This includes both core CS technical knowledge and the means by which this knowledge can be applied in the practical engineering of complex software in real-world settings. Topics related to software artifacts include coding, software architecture, measurement, and quality assurance of various qualities (e.g., robustness, security, performance, maintainability) with static and dynamic analysis, testing, code review, and inspection. Topics related to software process include requirements engineering, process models and evaluation, personal and team development, and supply chain issues including outsourcing and open source. This course has a strong technical focus, a strong focus on developing team skills, and will include both written and programming assignments. Students will get experience with the latest software engineering tools and practices.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
17314	Software Engineering	Formal Methods	Scientific foundations for software engineering depend on the use of precise, abstract models for describing and reasoning about properties of software systems. This course considers a variety of standard models for representing sequential and concurrent systems, such as state machines, algebras, and traces. It shows how different logics can be used to specify properties of systems, such as functional correctness, deadlock freedom, and internal consistency. Concepts such as compositionality, abstraction, invariants, non-determinism, and inductive definitions are recurrent themes throughout the course. After completing this course, students will: 1. Understand the strengths and weaknesses of certain models and logics including state machines, algebraic and process models, and temporal logic; 2. Be able to select and describe appropriate abstract formal models for certain classes of systems, describe abstraction relations between different levels of description, and reason about the correctness of refinements; 3. Be able to prove elementary properties about systems described by the models introduced in the course; and 4. Understand some of the strengths and weakness of formal automated reasoning tools. Prerequisites: Undergraduate discrete math including first-order logic, sets, functions, relations, and simple proof techniques such as induction.	U	4, 9, 16	focused
17322	Software Engineering	Agile Methods	Agile methods refers to a number of software development approaches that adopt self-organization, adaptive planning, evolutionary development, frequent delivery and working closely with and incorporating feedback from customers throughout the development process as their principles of operation to achieve responsiveness. This course will introduce students to two well known agile methods: Scrum and Kanban, connecting their practices to established group dynamics and knowledge management theories to explain why they work and under what circumstances	U	4, 17, 9	focused
17323	Software Engineering	Quality Assurance	This class is fundamentally about software quality assurance and control. This course will introduce various quality assurance tools and techniques to software engineering students. Students will build their "quality toolbox" not only with useful tools and techniques, but with the knowledge of when those tools should be used, how to evaluate their results, and what assurances they can provide. The key learning objectives of the course include: 1. Understand software quality: how to define it, analyze it, and measure it. 2. Select the proper analytical tool/technique for a given situation and explore how to analyze results. 3. Understand the strengths and weaknesses of different quality assurance techniques, such as software testing, static analysis, code review, and demonstration. 4. Learn to collect, manage, and evaluate quality metrics. 5. Analyze and verify a variety of software properties including, but not limited to, functionality, security, reliability, and performance. 6. Gain experience with real quality assurance tools including static analysis tools, software testing frameworks, and software quality measurement tools	U	4, 9, 1	focused
17324	Software Engineering	Advanced Formal Methods	This course builds on the introductory Models class to cover more advanced techniques for modeling and reasoning about complex software systems. Concepts introduced in this course include abstraction and refinement, declarative specifications, advanced temporal logics, and probabilistic modeling. The course will also explore applications of modeling and automated reasoning techniques in various domains, such as security, distributed computing, and cyber-physical systems. After completing this course, students will: 1. Understand how to specify and reason about operations over complex system structures, 2. Understand relationships between software artifacts at different levels of abstraction; 3. Be able to model and reason about systems with uncertainty and stochastic behaviors; and 4. Understand potential applications of modeling techniques to practical software engineering problems. Prerequisites: Completion of Mini 1: Models of Software Systems. Sections D, PP and G are NOT available for on-campus students. Admission to the class is by approval from the instructor: If you are not a software engineering master's student, send email to garlan@cs.cmu.edu for permission to enroll. The email should briefly describe your background, whether you have taken a course with similar materials as in Mini 1, and why you would like to take the course. The course must be taken for a letter grade (not pass/fail). This is a graduate level course.	U	4, 9, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
17331	Software Engineering	Information Security, Privacy, and Policy	Note: This course previously offered as 15-421. As layers upon layers of technology mediate increasingly rich business processes and social interactions, issues of information security and privacy are growing more complex too. This course takes a multi-disciplinary perspective of information security and privacy, looking at technologies as well as business, legal, policy and usability issues. The objective is to prepare students to identify and address critical security and privacy issues involved in the design, development and deployment of information systems. Examples used to introduce concepts covered in the class range from enterprise systems to mobile and pervasive computing as well as social networking. Format: Lectures, short student presentations on topics selected together with the instructor, and guest presentations. Target Audience: Primarily intended for motivated undergraduate and masters students with CS background. Also open to PhD students interested in a more practical, multi-disciplinary understanding of information security and privacy.	U	4, 9, 1	focused
17332	Software Engineering	Software Project Management	Projects are temporary organizations set up to achieve a one time objective in an agreed time frame. They are characterized by requiring the execution of interrelated, normally non repeating activities, by multidisciplinary groups. Because of its temporary nature and the interrelatedness of its activities, projects require prescriptive planning, budgeting, staffing and risk management. This course will introduce student to fundamental project management techniques and tools such as activity planning, milestone planning, estimation, work breakdown structures, critical paths. The course will also look at hybrid methods such as Milestone Driven Agile Execution and Disciplined Agile Delivery.	U	4, 9, 17	focused
17333	Software Engineering	Privacy Policy, Law, and Technology	Note: Previously offered as 08-533. This course focuses on policy issues related to privacy from the perspectives of governments, organizations, and individuals. We will begin with a historical and philosophical study of privacy and then explore recent public policy issues. We will examine the privacy protections provided by laws and regulations, as well as the way technology can be used to protect privacy. We will emphasize technology-related privacy concerns and mitigation, for example: social networks, smartphones, behavioral advertising (and tools to prevent targeted advertising and tracking), anonymous communication systems, big data, and drones. This is part of a series of courses offered as part of the MSIT-Privacy Engineering masters program. These courses may be taken in any order or simultaneously. Foundations of Privacy (Fall semester) offers more in-depth coverage of technologies and algorithms used to reason about and protect privacy. Engineering Privacy in Software (Spring semester) focuses on the methods and tools needed to design systems for privacy. This course is intended primarily for graduate students and advanced undergraduate students with some technical background. Programming skills are not required. 8-733, 19-608, and 95-818 are 12-unit courses for PhD students. Students enrolled under these course numbers will have extra assignments and will be expected to do a project suitable for publication. 8-533 is a 9-unit course for undergraduate students. Masters students may register for any of the course numbers permitted by their program. This course will include a lot of reading, writing, and class discussion. Students will be able to tailor their assignments to their skills and interests. However, all students will be expected to do some writing and some technical work.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
17334	Software Engineering	Usable Privacy and Security	There is growing recognition that technology alone will not provide all of the solutions to security and privacy problems. Human factors play an important role in these areas, and it is important for security and privacy experts to have an understanding of how people will interact with the systems they develop. This course is designed to introduce students to a variety of usability and user interface problems related to privacy and security and to give them experience in designing studies aimed at helping to evaluate usability issues in security and privacy systems. The course is suitable both for students interested in privacy and security who would like to learn more about usability, as well as for students interested in usability who would like to learn more about security and privacy. Much of the course will be taught in a graduate seminar style in which all students will be expected to do a weekly reading assignment and each week different students will prepare a presentation for the class. Students will also work on a group project throughout the semester. The course is open to all graduate students who have technical backgrounds. The 12-unit course numbers (08-734 and 5-836) are for PhD students and masters students. Students enrolled in these course numbers will be expected to play a leadership role in a group project that produces a paper suitable for publication. The 9-unit 500-level course numbers (08-534 and 05-436) are for juniors, seniors, and masters students. Students enrolled in these course numbers will have less demanding project and presentation requirements.	U	4, 9, 17	focused
17335	Software Engineering	Software Architectures	Successful design of complex software systems requires the ability to describe, evaluate, and create systems at an architectural level of abstraction. This course introduces architectural design of complex software systems. The course considers commonly-used software system structures, techniques for designing and implementing these structures, models and formal notations for characterizing and reasoning about architectures, tools for generating specific instances of an architecture, and case studies of actual system architectures. It teaches the skills and background students need to evaluate the architectures of existing systems and to design new systems in principled ways using well-founded architectural paradigms. After completing this course, students will be able to: 1. describe an architecture accurately 2. recognize major architectural styles in existing software systems 3. generate architectural alternatives for a problem and choose among them 4. construct a medium-sized software system that satisfies an architectural specification 5. use existing definitions and development tools to expedite such tasks 6. understand the formal definition of a number of architectures and be able to reason about the properties of those architectures 7. use domain knowledge to specialize an architecture for a particular family of applications.	U	4, 9, 8	focused
17336	Software Engineering	Applied Distributed Systems	Modern computing systems are frequently hosted on the cloud. That is, they are inherently distributed systems. To appropriately build and deploy these systems developers should know not only about development tools such as container management tools but also the structure of the cloud - in particular how it utilizes virtual machines, containers and networks. They should also understand security mechanisms both in the internet and how to authorize users and maintain credentials securely. Finally, to protect the system once it is placed into production, a developer needs to know how to enable the detection of problems during execution through collection and navigation of logs produced by the system. These are the topics covered by this course.	U	9, 12, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
17346	Software Engineering	DevOps and Continuous Integration	DevOps: Engineering for Deployment and Operations": DevOps is the term given to a modern movement to establish practices that significantly reduce the time to production of committed code. This time involves deployment - the period between the completion of the code by the developers and the placing of the code into normal production ¿ and dealing with operations issues. Deployment time can be days, weeks, or even months when using normal development practices. Operational issues such as dealing with incidents and errors introduce other delays. Modern internet companies deploy a system multiple or even dozens of times every day. Achieving this velocity requires coordinated process and design activities together with supporting tooling. This course will cover the deployment process and the associated tooling, it will highlight reasons why release schedules can be slow, and it will introduce the practices that are used to enable high velocity deployments. It will also cover the kinds of problems that are created because of high velocity and how modern internet companies deal with these problems. Please note: This is a required course for MSE-SS students. Students outside of the software engineering department may take this course but students of the MSE programs will have first priority.	U	4, 9, 16	focused
17355	Software Engineering	Program Analysis	This course covers both foundations and practical aspects of the automated analysis of programs, which is becoming increasingly critical to find software errors and assure program correctness. The theory of abstract interpretation captures the essence of a broad range of program analyses and supports reasoning about their correctness. Building on this foundation, the course will describe program representations, data flow analysis, alias analysis, inter-procedural analysis, dynamic analysis, Hoare Logic, and symbolic execution. Through assignments and projects, students will design and implement practical analysis tools that find bugs and verify properties of software. This course satisfies the Logic and Languages constrained elective category of the Computer Science major, and the Technical Software Engineering requirement for the Software Engineering minor.	U	4, 9	focused
17356	Software Engineering	Software Engineering for Startups	Startup engineering is critical to innovation. The skills required to effectively prototype, launch, and scale products are vital to engineers everywhere, from fledgling companies founded in dorm rooms to local mid-size companies to internal startups from multi-national tech giants. However, developing software in a startup environment poses unique engineering challenges. These challenges include making and justifying foundational architectural and technical decisions despite extreme uncertainty; rapidly prototyping and evaluating new ideas and features, while building minimum viable products; prioritizing engineering effort in severely constrained environments; and communicating effectively both within a small engineering team and with internal and external non-technical stakeholders. This course teaches the skills necessary to engineer successfully in a startup environment, through lectures, group projects, case study discussions, and guest speakers drawn from experienced, practicing startup engineers. This is an engineering-focused course; no entrepreneurship background is required or expected. Students do not need to have a startup idea to participate fully. Prerequisites: 17-214 OR 15-213	U	9, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
17397	Software Engineering	Intro to Qualitative Research: Social Media Apps and Video Content Creation	Short-video apps, such as TikTok, have revealed themselves to be highly accessible and increasingly ubiquitous in regards to online social interaction and are currently the most popular social media among mostly young(er) users. This course focuses on how humans as users interact with and understand social technology and how the use of social media apps is connected to and integrated into our everyday life by asking questions like: What are users' motivations to participate in video creation and sharing on social media? What are their practices, strategies, and routines in creating short-form videos as part of digital online culture? What do they know about socio-technical aspects in using short-video apps and creating short-form video content? How does their understanding of socio-technological aspects influence their use of social media apps? This course is designed to enable students to develop and conduct their own individual research project. For this, students will learn how to design, conduct, and analyze qualitative interviews to research socio-technical, cultural, and political perspectives of usage of and engagement with short-form videos and short-video apps, such as TikTok. The course instructor will closely mentor and supervise students' research projects throughout the semester and will provide expertise and background in qualitative methods and social media research to guide students through the research process.	G	4, 9, 17	focused
17400	Software Engineering	Machine Learning and Data Science at Scale	Datasets are growing, new systems for managing, distributing, and streaming data are being developed, and new architectures for AI applications are emerging. This course will focus on techniques for managing and analyzing large datasets, and on new and emerging architectures for applications in machine learning and data science. Topics include machine learning algorithms and how they must be reformulated to run at scale on petabytes of data, as well as data management and cleaning techniques at scale. In addition to large-scale aspects of data science and machine learning, this course will also cover core concepts of parallel and distributed computing and cloud computing, including hands-on experience with frameworks like Spark, streaming architectures like Flink or Spark Streaming, MLlib, TensorFlow, and more. The course will include programming assignments and a substantial final project requiring students to get hands-on experience with large-scale machine learning pipelines or emerging computing architectures.	U	4, 9, 17	focused
17413	Software Engineering	Software Engineering Practicum	This course is a project-based course in which students conduct a semester-long project for a real client in small teams. This is not a lecture-based course; after the first few weeks the course consists primarily of weekly team meetings with the course instructors, with teams making regular presentations on their software development process. Students will leave the course with a firsthand understanding of the software engineering realities that drive SE practices, will have concrete experience with these practices, and will have engaged in active reflection on this experience. After the course, students will have the teamwork, process, and product skills to be immediately competent in a software engineering organization, and will be able to evaluate the new processes and techniques they will encounter in the workplace.	U	4, 17, 8	focused
17415	Software Engineering	Software Engineering Reflection	Note: This course previously offered as 17-413. This course is an opportunity to reflect on a software engineering experience you have had in industry. It is structured as a writers workshop, in which you will work with the instructor and other students to identify and flesh out a software engineering theme that is illustrated by your industry experience. You will prepare a 10-page report on this theme, comparable to a practitioner's report at a conference like ICSE or OOPSLA, and a 30-minute presentation to match. This course fulfills a requirement of the Software Engineering Minor program, but students in other programs may take the course if they meet the prerequisite industry experience and if space is available.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
17422	Software Engineering	Building User-Focused Sensing Systems	These days we are surrounded by sensing and computation. Smart devices, such as smartphones, smartwatches, are packed with sensors. While they are already very useful devices, we have only started to scratch the surface here. The aim of this class will be to introduce the students to building and understanding smart sensing devices. The course will include discussion into contribution of various fields, including human-computer interaction, embedded computing, computer vision, distributed systems, machine learning, signal processing, security, and privacy. We will discuss how these various disciplines are coming together to form an end-to-end system that generates useful and user-actionable data. We will take a hands-on approach towards building and evaluating these systems. The students will gain practical experience in developing sensing systems in different application domains, such as activity recognition, health sensing, gestural interaction, etc. You will learn about embedded systems and understand the advantages and limitations of different platforms. You will learn about sensors and how to interface them with the real world to be able to get useful and actionable data. You will learn how to build a network of sensors that can communicate with each other. You will also learn about storing the sensor data for visualization, analysis and presentation both locally and to the cloud. The course will be a combination of lectures, tutorials, class discussions, and demonstrations. Students will be evaluated based on 5 mini-projects/assignments, class participation, weekly reading summaries, and a final project. All hardware resources will be provided to the students and they will be given an option to take their final prototypes with them for the cost of the hardware components. Students should have reasonable programming experience and an interest in tinkering.	U	4, 9, 17	focused
17428	Software Engineering	Machine Learning and Sensing	Machine learning and sensors are at the core of most modern computing devices and technology. From Amazon Echo to Apple Watch to Google Photos to self-driving cars, making sense of the data coming from powerful but noisy sensors is the key challenge. The aim of the course will be to explore this intersection of sensors and machine learning, understand the inner workings on modern computing technologies, and design the future ones. We will cover data collection, signal processing, data processing, data visualization, feature engineering, machine learning tools, and some prototyping technologies. The course will focus on class discussions, hands-on demonstrations, and tutorials. Students will be evaluated on their class participation, multiple mini projects, and a final team project.	U	9, 4, 17	focused
17437	Software Engineering	Web Application Development	Note: This course previously offered as 15437. This course will introduce concepts in programming web application servers. We will study the fundamental architectural elements of programming web sites that produce content dynamically. The primary technologies introduced will be the Django framework for Python and Java Servlets, but we will cover related topics as necessary so that students can build significant applications. Such topics include: HTTP, HTML, CSS, Javascript, XML, Design Patterns, Relational and Non-relational Databases, Object-Relation Mapping tools, Security, Web Services, Cloud Deployment, Internationalization, and Scalability and Performance Issues. Students must be comfortable programming in Java and/or Python to register for this course. Students must provide their own computer hardware for this course. Please see the Related URL above for more information.	U	4, 9, 17	focused
17442	Software Engineering	Software Management Theory	This course will look at software development from an organizational perspective and its designed for students who want to understand the relationship between business context, software development processes, knowledge creation, culture and organizational structure with the purpose of becoming change agents or manage the software development function at the department, business unit level or above. The course will also highlight the need to follow good work principles in order to avoid ethical failures as evidenced by recent affairs	U	4, 8, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
17443	Software Engineering	Quality Management	Managing software quality is a critical part of all software projects. Software engineers must consider quality during every phase of a project from inception to delivery and beyond. This class will introduce students to the managerial challenges of developing high quality software systems. The key learning objectives of this course include: 1. Define a quality management process in the context of a software project. 2. Understand the costs associated with achieving quality goals and not achieving them 3. Understand the tradeoffs required to implement quality assurance techniques. 4. Gain experience using collected quality metrics to inform project-level decisions.	U	4, 17, 9	focused
17445	Software Engineering	Software Engineering for AI-Enabled Systems	The course takes a software engineering perspective on building software systems with a significant machine learning or AI component. It discusses how to take an idea and a model developed by a data scientist (e.g., scripts and Jupyter notebook) and deploy it as part of scalable and maintainable system (e.g., mobile apps, web applications, IoT devices). Rather than focusing on modeling and learning itself, this course assumes a working relationship with a data scientist and focuses on issues of design, implementation, operation, and assurance and how those interact with the data scientist's modeling. This course is aimed at software engineers who want to understand the specific challenges of working with AI components and at data scientists who want to understand the challenges of getting a prototype model into production; it facilitates communication and collaboration between both roles.	U	9, 4	focused
17450	Software Engineering	Crafting Software	Do you use programming to solve problems in your field of study? Do you know enough to be dangerous, but wish you could be proud of your code? This course aims to provide students with sufficient knowledge and skills to use programming as part of their work. In this class, you will learn how to identify and find problems in your code. You will learn to read, parse, organize, and transform data. We will teach you to write code collaboratively and refine your programs so others can use them.The course will be a mixture of lecture and guided exercise with a recitation focused on hands on instruction. In this course, students are expected to have been exposed to some basic programming concepts, such as variables, if-statements, loops, and arrays. However, students are not expected to have extensive programming experience. This course is not appropriate for students that have completed more than two courses involving programming. We expect students in this class to have diverse backgrounds and experience. Some students will be self-taught, while others will have taken a programming course such as 02-201, 15-110, 95-898, or the library's Software Carpentry workshop. If you have questions about your background and the fit for this class, please don't hesitate to reach out to the instructors.	U	4, 17, 8	focused
17480	Software Engineering	API Design and Implementation	This class focuses on the design of programming interfaces, the APIs, within larger real-world software and ecosystems. We discuss the history and importance of APIs, and the principles behind designing good APIs. This includes study of specific examples of APIs, both good and bad, for inspiration and precaution. Students gain experience with the major steps of API design: gathering requirements, documenting, testing, implementing, refining, evolving, and reimplementing APIs. The principles taught are largely language-independent, though most examples are in Java or C. Students may be able to do assignments in other languages, within reason.	U	4, 17, 15	focused
17514	Software Engineering	Principles of Software Construction: Objects, Design, and Concurrency	Software engineers today are less likely to design data structures and algorithms from scratch and more likely to build systems from library and framework components. In this course, students engage with concepts related to the construction of software systems at scale, building on their understanding of the basic building blocks of data structures, algorithms, and program and computer structures. The course covers technical topics in four areas: (1) concepts of design for complex systems, (2) object-oriented programming, (3) static and dynamic analysis for programs, and (4) concurrency. At the conclusion of this course, students will have substantial experience building medium-sized software systems in Java.	U	9, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
17537	Software Engineering	Artificial Intelligence Methods for Social Good	Optimization: mathematical programming, robust optimization, influence maximization Game Theory and Mechanism Design: security games, human behavior modeling, auction and market equilibrium, citizen science Machine Learning: classification, clustering, probabilistic graphical models, deep learning Sequential Decision Making: Markov Decision Processes (MDPs), partially observable MDPs, online planning, reinforcement learning In addition to providing a deep understanding of these methods, the course will introduce which societal challenges they can tackle and how, in the areas of (i) healthcare, (ii) social welfare, (iii) security and privacy, (iv) environmental sustainability. The course will also cover special topics such as AI and Ethics and AI and Humans. The course content is designed to not have too much overlap with other AI courses offered at CMU. Although the course is listed within SCS, it should be of interest to students in several other departments, including ECE, EPP and SDS. The students in this 9-unit course are expected to have taken at least three mathematics courses covering linear algebra, calculus, and probability. The students will work in groups on a systematic literature review or a project exploring the possibility of applying existing AI tools to a societal problem, with a survey paper or technical report and presentation delivered at the end of the semester.	U	4, 12, 1	focused
17562	Software Engineering	Law of Computer Technology	NOTE: Previously offered as 08-532. A survey of how legislatures and courts cope with rapidly advancing computer technologies and how scientific information is presented to, and evaluated by, civil authorities. The course is also an introduction to the legal process generally and the interaction between the legal system and technology organizations. Topics include: patents, copyrights in a networked world, law of the Internet, free speech, data security, technology regulation, international law, and trans-border crime. Open to juniors, seniors and graduate students in any school. Open to sophomores by permission of the instructor. Prerequisites: none.	U	4, 16, 9	focused
17599	Software Engineering	Advanced Topics in Machine Learning and Game Theory	This course is designed to be a graduate-level course covering the topics at the intersection of machine learning and game theory. Recent years have witnessed significant advances in machine learning and their successes in detection, prediction, and decision-making problems. However, in many application domains, ranging from auction and ads bidding, to entertainment games such as Go and Poker, to autonomous driving and traffic routing, to the intelligent warehouse, to home assistants and the Internet of Things, there is more than one agent interacting with each other. Game theory provides a framework for analyzing the strategic interaction between multiple agents and can complement machine learning when dealing with challenges in these domains. Therefore, in the course, we will introduce how to integrate machine learning and game theory to tackle challenges in multi-agent systems. The course will multiple topics as listed below	U	4, 11, 9	focused
17612	Software Engineering	Business and Marketing Strategy	Given resources viz., money, labor, capital and land are finite, it follows that not all ideas that are seemingly game-changing or promise new efficiencies, end up being funded or pursued. It is imperative that organizations protect their profitability goals through prudent investment in well-supported engineering proposals while avoiding misdirected initiatives. This only pushes the onus of due diligence back on engineers and their leaders to support the wealth-creating promise their business proposals hold. So that begs some key questions amongst others: How could our engineers handle financial due diligence, if they do not know what it entails? How could they invoke management favor for their proposal(s) amongst several others? How could they aspire to be leaders or agents of change, if they had no familiarity of what it takes above and beyond their engineering skills, to be one? How could they compete in a world where cost containment or cost leadership and market share play an equally critical role in keeping a going concern competitive, as does innovation and engineering prowess? The course offers a broad exposure to key business concepts to consider in their professional or entrepreneurial careers.	G	9, 8, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
17621	Software Engineering	Computational Modeling of Complex Socio-Technical Systems	How likely is an intervention like social distancing to save lives? Will a law legislating sanctions against social media platforms that spread disinformation stop the spread? We live and work in complex adaptive and evolving socio-technical systems where questions such as these arise constantly. Questions such as these are often only addressable through computational modeling, i.e., through simulation. Simulation models are a critical method for understanding how to adaptation and learning will change the status-quo. Computational modeling can be used to help analyze, reason about, predict the behavior of, and possibly control complex human systems of "networked" agents. Using simulation it is possible to advance theory, test policies before enacting them, and think through non-linear social effects.	G	4, 9, 1	focused
17624	Software Engineering	Advanced Formal Methods	This course builds on the introductory Models class to cover more advanced techniques for modeling and reasoning about complex software systems. Concepts introduced in this course include abstraction and refinement, declarative specifications, advanced temporal logics, and probabilistic modeling. The course will also explore applications of modeling and automated reasoning techniques in various domains, such as security, distributed computing, and cyber-physical systems. After completing this course, students will: 1. Understand how to specify and reason about operations over complex system structures, 2. Understand relationships between software artifacts at different levels of abstraction; 3. Be able to model and reason about systems with uncertainty and stochastic behaviors; and 4. Understand potential applications of modeling techniques to practical software engineering problems. Prerequisites: Completion of Mini 1: Models of Software Systems. Sections D, PP and G are NOT available for on-campus students. Admission to the class is by approval from the instructor: If you are not a software engineering master's student, send email to garlan@cs.cmu.edu for permission to enroll. The email should briefly describe your background, whether you have taken a course with similar materials as in Mini 1, and why you would like to take the course. The course must be taken for a letter grade (not pass/fail). This is a graduate level course.	G	4, 9, 11	focused
17626	Software Engineering	Requirements for Information Systems	Software engineering requires understanding the problem, before identifying solutions. In this course, students study ways to elicit and analyze problem statements using scenarios, use cases and mockups.	G	4, 9, 17	focused
17627	Software Engineering	Requirements for Embedded Systems	Software engineering requires understanding the problem, before identifying solutions. In this course, students study ways to elicit and analyze problem statements for real-time systems along multiple dimensions, including concurrency, dependability and safety.	G	4, 9, 17	focused
17634	Software Engineering	Applied Machine Learning	Autonomous and intelligent systems increasingly rely on automated decision making based on statistical models used for classification or prediction. The practical application of machine learning requires understanding the underlying theoretical assumptions behind a wide variety of statistical models, how to analyze the performance of such models, and how to integrate models into data processing pipelines. This course introduces students to supervised and unsupervised machine learning in the context of software engineering, including the analysis of natural language in bug reports and mobile app reviews. Techniques covered include latent Dirichlet allocation, TF/IDF, naive Bayes, linear regression, decision trees, and random forests.	G	4, 15, 9	focused
17644	Software Engineering	Applied Deep Learning	Deep neural networks have made in-roads in virtually every industry, propelled by exponential increases in compute power and fundamental progress in modeling. Knowledge of these models is fast becoming a key asset for software engineers, as current systems are quickly starting to include many neural components, and the practice of software engineering itself is starting to benefit from neural program assistance (incl. automated bug finding, translation between programming languages). This course equips the next generation of software engineers with knowledge of neural models, the software engineering challenges involved in using these, and hands-on experience with their applications. It teaches both a rich vocabulary of general, essential concepts (including architectures), and recent work on applications of these models, aimed primarily at applications for and in software engineering itself. The course includes a group project aimed at constructing a neural solution for an existing application that will be used to teach the various stages (and their pitfalls) of building and deploying deep learners.	G	9, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
17648	Software Engineering	Sensor Based Systems	Internet services companies such as Google, Yahoo!, Amazon, and Facebook have pioneered systems that have achieved unprecedented scale while still providing high level availability and a high cost-performance. These systems differ from mainstream high performance systems in fundamental ways. They are data intensive rather than compute intensive as we see with mainstream super computers spending the bulk of their time performing data I/O and manipulation rather than computation. They need to inherently support scalability, typically having high reliability and availability demands as well. Given that they often operate in the commercial space the cost-performance of these systems needs to be such that the organizations dependent on such systems can turn a profit. Designing and building these systems require a specialized set of skills. This course will cover the set of topics needed in order to design and build data intensive scalable systems. In this domain engineers not only need to know how to architect systems that are inherently scalable, but to do so in a way that also supports high availability, reliability, and performance. Given the large distributed nature of these systems basic distributed systems concepts such as consistency and time and synchronization are also important. These systems largely operate around the clock, placing an emphasis on operational concerns. This course will introduce students to these concerns with the intent that they understand the extent to which things like deploying, monitoring, and upgrading impact the design. The course will be a hands-on project oriented course. The basic concepts will be given during the lectures and applied in the project. The students will gain exposure to the core concepts needed to design and build such systems as well as current technologies in this space. Class size will be limited.	G	9, 4, 8	focused
17685	Software Engineering	Dynamic Network Analysis	Who knows who? Who knows what? Who is influential? What is the social network, the knowledge network, the activity network? How do ideas, products & diseases propagate through groups and impact these networks? Does social media change the way these networks operate? Questions such as these & millions of others require a network perspective and an understanding of how ties among people, ideas, things, & locations connect, constrain & enable activity. In the past decade there has been an explosion of interest in network science moving from the work on social networks and graph theory to statistical and computer simulation models. Network analysis, like statistics, now plays an role in most empirical fields. Network science is a broad and multi-disciplinary field. In this class, students will gain an appreciation of the history of the field, the difference between social networks and social media, the difference graph-based metrics for network analysis and graphical models, the use of traditional and high dimensional network models, and the advances in this field. Applications and issues discussed will include: social media analytics, semantic networks, task networks, organizational design and teams, machine learning and network analysis, generative models, terrorism and crime, health, and fake news. Methods for network data collection, analysis, visualization, and interpretation are covered. Students produce original research in which network data is analyzed using the methods covered in the class	G	4, 16, 3	focused
17702	Software Engineering	Current Topics in Privacy Seminar	Note: Previously offered as 08-602. In this seminar course students will discuss recent papers and current public policy issues related to privacy. Privacy professionals from industry, government, and non-profits will deliver several guest lectures each semester.	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
17731	Software Engineering	Foundations of Privacy	Note: Previously offered as 08-604. Privacy is a significant concern in modern society. Individuals share personal information with many different organizations - healthcare, financial and educational institutions, the census bureau, Web services providers and online social networks - often in electronic form. Privacy violations occur when such personal information is inappropriately collected, shared or used. We will study privacy in a few settings where rigorous definitions and enforcement mechanisms are being developed - statistical disclosure limitation (as may be used by the census bureau in releasing statistics), semantics and logical specification of privacy policies that constrain information flow and use (e.g., by privacy regulations such as the HIPAA Privacy Rule and the Gramm-Leach-Bliley Act), principled audit and accountability mechanisms for enforcing privacy policies, anonymous communication protocols - and other settings in which privacy concerns have prompted much research, such as in social networks, location privacy and Web privacy (in particular, online tracking & targeted advertising).	G	4, 17, 1	focused
17733	Software Engineering	Privacy Policy, Law, and Technology	NOTE: Previously offered as 08-733. This course focuses on policy issues related to privacy from the perspectives of governments, organizations, and individuals. We will begin with a historical and philosophical study of privacy and then explore recent public policy issues. We will examine the privacy protections provided by laws and regulations, as well as the way technology can be used to protect privacy. We will emphasize technology-related privacy concerns and mitigation, for example: social networks, smartphones, behavioral advertising (and tools to prevent targeted advertising and tracking), anonymous communication systems, big data, and drones. This is part of a series of courses offered as part of the MSIT-Privacy Engineering masters program. These courses may be taken in any order or simultaneously. Foundations of Privacy (Fall semester) offers more in-depth coverage of technologies and algorithms used to reason about and protect privacy. Engineering Privacy in Software (Spring semester) focuses on the methods and tools needed to design systems for privacy. This course is intended primarily for graduate students and advanced undergraduate students with some technical background. Programming skills are not required. 8-733, 19-608, and 95-818 are 12-unit courses for PhD students. Students enrolled under these course numbers will have extra assignments and will be expected to do a project suitable for publication. 8-533 is a 9-unit course for undergraduate students. Masters students may register for any of the course numbers permitted by their program. This course will include a lot of reading, writing, and class discussion. Students will be able to tailor their assignments to their skills and interests. However, all students will be expected to do some writing and some technical work.	G	4, 9, 17	focused
17735	Software Engineering	Engineering Privacy in Software	Note: Previously offered as 08-605. Privacy harms that involve personal data can often be traced back to software design failures, which can be prevented through sound engineering practices. In this course, students will learn how to identify privacy threats due to surveillance activities that enhance modern information systems, including location tracking, behavioral profiling, recommender systems, and social networking. Students will learn to analyze systems to identify the core operating principles and technical means that introduce privacy threats, and they will learn to evaluate and mitigate privacy risks to individuals by investigating system design alternatives. Strategies to mitigating privacy risk will be based on emerging standards and reliable privacy preference data. Students will have the opportunity to study web-, mobile- and cyber-physical systems across a range of domains, including advertising, healthcare, law enforcement and social networking. In addition, students will know how, and when, to interface with relevant stakeholders, including legal, marketing and other developers in order to align software design with privacy policy and law.	G	4, 9, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
17801	Software Engineering	Dynamic Network Analysis	Who knows who? Who knows what? Who is influential? What is the social network, the knowledge network, the activity network? How do ideas, products & diseases propagate through groups and impact these networks? Does social media change the way these networks operate? Questions such as these & millions of others require a network perspective and an understanding of how ties among people, ideas, things, & locations connect, constrain & enable activity. In the past decade there has been an explosion of interest in network science moving from the work on social networks and graph theory to statistical and computer simulation models. Network analysis, like statistics, now plays an role in most empirical fields. Network science is a broad and multi-disciplinary field. In this class, students will gain an appreciation of the history of the field, the difference between social networks and social media, the difference graph-based metrics for network analysis and graphical models, the use of traditional and high dimensional network models, and the advances in this field. Applications and issues discussed will include: social media analytics, semantic networks, task networks, organizational design and teams, machine learning and network analysis, generative models, terrorism and crime, health, and fake news. Methods for network data collection, analysis, visualization, and interpretation are covered. Students produce original research in which network data is analyzed using the methods covered in the class.	G	4, 16, 3	focused
17821	Software Engineering	Computational Modeling of Complex Socio-Technical Systems	How likely is an intervention like social distancing to save lives? Will a law legislating sanctions against social media platforms that spread disinformation stop the spread? We live and work in complex adaptive and evolving socio-technical systems where questions such as these arise constantly. Questions such as these are often only addressable through computational modeling, i.e., through simulation. Simulation models are a critical method for understanding how to adaptation and learning will change the status-quo. Computational modeling can be used to help analyze, reason about, predict the behavior of, and possibly control complex human systems of "networked" agents. Using simulation it is possible to advance theory, test policies before enacting them, and think through non-linear social effects.	G	4, 9, 1	focused
17880	Software Engineering	Algorithms for Private Data Analysis	We study the following question in this course: How do we perform useful analysis on a data set that contains sensitive information about individuals without compromising the privacy of those individuals? To study this question, we will introduce differential privacy, a framework of designing data analysis algorithms with strong, meaningful, and mathematically provable privacy guarantees. We will survey a set of algorithmic tools that allow us to privately perform a wide range of statistical analyses. Of course, privacy does not come for free, and we will also study some of the fundamental limitations imposed by the requirement of differential privacy. Through the discussion of these results, we will also demonstrate some of the most novel and surprising connections between differential privacy and other areas of theoretical computer science, including machine learning theory, cryptography, convex geometry, and game theory.	G	4, 17, 9	focused
18090	Electrical & Computer Engineering	Twisted Signals: Multimedia Processing for the Arts	[IDeATe portal course] - This course presents an overview on manipulating and synthesizing sound, video, and control signals. Signals are the raw materials used in many forms of electronic art and design - electronic music, interactive art, video art, kinetic sculpture, and more. In these fields, signals are used to represent information about sound, images, sensors, and movement. By transforming and manipulating these types of signals, we are able to create powerful new tools for digital art, multimedia applications, music, responsive environments, video and sound installation, smart products, and beyond. In this course we will study Signal Processing from a practical point-of-view, developing tools that can be easily integrated into art-making using the graphical programming environment Max (a.k.a. Max/MSP/Jitter). We will present a survey of Signal Processing techniques used in the sonic and visual arts, and will discuss the mathematical theories underlying these techniques. Students will be encouraged to combine, modify, and extend working examples of software to create original digital artworks.	U	4, 9, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
18100	Electrical & Computer Engineering	Introduction to Electrical and Computer Engineering	The goals of this freshman engineering course are: * To introduce basic concepts in electrical and computer engineering in an integrated manner; * To motivate basic concepts in the context of real applications; * To illustrate a logical way of thinking about problems and their solutions, and; * To convey the excitement of the profession. These goals are attained through analysis, construction and testing of an electromechanical system (e.g., a robot) that incorporates concepts from a broad range of areas within Electrical and Computer Engineering. Some of the specific topics that will be covered include system decomposition, ideal and real sources, Kirchhoff's Current and Voltage Laws, Ohm's Law, piecewise linear modeling of nonlinear circuit elements, Ideal Op-Amp characteristics, combinational logic circuits, Karnaugh Maps, Flip-Flops, sequential logic circuits, and finite state machines. 3 hrs. lec., 1 hr. rec., 3 hr. lab.	U	4, 9	focused
18200	Electrical & Computer Engineering	ECE Sophomore Seminar	"The class comprises of a series of lectures from our own faculty and alumni, Department and University staff, and student groups. Students are required to attend each lecture. The lectures are designed to serve the following purposes: 1. Introduce to students to the faculty member's research field and the most current world advancements in engineering and technology in that area; 2. Provide students a good understanding of our curriculum structure and the courses in various areas; 3. Present correlations between the present technological developments and our courses for each course area; 4. Introduce new undergraduate courses; 5. Advertise on-campus/off-campus research opportunities for undergraduate students and explain the corresponding research projects; 6. Motivate students with positive presentations on the importance of obtaining education and gaining self-learning ability; 7. Provide basic education on learning and working ethics."	U	4, 9, 17	focused
18202	Electrical & Computer Engineering	Mathematical Foundations of Electrical Engineering	This course covers topics from engineering mathematics that serve as foundations for descriptions of electrical engineering devices and systems. It is the corequisite mathematics course for 18-220, Fundamentals of Electrical Engineering. The topics include: 1.MATLAB as a robust computational tool, used to reinforce, enrich and integrate ideas throughout the course, including software exercises and projects in combination with homework assignments; 2.Complex Analysis, including rectangular and polar representations in the complex plane with associated forms of complex arithmetic, powers, roots and complex logarithms, complex differentiation, analytic functions and Cauchy-Riemann equations, complex Taylor series, complex exponential, sinusoidal and hyperbolic functions, and Euler's formula; 3.Fourier Analysis, including orthogonality of sinusoids, trigonometric and exponential forms of Fourier series, Fourier integrals and Fourier transforms; 4.Linear, Constant-Coefficient Differential Equations, including complex exponential solutions to homogeneous equations and particular solutions with polynomial and sinusoidal driving functions described by phasors; 5.Difference Equations, with emphasis upon their relationship to differential equations, and; 6.Linear Algebra and Matrices, including matrix arithmetic, linear systems of equations and Gaussian elimination, vector spaces and rank of matrices, matrix inverses and determinants, eigenvalue problems and their relationship to systems of homogeneous differential equations.	U	9, 4	focused
18213	Electrical & Computer Engineering	Introduction to Computer Systems	This course provides a programmer's view of how computer systems execute programs, store information, and communicate. It enables students to become more effective programmers, especially in dealing with issues of performance, portability and robustness. It also serves as a foundation for courses on compilers, networks, operating systems, and computer architecture, where a deeper understanding of systems-level issues is required. Topics covered include: machine-level code and its generation by optimizing compilers, performance evaluation and optimization, computer arithmetic, memory organization and management, networking technology and protocols, and supporting concurrent computation. NOTE: students must achieve a C or better in order to use this course to satisfy the pre-requisite for any subsequent Computer Science course. Prerequisites: 15-122 (Grade of C or higher is required in the prerequisite)	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
18220	Electrical & Computer Engineering	Electronic Devices and Analog Circuits	This course covers fundamental topics that are common to a wide variety of electrical engineering devices and systems. The topics include an introduction to semiconductor devices and technology, DC circuit analysis techniques, operational amplifiers, energy storage elements, sinusoidal steady-state response, frequency domain analysis, filters, and transient response of first- and second-order systems. The laboratories allow students to use modern electronic instrumentation and to build and operate circuits that address specific concepts covered in the lectures, including semiconductor devices and sensors, layout, operational amplifiers, filters, signal detection and processing, power converters and circuit transients. 3 hrs. lec., 1 hr. rec., 3 hrs. lab.	U	7, 9, 4	focused
18240	Electrical & Computer Engineering	Structure and Design of Digital Systems	This course introduces basic issues in design and verification of modern digital systems. Topics include: Boolean algebra, digital number systems and computer arithmetic, combinational logic design and simplification, sequential logic design and optimization, register-transfer design of digital systems, basic processor organization and instruction set issues, assembly language programming and debugging, and a hardware description language. Emphasis is on the fundamentals: the levels of abstraction and hardware description language methods that allow designers to cope with hugely complex systems, and connections to practical hardware implementation problems. Students will use computer-aided digital design software and actual hardware implementation laboratories to learn about real digital systems. 3 hr. lec., 1 hr. rec., 3 hr. lab.	U	4, 9	focused
18290	Electrical & Computer Engineering	Signals and Systems	This course develops the mathematical foundation and computational tools for processing continuous-time and discrete-time signals in both time and frequency domain. Key concepts and tools introduced and discussed in this class include linear time-invariant systems, impulse response, frequency response, convolution, filtering, sampling, and Fourier transform. Efficient algorithms like the fast Fourier transform (FFT) will be covered. The course provides background to a wide range of applications including speech, image, and multimedia processing, bio and medical imaging, sensor networks, communication systems, and control systems. This course serves as entry and prerequisite for any higher level course in the fields of signal processing, communications, and control. Prerequisite(s): 18-100 Corequisite(s): 18-202	U	9, 12, 7	focused
18300	Electrical & Computer Engineering	Fundamentals of Electromagnetics	This course introduces electromagnetic principles and describes ways in which those principles are applied in engineering devices and systems. Topics include: vector calculus as a mathematical foundation for field descriptions, Maxwell's equations in integral and differential forms with associated boundary conditions as descriptions of all electromagnetic principles, quasistatic electric fields in free space and in materials, superposition for known charge sources, conduction and polarization, resistance and capacitance, charge relaxation, analytic and numerical methods for electric field boundary value problems, quasistatic magnetic fields in free space and in materials, superposition for known current sources, magnetization, inductance, magnetic diffusion, and analytic and numerical methods for magnetic field boundary value problems. 4 hrs. lec.	U	9, 7, 12	focused
18310	Electrical & Computer Engineering	Fundamentals of Semiconductor Devices	This course replaced 18311 in Spring 2005. In this course you will receive an introduction to the operation and fabrication of the most important semiconductor devices used in integrated circuit technology together with device design and layout. At the end of the course you will have a basic understanding of pn diodes, bipolar transistors, and MOSFETs as well as some light emitting and light detecting devices such as photodiodes, LEDs and solar cells. You will also receive an introduction to the fundamental concepts of semiconductor physics such as doping, electron and hole transport, and band diagrams. In the laboratory you will learn how to lay out both bipolar and MOS devices and you will design small (2-3 transistor) circuits. The laboratory portion of the course emphasizes the relation between device design and layout and circuit performance. You will also experimentally evaluate the operation of amplifier and gate circuits fabricated with discrete devices. This course will give you an excellent understanding of the operation and fabrication of the devices which is necessary for high-performance analog and digital circuit design. 3 hrs. lec. (Note: the prerequisite is typically waived for MSE students who intend to pursue the Electronic Materials Minor.)	U	7, 9, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
18320	Electrical & Computer Engineering	Microelectronic Circuits	18-320 introduces students to the fundamentals of microelectronic circuits. The course will emphasize the analysis and design of basic analog and digital integrated circuits in preparation for further study in analog, digital, mixed-signal, and radio-frequency integrated circuit design. Additionally, students will learn to design and analyze microelectronic circuits using industry standard computer aided design (CAD) software. Topics to be covered include: MOSFET fabrication and layout MOSFET models for analog and digital design Analysis and design of digital CMOS logic gates Analysis and design of clocked storage elements (e.g., flip-flops, latches, memory cells) Delay optimization of digital circuits Circuit topologies for arithmetic and logical functional units Analysis and design of single-stage MOS amplifiers Frequency response characteristics of single-stage amplifiers Differential amplifiers and simple operational amplifiers Analog filters using operational amplifiers The course includes a lab component which will give students hands-on experience in the design and implementation of analog and digital circuits. Labs will employ both design using discrete, SSI, and MSI parts, as well as using CAD design tools.	U	9, 4, 17	focused
18330	Electrical & Computer Engineering	Introduction to Computer Security	Security is becoming one of the core requirements in the design of critical systems. This course will introduce students to the intro-level fundamental knowledge of computer security and applied cryptography. Students will learn the basic concepts in computer security including software vulnerability analysis and defense, networking and wireless security, and applied cryptography. Students will also learn the fundamental methodology for how to design and analyze security critical systems.	U	4, 9, 1	focused
18334	Electrical & Computer Engineering	Network Security	Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to advance attacks on end systems. This course provides an in-depth study of network attack techniques and methods to defend against them. The course will cover topics spanning five broad themes: (1) infrastructure topics such as firewalls, network intrusion detection, secure routing protocols, and recent advances such as software-defined networking; (2)network attacks such as denial of service (DoS) and distributed denial-of-service (DDoS) attacks, worm and virus propagation; (3)analysis and inference topics such as network forensics and attack economics; (4) user related topics such as authentication, anonymity and censorship resilience; and (5) new technologies related to next-generation networks, and cellular and wireless networks. Students in 18-334 will share lectures and homeworks with students in 18-731. However, 18-731 will have additional requirements not shared by 18-334, including the requirement to produce scribe notes and to practice and demonstrate the ability to read and summarize scientific papers on the topics covered by the course.	U	9, 4, 16	focused
18335	Electrical & Computer Engineering	Secure Software Systems	Poor software design and engineering are the root causes of most security vulnerabilities in deployed systems today. Moreover, with code mobility now commonplace--particularly in the context of web technologies and digital rights management--system designers are increasingly faced with protecting hosts from foreign software and protecting software from foreign hosts running it. This class takes a close look at software as a mechanism for attack, as a tool for protecting resources, and as a resource to be defended. Topics covered include the software design process; choices of programming languages, operating systems, databases and distributed object platforms for building secure systems; common software vulnerabilities, such as buffer overflows and race conditions; auditing software; proving properties of software; software and data watermarking; code obfuscation; tamper resistant software; and the benefits of open and closed source development. Students in 18-335 will share lectures and homeworks with students in 18-732. However, 18-732 has additional requirements not shared by 18-335, including the requirement to produce scribe notes and to practice and demonstrate the ability to read and summarize scientific papers on the topics covered by the course.	U	4, 9, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
18340	Electrical & Computer Engineering	Hardware Arithmetic for Machine Learning	In this course, students explore the techniques for designing high-performance digital circuits for computation along with methods for evaluating their characteristics. We begin by reviewing number systems and digital arithmetic along with basic arithmetic circuits such as ripple-carry adders. From there, we move to more complex adders (carry-look-ahead, carry-skip, carry-bypass, etc.), multipliers, dividers, and floating-point units. For each circuit introduced, we will develop techniques and present theory for evaluating their functionality and speed. Other methods will be described for analyzing a circuit's power consumption, testability, silicon area requirements, correctness, and cost. In addition, we will utilize various CAD tools to evaluate the circuits described. Finally, advanced timing and clocking concepts will be investigated. For example, the notion of clock skew will be introduced and its impact on clock period for sequential circuits will be analyzed. We will also learn how to analyze and design asynchronous circuits, a class of sequential circuits that do not utilize a clock signal. Course projects focus on key arithmetic aspects of various machine learning algorithms including: K-nearest neighbors, neural networks, decision trees, and support vector machines. *Note: Although students in 18-340 and 18-640 will share lectures, labs, and recitations, students in 18-340 and 18-640 will receive different homework assignments, design projects, and exams. In some cases 18-640 students will also have different or additional lab sessions. The homework assignments, design projects, and exams that are given to the students registered for 18-640 will be more challenging than those given to the students registered for 18-340 in that they will have more complex designs, involve additional theoretical analysis, and have more stringent specifications (e.g., in area, power, performance, and robustness).	U	4, 9, 7	focused
18341	Electrical & Computer Engineering	Logic Design and Verification	This course is a second level logic design course, studying the techniques of designing at the register-transfer and logic levels of complex digital systems using modern modeling, simulation, synthesis, and verification tools. Topics include register-transfer level systems (i.e., finite state machines and data paths), bus and communication system interfacing (such as a simplified USB interface), discrete-event simulation, testbench organization, assertion-based verification and functional coverage. Design examples will be drawn from bus and communication interfaces, and computation systems, emphasizing how these systems are designed and how their functionality can be verified. A modern hardware description language, such as SystemVerilog, will serve as the basis for uniting these topics. Quizzes, homeworks and design projects will serve to exercise these topics.	U	9, 11, 4	focused
18349	Electrical & Computer Engineering	Introduction to Embedded Systems	This practical, hands-on course introduces the various building blocks and underlying scientific and engineering principles behind embedded real-time systems. The course covers the integrated hardware and software aspects of embedded processor architectures, along with advanced topics such as real-time, resource/device and memory management. Students can expect to learn how to program with the embedded architecture that is ubiquitous in cell-phones, portable gaming devices, robots, PDAs, etc. Students will then go on to learn and apply real-time principles that are used to drive critical embedded systems like automobiles, avionics, medical equipment, the Mars rover, etc. Topics covered include embedded architectures (building up to modern 16/32/64-bit embedded processors); interaction with devices (buses, memory architectures, memory management, device drivers); concurrency (software and hardware interrupts, timers); real-time principles (multi-tasking, scheduling, synchronization); implementation trade-offs, profiling and code optimization (for performance and memory); embedded software (exception handling, loading, mode-switching, programming embedded systems). Through a series of laboratory exercises with state-of-the-art embedded processors and industry-strength development tools, students will acquire skills in the design/implementation/debugging of core embedded real-time functionality. Anti-requisites: 18342 or 18348	U	9, 4, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
18370	Electrical & Computer Engineering	Fundamentals of Control	An introduction to the fundamental principles and methodologies of classical feedback control and its applications. Emphasis is on problem formulation and the analysis and synthesis of servomechanisms using frequency and time domain techniques. Topics include analytical, graphical, and computer-aided (MATLAB) techniques for analyzing and designing automatic control systems; analysis of performance, stability criteria, realizability, and speed of response; compensation methods in the frequency domain, root-locus and frequency response design, and pole-zero synthesis techniques; robust controller design; systems with delay and computer control systems; transfer function and state space modeling of linear dynamic physical systems; nonlinearities in control systems; and control engineering software (MATLAB). 4 hrs. lec., 1 hr. rec.	U	9, 4, 8	focused
18372	Electrical & Computer Engineering	Fundamental Electrical Power Systems	This course introduces the fundamentals in electric energy systems which will enable you to understand current issues and challenges in electric power systems ("smart grid") and what it takes for you to have a reliable electric power supply at your house. First, the general structure of an electric power system (current and future trends) will be introduced. This includes electric power plants (renewable and non-renewable); transmission and distribution; and consumers. Then, electric power is addressed from a mathematical point of view. The mathematical formulae for AC power and models for the above mentioned elements are derived which will enable you to calculate how much power is flowing over which lines on its way from the power plant to the consumer. Maintaining the balance between generation and consumption is important to avoid catastrophic blackout events. Hence, the notion of stability and available control concepts will be introduced.	U	7, 13, 9	focused
18390	Electrical & Computer Engineering	ECE CO-OP	The Department of Electrical and Computer Engineering at Carnegie Mellon considers experiential learning opportunities important educational options for its undergraduate students. One such option is cooperative education, which provides a student with an extended period of exposure with a company. To participate, students must complete an ECE Co-op Approval form (located in HH 1115) and submit for approval. Students must possess at least junior status and have an overall grade point average of 3.0 or above. All co-ops must be approximately 8 months in uninterrupted length. If the co-op is approved, the ECE Undergraduate Studies Office will add the course to the student's schedule. Upon completion of the co-op experience, students must submit a 1-2 page report of their work experience, and a 1-2 page evaluation from the company supervisor to the ECE Undergraduate Office. International students should also be authorized by the Office of International Education (OIE). More information regarding CPT is available on OIE's website.	U	4, 9, 17	focused
18416	Electrical & Computer Engineering	Nano-Bio-Photonics	Light can penetrate biological tissues non-invasively. Most of the available bio-optic tools are bulky. With the advent of novel nanotechnologies, building on-chip integrated photonic devices for applications such as sensing, imaging, neural stimulation, and monitoring is now a possibility. These devices can be embedded in portable electronic devices such as cell phones for point of care diagnostics. This course is designed to convey the concepts of nano-bio-photonics in a practical way to prepare students to engage in emerging photonic technologies. The course starts with a review of electrodynamics of lightwaves. The appropriate choice of wavelength and material platform is the next topic. Then optical waveguides and resonators are discussed. Resonance-based sensing is introduced followed by a discussion of the Figure of Merits (FOMs) used to design on-chip sensors. Silicon photonics is introduced as an example of a CMOS-compatible platform. On-chip spectroscopy is the next topic. The second part covers nano-plasmonics for bio-detection and therapy. The design methods are discussed, followed by an overview of nanofabrication and chemical synthesis, and then a discussion of applications. The last part of this course will be dedicated to a review of recent applications such as Optogenetic neural stimulation, Calcium imaging, Cancer Imaging and Therapy. Senior or graduate standing required. This course is cross-listed with 18616. Although students in 18-616 and 18-416 will share the same lectures and recitations, students in 18-616 will receive distinct course projects. Students in 18-416 and 18-616 will be graded on separate curves.	U	3, 9, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
18421	Electrical & Computer Engineering	Analog Integrated Circuit Design	Some form of analog circuit design is a critical step in the creation of every modern IC. First and foremost, analog circuits act as the interface between digital systems and the real world. They act to amplify and filter analog signals, and to convert signals from analog to digital and back again. In addition, high performance digital cell design (either high speed or low power) also invokes significant analog circuit design issues. The goal of this course is to teach students some of the methods used in the design and analysis of analog integrated circuits, to illustrate how one approaches design problems in general, and to expose students to a broad cross-section of important analog circuit topologies. The course will focus on learning design through carrying out design projects. Design and implementation details of wide-band amplifiers, operational amplifiers, filters and basic data converters will be covered. Example topics to be covered include transistor large- and small-signal device models, small-signal characteristics of transistor-based amplifiers, large-signal amplifier characteristics and nonidealities, operational amplifier design, basic feedback amplifier stability analysis and compensation, and comparator design. The course will focus primarily on analog CMOS, but some aspects of BJT design will be discussed. 18-290 and 18-320 or equivalent background material with permission of the instructor. Although students in 18-623 will share Lectures and Recitations with students in 18-421, students in 18-623 will receive distinct homework assignments, distinct design problems, and distinct exams from the ones given to students in 18-421 and will be graded on a separate curve from students taking 18-421.	U	4, 9, 7	focused
18422	Electrical & Computer Engineering	Digital Integrated Circuit Design	This course covers the design and implementation of digital circuits in a modern VLSI process technology. Topics will include logic gate design, functional unit design, latch/flip-flop design, system clocking, memory design, clock distribution, power supply distribution, design for test, and design for manufacturing. The lab component of the course will focus on using modern computer aided design (CAD) software to design, simulate, and lay out digital circuits. The final project for the course involves the design and implementation to the layout level of a small microprocessor. 18-240 and 18-320 or equivalent background material with permission of the instructor. Although students in 18-422 and 18-622 will share lectures, labs, and recitations, students in 18-422 and 18-622 will receive different homework assignments, design projects, and exams, and in some cases 18-622 students will also have different or additional lab sessions.	U	9, 4, 17	focused
18441	Electrical & Computer Engineering	Computer Networks	The Internet has transformed our everyday lives, bringing people closer together and powering multi-billion dollar industries. The mobile revolution has brought Internet connectivity to the last-mile, connecting billions of users worldwide. But how does the Internet work? What do oft repeated acronyms like "LTE", "TCP", "WWW" or a "HTTP" actually mean and how do they work? This course introduces fundamental concepts of computer networks that form the building blocks of the Internet. We trace the journey of messages sent over the Internet from bits in a computer or phone to packets and eventually signals over the air or wires. We describe concepts that are common to and differentiate traditional wired computer networks from wireless and mobile networks. Finally, we build up to exciting new trends in computer networks such as the Internet of Things, 5-G and software defined networking. Topics include: physical layer and coding (CDMA, OFDM, etc.); data link protocol; flow control, congestion control, routing; local area networks (Ethernet, Wi-Fi, etc.); transport layer; and introduction to cellular (LTE) and 5-G networks. A final project asks you to a build a HTTP video server of your own. This course is cross-listed with 18-741 - both editions will share Lectures and Recitations. However, students in the two courses will receive different exams and will have a different project. The students in the two versions of the course will be graded on a separate curve.	U	4, 9, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
18447	Electrical & Computer Engineering	Introduction to Computer Architecture	Computer architecture is the science and art of selecting and interconnecting hardware components to create a computer that meets functional, performance and cost goals. This course introduces the basic hardware structure of a modern programmable computer, including the basic laws underlying performance evaluation. We will learn, for example, how to design the control and data path hardware for a MIPS-like processor, how to make machine instructions execute simultaneously through pipelining and simple superscalar execution, and how to design fast memory and storage systems. The principles presented in the lecture are reinforced in the laboratory through the design and simulation of a register transfer (RT) implementation of a MIPS-like pipelined superscalar in Verilog. Learning to design programmable systems requires that you already have the knowledge of building RT systems, the knowledge of the behavior storage hierarchies (e.g., cache memories) and virtual memory, and the knowledge of assembly language programming.	U	4, 9	focused
18452	Electrical & Computer Engineering	Wireless Networking and Applications	This course introduces fundamental concepts of wireless networks. The design of wireless networks is influenced heavily by how signals travel through space, so the course starts with an introduction to the wireless physical layer, presented in a way that is accessible to a broad range of students. The focus of the course is on wireless MAC concepts including CSMA, TDMA/FDMA, and CDMA. It also covers a broad range of wireless networking standards, and reviews important wireless network application areas (e.g., sensor networks, vehicular) and other applications of wireless technologies (e.g., GPS, RFID, sensing, etc.). Finally, we will touch on public policy issues, e.g., as related to spectrum use. The course will specifically cover: Wireless networking challenges Wireless communication overview Wireless MAC concepts Overview of cellular standards and LTE Overview of wireless MAC protocols WiFi, bluetooth and personal area networks, etc. Wireless in today's Internet: TCP over wireless, mobility, security, etc. Advanced topics, e.g., mesh and vehicular networks, sensor networks, DTNs, localization, sensing, etc. Although students in 18-750 will share Lectures and Recitations with students in 18-452, they will receive distinct homework assignments and exams from students in 18-452. The main project will also be different. The students in the two version of the course will also be graded on a separate curve.	U	4, 9, 17	focused
18460	Electrical & Computer Engineering	Optimization	Many design problems in engineering (e.g., machine learning, finance, circuit design, etc.) involve minimizing (or maximizing) a cost (or reward) function. However, solving these problems analytically is often challenging. Optimization is the study of algorithms and theory for numerically solving such problems, and it underpins many of the technologies we use today. This course is an introduction to optimization. Students will: (1)learn about common classes of optimization problems, (2) study (and implement) algorithms for solving them, and (3) gain hands-on experience with standard optimization tools. We will focus on convex optimization problems, but will also discuss the growing role of non-convex optimization, as well as some more general numerical methods. The course will emphasize connections to real-world applications including machine learning, networking, and finance. The course will involve lectures, homework, exams, and a project. This course is crosslisted with 18660. Although students in 18460 will share lectures with students in 18660, students in 18460 will receive distinct homework assignments, distinct design problems, and distinct exams from the ones given to students in 18660. Specifically, the homework assignments, design problems and exams that are given to the 18660 students will be more challenging than those given to the 18460 students.	U	4, 9, 17	focused
18461	Electrical & Computer Engineering	Introduction to Machine Learning for Engineers	This course provides an introduction to machine learning with a special focus on engineering applications. The course starts with a mathematical background required for machine learning and covers approaches for supervised learning (linear models, kernel methods, decision trees, neural networks) and unsupervised learning (clustering, dimensionality reduction), as well as theoretical foundations of machine learning (learning theory, optimization). Evaluation will consist of mathematical problem sets and programming projects targeting real-world engineering applications.	U	4, 9, 15	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
18462	Electrical & Computer Engineering	Principles and Engineering Applications of AI	This is a first-year graduate course in Principles and Engineering Applications of AI. The course will review the basic principles of AI. Some of the specific topics that will be covered are the following: 1) Intelligent Agents; 2) Single-Agents and Multi-Agent Systems (MAS); 3) Uncertain Knowledge and Reasoning (Probabilistic Reasoning and Probabilistic Reasoning over Time, Bayesian Networks, Dynamic Bayesian Networks, Hidden Markov Models, Kalman Filters, MCMC algorithms, etc.); 4) Learning; 5) Communicating, Perceiving, and Acting; 6) Robotics. The course will involve completing a set of challenging engineering applications of AI that will include: Medical applications, Video Games, Autonomous driving, Autonomous Robots, Finance and Economics, Military, Art, Advertising. Students should have a good background in basic probability theory, maturity in mathematical topics, and good programming skills. For seniors who would like to take the course but do not have the necessary prerequisites, instructor's permission will be required. Although students in 18462 will share lectures with students in 18662, students in 18462 will receive distinct homework assignments, distinct projects, and distinct exams from the ones given to students in 18662. Specifically, the homework assignments, projects, and exams that are given to the 18662 students will be more challenging than those given to the 18462 students.	U	4, 9, 8	focused
18464	Electrical & Computer Engineering	ULSI Technology Status and Roadmap for System on Chips and System in Package	This course will provide the necessary background for the state-of-the art technologies utilized by the leading edge products covering full spectrum of market drivers from mobile platforms, microprocessors, game chips to the highest performance systems for enterprise solutions computing. We will present all key components of such systems, i.e., logic, analog/RF and embedded memories. Then we present the technology roadmap for the upcoming generations in terms of device architecture options for logic devices (FinFET, Nanowire and Tunnel FET) and memories (Phase Change Memory , Resistive RAM and Magnetic RAM/Spin-Transfer Torque RAM) from the device level all the way to the system level specifications. The last part of the class will be devoted to the system integration issues, namely 3-dimensional integration approaches. This course is designed for MS and PhD students from diverse areas: System/Hardware Design, Circuits and Devices/Nanofabrication and is aimed at bridging the gap among these areas.	U	9, 4, 11	focused
18465	Electrical & Computer Engineering	Advanced Probability & Statistics for Engineers	This course will help masters and undergraduate students to obtain the background necessary for excelling in courses and careers in machine learning, artificial intelligence, and related fields. We will cover basic concepts of probability prerequisite to understanding the material typically taught in a ML course. We will also cover slightly more advanced topics including Markov Chains, hypothesis testing, and maximum-likelihood estimation. The remaining part of the semester will be devoted to introducing machine learning concepts such as supervised/unsupervised learning, model identification, clustering, expectation maximization, etc. Students should be familiar with basic calculus, linear algebra. Although students in 18465 will share lectures with students in 18665, students in 18465 will receive distinct homework assignments, distinct projects, and distinct exams from the ones given to students in 18665. Specifically, the homework assignments, projects, and exams that are given to the 18665 students will be more challenging than those given to the 18465 students.	U	4, 9, 8	focused
18469	Electrical & Computer Engineering	Special Topics in Integrated Systems Technology	Please refer to the ECE website for topic descriptions: https://courses.ece.cmu.edu/	U	9, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
18474	Electrical & Computer Engineering	Embedded Control Systems	This course introduces principles for design of embedded controllers. In applications ranging from airplanes, to automobiles, to manufacturing systems, embedded computers now close feedback loops that were previously closed by mechanical devices or by humans in the loop. This course emphasizes practical insight into the tools for modeling and simulating these dynamic physical systems, and methods for designing the real-time software for embedded computers to control them. Lectures cover relevant theory and background from real-time systems and control engineering, including event-based and clock-based sampling, switching control, PWM (pulse-width modulation), PID (proportional-integral-derivative) design, state-variable feedback, state estimation, and methods for setpoint control and trajectory tracking. Basic embedded computing, sensor, and actuator technologies are reviewed, including microcontrollers, DC motors and optical encoders. In the laboratory, students use commercial tools for simulation and automatic code generation to design and implement embedded control system experiments. 3 hrs. lecture, 3 hrs. lab.	U	9, 4, 8	focused
18490	Electrical & Computer Engineering	Electroacoustics	This course provides an introduction to physical, engineering, and architectural acoustics. The course begins with a review of the wave equation and some of its solutions that are relevant to the propagation of sound from planar and spherical sources, and from arrays of simple sources. Lumped-parameter electrical circuit analogies are developed to describe mechanical and acoustical systems, leading to a discussion of the constraints and tradeoffs involved in the design of loudspeakers, microphones, and other transducers. The characteristics of sound in regular and irregular enclosures will be developed and discussed in the context of the acoustical design for rooms and auditoriums. The interaction of sound and man is also discussed, with introductory lectures on auditory perception and the acoustics of speech production, with applications in the areas of efficient perceptually-based coding of music and speech, and virtual acoustical environments.	U	9, 12, 11	focused
18491	Electrical & Computer Engineering	Digital Signal Processing	This course addresses the mathematics, implementation, design and application of the digital signal processing algorithms widely used in areas such as multimedia telecommunications and speech and image processing. Topics include discrete-time signals and systems, discrete-time Fourier transforms and Z-transforms, discrete Fourier transforms and fast Fourier transforms, digital filter design and implementation, and multi-rate signal processing. The course will include introductory discussions of 2-dimensional signal processing, linear prediction, adaptive filtering, and selected application areas. Classroom lectures are supplemented with implementation exercises using MATLAB. Students in 18491 and 18691 will share the same lectures and recitations. Nevertheless, students receiving credit for 18691 will be required to complete an additional capstone project at the end of the semester. Students in 18691 may have additional homework problems on a weekly basis.	U	4, 9, 17	focused
18495	Electrical & Computer Engineering	Speech Processing	Speech Processing offers a practical and theoretical understanding of how human speech can be processed by computers. It covers speech recognition, speech synthesis and spoken dialog systems. The course involves practicals where the student will build working speech recognition systems, build their own synthetic voice and build a complete telephone spoken dialog system. This work will be based on existing toolkits. Details of algorithms, techniques and limitations of state of the art speech systems will also be presented. This course is designed for students wishing understand how to process real data for real applications, applying statistical and machine learning techniques as well as working with limitations in the technology.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
18500	Electrical & Computer Engineering	ECE Design Experience	The ECE Design Experience is a capstone design course that serves to introduce students to broad- based, practical engineering design and applications through an open-ended design problem. Students will work with a team on a project of their choosing (subject to instructor approval) throughout the semester culminating with a final project presentation, report, and public demonstration. The projects will need to encompass a minimum of two ECE areas. Throughout the semester, teams will need to give both written and oral project proposals and periodic performance updates. Team-building experiences designed to educate students on group dynamics, resource management, deadline planning, Big-picture implications of engineering applications: societal, human, ethical, and long-term impact will be explored. Please note that the prerequisite list of "Any 2 18-xxx ECE Area Courses" is too long to be put into the registration system. As a result ALL students will be waitlisted for 18-500. Students will be registered once it has been confirmed they have completed the prerequisites, after final grades for the current semester.	U	4, 17, 9	focused
18540	Electrical & Computer Engineering	Rapid Prototyping of Computer Systems	This is a project-oriented course which will deal with all four aspects of project development; the application, the artifact, the computer-aided design environment, and the physical prototyping facilities. The class, in conjunction with the instructors, will develop specifications for a mobile computer to assist in inspection and maintenance. The application will be partitioned between human computer interaction, electronics, industrial design, mechanical, and software components. The class will be divided into groups to specify, design, and implement the various subsystems. The goal is to produce a working hardware/software prototype of the system and to evaluate the user acceptability of the system. We will also monitor our progress in the design process by capturing our design escapes (errors) with the Orthogonal Defect Classification (ODC). Upon completion of this course the student will be able to: generate systems specifications from a perceived need; partition functionality between hardware and software; produce interface specifications for a system composed of numerous subsystems; use computer-aided design tools; fabricate, integrate, and debug a hardware/software system; and evaluate the system in the context of an end user application. Senior standing is required. This course is crosslisted as 18745	U	9, 4, 17	focused
18578	Electrical & Computer Engineering	Mechatronic Design	Mechatronics is the synergistic integration of mechanism, electronics, and computer control to achieve a functional system. Because of the emphasis upon integration, this course will center around system integration in which small teams of students will configure, design, and implement a succession of mechatronic subsystems, leading to a main project. Lectures will complement the laboratory experience with comparative surveys, operational principles, and integrated design issues associated with the spectrum of mechanism, electronics, and control components. Class lectures will cover topics intended to complement the laboratory work, including mechanisms, actuators, motor drives, sensors and electronic interfaces, microcontroller hardware and programming and basic controls. During the first week of class, each student will be asked to complete a questionnaire about their technical background. The class will then be divided into multi-disciplinary teams of three students. During the first half of the class, lab assignments will be made every 1-2 weeks to construct useful subsystems based on material learned in lecture. The lab assignments are geared to build to the main project. This course is cross-listed as 16-778 and 24-778. Students in other departments may take the course upon availability of slots with permission of instructor. Non ECE students may take the course upon availability of slots with permission of the instructor.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
18580	Electrical & Computer Engineering	Undergraduate Projects	The Department of Electrical and Computer Engineering at Carnegie Mellon considers experiential learning opportunities to be important educational options for its undergraduate students. One such option is conducting undergraduate research with a faculty member. Students do not need to officially register for undergraduate research unless they want it listed on their official transcripts. An ECE student who is involved in a research project and is interested in registering this undergraduate research for course credit on the official transcript may request to be enrolled in this course. To do this, the student should first complete the online undergraduate research form available on the ECE undergraduate student page. Once the form has been submitted and approved by the faculty member with whom the student is conducting the research, the ECE Undergraduate Office will add the course to the student's schedule. Typically, credit is granted according to one hour of research per week is equal to one unit of credit.	U	4, 17, 9	focused
18661	Electrical & Computer Engineering	Introduction to Machine Learning for Engineers	This course provides an introduction to machine learning with a special focus on engineering applications. The course starts with a mathematical background required for machine learning and covers approaches for supervised learning (linear models, kernel methods, decision trees, neural networks) and unsupervised learning (clustering, dimensionality reduction), as well as theoretical foundations of machine learning (learning theory, optimization). Evaluation will consist of mathematical problem sets and programming projects targeting real-world engineering applications. This course is crosslisted with 18461. Although students in 18461 will share lectures with students in 18661, students in 18461 will receive distinct homework assignments, distinct programming projects, and distinct exams from the ones given to students in 18661. Specifically, the homework assignments, programming projects, and exams that are given to the 18661 students will be more challenging than those given to the 18461 students.	G	4, 9, 15	focused
18733	Electrical & Computer Engineering	Applied Cryptography	A wide array of communication and data protections employ cryptographic mechanisms. This course explores modern cryptographic techniques in some detail. The course emphasizes how cryptographic mechanisms can be effectively used within larger security systems, and the dramatic ways in which cryptographic mechanisms can fail. Topics covered include cryptographic primitives such as symmetric encryption, public key encryption, digital signatures, message authentication codes, hash functions, commitments, and pseudo-random number generators. The course also covers cryptographic protocols, such as key exchange, remote user authentication, and interactive proof systems; threshold cryptography, oblivious transfers and secure multi-party computations; perfectly secure encryption and universal hash functions. The course also covers a variety of special applications including computing on encrypted data. Senior or graduate standing required.	G	9, 4, 7	focused
18883	Electrical & Computer Engineering	Special Topics in Energy Systems	Please see the ECE website for a full course description describing the sections of this course. https://courses.ece.cmu.edu/	G	7, 13, 4	focused
18989	Electrical & Computer Engineering	Introduction to Graduate Studies	The Introduction to Graduate Studies course is designed to increase awareness and understanding of academic integrity issues, Carnegie Mellon community standards and the ethical job search. This is done via various sessions/modules that are already offered via several entities throughout campus (such as the CPDC, ICC, and GCC). Topics covered include: paraphrasing and citation, participating in the US classroom, avoiding plagiarism, unconscious bias, combating sexual violence on campus, finding jobs and internships, negotiation, communication, relationship building and other topics of interest. The course culminates in students writing a reflection paper. For international students, the paper should compare western academic and cultural standards to those of their home country. For domestic students, the paper should be a reflection on CMU's community standards. Active participation in 5 sessions/modules in the above mentioned areas and the submission of the reflection paper will determine a pass/fail grade.	G	4, 16, 5	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
19101	Engineering & Public Policy	Introduction to Engineering and Public Policy	Technology plays an important role in shaping our worlds. At the same time, social forces play a central role in the evolution of a technology. These influences often result in societal impacts that call for public policy to intervene. This course examines interactions between technology and society, and the related processes of public and private decision-making and of policy formation. As an introduction to the field of engineering and public policy, the course includes concepts of public policy, introduces tools used for technology and policy analysis, and applies these concepts and tools to current technology-society issues.	U	9, 7, 4	focused
19201	Engineering & Public Policy	EPP Sophomore Seminar	EPP Sophomore Seminar is for students enrolling in the Engineering and Public Policy (EPP) Additional Major and the Science, Technology and Public Policy (STPP) Additional Major. The course presents the interdisciplinary nature of EPP/STPP problems at the interface of technology and society. Students are introduced to the technical and policy dimensions of these problems as well as to skills such as data collection and analysis, group work, and oral and written presentations. Sessions include discussion of case studies dealing with aspects of decision-making and ethics in policy issues with a technological basis. Seminars by EPP faculty and students are included to give the student an idea of careers and problems in this area.	U	4, 9, 8	focused
19211	Engineering & Public Policy	Ethics and Policy Issues in Computing	Should autonomous robots make life and death decisions on their own? Should we allow them to select a target and launch weapons? To diagnose injuries and perform surgery when human doctors are not around? Who should be permitted to observe you, find out who your friends are, what you do and say with them, what you buy, and where you go? Do social media and personalized search restrict our intellectual horizons? Do we live in polarizing information bubbles, just hearing echoes of what we already know and believe? As computing technology becomes ever more pervasive and sophisticated, we are presented with an escalating barrage of decisions about who, how, when, and for what purposes technology should be used. This course will provide an intellectual framework for discussing these pressing issues of our time, as we shape the technologies that in turn shape us. We will seek insight through reading, discussion, guest lectures, and debates. Students will also undertake an analysis of a relevant issue of their choice, developing their own position, and acquiring the research skills needed to lend depth to their thinking. The course will enhance students' ability to think clearly about contentious technology choices, formulate smart positions, and support their views with winning arguments.	U	4, 9, 1	focused
19213	Engineering & Public Policy	The American Railroad: Decline and Renaissance in the Age of Deregulation	Railroads in the USA are often considered as a subject for nostalgia or public sector failure, an image largely based on passenger service. However, the USA's private sector freight rail industry is considered a model for the world as the result of its renaissance following deregulation in 1980. This is a "stealth" industry whose history and economics are both intertwined and complex. Starting with the development of the first U. S. railroads, students will gain a basic understanding of the industry's history and economics, with special attention to the past half-century. In addition, students will participate in small group research projects in particular areas of special interest -- for example, economic history, industry culture, network economics, utility regulation or transportation policy.	U	8, 11, 9	focused
19250	Engineering & Public Policy	Special Topics: Statistical Models for Engineering Analysis and Design	An introduction to probability and statistics with examples drawn from across engineering and science to motivate the learning of fundamental concepts and methods. Population models and sample statistics; rules of probability and conditional events; discrete and continuous random variables; simulation and sampling distributions; parameter estimation; classical and Bayesian tests of hypothesis; goodness of fit; introduction to regression analysis; quality control.	U	4, 9, 10	focused
19301	Engineering & Public Policy	Decision Making Methods for Engineers and Scientists	This course covers various economic, statistical, and decision analysis techniques used for examining complex decisions where technology, society, and policy interconnect. Topics covered include: estimation techniques, benefit-cost analysis, decision trees, dealing with uncertainty, risk perception and analysis, survey design and implementation, utility theory, heuristics and biases in inference and prediction, methods for combining information from different sources and dealing with conflicting objectives.	U	8, 9, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
19351	Engineering & Public Policy	Applied Methods for Technology-Policy Analysis	This course synthesizes concepts from economics, statistics, decision analysis, and other humanities and social science areas as they relate to analysis of technology and public policy issues. Students will focus on applying skills, tools, and techniques of social science to critically examine issues of current importance to society that have engineering systems at the core, and how public policy can be informed by the results of these analyses. Students will discover the relationship between formulating research questions considering a wide range of perspectives (e.g., political, ethical, social, economic, and legal aspects) and implementing the appropriate research methods for answering them. The course will emphasize interpretation and communication of analysis results in written and oral presentation, especially to non-technical audiences. As a precursor to the EPP Project courses, the course also prepares EPP juniors for structuring real-world problems into a feasible work plan, and to deal with revising work plans as work proceeds.	U	4, 8, 9	focused
19403	Engineering & Public Policy	Policies of Wireless Systems	This course will address public policy issues related to wireless systems. It investigates policies related to a wide variety of emerging wireless systems and technologies, including current and next-generation cellular systems, wifi and white space devices, emerging methods of accessing spectrum, communications systems for emergency responders (firefighters, police, emergency medical services), current and next-generation television, and satellite communications. This can include the government role in facilitating the creation of infrastructure, in advancing competition among broadcasters and communications service providers, in using scarce spectrum efficiently, in promoting public safety and homeland security, and in protecting privacy and security. Because these are inherently interdisciplinary issues, the course will include detailed discussions of technology, economics, and law, with no prerequisites in any of these areas. This course is cross-listed as 18-650, 19-403, 19-713, and 95-824. Senior or graduate standing required.	U	9, 8, 4	focused
19411	Engineering & Public Policy	Science and Innovation Leadership for the 21st Century: Firms, Nations, and Tech	Science and Innovation Leadership for the 21st Century introduces students to the fundamental principles surrounding global competitiveness and technological change in the 21st century. The course is broken into three sections. The first section introduces students to competing economic, sociological, and political science theories on the structures supporting technological change. The second section presents the contemporary literature on technological change. The concluding section leverages lessons from the preceding two sections to evaluate national innovation systems, and the factors that lead to national comparative advantage. Students should leave the class able to reflect competently on what the existing literature tells us about the factors influencing global technology competitiveness, and on how modern changes in the structures supporting innovation as well as technology itself may be changing the rules of the game for firms and for nations. The course is open to undergraduate juniors, seniors & graduate students.	U	9, 4, 8	focused
19421	Engineering & Public Policy	Emerging Energy Policies	Interested in what's happening in energy policy and how to analyze potential policy options in response? Focusing on current hot topics in energy policy, students will learn the basic principles of public policy analysis and underlying techniques such as program evaluation, cost benefit analysis, life cycle analysis, prince analysis, and risk analysis as well as the variety of policy mechanisms available. Class time will include a combination of faculty and guest speaker lectures, discussion of issues, videos, and problem solving. Students will review and edit Wikipedia entries on an energy policy topic of their choice, and then analyze policy options resulting in an executive summary or paper on that topic. While the course has no prerequisites, students should feel comfortable with scientific and technical topics. Upon completion of this course, students should have a deeper and more strategic understanding of the opportunities and challenges associated with emerging energy policies. Open to seniors. Open to juniors with permission only.	U	7, 4, 13	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
19424	Engineering & Public Policy	Energy and the Environment	This course will explore the relationships between environmental impacts and the utilization of energy through a series of case studies on topics of current interest. Such topics might include the use of renewable and non-renewable fuels for electric power generation; energy use for automobiles and other transportation systems; energy use for buildings and industrial processes; and environmental issues such as urban air pollution, ozone formation, acid rain, and global warming. The emphasis will be on analysis of energy-environmental interactions and tradeoffs, and their dependency upon engineering design choices, economic variables, and public policy parameters. Junior or Senior standing in CIT or permission of instructor.	U	13, 7, 8	focused
19425	Engineering & Public Policy	Sustainable Energy for the Developing World	This course examines the current state of the energy system in developing countries and the challenges these countries will face in sustainably meeting their energy needs in the 21st century. The following are examples of questions and issues we will cover throughout the semester. What is the current status of the energy system in the developing world? What is the role of energy in supporting economic growth and alleviating poverty? What are the future energy needs of developing countries? What are the challenges developing countries will face as they build/improve their energy systems? What technologies are available to meet the energy challenges in the developing world?	U	1, 8, 7	focused
19433	Engineering & Public Policy	Data Science for Technology, Innovation and Policy	Students will learn how to use R to collect, organize, and analyze data in technology, innovation, and policy-related domains. The focus will be on the practical issues faced when conducting data analyses, correctly implementing and interpreting statistical models, and summarizing results for clients and research purposes.	U	9, 4, 17	focused
19440	Engineering & Public Policy	Combustion and Air Pollution Control	Formation and control of gaseous and particulate air pollutants in combustion systems. Basic principles of combustion, including thermochemical equilibrium, flame temperature, chemical kinetics, hydrocarbon chemistry, and flame structure. Formation of gaseous and particulate pollutants in combustion systems. Combustion modifications and postcombustion technologies for pollutant control. Relationship between technology and regional, national, and global air pollution control strategies. The internal combustion engine and coal-fired utility boiler are used as examples.	U	13, 6, 9	focused
19451	Engineering & Public Policy	EPP Projects I	Students work in multidisciplinary teams (engineers and scientists, humanities and social scientists, public policy and management graduates) on a cutting edge project topic with very little in the way of pre-digested analysis or solutions. Topics include both technical and social dimensions, multiple constraints on the solutions, and require multi-dimensional analyses. Students are given a general goal, and are expected to discover existing knowledge on the topic, and to research existing technologies and relevant policies. Using this background and their technical and social analysis education as appropriate, students then create new knowledge on the subject and analyzing technology impacts, policy alternatives, or other relevant options as topics necessitate. This knowledge is communicated to an external advisory panel, selected from experts and constituencies of importance to the issue through formal presentations and a written report. #19451 is the first of two EPP Projects course experiences for EPP additional majors, students taking EPP Projects I are learning how to use their skills from prior EPP courses in solving complex, unstructured problems and developing skills for effective project completion. Pre-requisite 19-101 and co-requisite 19-351 for students in the EPP additional major only.	U	4, 9, 17	focused
19452	Engineering & Public Policy	EPP Projects II	Interdisciplinary problem-solving projects in which students work as leaders or members of project teams. Problem areas are abstracted from local, state and national situations and involve the interaction of technology and public policy, with different projects being chosen each semester. Oral and written presentations concerning the results of project studies are required.	U	4, 9, 17	focused
19466	Engineering & Public Policy	Stochastic Discrete Choice Models: Estimation and Behavioral Theory	This course will cover the rational and behavioral foundations of discrete choice models, current behavioral theories, and estimation methods. Content will include an overview of the history of thinking about discrete choice models, rational foundations, behavioral theories, signal detection theory, multinomial logit, mixed logit using restricted MLE and monte-carlo simulation, and experimental design. If time permits we will cover item-response models and Bayesian methods.	U	9, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
19500	Engineering & Public Policy	Directed Study in EPP: Undergraduate	Students may do undergraduate research as one course for EPP technical elective credit, with an EPP faculty member, or on an approved project with a faculty member from another department. The research credits must be pre-approved by your advisor, and should result in a written product, one copy of which should be sent to EPP.	U	4, 17, 8	focused
19534	Engineering & Public Policy	Usable Privacy and Security	There is growing recognition that technology alone will not provide all of the solutions to security and privacy problems. Human factors play an essential role in these areas, and it is important for security and privacy experts to have an understanding of how people will interact with the systems they develop. This course is designed to introduce students to a variety of usability and user-interface problems related to privacy and security and to give them experience in understanding and designing studies aimed at helping to evaluate usability issues in security and privacy systems. The course is suitable both for students interested in privacy and security who would like to learn more about usability, as well as for students interested in usability who would like to learn more about security and privacy. Students will also work on a group project throughout the semester. The course is open to all students who have technical backgrounds. The 12-unit course numbers (17-734, 5-836, 19-734) are for PhD students and masters students. Students enrolled in these course numbers will have extended homework assignments and will be expected to play a leadership role in a group project that produces a paper suitable for publication. The 9-unit course numbers (17-334, 5-436, 19-534) are for undergraduates and masters students (if permitted by their program).	U	4, 9, 17	focused
19602	Engineering & Public Policy	Current Topics In Privacy Seminar	In this seminar course students will discuss recent papers and current public policy issues related to privacy. Privacy professionals from industry, government, and non-profits will deliver several guest lectures each semester.	G	4, 9, 17	focused
19603	Engineering & Public Policy	Data Science for Technology, Innovation and Policy	Students will learn how to use R to collect, organize, and analyze data in technology, innovation, and policy-related domains. The focus will be on the practical issues faced when conducting data analyses, correctly implementing and interpreting statistical models, and summarizing results for clients and research purposes.	G	9, 4, 17	focused
19608	Engineering & Public Policy	Privacy Policy, Law, and Technology	This course focuses on policy issues related to privacy from the perspectives of governments, organizations, and individuals. We will begin with a historical and philosophical study of privacy and then explore recent public policy issues. We will examine the privacy protections provided by laws and regulations, as well as the way technology can be used to protect privacy. We will emphasize technology-related privacy concerns and mitigation, for example: social networks, smartphones, behavioral advertising (and tools to prevent targeted advertising and tracking), anonymous communication systems, big data, and drones. This is part of a series of courses offered as part of the MSIT-Privacy Engineering masters program. These courses may be taken in any order or simultaneously. Foundations of Privacy (Fall semester) offers more in-depth coverage of technologies and algorithms used to reason about and protect privacy. Engineering Privacy in Software (Spring semester) focuses on the methods and tools needed to design systems for privacy. This course is intended primarily for graduate students and advanced undergraduate students with some technical background. Programming skills are not required. 8-733, 19-608, and 95-818 are 12-unit courses for PhD students. Students enrolled under these course numbers will have extra assignments and will be expected to do a project suitable for publication. 8-533 is a 9-unit course for undergraduate students. Masters students may register for any of the course numbers permitted by their program. This course will include a lot of reading, writing, and class discussion. Students will be able to tailor their assignments to their skills and interests. However, all students will be expected to do some writing and some technical work.	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
19624	Engineering & Public Policy	Emerging Energy Policies	Interested in what's happening in energy policy and how to analyze potential policy options in response? Focusing on current hot topics in energy policy, students will learn the basic principles of public policy analysis and underlying techniques such as program evaluation, cost benefit analysis, life cycle analysis, prince analysis, and risk analysis as well as the variety of policy mechanisms available. Class time will include a combination of faculty and guest speaker lectures, discussion of issues, videos, and problem solving. Students will review and edit Wikipedia entries on an energy policy topic of their choice, and then analyze policy options resulting in an executive summary or paper on that topic. While the course has no prerequisites, students should feel comfortable with scientific and technical topics. Upon completion of this course, students should have a deeper and more strategic understanding of the opportunities and challenges associated with emerging energy policies. Open to seniors. Open to juniors with permission only.	G	7, 4, 13	focused
19625	Engineering & Public Policy	Sustainable Energy for the Developing World	This course examines the current state of the energy system in developing countries and the challenges these countries will face in sustainably meeting their energy needs in the 21st century. The following are examples of questions and issues we will cover throughout the semester. What is the current status of the energy system in the developing world? What is the role of energy in supporting economic growth and alleviating poverty? What are the future energy needs of developing countries? What are the challenges developing countries will face as they build/improve their energy systems? What technologies are available to meet the energy challenges in the developing world?	G	1, 8, 7	focused
19639	Engineering & Public Policy	Policies of the Internet	This course will address public policy issues related to the Internet. This may include policy issues such as network neutrality and the open Internet, Internet governance and the domain name system (and the role of the United Nations), copyright protection of online content, regulation of indecency and pornography, universal access to Internet and Internet as a "human right", government surveillance of the Internet, Internet privacy and security, and taxation of electronic commerce. It will also teach some fundamentals of Internet technology. Because these are inherently interdisciplinary issues, the course will include detailed discussions of technology, economics, and law, with no prerequisites in any of these areas. Senior or graduate standing required.	G	9, 8, 4	focused
19666	Engineering & Public Policy	Energy Policy and Economics	This course will begin with a review of microeconomic concepts and tools necessary for analysis of the topics covered in the class. The course will explore how past energy technology policies and choices are intertwined with pathways of economic development, social impacts, macroeconomic measurement and performance. This course will explore how a wide variety of policy mechanisms- technology policy, utility regulation and restructuring, emissions policies, multilateral interventions and agreements, and corporate strategies-can shape energy use and the environmental impacts of energy systems. Study examples will draw from both developed and developing countries.	G	13, 8, 7	focused
19670	Engineering & Public Policy	Quantitative Entrepreneurship: Analysis for New Technology Commercialization	This course provides engineers with a multidisciplinary mathematical foundation for integrated modeling of engineering design, manufacturing, and enterprise planning decisions for commercializing new technologies and products. Topics include economics in product design, manufacturing and operations modeling and accounting, consumer choice modeling, survey design, conjoint analysis, optimization, model integration and interpretation, and professional communication skills. Students will apply theory and methods to a team project for a new product or emerging technology, developing a business plan to defend technical and economic competitiveness. This course assumes fluency with multivariable calculus, linear algebra, and probability theory.	G	9, 4, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
19671	Engineering & Public Policy	Tech Start-up: Market Discovery	The first three years of a technology start-up are the most critical; when the company's DNA or trajectory is set. Too few entrepreneurs appreciate this fact and, as a result, many start without the essential skills talents and capabilities needed to set the company on a successful path. Some of these entrepreneurial skills can only be learned through starting and growing a business while others can be learned. This course attempts to bridge the challenging gap between learning and doing entrepreneurship. We introduce you to an essential skill of market discovery or learning to create, develop and evaluate your concept of your business. Is my idea a real innovation? Is it also a business or a product or neither? How do I know how big the market is for my product? What are the technology market and competitive risks in my idea and how do I assess them? Can I compete? Can I sell it? How? When? Where? Students will have the opportunity to apply their newfound practical skills gathered in part from lectures from experienced entrepreneurs and investors to case studies role-playing and solving actual problems of local tech businesses. The best way to learn entrepreneurship is by doing, which is why this course will use 'true-to-life' scenarios as the anchor for the course. The class will be divided into 4 teams will focus on a company that is either (1) a student idea for new start-up, (2) an existing start-up (ideally local) or (3) a hypothetical start-up proposed/conceived by the students, the professor or both	G	4, 9, 8	focused
19672	Engineering & Public Policy	Special Topics: Tech Start-up: Building Your Own Company	(Session 2) - The first year or two of a tech start-up set the trajectory and character of that company for years to come. Too few entrepreneurs appreciate this reality and, as a result, many carry forward misperceptions and misconceptions about creating and building a successful tech company that set it on the path for failure. This class attempts to remedy that challenge by exposing the student the practical reality of building a team and funding a start-up team. This class should help the student answer (or know how to find the answer) to the following questions: How do I find manage and evaluate a start-up team Do I have the skill motivation and ability to be a tech entrepreneur? Can I build a company from scratch (really?)? Should I be the CEO Sales Account Manager VP of Engineering or something else altogether? How much money do I raise and where and when do I raise it? Students will have the opportunity to apply their newfound practical skills gathered in part from lectures from experienced entrepreneurs and investors to case studies.	G	4, 9, 8	focused
19680	Engineering & Public Policy	E&TIM Seminar on Innovation Management in Practice	Innovation has been described as "the intersection of invention and insight, leading to the creation of social and economic value." Companies increasingly rely on innovation to establish and drive their success. Public policy makers see innovation as a critical driver for economic development. This course is an opportunity to learn about innovation management from those in the front lines. How are innovation opportunities identified? What are the challenges to realizing these opportunities, and how can the challenges be addressed? What roles are played by processes, technologies and the business environment, as well as by individuals in organizations? This course will feature speakers who drive innovation in a variety of settings, paired with readings from the innovation literature that will help frame the presentations and discussion.	G	8, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
19681	Engineering & Public Policy	Managerial and Engineering Economics	This course will introduce students to the fundamentals of engineering and managerial economics. The course emphasizes the application of economic frameworks to understand how technology markets evolve and what strategies allow firms to capture value from innovation. The aim of the course is to develop a rigorous foundation in the relevant economic models that students can use to manage innovation in high-technology organizations. The course is oriented around developing answers to three key questions: (1) How should managers of technology firms evaluate potential strategies or projects when the outcome of innovation is uncertain? To address this question, the course introduces cost-benefit models for determining project value and how to use these models to make managerial decisions. (2) How do market characteristics shape the optimal pricing decisions of the firm? This part of the course provides economic models that translate the competitive dynamics of markets into the return-based measures required for optimal decision-making. (3) How do market characteristics shape a firm's ability to capture value from innovation? The final part of the course extends the frameworks in the second module to model value capture when firms invest in the development of breakthrough innovations. We will cover a number of different game theoretical models of innovation competition, bargaining, and pricing of platform and information products.	G	9, 8, 4	focused
19682	Engineering & Public Policy	The Strategy and Management of Technological Innovation	Strategy is distinctive approaches executives use to realize firm performance goals. In this course, we will prepare you for analyzing how technology and innovation affects how executives formulate and execute strategies. This course teaches how incorporating technology and innovation into the corporate strategy of the firm can achieve profitable and sustainable competitive advantage. It addresses the role of technology management in both emerging and established firms, and examines how all of the firm's activities, assets, and relationships must complement one another in order to capture value from innovation. The course will progress in two parts. We will first cover how strategy is formulate through frameworks, models, and tools essential for those actively engaged in the innovation process within a firm and apply these to case studies illustrating their importance in technology industries. We will then cover the obstacles that prevent firms form executing the ideal strategy. In each framework we analyze during the class, we will have the following objectives: 1) Recognizing the performance metric targeted by each framework 2) Identifying the assumptions each framework makes about firm structure, the speed of market and technological change 3) Analyze the strengths and weakness of each framework 4) Apply tools suited for each framework to determine the appropriate strategy that the firm should undertake 5) Using organizational theory to recognize obstacles that prevent the firm from implementing the desired strategies and how to overcome such barriers to implementation	G	9, 12, 8	focused
19684	Engineering & Public Policy	Engineering and Technology Innovation Management in Practice	Innovation takes place inside organizations, whether it's a small company, a large corporation, a university or a government laboratory or agency. In this course, we will focus on the people who lead innovative organizations, what they do to promote and sustain innovation, and the skills and attributes they need to be successful. The instructor's experience as President of Carnegie Mellon, guest lecturers from industry and the literature will be the sources from which the course will draw. Students will gain insight into the roles they may play in contributing to and leading innovative organizations, and the skills and attributes they will need for success. 19684 is part of the Engineering and Technology Innovation Management (E&TIM) Masters Program. E&TIM students should register for the 6 unit course, reflecting the supplemental course requirements for E&TIM. Other students are welcome to enroll for the 3 unit course.	G	9, 4, 17	focused
19687	Engineering & Public Policy	Managing Research, Development and Innovation	This course considers key issues and trade-off in R&D strategy and organization, paying attention to dynamic competitive contexts where technology plays a key role. These topics are treated assuming the perspective of the decision maker. It addresses typical problems of large, medium and small firms having a structured R&D and operating businesses where R&D is the source of competitive advantages. Although we will heavily focus on R&D, emphasis is placed on viewing R&D as a part (although, a key part) of the process of technological innovation; therefore, as an activity to be strongly and appropriately integrated with other functions to make innovation successful.	G	9, 17, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
19691	Engineering & Public Policy	Special Topics: Decision-Making Methods for Innovation Management	In this course, there will be several main elements all focused around the decision-making process that corporations typically use in making decisions regarding innovation / R&D investments. This course will build upon the financial concepts that were initially discussed in Finance of Innovation Management (19-689). Specifically this course will build on the following: Basic concepts around an appropriate decision-making process that should be used for making investment decisions related to innovation management and other strategic decisions. Discussion around the framework of decision quality and how this framework is used to improve the decision-making process around innovation decisions and other strategic decisions. Discussion of decision-making under uncertainty and the use of decision analysis methods that are commonly used to make Innovation / R&D investment decisions to assess the value of potential innovation decisions. Introduction to real options theory to include discussion of various calculation methods including the Black Scholes model and the binomial model and to consider the practical issues of implementing such an evaluation methodology. Should have taken 19-689 or elementary accounting / financial management course or by permission of instructor.	G	9, 8, 17	focused
19694	Engineering & Public Policy	Leadership and Innovation Management	The attributes and skills of the contributors to innovation are important elements in the effectiveness of the innovation process and the success of the outcome. In this course, we will focus on these skills and attributes, with an emphasis on the leaders of innovation and innovative organizations. Selected literature, case studies, and guest lectures by leaders, as well as the instructor's own experience as Carnegie Mellon's eighth president, will be the sources from which the course will draw. Students will gain insight into the roles they may play in contributing to and leading innovation and organizations and the skills and attributes they will need for success.	G	9, 4, 8	focused
19697	Engineering & Public Policy	Lean Product Development	Students in Lean Product Development will explore a wide variety of tools and techniques for evaluating the feasibility of proposed new products, services, and solutions to business problems. They will work with an iterative process of: proposing solutions structuring tests to evaluate those solutions with prototypes creating the prototype efficiently and cost-effectively evaluating the effectiveness of the prototype learning from the experiment and iterating until an acceptable solution is found. There will be a strong focus on soliciting customer feedback as a basis for improvement and validation throughout the process. Students will learn prototyping techniques for addressing design, business, and technical problems. This will be a very hands-on course. Students will learn to use, and practice using, a diverse set of prototyping tools to complete their projects including computational, physical, visual design, and ethnographic tools. Students will also spend substantial time in the course practicing and developing their communication skills through written and oral presentations of their experimental results and recommendations.	G	4, 9, 8	focused
19701	Engineering & Public Policy	Introduction to the Theory and Practice of Policy Analysis	This course reviews and critically examines a set of problems, assumptions and analytical techniques that are common to research and policy analysis in technology and public policy. Topics covered include the difference between science, trans-science and policy analysis, policy problems formulated in terms of utility maximization, issues in the valuation of intangibles, uncertainty in policy analysis, selected topics in risk analysis, limitations and alternatives to the paradigm of utility maximization, issues in behavioral decision theory, issues related to organizations and multiple agents, and selected topics in policy advice and policy analysis for the federal government. The objective is to look critically at the strengths, limitations and underlying assumptions of key policy research and analysis tools and problem framing and sensitize students to some of the critical issues of taste, professional responsibility, ethics, and values that are associated with policy analysis and research.	G	4, 9, 17	focused
19702	Engineering & Public Policy	Quantitative Methods for Policy Analysis	Economic framework for identifying and analyzing investment and operation options facing agencies and firms, (both in theory and in practice); economic efficiency, utilization, pricing, and investment; and multi-objective evaluation.	G	8, 9, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
19703	Engineering & Public Policy	Special Topics: Applied Data Analysis 1	Students will gain a basic understanding of the estimation, interpretation, and diagnostic assessment of the most widely used statistical models in the social sciences. This includes: graphical and inferential statistics, multiple regression with interactions, logistic regression, multi-level models, and panel data. Assignments include six data analysis projects in R. 19703 is part 1, 19704 is part 2.	G	4, 1, 9	focused
19704	Engineering & Public Policy	Applied Data Analysis 2	Students will gain a basic understanding of the estimation, interpretation, and diagnostic assessment of the most widely used statistical models in the social sciences. This includes: graphical and inferential statistics, multiple regression with interactions, logistic regression, multi-level models, and panel data. Assignments include six data analysis projects in R. 19703 is part 1, 19704 is part 2.	G	4, 1, 9	focused
19705	Engineering & Public Policy	Workshop Applied Policy Analysis	This workshop course is about learning how to structure messy un-structured policy problems. It is designed to provide experience in setting up, analyzing, and writing about policy problems of the type that are used in the EPP Part B qualifying exam. Over the course of the semester, the class works through six or seven policy case problems. Much of the work is done in small groups. The principal focus is on integrating the qualitative and quantitative aspects of the problems and on identifying and practicing general problem-solving strategies.	G	4, 9, 17	focused
19707	Engineering & Public Policy	Special Topics: Multiple Criteria Decision Making	Problems with multiple, conflicting objectives are ubiquitous in the private and, especially, the public sector. The objective of this course is to provide an overview of the techniques for the analysis and resolution of multiple criteria decision making (MCDM) problems. Topics will include multi-objective programming, multi-attribute utility theory and several MCDM methods such as the Analytical Hierarchy Process. The emphasis will be on theory and technique, but there will be several applications to demonstrate the methods. Undergraduate students require permission of the instructor to enroll.	G	4, 6, 7	focused
19713	Engineering & Public Policy	Policies of Wireless Systems	This course will address public policy issues related to wireless systems, and to the Internet. It begins by investigating policies related to a wide variety of emerging wireless systems and technologies, including wifi computer networks, broadband to the home, broadcast radio and television, and satellite communications. This can include the government role in facilitating the creation of infrastructure, in advancing competition among broadcasters and communications service providers, in managing spectrum, and in protecting privacy and security. The course will then address Internet policy issues, which can include Internet governance and the domain name system, taxation, privacy and security, and intellectual property. Because these are inherently interdisciplinary issues, the course will include detailed discussions of technology, economics, and law, with no prerequisites in any of these areas. Note: ECE students must take this course under #18-650 only	G	9, 4, 8	focused
19714	Engineering & Public Policy	Environmental Life Cycle Assessment	Cradle-to-grave analysis of new products, processes and policies is important to avoid undue environmental harm and achieve extended product responsibility. This course provides an overview of approaches and methods for life cycle assessment and for green design of typical products and processes using the ISO 14040 family of standards. This includes goal and scoping definition, inventory analysis, life cycle impact assessment (LCIA), interpretation, and guidance for decision support. Process-based analysis models, input-output and hybrid approaches are presented for life cycle assessment. Example software such as MATLAB, Excel, and Simapro are introduced and used in assignments. A group life cycle assessment project consistent with the principles and tools of sustainability to solve real-world engineering problems is required.	G	12, 9, 13	focused
19717	Engineering & Public Policy	Sustainable Engineering Principles	This course presents an overview of the concept of sustainability, including changing attitudes and values toward technology and the environment through the late twentieth and early twenty-first centuries. Relevant issues in sustainable engineering, including population growth, urbanization, energy, water, food and material resources are discussed. Tools for sustainable engineering are presented, including metrics of sustainability, principles of design for the environment, and use of material and energy balances in sustainable systems. Publicly available data sets and computational models will be explored to assess sustainability. A team-based project is required.	G	6, 12, 7	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
19718	Engineering & Public Policy	Public Policy and Regulations	Regulations are critical in determining how our society works. How we decide to run our economy, take care of our health, and sustain our environment are all determined through regulations. Everything that you encounter on a daily basis has some regulation lurking behind the scenes. Trying to understand why things are the way they are without understanding the importance, functioning, and limits of regulatory policy is impossible. Despite their importance, regulations are not in the US Constitution. In fact, much to the dismay of some citizens, the "Administrative bureaucracy" that runs the regulatory process is often referred to as the fourth branch of government (on par with the other three: Legislative, Executive, and Judicial). This course will introduce a range of topics related regulatory policies and provide numerous case studies to motivate discussions and comprehension.	G	8, 1, 16	focused
19786	Engineering & Public Policy	Stochastic Discrete Choice Models: Estimation and Behavioral Theory	This course will cover the rational and behavioral foundations of discrete choice models, current behavioral theories, and estimation methods. Content will include an overview of the history of thinking about discrete choice models, rational foundations, behavioral theories, signal detection theory, multinomial logit, mixed logit using restricted MLE and monte-carlo simulation, and experimental design. If time permits we will cover item-response models and Bayesian methods.	G	9, 11	focused
21122	Mathematical Sciences	Integration and Approximation	Integration by trigonometric substitution and partial fractions; arclength; improper integrals; Simpson's and Trapezoidal Rules for numerical integration; separable differential equations, Newton's method, Euler's method, Taylor's Theorem including a discussion of the remainder, sequences, series, power series. Parametric curves, polar coordinates, vectors, dot product. 3 hrs lec., 2 hrs. rec.	U	7, 9, 11	focused
21124	Mathematical Sciences	Calculus II for Biologists and Chemists	This is intended as a second calculus course for biology and chemistry majors. It uses a variety of computational techniques based around the use of MATLAB or a similar system. Topics to be covered include: Integration: techniques and numerical integration. Ordinary differential equations: techniques for solving ODEs and numerical methods. Modeling with ODEs (e.g., infection, population models). Linear algebra: matrices, complex numbers, eigenvalues, eigenvectors. Systems of ordinary differential equations (if time allows: stability of differential systems). Probability: discrete and continuum probability, conditional probability and independence, limit theorems, important distributions, probabilistic models. 3 hrs. lec., 2 hrs. rec. Prerequisite: 21-112 or 21-120.	U	3, 4, 10	focused
21127	Mathematical Sciences	Concepts of Mathematics	This course introduces the basic concepts, ideas and tools involved in doing mathematics. As such, its main focus is on presenting informal logic, and the methods of mathematical proof. These subjects are closely related to the application of mathematics in many areas, particularly computer science. Topics discussed include a basic introduction to elementary number theory, induction, the algebra of sets, relations, equivalence relations, congruences, partitions, and functions, including injections, surjections, and bijections. A basic introduction to the real numbers, rational and irrational numbers. Supremum and infimum of a set. 3 hrs. lec., 2 hrs. rec.	U	4, 9	focused
21128	Mathematical Sciences	Mathematical Concepts and Proofs	This course is intended for MCS first-semester students who are interested in pursuing a major in mathematical sciences. The course introduces the basic concepts, ideas and tools involved in doing mathematics. As such, its main focus in on presenting informal logic, and the methods of mathematical proof. These subjects are closely related to the application of mathematics in many areas, particularly computer science. Topics discussed include a basic introduction to elementary number theory, induction, the algebra of sets, relations, equivalence relations, congruences, partitions, and functions, including injections, surjections, and bijections. A basic introduction to the real numbers, rational and irrational numbers. Supremum and infimum of a set. This course is a superset of 21-127, with additional out of class time devoted to proofs and additional topics in math. 3 hrs. lec., 2 hrs. rec.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
21228	Mathematical Sciences	Discrete Mathematics	The techniques of discrete mathematics arise in every application of mathematics, which is not purely continuous, for example in computer science, economics, and general problems of optimization. This course introduces two of the fundamental areas of discrete mathematics: enumeration and graph theory. The introduction to enumeration includes permutations, combinations, and topics such as discrete probability, combinatorial distributions, recurrence relations, generating functions, Ramsey's Theorem, and the principle of inclusion and exclusion. The introduction to graph theory includes topics such as paths, walks, connectivity, Eulerian and Hamilton cycles, planar graphs, Euler's Theorem, graph coloring, matchings, networks, and trees. 3 hrs. lec, 1 hr. rec.	U	4, 8, 15	focused
21235	Mathematical Sciences	Mathematical Studies Analysis I	An honors version of 21-355 for students of greater aptitude and motivation. Topics to be covered include: The Real Number System: sups and infs, completeness, integers and rational numbers. Metric spaces, normed spaces, inner product spaces and their specialization to the Euclidean space. Topological properties of metric spaces (open sets, closed sets, density, compactness, Heine-Borel Theorem). Sequences and convergence; completeness. Baire Category Theorem. Real sequences: limsup and liminf, subsequences, monotonic sequences, Bolzano-Weierstrass Theorem. Real series (criteria for convergence). Continuity, limits of functions, attainment of extrema, Intermediate Value Theorem, uniform continuity. Differentiation of functions of one variable: Chain Rule, local extrema, Mean-Value Theorems, L'Ho'pital's Rule, Taylor's Theorem. Riemann Integration: Partitions, upper and lower integrals, sufficient conditions for integrability, Fundamental Theorem of Calculus. 3 hrs. lec.	U	9, 7, 2	focused
21236	Mathematical Sciences	Mathematical Studies Analysis II	An honors version of 21-356 for students of greater aptitude and motivation. Topics to be covered include: Vector differential calculus: differentiability, partial derivatives, directional derivatives, gradients, Jacobians, the chain rule, implicit function theorem, inverse function theorem. Local extrema, constrained problems (Lagrange multipliers). Integration of differential forms: Manifolds, Differential forms (properties, differentiation, change of variables), partition of unity, integration, volume form, area form, Stokes' theorem. Sequences of Functions: Pointwise convergence, uniform convergence, Arzela-Ascoli, Weierstrass approximation theorem. Series of functions: Power series, Fourier series, orthonormal bases. 3 hrs. lec.	U	9, 13	focused
21237	Mathematical Sciences	Mathematical Studies Algebra I	An honors version of 21-373 Algebraic structures for students of greater aptitude and motivation. Abstract algebra is the study of algebraic systems by the axiomatic method, and it is one of the core areas of modern mathematics. This course is a rigorous and fast-paced introduction to the basic objects in abstract algebra. Topics to be covered include: Homomorphisms. Subgroups, cosets, Lagrange's theorem. Conjugation. Normal subgroups, quotient groups, first isomorphism theorem. Automorphisms, the automorphism group, characteristic subgroups. Group actions, Cauchy's Theorem, Sylow's theorem. Normalisers and centralisers, class equation, finite p-groups. Dihedral and alternating groups. The second and third isomorphism theorems. Simple groups, statement of Jordan-Holder theorem, semidirect product of groups. Subrings, ideals, quotient rings, first isomorphism theorem. Polynomial rings. Zorn's Lemma. Prime and maximal ideals, prime and irreducible elements. PIDs and UFDs. Noetherian domains. Hilbert Basis Theorem. Gauss' lemma. Eisenstein criterion. Field of fractions of an integral domain. k a field implies k[x] a PID, R a UFD implies R[x] a UFD. Finite fields and applications. 3 hrs. lec.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
21238	Mathematical Sciences	Mathematical Studies Algebra II	An honors version of 21-341 Linear Algebra for students of greater aptitude and motivation. Linear algebra is a crucial tool in pure and applied mathematics. This course aims to introduce the main ideas at a high level of rigour and generality. The course starts with the study of (potentially) infinite-dimensional vector spaces over an arbitrary field, continues with the theory of modules (where the role of the field is now played by an arbitrary ring), and concludes with the development of real and complex inner product spaces. Topics to be covered include: Review of fields. Review of Zorn's Lemma. Vector spaces (possibly in finite dimensional) over an arbitrary field. Independent sets, bases, existence of a basis, exchange lemma, dimension. Linear transformations, dual space. Multilinear maps, tensor product, exterior power, determinant of a transformation. Eigenvalues, eigenvectors, characteristic and minimal polynomial of a transformation, Cayley-Hamilton theorem. Review of commutative rings. R-modules. Sums and quotients of modules. Free modules. Structure theorem for fg modules over a PID and applications (Jordan and rational canonical form, structure theory of fg abelian groups). Review of real and complex numbers. Real and complex inner product spaces. Orthonormal sets, orthonormal bases, Gram-Schmidt. Examples: F^n and l^2(F) for F = R; C. Operators: Symmetric/Hermitian and Orthogonal/Unitary operators. Spectral theorem. Quadratic forms. Singular value decomposition. Possible additional topics (time permitting): applications to combinatorics, category theory, representations of finite groups, normed spaces. 3 hrs. lec.	U	9, 4, 17	focused
21240	Mathematical Sciences	Matrix Algebra with Applications	Vectors and matrices, the solution of linear systems of equations, vector spaces and subspaces, orthogonality, determinants, real and complex eigenvalues and eigenvectors, linear transformations. The course is intended for students in Economics, Statistics, Information Systems, and it will focus on topics relevant to these fields. 3 hrs. lec., 1 hr. rec.	U	4, 8, 9	focused
21241	Mathematical Sciences	Matrices and Linear Transformations	A first course in linear algebra intended for scientists, engineers, mathematicians and computer scientists. Students will be required to write some straightforward proofs. Topics to be covered: complex numbers, real and complex vectors and matrices, rowspace and columnspace of a matrix, rank and nullity, solving linear systems by row reduction of a matrix, inverse matrices and determinants, change of basis, linear transformations, inner product of vectors, orthonormal bases and the Gram-Schmidt process, eigenvectors and eigenvalues, diagonalization of a matrix, symmetric and orthogonal matrices. 21-127 is strongly recommended. 3 hrs. lec., 1 hr. rec	U	4, 9, 13	focused
21242	Mathematical Sciences	Matrix Theory	An honors version of 21-241 (Matrix Algebra and Linear Transformations) for students of greater aptitude and motivation. More emphasis will be placed on writing proofs. Topics to be covered: complex numbers, real and complex vectors and matrices, rowspace and columnspace of a matrix, rank and nullity, solving linear systems by row reduction of a matrix, inverse matrices and determinants, change of basis, linear transformations, inner product of vectors, orthonormal bases and the Gram-Schmidt process, eigenvectors and eigenvalues, diagonalization of a matrix, symmetric and orthogonal matrices, hermitian and unitary matrices, quadratic forms. 3 hrs. lec., 1 hr. rec.	U	9, 4, 13	focused
21254	Mathematical Sciences	Linear Algebra and Vector Calculus for Engineers	This course will introduce the fundamentals of vector calculus and linear algebra. The topics include vector and matrix operations, determinants, linear systems, matrix eigenvalue problems, vector differential calculus including gradient, divergence, curl, and vector integral calculus including line, surface, and volume integral theorems. Lecture and assignments will emphasize the applications of these topics to engineering problems. (Three 50 minute lectures, one 50 minute recitation)	U	9, 4	focused
21256	Mathematical Sciences	Multivariate Analysis	This course is designed for students in Economics or Business Administration. Matrix algebra: vectors, matrices, systems of equations, dot product, cross product, lines and planes. Optimization: partial derivatives, the chain rule, gradient, unconstrained optimization, constrained optimization (Lagrange multipliers and the Kuhn-Tucker Theorem). Improper integrals. Multiple integration: iterated integrals, probability applications, triple integrals, change of variables. 3 hrs lec., 1 hr rec.	U	4, 8, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
21261	Mathematical Sciences	Introduction to Ordinary Differential Equations	A first course in ordinary differential equations intended primarily for math majors and for those students interested in a more conceptual treatment of the subject. One of the goals of this course is to prepare students for upper level courses on differential equations, mathematical analysis and applied mathematics. Students will be required to write rigorous arguments. Topics to be covered: Ordinary differential equations: first and second order equations, applications, Laplace transform, systems of linear ordinary differential equations; systems of nonlinear ordinary differential equations, equilibria and stability, applications. Note: courses 21-259, or 21-268, or 21-269 are recommended. 21-128 or 15-151 can replace 21-127 as a corequisite. 3 hrs. lec., 1 hr. rec.	U	4, 9	focused
21268	Mathematical Sciences	Multidimensional Calculus	A serious introduction to multidimensional calculus that makes use of matrices and linear transformation. Results will be stated carefully and rigorously. Students will be expected to write some proofs; however, some of the deeper results will be presented without proofs. Topics to be covered include: functions of several variables, regions and domains, limits and continuity, partial derivatives, linearization and Jacobian matrices, chain rules, inverse and implicit functions, geometric applications, higher derivatives, Taylor's theorem, optimization, vector fields, multiple integrals and change of variables, Leibnitz's rule, line integrals, Green's theorem, path independence and connectedness, conservative vector fields, surfaces and orientability, surface integrals, divergence theorem and Stokes's theorem. 3 hrs. lec.	U	4, 12, 13	focused
21269	Mathematical Sciences	Vector Analysis	An honors version of 21-268 for students of greater aptitude and motivation. More emphasis will be placed on writing proofs. Topics to be covered include: basic geometry and topology of Euclidean space, curves in space, arclength, curvature and torsion, functions on Euclidean spaces, limits and continuity, partial derivatives, gradients and linearization, chain rules, inverse and implicit function theorems, geometric applications, higher derivatives, Taylor's theorem, optimization, vector fields, multiple integrals and change of variables, Leibnitz's rule, conservative and solenoidal vector fields, divergence and curl, surfaces and orientability, surface integrals, Gauss-Green theorems and Stokes's theorem. A grade of B or better in 21-242 is required. 3 hrs. lec.	U	12, 9, 13	focused
21270	Mathematical Sciences	Introduction to Mathematical Finance	This is a first course for those considering majoring or minoring in Computational Finance. The theme of this course is pricing derivative securities by replication. The simplest case of this idea, static hedging, is used to discuss net present value of a non-random cash flow, internal rate of return, and put-call option parity. Pricing by replication is then considered in a one-period random model. Risk-neutral probability measures, the Fundamental Theorems of Asset Pricing, and an introduction to expected utility maximization and mean-variance analysis are presented in this model. Finally, replication is studied in a multi-period binomial model. Within this model, the replicating strategies for European and American options are determined. 3 hrs. lec.	U	8, 6, 9	focused
21292	Mathematical Sciences	Operations Research I	Operations research offers a scientific approach to decision making, most commonly involving the allocation of scarce resources. This course develops some of the fundamental methods used. Linear programming: the simplex method and its linear algebra foundations, duality, post-optimality and sensitivity analysis; the transportation problem; the critical path method; non-linear programming methods. 3 hrs. lec., 1 hr. rec.	U	11, 4, 17	focused
21295	Mathematical Sciences	Putnam Seminar	A problem solving seminar designed to prepare students to participate in the annual William Lowell Putnam Mathematical Competition. Students solve and present their solutions to problems posed.	U	4, 17, 9	focused
21301	Mathematical Sciences	Combinatorics	A major part of the course concentrates on algebraic methods, which are relevant in the study of error correcting codes, and other areas. Topics covered in depth include permutations and combinations, generating functions, recurrence relations, the principle of inclusion and exclusion, and the Fibonacci sequence and the harmonic series. Additional topics may include existence proofs, partitions, finite calculus, generating combinatorial objects, Polya theory, codes, probabilistic methods. 3 hrs. lec	U	17, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
21325	Mathematical Sciences	Probability	This course focuses on the understanding of basic concepts in probability theory and illustrates how these concepts can be applied to develop and analyze a variety of models arising in computational biology, finance, engineering and computer science. The firm grounding in the fundamentals is aimed at providing students the flexibility to build and analyze models from diverse applications as well as preparing the interested student for advanced work in these areas. The course will cover core concepts such as probability spaces, random variables, random vectors, multivariate densities, distributions, expectations, sampling and simulation; independence, conditioning, conditional distributions and expectations; limit theorems such as the strong law of large numbers and the central limit theorem; as well as additional topics such as large deviations, random walks and Markov chains, as time permits. 3 hrs. lec.	U	4, 9, 8	focused
21329	Mathematical Sciences	Set Theory	Set theory was invented about 110 years ago by George Cantor as an instrument to understand infinite objects and to compare different sizes of infinite sets. Since then set theory has come to play an important role in several branches of modern mathematics, and serves as a foundation of mathematics. Contents: Basic properties of natural numbers, countable and uncountable sets, construction of the real numbers, some basic facts about the topology of the real line, cardinal numbers and cardinal arithmetic, the continuum hypothesis, well ordered sets, ordinal numbers and transfinite induction, the axiom of choice, Zorn's lemma. Optional topics if time permits: Infinitary combinatorics, filters and large cardinals, Borel and analytic sets of reals. 3 hrs. lec.	U	4, 9	focused
21341	Mathematical Sciences	Linear Algebra	21-341 Linear Algebra. A mathematically rigorous treatment of Linear Algebra over an arbitrary field. Topics studied will include abstract vector spaces, linear transformations, determinants, eigenvalues, eigenvectors, inner products, invariant subspaces, canonical forms, the spectral theorem and the singular value decomposition. 21-373 recommended. 3 hrs. lec.	U	4, 9	focused
21344	Mathematical Sciences	Numerical Linear Algebra	An introduction to algorithms pertaining to matrices and large linear systems of equations. Direct methods for large sparse problems including graph data structures, maximum matchings, row and column orderings, and pivoting strategies. Iterative methods including Conjugate Gradient and GMRES, with a discussion of preconditioning strategies. Additional topics include: computation of eigenvalues and eigenvectors, condition numbers, the QR and singular value decompositions, least-squares systems. (Three 50 minute lectures)	U	9, 4	focused
21366	Mathematical Sciences	Topics in Applied Mathematics	Typical of courses that might be offered from time to time are game theory, non-linear optimization, and dynamic programming. Prerequisites will depend on the content of the course. 3 hrs. lec.	U	4, 9	focused
21369	Mathematical Sciences	Numerical Methods	This course provides an introduction to the use of computers to solve scientific problems. Methods for the computational solution of linear algebra systems, nonlinear equations, the interpolation and approximation of functions, differentiation and integration, and ordinary differential equations. Analysis of roundoff and discretization errors and programming techniques. 21-268 or 21-269 are recommended rather than 21-259. 3 hrs. lec.	U	4, 9	focused
21370	Mathematical Sciences	Discrete Time Finance	This course introduces the Black-Scholes option pricing formula, shows how the binomial model provides a discretization of this formula, and uses this connection to fit the binomial model to data. It then sets the stage for Continuous-Time Finance by discussing in the binomial model the mathematical technology of filtrations, martingales, Markov processes and risk-neutral measures. Additional topics are American options, expected utility maximization, the Fundamental Theorems of Asset Pricing in a multi-period setting, and term structure modeling, including the Heath-Jarrow-Morton model. Students in 21-370 are expected to read and write proofs. 3 hrs lec.	U	4, 9, 8	focused
21371	Mathematical Sciences	Functions of a Complex Variable	This course provides an introduction to one of the basic topics of both pure and applied mathematics and is suitable for those with both practical and theoretical interests. Algebra and geometry of complex numbers; complex differentiation and integration. Cauchy's theorem and applications; conformal mapping; applications. 21-268 or 21-269 are recommended prerequisites, rather than 21-259. (Three 50 minute lectures)	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
21374	Mathematical Sciences	Field Theory	The purpose of this course is to provide a successor to Algebraic Structures, with an emphasis on applications of groups and rings within algebra to some major classical problems. These include constructions with a ruler and compass, and the solvability or unsolvability of equations by radicals. It also offers an opportunity to see group theory and basic ring theory "in action", and introduces several powerful number theoretic techniques. The basic ideas and methods required to study finite fields will also be introduced. These ideas have recently been applied in a number of areas of theoretical computer science including primality testing and cryptography. (Three 50 minute lectures)	U	4, 9, 17	focused
21378	Mathematical Sciences	Mathematics of Fixed Income Markets	A first course in fixed income. Students will be introduced to the most common securities traded in fixed income markets and the valuation methods used to price them. Topics covered include discount factors; interest rates basics; pricing of coupon bonds; identifying the yield to maturity, as well as bond sensitivities to interest rates; term structure modeling; forward and swap rates; fixed income derivatives (including mortgage backed securities) and their valuation through backwards induction; fixed income indexes and return attribution. For a co-requisite, 36-225 can be accepted as an alternative for 21-325.	U	4, 8, 1	focused
21393	Mathematical Sciences	Operations Research II	Building on an understanding of Linear Programming developed in 21-292 Operations Research I, this course introduces more advanced topics. Integer programming, including cutting planes and branch and bound. Dynamic programming. An introduction to Combinatorial Optimization including optimal spanning trees, shortest paths, the assignment problem and max-flow/min-cut. The traveling salesman problem and NP-completeness. An important goal of this course is for the student to gain experience with the process of working in a group to apply operations research methods to solve a problem. A portion of the course is devoted to a group project based upon case studies and the methods presented. 36-410 recommended. 3 hrs. lec.	U	17, 4, 15	focused
21420	Mathematical Sciences	Continuous-Time Finance	This course begins with Brownian motion, stochastic integration,and Ito's formula from stochastic calculus. This theory is used to develop the Black-Scholes option pricing formula and the Black-Scholes partial differential equation. Additional topics may include models of credit risk, simulation, and expected utility maximization. 3 hrs lec.	U	8, 9, 6	focused
21441	Mathematical Sciences	Number Theory	Number theory deals with the integers, the most basic structures of mathematics. It is one of the most ancient, beautiful, and well-studied branches of mathematics, and has recently found surprising new applications in communications and cryptography. Course contents: Structure of the integers, greatest common divisiors, prime factorization. Modular arithmetic, Fermat's Theorem, Chinese Remainder Theorem. Number theoretic functions, e.g. Euler's function, Mobius functions, and identities. Diophantine equations, Pell's Equation, continued fractions. Modular polynomial equations, quadratic reciprocity. 3 hrs. lec.	U	4, 9, 11	focused
21469	Mathematical Sciences	Computational Introduction to Partial Differential Equations	A Partial Differential Equation (PDE for short) is a differential equation involving derivatives with respect to more than one variable. These arise in numerous applications from various disciplines. Most PDEs do not have explicit solutions, and hence computational methods are essential for understanding the underlying phenomena. This course will serve as a first introduction to PDEs and their numerical approximation, and will focus on a variety of mathematical models. It will cover both analytical methods, numerical methods (e.g. finite differences) and the use of a computer to approximate and visualize solutions. The mathematical ideas behind phenomena observed in nature will be studied at the theoretical level and in numerical simulations (e.g. speed of wave propagation, and/or shocks in traffic flow). Topics will include: Derivation of PDEs from physical principles, analytical and computational tools for the transport equation and the Poisson equation, Fourier analysis, analytical and numerical techniques for the solution of parabolic equations and if time permits, the wave equation. 3 hr. lect. 80 min. rec.	U	11, 9, 10	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
21484	Mathematical Sciences	Graph Theory	Graph theory uses basic concepts to approach a diversity of problems and nontrivial applications in operations research, computer science and other disciplines. It is one of the very few mathematical areas where one is always close to interesting unsolved problems. Topics include graphs and subgraphs, trees, connectivity, Euler tours and Hamilton cycles, matchings, graph colorings, planar graphs and Euler's Formula, directed graphs, network flows, counting arguments, and graph algorithms. 3 hrs. lec.	U	17, 9, 10	focused
21590	Mathematical Sciences	Practicum	Students in this course gain experience with the application of mathematical models to business and/or industrial problems during an internship. The internship is set up by the student in consultation with a faculty member. The students must also have a mentor at the firm providing the internship, who together with the faculty member develops a description of the goals of the internship. The internship must include the opportunity to learn about problems which have mathematical content.	U	4, 9, 17	focused
21599	Mathematical Sciences	Undergraduate Reading and Research	Individual reading courses or projects in mathematics and its applications. Prerequisites and units to be negotiated with individual instructors.	U	4, 17, 9	focused
21602	Mathematical Sciences	Introduction to Set Theory I	First order definability and the Zermelo-Fraenkel axioms; cardinal arithmetic, ordered sets, well-ordered sets (axiom of choice), transfinite induction, the filter of closed unbounded sets (Fodor, Ulm and Solovay's theorems), Delta systems, basic results in partition calculus (e.g., Ramsey's Theorem and the Erdos-Rado Theorem); small to medium large cardinals; applications to general topology (e.g., Alexandroff's conjecture), and the basic ideas of descriptive set theory. The independence of Suslin conjecture from the usual axioms. Godel's axiom of constructibility. Time permitting, the Galvin-Hajnal-Shelah inequality will be proved. 3 hrs. lec.	G	10, 1, 9	focused
21603	Mathematical Sciences	Model Theory I	Similarity types, structures; downward Lowenheim Skolem theorem; construction of models from constants, Henkin's omitting types theory, prime models; elementary chains of models, basic two cardinal theorems, saturated models, basic results on countable models including Ryll-Nardzewski's theorem; indiscernible sequences, Ehrenfeucht-Mostowski models; introduction to stability, rank functions, primary models, and a proof of Morley's catagoricity theorem; basic facts about infinitary languages, computation of Hanf-Morley numbers.	G	4, 9	focused
21623	Mathematical Sciences	Complex Analysis	The complex plane, holomorphic functions, power series, complex integration, and Cauchy's Theorem. Calculus of residues. Additional topics may include conformal mappings and the application of complex transforms to differential equations. (Three 50 minute lectures)	G	7, 6, 14	focused
21630	Mathematical Sciences	Ordinary Differential Equations	Basic concepts covered are existence and uniqueness of solutions, continuation of solutions, continuous dependence, and stability. For autonomous systems, topics included are: orbits, limit sets, Liapunov's direct method, and Poincar-Bendixson theory. For linear systems, topics included are: fundamental solutions, variation of constants, stability, matrix exponential solutions, and saddle points. Time permitting, one or more of the following topics will be covered: differential inequalities, boundary-value problems and Sturm-Liouville theory, Floquet theory.	G	10, 9, 1	focused
21632	Mathematical Sciences	Introduction to Differential Equations	This course serves as a broad introduction to Ordinary and Partial Differential Equations for beginning graduate students and advanced undergraduate students in mathematics, engineering, and the applied sciences. Mathematical sophistication in real analysis at the level of 21-355/356 is assumed. Topics include: essentials of Ordinary Differential Equations, origins of Partial Differential Equations, the study of model problems including the Poisson and Laplace equations, the heat equation, the transport equation, and the wave equation. 3 hrs. lec.	G	4, 9, 17	focused
21651	Mathematical Sciences	General Topology	Metric spaces: continuity, compactness, Arzela-Ascoli Theorem, completeness and completion, Baire Category Theorem. General topological spaces: bases and subbases, products, quotients, subspaces, continuity, topologies generated by sets of functions, homeomorphisms. Convergence: nets, filters, and the inadequacy of sequences. Separation: Hausdorff spaces, regular spaces, completely regular spaces, normal spaces, Urysohn's Lemma, Tietze's Extension Theorem. Connectedness. Countability conditions: first and second countability, separability, Lindelof property. Compactness: Tychonoff's Theorem, local compactness, one-point compactification. 3 hrs. lec.	G	9, 2	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
21681	Mathematical Sciences	Stochastic Calculus in Finance	This is a graduate-level introduction to continuous-time equilibrium asset pricing models. Using tools from Ito calculus, the first part of the course covers the benchmark case of complete, frictionless markets, for which a fairly general theory and a number of solvable examples have been developed. The second part of the course then provides an overview of cutting-edge research on extensions of the baseline model that account for "flaws and frictions" such as heterogeneous beliefs, trading costs, or asymmetric information. In the third part of the course, students will present a related research paper, chosen together with the instructor in accordance with their background and research interests. (One 80 minute lecture)	G	4, 8, 17	focused
21690	Mathematical Sciences	Methods of Optimization	An introduction to the theory and algorithms of linear and nonlinear programming with an emphasis on modern computational considerations. The simplex method and its variants, duality theory and sensitivity analysis. Large-scale linear programming. Optimality conditions for unconstrained nonlinear optimization. Newton's method, line searches, trust regions and convergence rates. Constrained problems, feasible-point methods, penalty and barrier methods, interior-point methods.	G	9, 1	focused
21703	Mathematical Sciences	Model Theory II	The course concentrates in what is considered "main stream model theory" with is Shelah's classification theory (known also as Stability). Among the topics to be presented are stability, superstability, the theory of various notions of primeness, rank functions, forking calculus, the stability spectrum theorem, finite equivalence relations theorem, stable groups (up to and including the Macintyre-Cherlin-Shelah theorem on super-stable fields), and some elementary geometric model theory. If time permits also: basic facts about infinitary languages, computation of Hanf-Morley numbers; some of the Ax-Kochen-Ershov theory of model theory for fields with valuations (will apply this to solve Artin's conjecture). (Three 50 minute lectures)	G	4, 8	focused
21720	Mathematical Sciences	Measure and Integration	The Lebesgue integral, absolute continuity, signed measures and the Radon-Nikodym Theorem, Lp spaces and the Riesz Representation Theorem, product measures and Fubini's Theorem.	G	9, 6	focused
21721	Mathematical Sciences	Probability	Probability spaces, random variables, expectation, independence, Borel-Cantelli lemmas. Kernels and product spaces, existence of probability measures on infinite product spaces, Kolmogorov's zero-one law. Weak and strong laws of large numbers, ergodic theorems, stationary sequences. Conditional expectation: characterization, construction and properties. Relation to kernels, conditional distribution, density. Filtration, adapted and predictable processes, martingales, stopping times, upcrossing inequality and martingale convergence theorems, backward martingales, optional stopping, maximal inequalities. Various applications of martingales: branching processes, Polya's urn, generalized Borel-Cantelli, Levy's 0-1 law, martingale method, strong law of large numbers, etc. Weak convergence of probability measures, characteristic functions of random variables, weak convergence in terms of characteristic functions. Central limit theorem, Poisson convergence, Poisson process. Large deviations, rate functions, Cramer's Theorem.	G	10, 1, 9	focused
21723	Mathematical Sciences	Advanced Real Analysis	This course is a sequel to 21-720 (Measure and Integration). It is meant to introduce students to a number of important advanced topics in analysis.Topics include: distributions, Fourier series and transform, Sobolev spaces, Bochner integration, basics of interpolation theory, integral transforms. 3 hrs. lec.Prerequisites: 21-720 Corequisites: 21-640	G	4, 9	focused
21737	Mathematical Sciences	Probabilistic Combinatorics	This course covers the probabilistic method for combinatorics in detail and introduces randomized algorithms and the theory of random graphs. Methods covered include the second moment method, the Rödl nibble, the Lovász local lemma, correlation inequalities, martingale's and tight concentration, Janson's inequality, branching processes, coupling and the differential equations method for discrete random processes. Objects studied include the configuration model for random regular graphs, Markov chains, the phase transition in the Erdős-Rényi random graph, and the Barabási-Albert preferential attachment model. (Three 50 minute lectures)	G	10, 1, 5	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
21765	Mathematical Sciences	Introduction to Parallel Computing and Scientific Computation	Course objectives: to develop structural intuition of how the hardware and the software work, starting from simple systems to complex shared resource architectures; to provide guidelines about how to write and document a software package; to familiarize the audience with the main parallel programming techniques and the common software packages/libraries. (One 110 minute lecture)	G	9, 4	focused
21801	Mathematical Sciences	Advanced Topics in Discrete Mathematics	Content varies. May be taken more than once if content is sufficiently different.	G	4, 9	focused
24101	Mechanical Engineering	Fundamentals of Mechanical Engineering	The purpose of this course is to introduce the student to the field of mechanical engineering through an exposition of its disciplines, including structural analysis, mechanism design, fluid flows, and thermal systems. By using principles and methods of analysis developed in lectures, students will complete two major projects. These projects will begin with conceptualization, proceed with the analysis of candidate designs, and culminate in the construction and testing of a prototype. The creative process will be encouraged throughout. The course is intended primarily for CIT first year students.	U	4, 9	focused
24104	Mechanical Engineering	Maker Series: Intro to Modern Making	This course teaches the safe operation of fabrication tools, including 3D printer, laser cutter-engraver machine, and soldering through structured hands-on activities. A significant portion of the course is dedicated to learning SolidWorks 3D CAD software and Arduino microcontroller for integrating physical computing into prototypes. The acquisition of these skills culminates in the development and fabrication of a prototype that solves a real-world problem. 3-unit mini (7-weeks)	U	4, 9, 8	focused
24105	Mechanical Engineering	Special Topics: Maker Series: Intro to Laser Cutting & Engraving	This course teaches the safe operation of the laser cutter-engraver machine through structured hands-on activities. A significant portion of this course is dedicated to learning joinery, color mapping, and material selection for prototyping. Homework assignments are important for reinforcement of skills learned, and are flexible for students to complete guided or self-directed projects. 1-unit micro (2-weeks)	U	4, 9, 8	focused
24200	Mechanical Engineering	Maker Series: Intro to Manual Machining	This course teaches safe operation of manual machining equipment through structured hands-on activities. A significant portion of the course is dedicated to learning subtractive manufacturing, the industrial standard for the mass manufacture of products around the world. The skills learned in this course can be applied to fabricate durable components for design projects, research equipment, and extracurricular activities. 1-unit mini (7-weeks)	U	9, 4, 8	focused
24202	Mechanical Engineering	Introduction to Computer Aided Design	This course expands upon the knowledge of basic model, assembly, and drawing generation using SolidWorks 3D CAD software. Topics include structural analysis, flow analysis, motion analysis, global variables, equations, 3D visualization, and GD&T through guided activities. 1-unit mini (7-weeks)	U	9, 4, 8	focused
24204	Mechanical Engineering	Special Topics: Maker Series: Intro to Metal Jewelry	This course teaches introductory level metal jewelry fabrication. Students will learn to safely use various tools and metal working techniques including cold forging, investment casting, bezel settings, soldering, and patinas. These will be taught in class and reinforced by homework through structured activities to create their own personal jewelry, such as earrings, pendants, and rings. Upon completion of this class, students will be familiar with the Metals Room in TechSpark, and will be have access to the facility for future use. Materials fee will be required. Spaces are limited. 3-unit Mini (6 weeks).	U	4, 9, 8	focused
24205	Mechanical Engineering	Special Topics: Maker Series: Intro to Welding	This course teaches the safe operation of MIG welding equipment through structured hands-on activities. A significant portion of the course is dedicated to learning workpiece setup, material selection, and quality assessment for building structures. Homework assignments are important for reinforcement of skills learned, and are flexible for students to complete guided or self-directed projects. 1-unit micro (2-weeks)	U	4, 9, 8	focused
24206	Mechanical Engineering	Special Topics: Maker Series: Intro to Wood Working	This course teaches the safe operation of wood working equipment, including table saw, panel saw, and miter saw through structured hands-on activities. A significant portion of the course is dedicated to learning optimal workflow, tool selection, and equipment selection for building structures. Homework assignments are important for reinforcement of skills learned, and are flexible for students to complete guided or self-directed projects. 1-unit micro (2-weeks)	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
24207	Mechanical Engineering	Special Topics: Maker Series: Intro to CNC Router	This course teaches the safe operation of a CNC router machine through structured hands-on activities. A significant portion of the course is dedicated to software for fabrication of 2D and 3D parts. Homework assignments are important for reinforcement of skills learned, and are flexible for students to complete guided or self-directed projects. 1-unit micro (2-weeks)	U	4, 9, 8	focused
24210	Mechanical Engineering	Special Topics: Maker Series: Inventive Projects	This course supports students in pursuing a self-defined project. Students will apply their preexisting access to equipment towards prototyping an inventive project, either as an individual or a group member. Students will receive weekly one-on-one consultations with the instructor to conduct project planning, design for fabrication, prototype testing, and more. This course is useful for students interested in initiating, progressing, and/or completing a prototyping project for research, student orgs, entrepreneurship, hobbies, or other interests.	U	4, 9, 17	focused
24221	Mechanical Engineering	Thermodynamics	Temperature and thermometry; equations of state for fluids and solids; work, heat, and the first law; internal energy, enthalpy, and specific heats; energy equations for flow; change of phase; the second law, reversibility, absolute temperature, and entropy; combined first and second laws; availability; power and refrigeration cycles. Applications to a wide range of processes and devices. 3 hrs. lec., 1 hour recitation	U	7, 13, 6	focused
24231	Mechanical Engineering	Fluid Mechanics	Hydrostatics. Control volume concepts of mass, momentum, and energy conservation. Euler's and Bernoulli's equations. Viscous flow equations. Head loss in ducts and piping systems. Dimensional analysis and similitude as an engineering tool. Measurement techniques. 3 hrs. lec., 1 hr. rec.	U	15, 7, 14	focused
24261	Mechanical Engineering	Statics	This course is the first in a two-semester sequence on the solid mechanics of engineering structures and machines. The course begins with a review of the statics of rigid bodies, which includes the identification of statically indeterminate problems. Two- and three-dimensional statics problems are treated. Thereafter, the course studies stresses and deflections in deformable components. In turn, the topics covered are: simple tension, compression, and shear; thin-walled pressure vessels; torsion; and bending of beams. For each topic, statically indeterminate problems are analyzed and elementary considerations of strength are introduced. 3 hrs. lec., 1 hr. rec./lab.	U	9, 4	focused
24262	Mechanical Engineering	Stress Analysis	This course is the second in a two-semester sequence on the solid mechanics of engineering structures and machines. The basic topics of uniaxial tension/compression, torsion, and flexural deformation from 24-261 are reviewed. Combined loadings and stresses are then treated, which lead to a consideration of failure criteria. Two-dimensional elasticity and the finite element method are introduced. Stress concentrations are quantified analytically, numerically, and with the use of engineering handbooks. Cyclic failure criteria are introduced, and both static and cyclic failure criteria are applied to results from numerical analysis. 3 hrs. lec., 1 hr. rec./lab.	U	9, 4, 8	focused
24280	Mechanical Engineering	Special Topics: C++ Programming for Engineers	Using the C++ programming language as a platform, this course serves as an intermediate-level programming course with a strong emphasis on software requirements for engineering applications. Students will refine and enhance their coding skills while applying their mathematical, analytical and design backgrounds. Topics covered include data structures, algorithm design, numerical computation, modular programming, data modeling, interactive graphics, object-orientation, and user interfaces, all in an engineering-specific domain.	U	4, 9, 8	focused
24281	Mechanical Engineering	Introduction to Scientific Computing	This course provides an introduction to scientific computing with Matlab for engineers. The course introduces the basics of Matlab syntax and programming, data analysis, visualization, curve fitting and interpolation, symbolic computation, differential equations, and debugging. The use of Matlab in solving mechanical engineering applications will be demonstrated.	U	9, 4	focused
24282	Mechanical Engineering	Special Topics: Linear Algebra and Vector Calculus for Engineers	This course will introduce the fundamentals of vector calculus and linear algebra. The topics include vector and matrix operations, determinants, linear systems, matrix eigenvalue problems, vector differential calculus including gradient, divergence, curl, and vector integral calculus including integral theorems. Lecture and assignments will emphasize the applications of these topics to engineering problems. The content covered in 24-281 Introduction to Scientific Computing will be a part of this course. Student evaluation will include weekly homework assignments (requiring both written answers as well as Matlab scripts), two midterms and a final exam.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
24291	Mechanical Engineering	Special Topics: Environmental Systems on a Changing Planet	This course introduces the interconnected Earth systems that regulate our climate and ecosystems, providing the resources required to sustain all life, including human societies. Environmental systems are the fascinating connections between the oceans, atmosphere, continents, ecosystems, and people that provide our planet with resources that all life depends on. Human activities disrupt these natural systems, posing critical threats to the sustainable functioning of environmental systems. The course will explore how solar and biochemical energy moves through the Earth's interconnected systems, recycling nutrients; how complex environmental systems function to produce critical resources such as food and water; and how human activities interfere with environmental systems. Case studies include the interplay between climate change feedbacks, wildfires, and forest ecosystems; the hazards that everyday chemical toxins pose to ecosystems and human health and reproduction; and growing threats to ecosystem health and biodiversity. We will also develop the environmental, scientific, and information literacy required to understand current environmental issues that are frequently debated in the public sphere. This course draws on principles learned in high school science and satisfies the science requirement for the interdisciplinary Minor in Environmental and Sustainability Studies.	U	12, 13, 7	focused
24292	Mechanical Engineering	Renewable Energy Engineering	Introduction to engineering principles of various renewable energy systems, including the following topics: background on climate change and carbon sequestration, engineering analysis of renewable energy systems such as solar photovoltaic, (solar thermal), wind power, hydropower, wave energy, bio mass energy, geothermal energy, and hydrogen based fuel cells. In addition, transitional energy systems such as nuclear power and advanced combined cycles will be introduced. Both engineering performance and present state of development will be discussed. Students will review and present their progress on various subjects, which will be selected based on personal interest.	U	7, 13, 8	focused
24300	Mechanical Engineering	Fundamentals of CNC Machining	This course expands upon basic machining principles gained in 24-200 to translate into automated machining. Topics covered include advanced fixturing, CAM programming using Mastercam X7 to produce toolpaths for automated machining and set up and operation of 3 axis vertical CNC machining centers. This course will focuss on the programming of these machine tools using geometry from CAD data. Students learn in this course how to do part orientation, plan operation ordering, tool selection, speeds and feeds, cut verification, and to assign all of the above to a specific geometry in the CAD model. Both 2½D and 3D machining will be practiced. 24-200 Machine Shop Practice is a pre-requisite for this course.	U	4, 9, 17	focused
24302	Mechanical Engineering	Mechanical Engineering Seminar I	The purpose of this course is to help students develop good presentation skills and to provide a forum for presentations and discussions of professional ethics. Students will make at least two presentations, one of which is related to professional ethics. Student grades will be based on their presentation skills and their participation in class discussions. 1 hr. rec. Prerequisites: Junior standing or permission of instructor	U	4, 17, 9	focused
24311	Mechanical Engineering	Numerical Methods	Use of numerical methods for solving engineering problems with the aid of a digital computer. The course will contain numerical methods such as roots of equations, linear algebraic equations, optimization, curve fitting, integration, and differential equation solving. MATLAB will be used as the programming language. Programming cluster laboratory times will be available twice a week. Problems will be drawn from all fields of interest to mechanical engineers. 3 hrs. lecture plus lab	U	9, 4	focused
24322	Mechanical Engineering	Heat Transfer	Introduction to basic concepts of engineering heat transfer. Steady and transient heat conduction in solids, including the effect of heat generation. Finned surfaces. Correlation formulas for forced and free convection, condensation, and boiling. Design and analysis of heat exchangers. Radiation heat transfer. Problems in combined convection and radiation. Measurement techniques. 3 hrs. lec., 1 hr. recitation.	U	9, 6	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
24351	Mechanical Engineering	Dynamics	This first course on the modeling and analysis of dynamic systems concentrates on the motion of particles, systems of particles, and rigid bodies under the action of forces and moments. Topics include the kinematics of motion in rectangular, polar, and intrinsic coordinates; relative motion analysis with multiple reference frames; and planar kinetics through the second law, work-energy method, and impulse-momentum method. Time and frequency domain solutions to first and second order equations of motion are discussed. 3 hrs. lec. 1 hr rec.	U	7, 13, 9	focused
24354	Mechanical Engineering	Gadgetry: Sensors, Actuators, and Processors	This course will introduce the components used in mechatronic design. Topics include microcontrollers, circuit design and analysis, and sensors and actuators commonly used in mechatronic systems. The course will contain a substantial hands-on component in which students will program microcontrollers to read sensors and drive actuators.	U	4, 9, 2	focused
24358	Mechanical Engineering	Culinary Mechanics	This course discusses how mechanical quantities and processes such as force, motion, and deformation influence food and the culinary arts. The aim of the course is to apply important aspects of mechanics to ideas in cooking. Specific topics include: (1) how do stress and strain affect food and its perceived taste; (2) what is the role of cell mechanics in the resulting micro structure of both consumed plant and animal tissues; (3) how can mechanics be used to alter nutrition; (4) what are the roles of common and uncommon mechanical tools such as a knife or mortar and pestle in food preparation. Emphasis will be placed on the biomechanics of edible matter across multiple length scales, including at the tissue, cellular, and molecular levels; additionally, impact on global health and engineering implications will be elucidated. During this course, we will introduce you to these concepts,train you to use them in real world applications, and allow you to pursue a creative group-defined project, which will be shared in both written and oral formats. We will integrate a hands-on kitchen experience in at least 3 specific laboratory classes so that students will get a true feel and understanding for culinary mechanics. We also will be visiting the restaurant of at least one first-rate Pittsburgh chef to gain real world insight into mechanics and cooking.	U	4, 9, 2	focused
24370	Mechanical Engineering	Engineering Design I: Methods and Skills	In this course, students will learn methods and skills for the engineering design process, consisting of four stages: concept design, detail design, analysis, and manufacturing. The course covers the engineering design process in a holistic fashion by discussing theories and practices of the four stages and inter-relating them. Hands-on assignments, including computational and physical projects, are given to enhance the learning outcome. After taking this course, students will be able to: express ideas in sketches; interpret and create engineering drawings; select and apply machine elements; model detailed shapes with CAD tools; analyze product performance with CAE tools; choose materials and manufacturing schemes, and create and test prototypes. Recommended: 24-200 (machine shop practice).	U	9, 4, 8	focused
24371	Mechanical Engineering	Special Topics: Design of Machine Elements	In this class, the students will gain an understanding of the best practices in the design of machine elements such as shafts, gears, power screws, fasteners, brakes/couplings, flywheels, bearings, etc. The course material consists of the study of stress and deflection under common loading conditions, effect of material properties, static and fatigue failure models, cost considerations, and manufacturability in the context of the machine components. Student learning will be achieved through interactive lectures on underlying technical approaches in conjunction with a group project where students will be required to design and fabricate an ensemble of machine elements. Students will also learn about the strong connections between theory, analytical methods, available computational tools, and field design. Assessment of the learning objectives will happen via homework, class exams, and demonstration of the group project. This course builds upon the skills and methods taught in Design-I (24-370) and will help students prepare to enter the modern workplace where mechanical design takes place.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
24390	Mechanical Engineering	Mechanical Engineering Co-op	The Department of Mechanical Engineering at Carnegie Mellon considers practical learning opportunities important educational options for its undergraduate students. One such option is cooperative education, which provides a student with an extended work experience with a company or government institution. To participate, students must possess at least junior status and have an overall grade point average of 3.0 or above. Students must complete a Co-Op Approval Form and submit it for approval. If the application is approved, the course will be added to the student's schedule and the student will be assessed tuition for 0 units for each semester that the student participates. All co-ops must be approximately 5-8 months in uninterrupted length. Upon completion of the co-op experience, students must submit a 1-2 page report of their work experience, and a 1-2 page evaluation from the company supervisor to the ME Undergraduate Education Committee. If the reports are approved, a "P" grade will be assigned. International students should contact their academic advisor for additional information. Prerequisite: Special permission required	U	4, 9, 1	focused
24391	Mechanical Engineering	Mechanical Engineering Project	Practice in the organization, planning, and execution of appropriate engineering projects. These investigations may be assigned on an individual or a team basis and in most cases will involve experimental work.	U	9, 17, 4	focused
24392	Mechanical Engineering	Mechanical Engineering Project	Practice in the organization, planning, and execution of appropriate engineering projects. These investigations may be assigned on an individual or a team basis and in most cases will involve experimental work.	U	9, 17, 4	focused
24424	Mechanical Engineering	Energy and the Environment	Fuel cycles for conventional and non-conventional energy resources; relationships between environmental impacts and the conversion or utilization of energy; measures of system and process efficiency; detailed study and analysis of coal-based energy systems including conventional and advanced power generation, synthetic fuels production, and industrial processes; technological options for multi-media (air, water, land) pollution control; mathematical modeling of energy-environmental interactions and tradeoffs and their dependency on technical and policy parameters; methodologies for energy and environmental forecasting; applications to issues of current interest. Junior or Senior standing in CIT or permission of instructor. 3 hrs lecture	U	6, 7, 13	focused
24425	Mechanical Engineering	Combustion and Air Pollution Control	Formation and control of gaseous and particulate air pollutants in combustion systems. Basic principles of combustion, including thermochemical equilibrium, flame temperature, chemical kinetics, hydrocarbon chemistry, and flame structure. Formation of gaseous and particulate pollutants in combustion systems. Combustion modifications and post-combustion technologies for pollutant control. Relationship between technology and regional, national, and global air pollution control strategies. The internal combustion engine and coal-fired utility boiler are used as examples. 3 hours lecture Cross listed as 24-740 and 19440/19-740	U	13, 6, 9	focused
24428	Mechanical Engineering	Computational Analysis of Transport Phenomena	In this course, students will develop basic understanding and skill sets to perform simulations of transport phenomena (mass, momentum, and energy transport) for engineering applications using a CAE tool, learn to analyze and compare simulation results with theory or available data, and develop ability to relate numerical predictions to behavior of governing equations and the underlying physical system. First 8 weeks of the course will include lectures and simulation-based homework assignments. During last 7 weeks, teams of students will work on self-proposed projects related to computational analysis of transport phenomena. In the project, students will learn to approach loosely defined problems through design of adequate computational mesh, choice of appropriate numerical scheme and boundary conditions, selection of suitable physical models, efficient utilization of available computational resources etc. Each team will communicate results of their project through multiple oral presentations and a final written report. Detailed syllabus of the course is provided on the URL given below.	U	7, 4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
24441	Mechanical Engineering	Engineering Design II: Conceptualization and Realization	This course guides students through the design process in the applied design of a practical mechanical system. Lectures describe the typical design process and its associated activities, emphasizing methods for innovation and tools for design analysis. Professional and ethical responsibilities of designers, interactions with clients and other professionals, regulatory aspects, and public responsibility are discussed. The design project is typically completed in teams and is based on a level of engineering knowledge expected of seniors. Proof of practicality is required in the form of descriptive documentation. Frequently, a working model will also be required. Oral progress reports and a final written and oral report are required. 3 hrs. rec., 3 hrs lab Senior standing and Machine Shop Practice 24-200 required.	U	9, 4, 17	focused
24452	Mechanical Engineering	Mechanical Systems Experimentation	Experimentation in dynamic systems and controls. The course will cover translational and rotational systems. Topics will include mechanical elements, natural frequencies, mode shapes, free and forced response, frequency response and Bode plots, time constants, transient response specifications, feedback controls such as PID control, and stability for single-degree-of-freedom and multi-degree-freedom systems. The course will introduce and use state-of-the-art experimentation hardware and software. 24-352 Dynamic Systems and Controls- prerequisite- MSE is a fall only senior course.	U	16, 9, 4	focused
24480	Mechanical Engineering	Special Topics: Artificial Intelligence and Machine Learning for Engineering	This course introduces algorithms that are at the center of modern day artificial intelligence (AI) and machine learning (ML) techniques. The course takes an engineering-focused approach to AIML by investigating the wide array of sources of data available in the world, how these sources generate data, and algorithms and methods that are used to transform this data into knowledge/insights.	U	4, 9	focused
24491	Mechanical Engineering	Department Research Honors	This course is designed to give students increased exposure to "open-ended" problems and research type projects. It involves doing a project on a research or design topic and writing a thesis describing that project. The project would be conducted under the supervision of a mechanical engineering faculty member (the advisor), and must be approved by the advisor before inception. This course can be taken at any time after the Junior year and before graduation which includes the summer after the Junior year. Completion of 18 units of this course with a grade of B or better is a partial fulfillment of the requirements for Departmental Research Honors.	U	4, 17, 9	focused
24492	Mechanical Engineering	Department Research Honors	This course is designed to give students increased exposure to "open-ended" problems and research type projects. It involves doing a project on a research or design topic and writing a thesis describing that project. The project would be conducted under the supervision of a mechanical engineering faculty member (the advisor), and must be approved by the advisor before inception. This course can be taken at any time after the Junior year and before graduation which includes the summer after the Junior year. Completion of 18 units of this course with a grade of B or better is a partial fulfillment of the requirements for Departmental Research Honors.	U	4, 17, 9	focused
24623	Mechanical Engineering	Molecular Simulation of Materials	The purpose of this course is to expose engineering students to the theory and implementation of numerical techniques for modeling atomic-level behavior. The main focus is on molecular dynamics and Monte Carlo simulations. Students will write their own simulation computer codes, and learn how to perform calculations in different thermodynamic ensembles. Consideration will be given to heat transfer, mass transfer, fluid mechanics, mechanics, and materials science applications. The course assumes some knowledge of thermodynamics and computer programming. 4 hrs lec.	G	4, 9, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
24626	Mechanical Engineering	Air Quality Engineering	The course provides a quantitative introduction to the processes that control atmospheric pollutants and the use of mass balance models to predict pollutant concentrations. We survey major processes including emission rates, atmospheric dispersion, chemistry, and deposition. The course includes discussion of basic atmospheric science and meteorology to support understanding air pollution behavior. Concepts in this area include vertical structure of the atmosphere, atmospheric general circulation, atmospheric stability, and boundary layer turbulence. The course also discusses briefly the negative impacts of air pollution on society and the regulatory framework for controlling pollution in the United States. The principles taught are applicable to a wide variety of air pollutants but special focus is given to tropospheric ozone and particulate matter. The course is intended for graduate students as well as advanced undergraduates. It assumes a knowledge of mass balances, fluid mechanics, chemistry, and statistics typical of an undergraduate engineer but is open to students from other scientific disciplines. 12 units	G	13, 4, 6	focused
24631	Mechanical Engineering	Thermal Design	This course guides students through the design process of a practical thermal system. The course plan assumes a mastery of the fundamentals of thermodynamics, fluid mechanics and heat transfer at the undergraduate level. Lectures aim at design aspects and analysis techniques commonly used in the development of thermal systems. Lecture topics include heat sinks, heat pipes, compact heat exchangers, sensors and instrumentation, thermoelectric devices, and special topics closely related to the theme of the design activity for the semester. Design activity is conducted in teams and includes several cycles of oral presentations, class discussions, and a final written report. System design and analysis of performance are heavily based on computer-added design tools and simulation means. Student performance in this course is evaluated based on individual homework assignments on the various topics presented in class and on a team design project.	G	4, 9, 17	focused
24632	Mechanical Engineering	Special Topics: Additive Manufacturing Processing and Product Development	Introduction to additive manufacturing (AM) processing fundamentals and applications using Solidworks 3-D CAD software and a variety of polymer and metal AM machines. Includes a brief history of AM processing, a review of and technical fundamentals of current AM processes, a study of the current AM market, and future directions of the technology. Lab Sessions will support an open-ended product development project. Lectures on metals AM will address current research impacting industry. Students will also perform a literature review of papers on the state of the art. Basic Solidworks knowledge required.	G	9, 4, 17	focused
24635	Mechanical Engineering	Structural Analysis	Classical and matrix-based methods of structural analysis; energy principles in structural mechanics. Basic concepts of force and displacement methods for analyzing redundant structural systems. Matrix methods utilizing the flexibility (force) and stiffness (displacement) concepts.	G	7, 13, 9	focused
24636	Mechanical Engineering	Energy Modalities in Biology and Medicine	This course covers a wide range of energy-based applications in biology and medicine, such as cancer treatments by cryosurgery (freezing), thermal ablation (heating), photodynamic therapy (light-activated drugs), and irreversible electroporation (a non-thermal electrical application). This course also covers thermal regulation in humans and other mammals, as well as cryopreservation (low-temperature preservation) of tissues and organs for the benefit of organ banking and transplant medicine. The course combines lectures and individual assignments relating to the underlying principles of engineering, with teamwork on open-ended projects relating to concurrent challenges at the convergence of engineering and medical sciences. The course plan assumes a mastery of the fundamentals of heat transfer at the undergraduate level.	G	3, 7, 15	focused
24643	Mechanical Engineering	Energy Storage Materials and Systems	Contemporary energy needs require large scale electrochemical energy conversion and storage systems. Batteries are playing a prominent role in portable electronics and electric vehicles. This course introduces principles and mathematical models of electrochemical energy conversion and storage. Students will study thermodynamics, reaction kinetics pertaining to electrochemical reactions, phase transformations relating to batteries. This course includes applications to batteries, fuel cells, supercapacitors	G	7, 4, 13	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
24650	Mechanical Engineering	Applied Finite Element Analysis	This is an introductory course on the finite element method with emphasis on application of the method to a wide variety of problems. The theory of finite element analysis is presented and students learn various applications of the method through assignments utilizing standard finite element software packages commonly used in industry. Various types of analyses are considered, which may include, for example, static, pseudo-static, dynamic, modal, buckling, contact, heat transfer, thermal stress and thermal shock. Students also learn to use a variety of element types in the models created, such as truss, beam, spring, solid, plate, and shell elements.	G	4, 9, 8	focused
24653	Mechanical Engineering	Special Topics: Materials and Their Processing for Mechanical Engineers	The study of the major classes of materials (e.g., metals, alloys, ceramics, polymers, composites) and their structure-processing-property relationships is integral to many engineering disciplines. This course will introduce the fundamental concepts behind how the processing of materials influences their atomic/molecular structures and resulting properties. The course will adopt a game-based learning approach in which students will utilize the virtual Minecraft environment to study crystal structures, imperfections (defects), diffusion, and phase equilibria. These concepts are then applied to characterize and interpret the (mechanical, electrical, magnetic, and optical) properties of various material systems as part of a final collaborative group project.	G	4, 9, 17	focused
24663	Mechanical Engineering	Special Topics: Biomechanics of Human Movement	This course provides an overview of the mechanical principles underlying human movement biomechanics and the experimental and modeling techniques used to study it. Specific topics will include locomotion, motion capture systems, force plates, muscle mechanics, musculoskeletal modeling, three dimensional kinematics, inverse dynamics, forward dynamic simulations, and imaging-based biomechanics. Homework and final class projects will emphasize applications of movement biomechanics in orthopedics, rehabilitation, and sports. ***Students are expected to have knowledge of ordinary differential equations and rigid body dynamics at the level of 24-351.***	G	4, 9, 17	focused
24664	Mechanical Engineering	Introduction to Biomechanics	The purpose of this course is to achieve a broad overview of the application of mechanics to the human body. This includes solid, fluid, and viscoelastic mechanics applied to single cells, the cardiovascular system, lungs, muscles, bones, and human movement. The physiology of each system will be reviewed as background prior to discussing mechanics applications within that system. There are no firm prerequisites, but statics, fluid mechanics, and biology are helpful.	G	3, 9, 4	focused
24665	Mechanical Engineering	Special Topics: Wearable Health Technologies	This course will provide an overview of emerging wearable health technologies and give students hands-on experience in solving ongoing technical challenges. The wearable sensing field is experiencing explosive growth, with exciting applications in medicine. New lightweight devices will make it easier to monitor health conditions in real time, automatically import data into health informatics systems, and provide haptic feedback with humans in the loop. We will review several aspects of these technologies, including hardware, software, user experience, communication networks, applications, and big data analytics. Students will be paired with a company for a semester-long project that tackles timely computational challenges. Programing experience, in any language, is a pre-requisite.	G	4, 9, 8	focused
24667	Mechanical Engineering	Special Topics: Introduction to Geometric Dimensioning and Tolerancing	Geometric Dimensioning and Tolerancing (GD&T) encompasses a language and system of rules used to precisely and unambiguously communicate the intended geometry and allowable variation of manufactured objects. This tolerance informs the design, process selection, tooling, and inspection of a part. This course will introduce students to this system of communication and its applications. Topics will include interpreting GD&T on engineering drawings, implementing it in Solidworks, and performing tolerance analyses.	G	4, 9, 5	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
24671	Mechanical Engineering	Electromechanical Systems Design	This course guides students through the design process as applied to mechatronic systems, which feature electrical, mechanical, and computational components. Lectures describe the typical design process and its associated activities, emphasizing methods for analyzing and prototyping mechatronic systems. Professional and ethical responsibilities of designers, interactions with clients and other professionals, regulatory aspects, and public responsibility are discussed. The design project is team-based and is based on a level of engineering knowledge expected of seniors. Proof of practicality is required in the form of descriptive documentation and a working prototype system at the end of the course. Oral progress reports and a final written and oral report are required.	G	9, 4, 17	focused
24677	Mechanical Engineering	Special Topics: Linear Control Systems	This course offers a practical introduction to the analysis and design of model-based control for linear systems. Topics include modeling and linearization of multi-input multi-output dynamic systems using the state-variable description, fundamentals of linear algebra (linear space, linear transformation, linear dynamics), analytical and numerical solutions of systems of linear time-invariant differential and difference equations, structural properties of linear dynamic physical systems (controllability, observability and stability), canonical realizations, and design of state feedforward/feedback, optimal, and stochastic controllers and observers (pole placement, LQR, MPC, Kalman filter approaches). Students will learn how to design linear controllers and implement them to solve real-world problems in control and robotics.	G	4, 9, 8	focused
24680	Mechanical Engineering	Quantitative Entrepreneurship: Analysis for New Technology Commercialization	This course provides engineers with a multidisciplinary mathematical foundation for integrated modeling of engineering design and enterprise planning decisions in an uncertain, competitive market. Topics include economics in product design, manufacturing and operations modeling and accounting, consumer choice modeling, survey design, conjoint analysis, decision-tree analysis, optimization, model integration and interpretation, and professional communication skills. Students will apply theory and methods to a team project for a new product or emerging technology, developing a business plan to defend technical and economic competitiveness. This course assumes fluency with basic calculus, linear algebra, and probability theory.	G	9, 4, 8	focused
24681	Mechanical Engineering	Computer-Aided Design	his course is the first section of the two-semester sequence on computational engineering. Students will learn how computation and information technologies are rapidly changing the way engineering design is practiced in industry. The course covers the theories and applications of the measurement, representation, modeling, and simulation of three-dimensional geometric data used in the engineering designed process. Students taking this course are assumed to have knowledge of the first course in computer programming. 4 hrs lecture, 2 hrs computer cluster	G	9, 4	focused
24684	Mechanical Engineering	Special Topics: Nanoscale Manufacturing Using Structural DNA Nanotechnology	This course provides an introduction to modern nanoscale manufacturing using structural DNAnanotechnology. This DNA-based approach to manufacturing has much in common with other fabrication methods in micro- and nano-engineering: computer aided design tools are necessary for device design and resulting structures can only be seen using advanced microscopy. However, instead of machining larger materials down to micro- and nanostructures, DNA origami is fabricated using a "bottom up" approach for self-assembling individual oligonucleotides into 2D and 3D nanostructures. Resulting structures can be designed to have novel mechanical and electrical properties and have applications as broad-ranging as medicine, biological computing, and energy systems. The course will include lectures, hands-on physical modeling, homework problems, 3D modeling of DNA origami using caDNAno and CANDO software, and student team projects and presentations.	G	9, 7, 13	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
24685	Mechanical Engineering	Engineering Optimization without Project	This course introduces students to 1) the process of formally representing an engineering design or decision-making problem as a mathematical problem and 2) the theory and numerical methods needed to understand and solve the mathematical problem. Theoretical topics focus on constrained nonlinear programming, including necessary and sufficient conditions for local and global optimality and numerical methods for solving nonlinear optimization problems. Additional topics such as linear programming, mixed integer programming, global optimization, and stochastic methods are briefly introduced. Model construction and interpretation are explored with metamodeling and model reformulation techniques, study of model boundedness, constraint activity, and sensitivity analysis. Matlab is used in homework assignments for visualization and algorithm development, and students apply theory and methods to a topic of interest in a course project. Fluency with multivariable calculus, linear algebra, and computer programming is expected. Students who are unfamiliar with Matlab are expected to learn independently using available tutorials and examples provided. This course is identical to 24-785 Engineering Optimization, except students in 24-685 will not complete the project, but will be responsible for any homework assignments and exams. 19785 and 24785: 12-units including the team-based engineering optimization project 19685 and 24685: 9-units excluding the project	G	4, 17, 9	focused
24688	Mechanical Engineering	Introduction to CAD and CAE Tools	This course offers the hands-on training on how to apply modern CAD and CAE software tools to engineering design, analysis and manufacturing. In the first section, students will learn through 7 hands-on projects how to model complex free-form 3D objects using commercial CAD tools. In the second section, students will learn through 7 hands-on projects how to simulate complex multi-physics phenomena using commercial CAE tools. Units: 12 Format: 2 hrs. Lec., 2 hrs. computer lab	G	9, 4, 8	focused
24691	Mechanical Engineering	Mechanical Engineering Project Management	Organizations are increasingly adopting formal project management techniques to successfully initiate, plan, execute, monitor, control, and close out projects. In this course, students will learn project management tools which are commonly applied in industry. Working in teams, students will incorporate these tools into a documented plan for a project on which they are currently working or have previously completed. The project plan will address the ten knowledge areas of project management, including the management of project integration, scope, schedule, cost, quality, resources, communications, risk, procurement, and stakeholders. Students will also work in teams to plan and manage simulated projects. Real world constraints, challenges, and incentives will be applied. Additional special topics in project management will be discussed based on student interest, which may include lean, iterative, incremental, and industry-specific approaches, as well as productivity and human relations principles, and project management professional certification.	G	9, 4, 8	focused
24692	Mechanical Engineering	Special Topics: Engineering a Startup: How to Start and Grow a Hardware Company	Many modern devices are created by entrepreneurs starting their own enterprises. This course will provide a practical foundation for creating a new technology company. Specifically, it focuses on the unique challenges with creating, funding, and scaling a hardware-centric startup, with a heavy focus on examining real world examples of engineered product companies. Topics will include: strategies for developing products in a startup setting, identifying market value, launching a product to market, fund raising strategies, establishing and scaling manufacturing, and creating and understanding financial statements. This class is geared towards students with no business experience. The class will feature guest speakers with entrepreneurial experience developing and launching high tech products. The class will culminate with students creating and presenting an original pitch deck to a review board of entrepreneurs and investors.	G	9, 4, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
24693	Mechanical Engineering	Special Topics: Leadership and Communication	The objective of this course is to prepare students to be better leaders and communicators in their future careers, in industry, academia, and elsewhere. Topics include: psychological analysis of leaders and followers, negotiation and conflict resolution, interviewing, organizational decision making, and harnessing and deploying skills in challenging situations. To address these topics, the course employs new teaching techniques involving hands on activities, for example mock interviews and role playing around challenging situations. Learning outcomes include: improved ability to adapt, communicate, and lead in difficult situations in real time, understand team interactions and group dynamics to become a successful leader and follower, best practices in negotiating and resolving conflict in team situations and business interactions, and understand fundamentals of the interview process to achieve best outcomes.	G	4, 9, 8	focused
24695	Mechanical Engineering	Telling Your Story: Methods and Skills for Communicating Compelling Research	This course will examine approaches to communicating research to a technical audience in a way that is engaging and effective. The course will examine established methods in story telling, and discuss skills necessary to develop and master. The course will cover both written and oral communication. This course is open only to MechE students in at least their third year of their PhD, and students must have completed research ready for dissemination to use as a basis for their course projects. Students will develop written documents and give presentations throughout the class.	G	4, 17, 9	focused
24703	Mechanical Engineering	Numerical Methods in Engineering	This course emphasizes numerical methods to solve differential equations that are important in engineering. Procedures will be presented for solving systems of ordinary differential equations and boundary value problems in partial differential equations. Students will be required to develop computer algorithms and employ them in a variety of engineering applications. Comparison with analytical results from 24-701 will be made whenever possible. 4 hrs. lec. Prerequisite: some programming experience is required.	G	4, 9	focused
24711	Mechanical Engineering	Fluid Dynamics	This course focuses on development and application of control volume forms of mass, momentum and energy conservation laws, differential forms of these laws in Eulerian and Lagrangian coordinates, and Navier-Stokes equations. Students also explore applications to problems in incompressible and compressible laminar flows, boundary layers, hydrodynamic lubrication, transient and periodic flows, thermal boundary layers, convective heat transfer, and aerodynamic heating. 4 hrs. lec. Prerequisites: 24-701 or permission of the instructor.	G	15, 7, 4	focused
24718	Mechanical Engineering	Computational Fluid Dynamics	This course focuses on numerical techniques for solving partial differential equations including the full incompressible Navier-Stokes equations. Several spatial-temporal discretization methods will be taught, namely the finite difference method, finite volume method and briefly, the finite element method. Explicit and implicit approaches, in addition to methods to solve linear equations are employed to study fluid flows. A review of various finite difference methods which will be used to analyze elliptic, hyperbolic, and parabolic partial differential equations and the concepts of stability, consistency and convergence are presented at the beginning of the course to familiarize the students with general numerical methods. Detailed syllabus of the course is provided on the URL given below. 4 hr. lec	G	4, 17, 9	focused
24721	Mechanical Engineering	Advanced Thermodynamics	The course covers advanced macroscopic thermodynamics and introduces statistical thermodynamics. Review of first and second laws. Axiomatic formulation of macroscopic equilibrium thermodynamics and property relationships. Criteria for thermodynamic equilibrium with application to multiphase and multi-component systems. Thermodynamic stability of multiphase systems. Elementary kinetic theory of gases and evaluation of transport properties. Statistical-mechanical evaluation of thermodynamic properties of gases, liquids, and solids. Students are expected to have an undergraduate level of understanding of Thermodynamics (comparable to 24-221). 4 hrs. lec.	G	4, 13, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
24722	Mechanical Engineering	Energy System Modeling	This course focuses on the thermodynamic modeling of energy systems with emphasis on energy/availability analysis techniques. These techniques are developed and applied to both established and emerging energy technologies, such as internal combustion engines, gas- and coal-fired power plants, solar and wind energy systems, thermochemical hydrogen production cycles, and fuel cells. The course will also consider the integration of components such as reformers and electrolyzers. Modern computational tools are used throughout the course. The course culminates with a group project that requires developing sophisticated, quantitative models of an integrated energy system. Students are expected to have completed an undergraduate course in thermodynamics comparable to 24-221.	G	7, 13, 4	focused
24730	Mechanical Engineering	Advanced Heat Transfer	This course is open to students from all areas of engineering, although an undergraduate background in heat transfer is assumed. This class is an appropriate preparation for the doctoral qualifying exam.Topics to be covered include: mathematical formulation of heat transfer problems, heat conduction, thermal radiation, hydraulic boundary layers, and laminar and turbulent convection. Problems and examples will include theory and applications drawn from a spectrum of engineering design problems. Prerequisite: Undergraduate Heat Transfer 24-322 or equivalent.	G	4, 9, 6	focused
24740	Mechanical Engineering	Combustion and Air Pollution Control	24-740 Combustion and Air Pollution Control This course examines the generation and control of air pollution from combustion systems. The course's first part provides a brief treatment of combustion fundamentals, including thermochemical equilibrium, flame temperature, chemical kinetics, hydrocarbon chemistry, mass transfer, and flame structure. This foundation forms the basis for exploring the formation of gaseous (oxides of nitrogen, carbon monoxide, hydrocarbons, and sulfur dioxide) and particulate pollutants in combustion systems. The course then describes combustion modifications for pollutant control and theories for pollutant removal from effluent streams. The internal combustion engine and utility boilers serve as prototypical combustion systems for discussion. The course also addresses the relationship between technology and the formulation of rational regional, national, and global air pollution control strategies. Cross listed 19-740, 19-440, 24-425	G	13, 6, 12	focused
24751	Mechanical Engineering	Introduction to Solid Mechanics I	This is the first course in a two-part professionally oriented course sequence covering a variety of important problems in solid mechanics. Topics covered typically include torsion of non-circular cross sections, the field equations of elasticity and boundary conditions, and a number of classical plane stress/plane strain solutions in rectangular and polar coordinates. Emphasis is placed on not only elasticity theory and how classical elasticity solutions are derived, but also on their use in constructing and interpreting the results from finite element simulations of applied engineering problems. Where applicable, comparisons are also made between solutions derived via the full theory of elasticity and simplified solutions developed in strength of materials courses. 4 hrs. lec.	G	9, 4, 12	focused
24753	Mechanical Engineering	Special Topics: Robotic Materials: Designs, Principles & Mechanics	This is an interdisciplinary course focused on principles, theoretical models, and material architectures relevant to applications of condensed soft matter to problems in engineering. Special attention will be given to the design of soft, elastically-deformable machines and electronics that are primarily composed of elastomers, gels, fluids, gas, and other non-rigid matter. Specific topics will include the mechanics of hyperelastic solids, statistical mechanics of polymers and polymer composites, energy-based modeling techniques derived from the Laws of Thermodynamics, and their applications in modeling soft multifunctional material systems. Additionally, we will explore emerging paradigms in soft robotics, wearable computing, and human machine interaction, including material architectures for artificial muscles, stretchable electronics, and sensorized robotic skin. This course will include extensive reading with problem set assignments, a take-home exam, and final report. Students need familiarity with undergraduate-level solid mechanics, vector mechanics, thermodynamics, and ODEs	G	9, 7, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
24755	Mechanical Engineering	Finite Elements in Mechanics I	The basic theory and applications of the finite element method in mechanics are presented. Development of the FEM as a Galerkin method for numerical solution of boundary value problems. Applications to second-order steady problems, including heat conduction, elasticity, convective transport, viscous flow and others. Introduction to advanced topics, including fourth-order equations, time dependence and nonlinear problems. 12 Units Prerequisite(s): Graduate standing or consent of instructor	G	4, 17, 11	focused
24760	Mechanical Engineering	Special Topics: Robot Dynamics and Analysis	This course covers the dynamics of robotic systems with a focus on the mathematical structure of the dynamics and numerical analysis. Topics will start by reintroducing basic kinematics and dynamics in a more formal mathematical framework before moving on to contact conditions, friction, terramechanics, hybrid dynamical systems, timestepping simulation, and contact invariant optimization. After the course students will be able to write simulation and optimization methods for analyzing robotic systems. Students should have taken a prior course in dynamics, and be comfortable with linear algebra, multivariable calculus, and programming in Matlab.	G	4, 9, 7	focused
24771	Mechanical Engineering	Linear Systems	Topics include review of classical feedback control; solution of differential and difference equations; Laplace and Z-transforms, matrix algebra, and convolution; state variable modeling of dynamic continuous and discrete processes; linearization of nonlinear processes; state variable differential and difference equations; computer-aided analysis techniques for control system design; state variable control principles of controllability, observability, stability, and performance specifications; trade-offs between state variable and transfer function control engineering design techniques; and design problems chosen from chemical, electrical, and mechanical processes. 4 hrs. lec. Prerequisite: An undergraduate course in classical control engineering or consent of the instructor.	G	4, 9, 6	focused
24774	Mechanical Engineering	Special Topics: Advanced Control Systems Integration	This course focuses on the practical implementation of feedback / feedforward controllers. The entire controller design process is presented, including system modeling and identification, compensator design, simulation, and hardware prototyping. This is a project-based course in which students complete the controller design process on a nonlinear, MIMO hardware system. The goal is train students on the system integration skills necessary for success in industry or experimental laboratory work.	G	4, 9, 17	focused
24776	Mechanical Engineering	Non Linear Control	Nonlinear Control (12 Units) This course provides an introduction to the analysis and design of nonlinear systems and nonlinear control systems; stability analysis using Lyapunov, input-output and asymptotic methods; and design of stabilizing controllers using a variety of methods selected from linearization, vibrational control, sliding modes, feedback linearization and geometric control. 4 hrs. lec.	G	9, 8	focused
24780	Mechanical Engineering	Engineering Computation	This course covers the practical programming and computational skills necessary for engineers. These include: (1) programming in C++, (2) visualization using OpenGL, (3) basic data structures, and (4) basic algorithms. The course covers computational techniques required for solving common engineering problems and background algorithms and data structures used in modern Computer-Aided Design, Computer-Aided Manufacturing, and Computer-Aided Engineering tools. The course also offers intensive hands-on computational assignments for practice of common applications.	G	9, 4, 8	focused
24781	Mechanical Engineering	Engineering Computation Project	24-781 This project course is the first section of the two-semester sequence of Computational Engineering Projects. The course provides the students with hands-on problem-solving experience by using commercial computational tools and/or developing their own custom software. Each student, individually or along with other students, will work on a project under the guidance of Carnegie Mellon faculty members and/or senior engineers from industry. Students may select a project topic from those presented by advising faculty members and/or industry engineers. Alternatively, a student may propose and work on his/her own project topic if he/she can identify a sponsoring faculty member or industry engineer.	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
24784	Mechanical Engineering	Special Topics: Trustworthy AI Autonomy	Innovations driven by recent progress in artificial intelligence such as deep learning and reinforcement learning, have shown human-competitive performance. However, as research expands to real-world cyber-physical autonomy, the question of safety is becoming a crux for the transition from theories to practice. This course will first review fundamental knowledge for trustworthy AI autonomy, including adversarial attack/defend, generative models, hierarchical Bayesian models, safe reinforcement learning, rare-event/few-shot learning, and robust evaluation. Then from the research perspective, students will explore the novelty and potential extension of various state-of-the-art trustworthy AI research and their implementation through a series of readings. Students will develop the ability to conduct research in teams. Knowledge and research skills learned in this course can be applied to self-driving, healthcare devices, assistant robots, and intelligent manufacturing. This course is devised for research-focused students who have backgrounds and interests in statistical machine learning, robotics and control, and human-machine interaction. Other interested students should contact the instructor to determine if it is a good fit for them.	G	9, 4, 8	focused
24785	Mechanical Engineering	Engineering Optimization	Engineering Optimization Intermittent: 12 units This course introduces students to 1) the process of formally representing an engineering design or decision-making problem as a mathematical problem and 2) the theory and numerical methods needed to understand and solve the mathematical problem. Theoretical topics focus on constrained nonlinear programming, including necessary and sufficient conditions for local and global optimality and numerical methods for solving nonlinear optimization problems. Additional topics such as linear programming, mixed integer programming, global optimization, and stochastic methods are briefly introduced. Model construction and interpretation are explored with metamodeling and model reformulation techniques, study of model boundedness, constraint activity, and sensitivity analysis. Matlab is used in homework assignments for visualization and algorithm development, and students apply theory and methods to a topic of interest in a course project. Fluency with multivariable calculus, linear algebra, and computer programming is expected. Students who are unfamiliar with Matlab are expected to learn independently using available tutorials and examples provided. 4 hrs.lecture Prerequisites: None 19785 and 24785: 12-units including the team-based engineering optimization project 19685 and 24685: 9-units excluding the project	G	4, 17, 9	focused
24787	Mechanical Engineering	Machine Learning and Artificial Intelligence for Engineers	This course introduces fundamental machine learning and artificial intelligence techniques useful for engineers working on data-intensive problems. Topics include: Probability and Bayesian learning, generative and discriminative classification methods, supervised and unsupervised learning, neural networks, support vector machines, clustering, dimensionality reduction, regression, optimization, evolutionary computation, and search. The lectures emphasize the theoretical foundations and the mathematical modeling of the introduced techniques, while bi-weekly homework assignments focus on the implementation and testing of the learned techniques in software. The assignments require knowledge of Python including text and image input/output, vector and matrix operations, simple loops, and data visualization. Students must have undergraduate level experience with linear algebra and vector calculus.	G	4, 9, 8	focused
24791	Mechanical Engineering	Graduate Seminar I	Graduate seminar speakers include faculty, students, and invited guests from industry and academia. Through seminars, students widen their perspectives and become more aware of other topics in mechanical engineering	G	4, 9, 17	focused
24794	Mechanical Engineering	Master of Science Research	This course is designed to be a training opportunity in engineering research and associated professional activity. Content includes a series of investigations under the student's initiative culminating in comprehensive reports, with special emphasis on orderly presentation and effective English composition for Master of Science candidates. Variable hrs. Prerequisite: permission of the instructor.	G	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
24799	Mechanical Engineering	Practicum in Mechanical Engineering	The Department of Mechanical Engineering at Carnegie Mellon considers experiential learning opportunities important educational options for its graduate students. One such option is an internship, normally completed during the summer. If a student receives an internship, the Mechanical Engineering Department will add the internship course to the student's schedule, and the student will be assessed tuition for 3 units. Upon completion of the internship, students must submit a 2-3 page report with supervisor signature detailing the work experience and including how the internship was related to Mechanical Engineering. After the report has been reviewed and approved, a letter grade will be assigned and these 3 units will count towards degree requirements. International students interested in registering for the practicum must also be authorized for Curricular Practical Training (CPT). Further information is available on the Office of International Education?s website: www.cmu.edu/oie.	G	4, 17, 9	focused
24892	Mechanical Engineering	Locomotion Seminar	The CMU Bipedal Locomotion Seminar is a weekly meeting amongst students and professors who study bipedal locomotion using a variety of approaches. Each week, one graduate student participant gives a presentation on a topic of their choosing related to their research. We encourage discussion and interaction, especially from fellow students. Each meeting is intended to work like a small, informal conference discussion or workshop, providing students with new perspectives on their projects, practice presenting and answering questions, and a forum for meeting colleagues. We encourage participation from all interested students and faculty, including members of Carnegie Mellon, The University of Pittsburgh, and Disney Research Pittsburgh. Please join the waitlist and contact one of the instructors for admission.	G	4, 17, 9	focused
27100	Materials Science & Engineering	Engineering the Materials of the Future	Materials form the foundation for all engineering applications. Advances in materials and their processing are driving all technologies, including the broad areas of nano-, bio-, energy, and electronic (information) technology. Performance requirements for future applications require that engineers continue to design both new structures and new processing methods in order to engineer materials having improved properties. Applications such as optical communication, tissue and bone replacement, fuel cells, and information storage, to name a few, exemplify areas where new materials are required to realize many of the envisioned future technologies. This course provides an introduction to how science and engineering can be exploited to design materials for many applications. The principles behind the design and exploitation of metals, ceramics, polymers, and composites are presented using examples from everyday life, as well as from existing, new, and future technologies. A series of laboratory experiments are used as a hands-on approach to illustrating modern practices used in the processing and characterization of materials and for understanding and improving materials' properties.	U	7, 9, 13	focused
27201	Materials Science & Engineering	Structure of Materials	This course covers the fundamentals of crystallography and diffraction. Topics covered include: the periodic table of the elements, bonding in different classes of materials, Bravais lattices, unit cells, directions and planes, crystal geometry computations, direct and reciprocal space, symmetry operations, point and space groups, nature of x-rays, scattering in periodic solids, Bragg's law, the structure factor, and the interpretation of experimental diffraction patterns. 24 crystal structure types of importance to various branches of materials science and engineering will be introduced. Amorphous materials, composites and polymers are also introduced. This course includes both lectures and laboratory exercises.	U	9, 4, 7	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
27202	Materials Science & Engineering	Defects in Materials	Defects have a fundamental influence on the properties of materials, including deformation, electrical, magnetic, optical, and chemical properties, as well as the rates of diffusion in solids. As such, by the controlling the population of intrinsic and extrinsic defects, one can tailor the properties of materials towards specific engineering applications. The objective of this course, which includes classroom and laboratory sessions, is to define approaches to quantifying the populations and properties of defects in crystals. The course will be divided into three sections: point defects, dislocations, and planar defects. The formation of point defects and their influence on diffusion, electrical, and magnetic properties will be considered. The properties and characteristics of dislocations and dislocation reactions will be presented, with a focus on the role of dislocations in deformation. The crystallography and energetics of planar defects and interfaces will also be described, with a focus on microstructural evolution at high temperatures. Time permitting, volume defects or other special topics are also discussed.	U	4, 9, 6	focused
27210	Materials Science & Engineering	Materials Engineering Essentials	This course approaches professional skill holistically, having materials science and engineering students understand that being a professional includes having competencies and responsibilities that are personal, organizational and professional.	U	4, 9, 12	focused
27211	Materials Science & Engineering	Structure of Materials (Minor Option)	This course is identical to 27-201, but without the 3-unit lab component.	U	9, 12	focused
27212	Materials Science & Engineering	Defects in Materials (Minor Option)	THIS IS FOR THE MSE MINOR ONLY: Defects have a fundamental influence on the properties of materials, including deformation, electrical, magnetic, optical, and chemical properties, as well as the rates of diffusion in solids. As such, by the controlling the population of intrinsic and extrinsic defects, one can tailor the properties of materials towards specific engineering applications. The objective of this courseis to define approaches to quantifying the populations and properties of defects in crystals. The course will be divided into three sections: point defects, dislocations, and planar defects. The formation of point defects and their influence on diffusion, electrical, and magnetic properties will be considered. The properties and characteristics of dislocations and dislocation reactions will be presented, with a focus on the role of dislocations in deformation. The crystallography and energetics of planar defects and interfaces will also be described, with a focus on microstructural evolution at high temperatures. Time permitting, volume defects or other special topics are also discussed.	U	9, 6, 10	focused
27215	Materials Science & Engineering	Thermodynamics of Materials	The first half of the course will focus on the laws of thermodynamics and the inter-relations between heat, work and energy. The concept of an equilibrium state of a system will be introduced and conditions which must be satisfied for a system to be at equilibrium will be established and discussed and the concepts of activity and chemical potential introduced. The second half of the course will focus on chemical reactions, liquid and solid solutions, and relationships between the thermodynamics of solutions and binary phase diagrams.	U	7, 13, 9	focused
27216	Materials Science & Engineering	Transport in Materials	This course is designed to allow the student to become familiar with the fundamental principles of heat flow, fluid flow, mass transport and reaction kinetics. In addition, the student will develop the skills and methodologies necessary to apply these principles to problems related to materials manufacture and processing. Topics will include thermal conductivity, convection, heat transfer equations, an introduction to fluid phenomena viscosity, etc., Newtons and Stokes Laws, mass momentum balances in fluids, boundary layer theory, diffusion and absolute reaction rate theory. Where appropriate, examples will be taken from problems related to the design of components and the processing of materials.	U	4, 9, 11	focused
27217	Materials Science & Engineering	Phase Relations and Diagrams	Stability of structures. Hume-Rothery rules. Free energy-composition curves with applications to binary and ternary phase diagrams. Quantitative concepts of nucleation and growth with examples from solidification. Development of microstructures in various classes of phase diagram under near-equilibrium conditions. Atomic mechanisms of solid state diffusion and approach to equilibrium through diffusion.	U	7, 13, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
27301	Materials Science & Engineering	Microstructure and Properties I	The objective of this course is to convey some of the essential concepts in materials science and engineering that relate properties (strength, toughness, formability, elasticity, magnetism, thermal expansion, for example) to the microstructure (crystal structure, dislocation structure, grain size, atoms in solids solution, precipitate characteristic, cellular materials). These relationships will be illustrated in terms of idealized materials and actual materials used in many applications. The course contains both lectures and laboratory exercises. The labs will include studies of recrystallization, the effect of microstructure on the properties of wood and the effect of microstructure on the mechanical behavior of a low ally steel, 4140.	U	9, 2, 6	focused
27357	Materials Science & Engineering	Introduction to Materials Selection	The objective of this course is to teach the fundamentals of materials science as related to metals and metal alloys. The topics to be covered include crystal structure, defects, diffusion, binary phase diagrams, microstructure and processing, elastic and plastic deformation, equations of elasticity for isotropic materials, deformation of single crystal, slip systems, the tensile test, Von Mises yield criteria, strengthening mechanisms, phase transformations in steels, microstructures of steels, fracture and toughness, creep and corrosion.	U	9, 4, 12	focused
27367	Materials Science & Engineering	Selection and Performance of Materials	This course teaches the selection methodologies for materials and processes for satisfaction of a design goal. Topics such as performance under load, shape effects, material properties (intrinsic and as influenced by processing) are discussed and applied so as to determine the fitness of use of materials for applications. Expanded topics include economics, codes and standards, environmental and safety regulations, professional ethics and life cycle analysis where applicable. The course incorporates a project where virtual teams work to provide material selection for a specific application problem. Prerequisites: 27-100	U	12, 8, 13	focused
27401	Materials Science & Engineering	MSE Capstone Course I	This is the first of 2 course that together fulfill the Capstone requirement. This capstone course introduces the student to the methodology used for projects and teams based research as practiced in the Materials Science and Engineering workplace. This is a project course that requires the knowledge relationship among processing, structure, and performance to address an important contemporary problem in materials science and engineering. Student taking this course will work in a team environment to complete a design project to resolve scientific and engineering issues relating to materials. Research topics will be selected from a list of material problems or research concepts generated from companies or academia - industry research partnerships. This course will establish the research goals, review applicable research methodologies, introduce project management skills and discuss ethical concepts as teams assemble and set their research directions. On the topic selected, the work product is a report that provides clear definition of the problem being addressed, sets out a methodology for the research, includes a literature review, and reports early experimentation results and provides recommendations for future work.	U	9, 4, 17	focused
27402	Materials Science & Engineering	MSE Capstone Course II	This is the spring extension of 27-401. Teams or team members that have the industry agreement and that wish to continue their research project may do so in this course. As with 27-401, all research is expected to be original, and proper scientific ethics, and methodologies are enforced for the research and reports. Team participation and communication is an important issue and the presentation and reports must be technical and professional in structure. The course requires full project management and accounting for the research being conducted. On the topic selected, the work product is a report that provides clear definition of the problem being addressed, a methodology for the research, literature review, experimentation and reporting of findings, conclusions based on findings, and recommendations for future work. Prerequisites:27-401	U	9, 17, 2	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
27406	Materials Science & Engineering	Sustainable Materials	This course is intended to instill a sense of how materials properties and performance are conceived and brought to market specifically under sustainability constraints arising from the increasing demand of materials, Students will be introduced to the global nature of materials and will explore the global influences on the materials supply and value chains. The student will explore issues through the framework of the materials lifecycle including resource availability, manufacturing choices, and disposable options for materials in light of their use and selection for application. As a result, the student will be able to make more informed material selection or be able to use this information to identify critical research directions for future material development.	U	9, 12, 4	focused
27421	Materials Science & Engineering	Processing Design	In this course, the concepts of materials and process design are developed, integrating the relevant fundamental phenomena in a case study of a process design. The course includes basic science and engineering as well as economic and environmental considerations. The case study is on environmentally acceptable sustainable steelmaking. Other case studies in materials processing could be used.	U	12, 8, 9	focused
27433	Materials Science & Engineering	Dielectric, Magnetic, Superconducting Properties of Materials & Related Devices	Fall odd years: 9 units This is Part II of a two-part course sequence (Part I is 27-432) concerned with the electrical, dielectric, magnetic and superconducting properties of materials. Students taking Part II will develop an in-depth understanding, based on the modern theories of solids, of the dielectric, magnetic and superconducting properties of materials and the principles of operation of selected products and devices made from these materials. Topics will include relationships between chemical bonds and energy bands in dielectric and magnetic materials; polarization mechanisms in materials and their relationship to capacitance, piezoelectricity, ferroelectricity, and pyroelectricity; magnetization and its classification among materials; magnetic domains; soft and hard magnets; and the origin, theory and application of superconductivity. Examples of commercial products will be introduced to demonstrate the application of the information presented in the text and reference books and class presentations.	U	7, 4, 9	focused
27445	Materials Science & Engineering	Structure, Properties and Performance Relationships in Magnetic Materials	This course introduces the student to intrinsic properties of magnetic materials including magnetic dipole moments, magnetization, exchange coupling, magnetic anisotropy and magnetostriction. This is followed by discussion of extrinsic properties including magnetic hysteresis, frequency dependent magnetic response and magnetic losses. This will serve as the basis for discussing phase relations and structure/properties relationships in various transition metal magnetic materials classes including iron, cobalt and nickel elemental magnets, iron-silicon, iron-nickel, iron-cobalt and iron platinum. This will be followed by a discussion of rare earth permanent magnets, magnetic oxides, amorphous and nanocomposite magnets. Polymers used in Electromagnetic Interference (EMI) Absorbers applications will also be covered.	U	4, 9, 12	focused
27477	Materials Science & Engineering	Introduction to Polymer Science and Engineering	This survey-level course introduces the fundamental properties of polymer materials and the principles underlying the synthesis, engineering, manufacturing, and design with polymer materials. Fundamental concepts of molecular interactions and structure formation in molecular materials will be introduced and the effect of chemical composition on physical properties of polymers will be discussed. The basic principles of polymer chemistry will be introduced and discussed in the context of step- and chain-growth reactions. This is followed by an introduction to technologically relevant engineering properties of polymer materials with focus on mechanical properties, concepts of viscoelasticity and their application to polymer product engineering, a survey of relevant forming technologies as well as the effect of processing on material performance. Case studies will introduce students to the various stages of technical product development, i.e. problem analysis, material selection and processing plan. A final section will discuss polymer recycling and sustainable polymer technologies for a circular economy.	U	12, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
27503	Materials Science & Engineering	Additive Manufacturing and Materials	This course will develop the understanding required for materials science and engineering for additive manufacturing. The emphasis will be on powder bed machines for printing metal parts, reflecting the research emphasis at CMU. The full scope of methods in use, however, will also be covered. The topics are intended to enable students to understand which materials are feasible for 3D printing. Accordingly, high power density welding methods such as electron beam and laser welding will be discussed, along with the characteristic defects. Since metal powders are a key input, powder-making methods will be discussed. Components once printed must satisfy various property requirements hence microstructure-property relationships will be discussed because the microstructures that emerge from the inherently high cooling rates differ strongly from conventional materials. Defect structures are important to performance and therefore inspection. Porosity is a particularly important feature of 3D printed metals and its occurrence depends strongly on the input materials and on the processing conditions. The impact of data science on this area offers many possibilities such as the automatic recognition of materials origin and history. Finally the context for the course will be discussed, i.e. the rapidly growing penetration of the technology and its anticipated impact on manufacturing.	U	9, 4, 8	focused
27505	Materials Science & Engineering	Exploration of Everyday Materials	This course is developed for upper level undergraduate and master level students outside of the College of Engineering that wish to learn about materials by experientially exploring a material and or an application of a material. Each year the course will select a material that through its' application, presents and opportunity or a concern in service. It will engage the students with studio-based exploration of the material and application, the selection criteria applicable, and engineering principles that influence the performance. It will explore a wide range of influential topics constraining material selection including societal concerns about materials and global sustainability.	U	4, 12, 9	focused
27514	Materials Science & Engineering	Bio-nanotechnology: Principles and Applications	"Have you ever wondered what is nanoscience and nanotechnology and their impact on our lives? In this class we will go through the key concepts related to synthesis (including growth methodologies and characterizations techniques) and chemical/physical properties of nanomaterials from zero-dimensional (0D) materials such as nanoparticles or quantum dots (QDs), one-dimensional materials such as nanowires and nanotubes to two-dimensional materials such as graphene. The students will then survey a range of biological applications of nanomaterials through problem-oriented discussions, with the goal of developing design strategies based on basic understanding of nanoscience. Examples include, but are not limited to, biomedical applications such as nanosensors for DNA and protein detection, nanodevices for bioelectrical interfaces, nanomaterials as building blocks in tissue engineering and drug delivery, and nanomaterials in cancer therapy."	U	3, 9, 4	focused
27520	Materials Science & Engineering	Tissue Engineering	This course will train students in advanced cellular and tissue engineering methods that apply physical, mechanical and chemical manipulation of materials in order to direct cell and tissue function. Students will learn the techniques and equipment of bench research including cell culture, immunofluorescent imaging, soft lithography, variable stiffness substrates, application/measurement of forces and other methods. Students will integrate classroom lectures and lab skills by applying the scientific method to develop a unique project while working in a team environment, keeping a detailed lab notebook and meeting mandated milestones. Emphasis will be placed on developing the written and oral communication skills required of the professional scientist. The class will culminate with a poster presentation session based on class projects. Pre-requisite: Knowledge in cell biology and biomaterials, or permission of instructor	U	4, 9, 17	focused
27533	Materials Science & Engineering	Principles of Growth and Processing of Semiconductors	Development of a fundamental understanding of material principles governing the growth and processing of semiconductors. Techniques to grow and characterize bulk crystals and epitaxial layers are considered. The processing of semiconductors into devices and the defects introduced thereby are discussed. The roles of growth- and processing-induced defects in determining long term reliability of devices are examined.	U	9, 8, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
27537	Materials Science & Engineering	Data Analytics for Materials Science	Materials Science and Engineering has traditionally been taught by emphasizing the development and application of technology. This course will present an alternative approach that combines data mining, data analytics, and material fundamentals (i.e. materials informatics). Students will be introduced to informatics techniques related to data mining and large database analysis. The topics will include: ¥ Principal Component Analysis (PCA) ¥ Canonical Correlation Analysis (CCA) ¥ Neural Networks ¥ Machine Learning ¥ Computer Vision There will be a project in which students will apply appropriate techniques to a data set of their choosing. Students should be comfortable writing, compiling, and running simple computer programs in MatLab, Python, R, or comparable environment.	U	4, 9, 17	focused
27542	Materials Science & Engineering	Processing and Properites of Thin Films	This course is designed to provide an introduction to the science and technology of thin films, with special emphasis on methods to produce thin films and relationships between growth conditions and thin film properties. Topics include (1) various methods of thin film production, such as evaporation, sputtering and chemical vapor deposition, (2) nucleation and growth processes, (3) dimensional, chemical, and structural characterization of thin films and (4) properties and applications, such as conductivity and thin film solar cells.	U	7, 9, 8	focused
27555	Materials Science & Engineering	Materials Project I	This course is designed to give experience in individualized research under the guidance of a faculty member. The topic is selected by mutual agreement, and will give the student a chance to study the literature, design experiments, interpret the results and present the conclusions orally and in writing.	U	17, 4, 9	focused
27556	Materials Science & Engineering	Materials Project II	Second semester of Materials Project. This course is designed to give experience in individualized research under the guidance of a faculty member. The topic is selected by mutual agreement, and will give the student a chance to study the literature, design experiments, interpret the results and present the conclusions orally and in writing.	U	4, 17, 9	focused
27565	Materials Science & Engineering	Nanostructured Materials	This course is an introduction to nanostructured materials or nanomaterials. Nanomaterials are objects with sizes larger than the atomic or molecular length scales but smaller than microstructures with at least one dimension in the range of 1-100 nm. The physical and chemical properties of these materials are often distinctively different from bulk materials. For example, gold nanoparticles with diameters ~15 nm are red and ~40 nm gold nanoparticles are purple whereas bulk gold has a golden color. The course starts with a discussion of top-down and bottom-up fabrication methods for making nanostructures as well as how to image and characterize nanomaterials including scanning probe microscopies. Emerging nanomaterials such as fullerenes, graphene, carbon nanotubes, quantum dots and nanocomposites are also discussed. The course then focuses on applications of nanomaterials to microelectronics, particularly nanoscale devices and the emerging field of molecular-scale electronics. The miniaturization of integrated systems that sense mechanical or chemical changes and produce as electrical signal is presented. The principles and applications of the quantum confinement effects on optical properties are discussed, mainly as sensors. The last part of the course is a discussion of nanoscale mechanisms in biomimetic systems and how these phenomena are applied in new technologies including molecular motors.	U	9, 13, 12	focused
27570	Materials Science & Engineering	Polymeric Biomaterials	This course will cover aspects of polymeric biomaterials in medicine from molecular principles to device scale design and fabrication. Topics include the chemistry, characterization, and processing of synthetic polymeric materials; cell-biomaterials interactions including interfacial phenomena, tissue responses, and biodegradation mechanisms; aspects of polymeric micro-systems design and fabrication for applications in medical devices. Recent advances in these topics will also be discussed.	U	9, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
27588	Materials Science & Engineering	Polymer Physics and Morphology	This course introduces the fundamental concepts necessary to understand and determine the structure and properties of polymers in the solid state. The structure of polymers will be discussed with focus on the amorphous, crystalline and liquid-crystalline state. One aim is to provide a student intuition about the organization of polymer molecules in the solid state based on the polymer's chemical structure. Particular attention will be given to scattering techniques as a tool to determine polymer structures in solution and the solid state. The glass transition in amorphous polymers as well as the morphology and kinetics of crystal formation in semi-crystalline polymers will be discussed in detail. The second part of the course will focus on polymer multicomponent materials. Basic concepts of lattice models will be introduced and applied to predict the phase behavior of polymer blends.	U	9, 4, 12	focused
27592	Materials Science & Engineering	Solidification Processing	Spring odd years: The goal of this course is to enable the student to solve practical solidification processing problems through the application of solidification theory. The objectives of this course are to: (1) Develop solidification theory so that the student can understand predict solidification structure; (2) Develop a strong understanding of the role of heat transfer in castings; (3) Develop an appreciation for the strengths and weaknesses of a variety of casting processes. The first half of the course will be theoretical, covering nucleation, growth, instability, solidification microstructure: cells, dendrites, eutectic and peritectic structures, solute redistribution, inclusion formation and separation, defects and heat transfer problems. The second part of the course will be process oriented and will include conventional and near net shape casting, investment casting, rapid solidification and spray casting where the emphasis will be on process design to avoid defects.	U	9, 8, 4	focused
27675	Materials Science & Engineering	Masters Report	This course is used to indicate whether a student has satisfied the final report requirement for the Master of Science in Materials Science Degree Program. Students in the program will be registered for the course in their final semester of the program.	G	4, 12, 9	focused
27700	Materials Science & Engineering	Energy Storage Materials and Systems	Contemporary energy needs require energy storage and conversion for a range of mobile and stationary applications. This course will examine electrochemically functional materials, devices, and systems that are used to convert, store, and release electrical energy. The principles and mathematical models of electrochemical energy conversion and storage will be examined in depth; students will study thermodynamics and reaction kinetics pertaining to electrochemical reactions, phase transformations, transport, and processing relating to a wide range of related technologies. This course also will also cover the practical aspects associated with the application of batteries, fuel cells, supercapacitor technologies. Students are asked to conduct a class project that involves interacting with outside industry and culminates in a end-of-semester poster session.	G	7, 9, 4	focused
27703	Materials Science & Engineering	Additive Manufacturing and Materials	This course will develop the understanding required for materials science and engineering for additive manufacturing. The emphasis will be on powder bed machines for printing metal parts, reflecting the research emphasis at CMU. The full scope of methods in use, however, will also be covered. The topics are intended to enable students to understand which materials are feasible for 3D printing. Accordingly, high power density welding methods such as electron beam and laser welding will be discussed, along with the characteristic defects. Since metal powders are a key input, powder-making methods will be discussed. Components once printed must satisfy various property requirements hence microstructure-property relationships will be discussed because the microstructures that emerge from the inherently high cooling rates differ strongly from conventional materials. Defect structures are important to performance and therefore inspection. Porosity is a particularly important feature of 3D printed metals and its occurrence depends strongly on the input materials and on the processing conditions. The impact of data science on this area offers many possibilities such as the automatic recognition of materials origin and history. Finally the context for the course will be discussed, i.e. the rapidly growing penetration of the technology and its anticipated impact on manufacturing.	G	9, 4, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
27704	Materials Science & Engineering	Principles of Surface Engineering and Industrial Coatings	Many modern technologies rely on the use of innovative, multi-functional coatings to ensure competitive advantage in the fast-changing global markets. Building such coatings requires advanced planning of the entire coating-substrate system, and of the manufacturing steps. This course will discuss the design principles of multi-functional coatings, present advanced coating architectures and review the relevant manufacturing steps. The course will be illustrated with design principles of functional coatings in three major industries: aerospace, automotive, and machining. We will identify the relevant key challenges, and follow the thinking process of the industry leaders addressing the challenge. Then, we will examine the developed coating solutions: multi-functional tribological coatings on cutting tools; thermal barrier coatings on nickel alloy turbine blades for aircraft and power generation; diamond like coatings and wear protective coatings for automotive diesel engines; and corrosion protection in the aerospace and in the automotive industries. The course will conclude with a discussion of new trends in surface engineering and in the design of multi-functional coatings, including self-healing, self-cleaning, and other smart coatings.	G	9, 7, 8	focused
27706	Materials Science & Engineering	Hard and Superhard Materials	This course will focus on the fundamental principles of hard and superhard materials. We will first discuss the origin of hardness across materials, and then describe important examples of materials prized for their intrinsic or extrinsic hardness. We will focus on the preparation, microstructure, and properties of materials such as diamond, cubic boron nitride and compound carbides. Then, we will emphasize the design of novel nano-structured and nano-composite materials and coatings, which are at the frontier of material science. Finally, the course will present examples of the architecture and processing methods used to generate hard materials and coatings in manufacturing automotive and aerospace industries.	G	9, 8, 12	focused
27709	Materials Science & Engineering	Engineering Biomaterials	This course will cover structure-processing-property relationships in biomaterials for use in medicine. This course will focus on a variety of materials including natural biopolymers, synthetic polymers, and soft materials with additional treatment of metals and ceramics. Topics include considerations in molecular design of biomaterials, understanding cellular aspects of tissue-biomaterials interactions, and the application of bulk and surface properties in the design of medical devices. This course will discuss practical applications of these materials in drug delivery, tissue engineering, biosensors, and other biomedical technologies. This course is a project-based option for graduate students that is taught concurrently with 42-411. Open only to graduate students in CIT or by permission of instructor.	G	9, 4, 12	focused
27719	Materials Science & Engineering	Computational Thermodynamics	Computational thermodynamics is a powerful tool of a Materials Engineer. We will examine how thermodynamic simulation software outputs an equilibrium calculation from a list of input conditions. This requires a description of Gibbs energy minimization calculations, Gibbs energy models, and the construction of these models from thermodynamic data. At the end of the class students should be able to use thermodynamic simulation software to solve engineering problems while recognizing its limitations. This class is for graduate students interested in these computational tools.	G	7, 4, 9	focused
27720	Materials Science & Engineering	Tissue Engineering	This course will train students in advanced cellular and tissue engineering methods that apply physical, mechanical and chemical manipulation of materials in order to direct cell and tissue function. Students will learn the techniques and equipment of bench research including cell culture, immunofluorescent imaging, soft lithography, variable stiffness substrates, application/measurement of forces and other methods. Students will integrate classroom lectures and lab skills by applying the scientific method to develop a unique project while working in a team environment, keeping a detailed lab notebook and meeting mandated milestones. Emphasis will be placed on developing the written and oral communication skills required of the professional scientist. The class will culminate with a poster presentation session based on class projects. Pre-requisite: Knowledge in cell biology and biomaterials, or permission of instructor	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
27721	Materials Science & Engineering	Processing Design	In this course, the concepts of materials and process design are developed, integrating the relevant fundamental phenomena in a case study of a process design. The course includes basic science and engineering as well as economic and environmental considerations. The case study is on environmentally acceptable sustainable steelmaking. Other case studies in materials processing could be used.	G	12, 8, 9	focused
27729	Materials Science & Engineering	Solid State Devices for Energy Conversion	Intensive research efforts have yielded promising new materials approaches to 'alternative' energy conversion technologies, such as solar cells or photovoltaics; thermoelectric materials, which convert waste heat to electricity; metal/semiconductor superlattices for thermionic energy conversion; and fuel cells. At the same time, notable advances have been made in devices that substantially enhance our energy efficiency: e.g., chemical sensors and light-emitting diodes for solid-state lighting. In all of these devices, interfaces between dissimilar materials often govern and/or limit the behavior. In addition to the basic structures and operating principles, this course will cover practical materials interface issues, such as electrical transport, thermal stability, contact resistance, and bandgap engineering, that significantly affect the performance of a variety of energy conversion and energy-saving devices.	G	7, 12, 13	focused
27734	Materials Science & Engineering	Methods of Computational Materials Science	This course introduces students to the theory and practice of computational materials science from the electronic to the microstructural scale. Both the underlying physical models and their implementation as computational algorithms will be discussed. Topics will include: Density functional theory Molecular dynamics Monte Carlo methods Phase field models Cellular automata Data science Examples and homework problems will be taken from all areas of materials science. Coursework will utilize both software packages and purpose-built computer codes. Students should be comfortable writing, compiling, and running simple computer programs in MatLab, Python, or comparable environment.	G	4, 12, 17	focused
27737	Materials Science & Engineering	Data Analytics for Materials Science	Materials Science and Engineering has traditionally been taught by emphasizing the development and application of technology. This course will present an alternative approach that combines data mining, data analytics, and material fundamentals (i.e. materials informatics). Students will be introduced to informatics techniques related to data mining and large database analysis. The topics will include:Principal Component Analysis (PCA)Canonical Correlation Analysis (CCA)Neural NetworksMachine LearningComputer VisionThere will be twoprojectsin which students will apply appropriate techniques to data setsof their choosing; in the second (graduate level) project, students will be asked to build, train, and execute a multi-layer neural net to automatically recognize shapes that are relevant to material microstructures. One quarter of the lectures in this course will focus on the custom creation of convolutional neural networks. Students should be comfortable writing, compiling, and running simple computer programs in MatLab, Python, R, or comparable environment.	G	4, 9, 17	focused
27740	Materials Science & Engineering	Practical Methods in Scanning Electron Microscopy	This course is designed to provide instrument training on scanning electron microscopes in the Materials Characterization Facility (MCF). Emphasis will be placed on acquiring the basic skills needed to successfully operate this type of microscopes; this will be achieved by a combination of lectures and hands-on lab sessions. Lectures will provide the necessary background to understand electron scattering techniques, including electron diffraction, secondary and back-scattered electron imaging, electron back-scatter diffraction, and energy dispersive x-ray spectroscopy. Lab sessions will inform the student on standard operating procedures for the techniques discussed in the lecture portion of the course. At the end of the course, the student is expected to demonstrate the ability to independently use the scanning electron microscope for basic operations; successful demonstration of such skills will lead to certification for day-use of scanning electron microscopes in the MCF.	G	7, 4, 13	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
27741	Materials Science & Engineering	Practical Methods in Transmission Electron Microscopy	This course is designed to provide instrument training on transmission electron microscopes in the Materials Characterization Facility (MCF). Emphasis will be placed on acquiring the basic skills needed to successfully operate this type of microscope; this will be achieved by a combination of lectures and hands-on lab sessions. Lectures will provide the necessary background to understand electron scattering techniques, including electron diffraction, bright field and dark field imaging, phase contrast microscopy, and energy dispersive x-ray spectroscopy. Lab sessions will inform the student on standard operating procedures for the techniques discussed in the lecture portion of the course. At the end of the course, the student is expected to demonstrate the ability to independently use the transmission electron microscope for basic operations; successful demonstration of such skills will lead to certification for day-use of transmission electron microscopes in the MCF.	G	7, 4, 13	focused
27752	Materials Science & Engineering	Fundamentals of Semiconductors and Nanostructures	This course is designed to provide students with a foundation of the physics required to understand nanometer-scale structures and to expose them to different aspects of on-going research in nanoscience and nanotechnology. Illustrative examples will be drawn from the area of semiconductor nanostructures, including their applications in novel and next-generation electronic, photonic, and sensing devices. The course begins with a review of basic concepts in quantum physics (wave-particle duality, Schrödinger's equation, particle-in-a-box, approximation methods in quantum mechanics, etc.) and then continues with a discussion of bulk three-dimensional solids (band structure, density of states, the single-electron effective-mass approximation). Size effects due to nanometer-scale spatial localization are then discussed within a quantum-confinement model in one-, two-, and three- dimensions for electrons. An analogous discussion for photons is also presented. The basic electronic, optical, and mechanical properties of the low-dimensional nanostructures are then discussed. A select number of applications in electronics, photonics, biology, chemistry, and bio-engineering will be discussed to illustrate the range of utility of nanostructures. Upon completion of the course, students will have an appreciation and an understanding of some of the fundamental concepts in nanoscience and nanotechnology. The course is suitable for first-year graduate students in engineering and science (but advanced undergraduates with appropriate backgrounds may also take it with permission from the instructor). Pre-requisites include 09-511, 09-701, 09-702, 18-311, 27-770, 33-225, 33-234 or familiarity with the material or basic concepts covered in these courses.	G	4, 9, 7	focused
27766	Materials Science & Engineering	Diffusion in Materials	This course is designed to allow the student to become familiar with the fundamental principles diffusion in solid materials. The course will include the treatment of diffusion from an atomic scale to micro-structural scales in metals, ceramics, glasses and polymers. In addition, the student will develop skills and methodologies necessary to apply mathematical methods to solve differential equations of relevance to diffusion problems including separation of variables, Laplace transforms ad Green's functions. An introduction will be given to the application of numerical solutions. Where appropriate, examples will be taken from problems related to the design of components and the processing and performance of materials.	G	4, 9, 12	focused
27788	Materials Science & Engineering	Defects in Materials	This course addresses the fundamental properties of defects in crystalline solids, as well as their effects on properties and behavior of materials. Primary attention is devoted to point and line defects. Somewhat less comprehensive coverage is given to extended defects, including grain boundaries, interphase boundaries and surfaces. 4 hrs. lec.	G	2, 6, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
27792	Materials Science & Engineering	Solidification Processing	The goal of this course is to enable the student to solve practical solidification processing problems through the application of solidification theory. The objectives of this course are to: (1) Develop solidification theory so that the student can understand predict solidification structure; (2) Develop a strong understanding of the role of heat transfer in castings; (3) Develop an appreciation for the strengths and weaknesses of a variety of casting processes. The first half of the course will be theoretical, covering nucleation, growth, instability, solidification microstructure: cells, dendrites, eutectic and peritectic structures, solute redistribution, inclusion formation and separation, defects and heat transfer problems. The second part of the course will be process oriented and will include conventional and near net shape casting, investment casting, rapid solidification and spray casting where the emphasis will be on process design to avoid defects.	G	9, 8, 4	focused
27796	Materials Science & Engineering	Structure of Materials	The skills and ideas necessary to understand the atomic structure of crystalline materials are presented. The objective is for the student to be able to describe crystal structures based on their symmetry (Bravais lattices, point groups and space groups)as well as packing configurations and to understand how diffraction is used to experimentally probe crystal structures.	G	4, 9, 12	focused
27797	Materials Science & Engineering	Bonding of Materials	Models for cohesive forces in crystals are reviewed; both quantitative and phenomenological descriptions of secondary, ionic, metallic, and covalent bonds are discussed. A band structure language is developed starting from free electron and LCAO models of metals and covalently bonded crystals, respectively. 4 hrs lecture	G	9, 12, 4	focused
27798	Materials Science & Engineering	Thermodynamics I	The laws, concepts, and definitions of classical thermodynamics as well as selected relationships that matter exhibits will be covered and applied to gas, liquid and crystalline systems. Concepts and classifications of thermodynamic systems, variables and relationships will be presented and discussed. General criteria and conditions for equilibrium will be developed and applied. The basic concepts of statistical thermodynamics will be introduced and applied to the interpretation of entropy. Phase equilibria of unary systems and the nature of real gases will be explored.	G	13, 9, 7	focused
27799	Materials Science & Engineering	Thermodynamics II	The course will apply thermodynamic fundamentals covered in Thermodynamics I (27-798) to multi-component materials systems. The course will also cover equilibrium phase diagrams (binary and ternary), predominance diagrams, chemical reactions, thermodynamics of surfaces and electrochemistry.	G	9, 12, 6	focused
27991	Materials Science & Engineering	Materials Science and Engineering Teaching Internship	Students enrolled in the MSE Ph.D. program are required to complete at least 12 units of a teaching internship at some time between their third and seventh semesters. Students should discuss the appropriate time to apply for and fulfill this requirement with their advisor. The requirements and units will vary depending on the instructor and class and might vary from directing labs experiments, grading, holding office hours or recitations, background research, preparing course demos, or giving guest lectures. The class instructor will also assign the teaching intern's grade. Students will apply for internships before each semester; the department Head will make the course assignments before the start of each semester. No more than 24 units of 27-991 can count toward the coursework requirement of the Ph.D. program. Passing of the Research Performance Evaluation (RPE) is required in order to eligible.	G	4, 17, 9	focused
32101	Naval Science - ROTC	Introduction to Naval Science	A general introduction to the naval profession and to concepts of Seapower. Instruction emphasizes the mission, organization, and warfare components of the Navy and Marine Corps. Included is an overview of officer and enlisted ranks and rates, training and education, and career patterns. The course also covers naval courtesy and customs, military justice, leadership, and nomenclature. This course exposes the student to the professional competencies required to become a naval officer.	U	4, 14, 9	focused
32102	Naval Science - ROTC	Seapower and Maritime Affairs	This course surveys US naval history from its European origins to the present with emphasis on major developments and the geopolitical forces shaping these developments. Also included is discussion of the theories and writings of naval historian and strategist Alfred Thayer Mahan. The course will finish by covering present day concerns in seapower and maritime affairs including the economic and political issues of merchant marine commerce, the law of the sea, the navy and merchant marine of the former Soviet Union (FSU), and a comparison of US and FSU maritime strategies to include the rise and decline of the Soviet Navy.	U	14, 8, 16	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
32200	Naval Science - ROTC	Naval Laboratory	Military drill, physical fitness, and leadership seminars.	U	4, 8	focused
32212	Naval Science - ROTC	Navigation	An in-depth study of piloting and an introduction to celestial navigation theory. Students learn piloting skills including the use of charts, visual and electronic aids, and the theory and operation of magnetic and gyro compasses. Students develop practical skills in both piloting and celestial navigation. Other topics include tides, currents effects of wind and weather, plotting, use of navigation instruments, types and characteristics of electronic navigation systems, and the typical day's work in navigation. Also included is a study of the international and inland rules of the nautical road, relative motion, vector analysis theory, and relative motion problems.	U	3, 4, 7	focused
32300	Naval Science - ROTC	Naval Laboratory	Military drill, physical fitness, and leadership seminars.	U	4, 8	focused
32310	Naval Science - ROTC	Evolution Of Warfare	This course is to provide the student with a very basic understanding of the art and concepts of warfare from the beginning of recorded history to the present day. The intent of the curriculum is to familiarize the student with an understanding of the threads of continuity and the interrelations of political, strategic, operational, tactical, and technical levels of war from the past, while bringing into focus the application of these same principles and concepts to the battlefields of today and the future.	U	4, 16, 9	focused
32311	Naval Science - ROTC	Naval Ship Systems I-Engineering	A detailed study of ship characteristics and types including ship design, hydrodynamic forces, stability, compartmentalization, propulsion, electrical and auxiliary systems, interior communications, ship control, and damage control. Included are basic concepts of the theory and design of steam, gas turbine, internal combustion, and nuclear propulsion. Shipboard safety and firefighting are also discussed.	U	7, 9, 13	focused
32312	Naval Science - ROTC	Naval Ship Systems II-Weapons	This course outlines the theory and employment of weapons systems. The student explores the processes of detection, evaluation, threat analysis, weapon selection, delivery, guidance and explosives. Fire control systems and major weapon types are discussed, including capabilities and limitations. The physical aspects of radar and underwater sound are described in detail. The facets of command, control, and communications are explored as a means of weapons system integration.	U	8, 1, 4	focused
32400	Naval Science - ROTC	Naval Laboratory	Military drill, physical fitness, and leadership seminars.	U	4, 8	focused
32402	Naval Science - ROTC	Leadership and Ethics	The study of naval junior officer responsibilities. The course exposes the student to a study of ethics, decision making and responsibility as well as counseling methods, military justice administration, naval human resources management, directives and correspondence, naval personnel administration, material management and maintenance and supply systems. This capstone course in the NROTC curriculum builds on and integrates the professional competencies developed in prior course work and professional training.	U	4, 17, 8	focused
32411	Naval Science - ROTC	Naval Operations and Seamanship	Designed as an introduction to naval operations and shipboard evolutions, vessel behavior and characteristics in maneuvering, applied aspects of ship handling, and afloat communications. This course builds upon the information presented in Navigation 32-212, Engineering 32-311, and Weapons Systems 32-312. An understanding of the nautical rules of the road, relative motion and vector analysis are utilized in discussion regarding the conduct of naval operation to include formation tactics and ship employment. The student will also be introduced to the various components of naval warfare and their role in sea control and power projection missions within naval and joint operations.	U	14, 9, 8	focused
33100	Physics	Basic Experimental Physics	This course provides students with a basic introduction to experimental physics. The content of the course and the particular experiments to be carried out are chosen to be especially useful for students who intend to work in the health sciences. Specific topics will range from mechanics to nuclear and atomic physics. This course is specifically geared toward pre-health students.	U	4, 7, 13	focused
33101	Physics	Physics First Year Seminar	Various seminars are offered that introduce first-year students to current topics of modern physics. These are mini courses that meet for half a semester. In the past, seminar topics have included: Science and Science Fiction, Astrophysics, Black Holes, Cosmology and Supernovae, Elementary Particles, and The Building Blocks of Matter. These seminars are open only to MCS first year students.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
33104	Physics	Experimental Physics	This course provides first year students and sophomores with an introduction to the methods of experimental physics. Particular emphasis is placed on three aspects of experimentation: laboratory technique, including both the execution and the documentation of an experiment; data analysis, including the treatment of statistical and systematic errors and computer-aided analysis of experimental data; and written communication of experimental procedures and results. The concepts and skills for measurement and data analysis are acquired gradually through a series of experiments covering a range of topics from mechanics to nuclear and atomic physics.	U	4, 7, 9	focused
33114	Physics	Physics of Musical Sound	An introduction to the physics and psychophysics of musical sound. Elementary physics of vibrating systems. Propagation of sound: traveling waves, reflection, and diffraction. Addition of waves: interference and beats. Anatomy of the ear and the perception of sound: loudness, pitch, and timbre. Standing waves and natural modes. Qualitative description of general periodic systems by Fourier analysis: the harmonic series and complex musical tones. The acoustics of musical instruments including percussion instruments, such as drums, bars, and struck and plucked strings; and instruments exhibiting self-sustained oscillations, including bowed strings, blown pipes, reeds, brasses, and singing. Intervals and consonance, musical scales, tuning and temperament. Basic room and auditorium acoustics. There are no formal prerequisites, but an ability to read music and having some previous musical experience will be very useful.	U	4, 9, 11	focused
33115	Physics	Physics for Future Presidents	Countless topics of social and political importance are intimately related to science in general and physics in particular. Examples include energy production, global warming, radioactivity, terrorism, and space travel. This course aims to provide key bits of knowledge based on which such issues can be discussed in a meaningful way, i.e., on the level of arguments and not just vague beliefs. We will cover an unusually wide range of topics, including energy, heat, gravity, atoms, radioactivity, chain reactions, electricity, magnetism, waves, light, weather, and climate. No calculus or algebra will be required. The course is open for all students at CMU.	U	13, 7, 4	focused
33120	Physics	Science and Science Fiction	We will view and critique the science content in a selection of science fiction films, spanning more than 100 years of cinematic history, and from sci-fi TV shows from the past 50+ years. Guided by selected readings from current scientific literature, and aided by order-of-magnitude estimates and careful calculations, we will ponder whether the films are showing things which may fall into one of the following categories: Science fiction at the time of production, but currently possible, due to recent breakthroughs. Possible, in principle, but beyond our current technology. Impossible by any science we know. Topics to be covered include the future of the technological society, the physics of Star Trek, the nature of space and time, extraterrestrial intelligence, robotics and artificial intelligence, biotechnology and more. Success of this course will depend upon class participation. Students will be expected to contribute to discussion of assigned readings and problems, and to give brief presentations in class on assigned films.	U	9, 4, 11	focused
33121	Physics	Physics I for Science Students	This calculus-based course combines the basic principles of mechanics with some quantum physics and relativity to explain nature on both a microscopic and macroscopic scale. The course will build models to describe the universe based on a small number of fundamental physics principles. Some simple computer modeling will be done to develop insight into the solving of problems using Newton's laws. Topics covered will include vectors, momentum, force, gravitation, oscillations, energy, quantum physics, center of mass motion, rotation, angular momentum, statistical physics, and the laws of thermodynamics. No computer experience is needed. Examples illustrating basic principles being presented will be taken from physics, chemistry, and biology.	U	7, 4, 13	focused
33122	Physics	Physics II for Biological Sciences and Chemistry Students	This is the second course in the introductory physics sequence for chemistry and biological science majors. The course will consist of eight portions covering (1) electrostatics and dynamics, (2) electrical circuits, (3) magnetism, (4) waves, (5) optics, (6) diffusive motion, and (7) hydrostatic forces and flow. Emphasis will be put on the application of the underlying physical principles in the study of biology and chemistry.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
33124	Physics	Introduction to Astronomy	Astronomy continues to enjoy a golden age of exploration and discovery. This course presents a broad view of astronomy, straightforwardly descriptive and without any complex mathematics. The goal of the course is to encourage non-technical students to become scientifically literate and to appreciate new developments in the world of science, especially in the rapidly developing field of astronomy. Subjects covered include the solar system, stars, galaxies and the universe as a whole. The student should develop an appreciation of the ever-changing universe and our place within it. Computer laboratory exercises will be used to gain practical experience in astronomical techniques. In addition, small telescopes will be used to study the sky. This course is specifically geared toward non-science/engineering majors.	U	7, 4, 9	focused
33141	Physics	Physics I for Engineering Students	This is a first semester, calculus-based introductory physics course. Basic principles of mechanics and thermodynamics are developed. Topics include vectors, displacement, velocity, acceleration, force, equilibrium, mass, Newton's laws, gravitation, work, energy, momentum, impulse, torque and angular momentum, temperature, heat, equations of state, thermodynamic processes, heat engines, refrigerators, first and second laws of thermodynamics, and the kinetic theory of gases.	U	7, 4, 13	focused
33142	Physics	Physics II for Engineering and Physics Students	This is the second half of a two-semester calculus-based introductory physics sequence for engineering and physics students. Two fifths of the course covers electricity, including electrostatics and electric fields, Gauss' law, electric potential, and simple circuits. Two fifths cover magnetism, including magnetic forces, magnetic fields, induction and electromagnetic radiation. One fifth of the course covers mechanical waves (including standing and traveling waves, superposition, and beats) and electromagnetic waves (including mode of propagation, speed, and other properties).	U	4, 7, 6	focused
33151	Physics	Matter and Interactions I	For students with a strong physics background who are interested using calculus-based mechanics to learn about topics such as dark matter, particle physics, and quantum phenomena, Matter and Interactions I provides an excellent alternative to Physics for Science Students. This course places great emphasis on constructing and using physical models, with a special focus on computer modeling to solve problems. Throughout the course, both traditional analytics techniques and scientific computing will be used to solve mechanical problems going from planetary systems, spring-based systems and nuclear scattering. Topics covered include Newton's Laws, microscopic models of solids, energy, energy quantization, mass-energy equivalence, multi particle systems, collisions, angular momentum including quantized angular momentum, kinetic theory of gases and statistical mechanics. Students are encouraged to do an optional research project that will be presented at a departmental poster session at the end of the semester.	U	7, 4, 13	focused
33152	Physics	Matter and Interactions II	A more challenging alternative to 33-142, Physics II for Engineering and Physics Students. There is an emphasis on atomic-level description and analysis of matter and its electric and magnetic interactions. Topics include: Coulomb's law, polarization, electric field, plasmas, field of charge distributions, microscopic analysis of resistor and capacitor circuits, potential, macroscopic analysis of circuits, Gauss' law, magnetic field, atomic model of magnetism, Ampere's law, magnetic force, relativistic issues, magnetic induction with emphasis on non-Coulomb electric field, Maxwell's equations, electromagnetic radiation including its production and its effects on matter, re-radiation, interference. There will also be computer modeling, visualization and desktop experiments.	U	4, 7, 9	focused
33201	Physics	Physics Sophomore Colloquium I	This course (together with 33-202) is designed to give students an overview of the field of Physics and to help students make knowledgeable choices in both their academic and professional careers. We discuss several of the sub-fields of Physics in order to give students an understanding of the types of activities, from research to industrial applications, in each. Over the two semesters, we typically discuss six subfields in some detail with the goal of providing a minimal literacy in the relevant concepts and language. The course consists of one classroom lecture per week plus one hour per week of reading and/or problem solving.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
33211	Physics	Physics III: Modern Essentials	Physics III is primarily for third-semester students of physics, including all physics majors, but is open to any qualified student who wants an introduction to the physics of the 20th century. The course will have a strong component of Special Relativity, dealing with kinematics and dynamics, but not electricity and magnetism. (See 33-213 description.) It will introduce students to a conceptual theory, which is mathematically simple but (initially) non-intuitive. The course also provides a broad exposure to quantum phenomena and early quantum theory without getting overly mathematical. It leads into the more formal Quantum Physics course (33-234).	U	4, 7, 9	focused
33213	Physics	Mini-Course in Special Relativity	This course spans the first six weeks of 33-211, Physics III: Modern Essentials. It treats the Mechanics aspects of Special Relativity, including topics such as simultaneity, the Lorentz transformation, time dilation, length contraction, space-time geometry, resolving some famous puzzles, and the momentum, mass, and energy relations. The Electricity and Magnetism portions of the subject are deferred until the junior/senior courses in E&M (33-338/33-339).	U	7, 13, 4	focused
33224	Physics	Stars, Galaxies and the Universe	The study of astronomy has blossomed over the past few decades as a result of new ground-based and space-based telescopes, and with the advantage of fast computers for analysis of the huge quantities of data. As our astronomical horizon expands, we are still able to use the laws of physics to make sense of it all. This course is for students who want to understand the basic concepts in astronomy and what drives astronomical objects and the universe. The course emphasizes the application of a few physical principles to a variety of astronomical settings, from stars to galaxies to the structure and evolution of the universe. Introductory classical physics is required, but modern physics will be introduced as needed in the course. The course is intended for science and engineering majors as well as students in other disciplines with good technical backgrounds. Computer lab exercises will be used to gain practical experience in astronomical techniques. In addition, small telescopes are available for personal sign-out for those who would like to use them, and outdoor observing sessions will be organized as weather permits.	U	4, 9, 17	focused
33225	Physics	Quantum Physics and Structure of Matter	This course introduces the basic theory used to describe the microscopic world of electrons, atoms, and photons. The duality between wave-like and particle-like phenomena is introduced along with the deBroglie relations which link them. We develop a wave description appropriate for quanta which are partially localized and discuss the interpretation of these wavefunctions. The wave equation of quantum mechanics is developed and applied to the hydrogen atom from which we extrapolate the structure of the Periodic Table. Other materials-related applications are developed, for example, Boltzmann and quantum statistics and properties of electrons in crystals. This course is intended primarily for non-physics majors who have not taken 33-211.	U	7, 13, 9	focused
33228	Physics	Electronics I	An introductory laboratory and lecture course with emphasis on elementary circuit analysis, design, and testing. We start by introducing basic circuit elements and study the responses of combinations to DC and AC excitations. We then take up transistors and learn about biasing and the behavior of amplifier circuits. The many uses of operational amplifiers are examined and analyzed; general features of feedback systems are introduced in this context. Complex functions are used to analyze all of the above linear systems. Finally, we examine and build some simple digital integrated circuits.	U	9, 4, 17	focused
33231	Physics	Physical Analysis	This course aims to develop analytical skills and mathematical modeling skills across a broad spectrum of physical phenomena, stressing analogies in behavior of a wide variety of systems. Specific topics include dimensional analysis and scaling in physical phenomena, exponential growth and decay, the harmonic oscillator with damping and driving forces, linear approximations of nonlinear systems, coupled oscillators, and wave motion. Necessary mathematical techniques, including differential equations, complex exponential functions, matrix algebra, and elementary Fourier series, are introduced as needed.	U	4, 8, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
33232	Physics	Mathematical Methods of Physics	This course introduces, in the context of physical systems, a variety of mathematical tools and techniques that will be needed for later courses in the physics curriculum. Topics will include, linear algebra, vector calculus with physical application, Fourier series and integrals, partial differential equations and boundary value problems. The techniques taught here are useful in more advanced courses such as Physical Mechanics, Electricity and Magnetism, and Advanced Quantum Physics.	U	4, 7, 9	focused
33234	Physics	Quantum Physics	An introduction to the fundamental principles and applications of quantum physics. A brief review of the experimental basis for quantization motivates the development of the Schrodinger wave equation. Several unbound and bound problems are treated in one dimension. The properties of angular momentum are developed and applied to central potentials in three dimensions. The one electron atom is then treated. Properties of collections of indistinguishable particles are developed allowing an understanding of the structure of the Periodic Table of elements. A variety of mathematical tools are introduced as needed.	U	9, 17, 8	focused
33241	Physics	Introduction to Computational Physics	This undergraduate course will provide an introduction to the numerical methods and computational algorithms used to solve a variety of problems in physics. In introductory physics courses, you are able to derive analytical solutions for simpler problems and often with simplifying assumptions. Have you wondered if a numerical solution can be obtained for a more complex problem that has no closed-form analytical solution? Computational physics provides a modern and powerful approach to compliment classical approaches to problem solving. Today's and tomorrow's scientists must be computationally fluent to be competitive and successful. In this course, you will learn to formulate problems by applying physical principles, select and apply numerical methods, develop and apply computational algorithms, solve physical problems analytically and numerically, and visualize quantitative results using plotting software	U	4, 9	focused
33301	Physics	Physics Upperclass Colloquium I	Upperclass Physics majors meet together for 1 hour a week to hear discussions on current physics research from faculty, undergraduate and graduate students, and outside speakers. Other topics of interest such as application to graduate school, areas of industrial research and job opportunities are also be presented.	U	4, 9, 8	focused
33331	Physics	Physical Mechanics I	Fundamental concepts of classical mechanics. Conservation laws, momentum, energy, angular momentum, Lagrange's and Hamilton's equations, motion under a central force, scattering, cross section, and systems of particles.	U	15, 7, 14	focused
33338	Physics	Intermediate Electricity and Magnetism I	This course includes the basic concepts of electro- and magnetostatics. In electrostatics, topics include the electric field and potential for typical configurations, work and energy considerations, the method of images and solutions of Laplace's Equation, multipole expansions, and electrostatics in the presence of matter. In magnetostatics, the magnetic field and vector potential, magnetostatics in the presence of matter, properties of dia-, para- and ferromagnetic materials are developed.	U	7, 13, 9	focused
33339	Physics	Intermediate Electricity and Magnetism II	This course focuses on electro- and magnetodynamics. Topics include Faraday's Law of induction, electromagnetic field momentum and energy, Maxwell's equations and electromagnetic waves including plane waves, waves in non-conducting and conducting media, reflection and refraction of waves, and guided waves. Electromagnetic radiation theory includes generation and characteristics of electric and magnetic dipole radiation. The Special Theory of Relativity is applied to electrodynamics: electric and magnetic fields in different reference frames, Lorentz transformations, four-vectors, invariants, and applications to particle mechanics.	U	7, 13, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
33340	Physics	Modern Physics Laboratory	Emphasis is on hands-on experience observing important physical phenomena in the lab, advancing the student's experimental skills, developing sophisticated data analysis techniques, writing thorough reports, and improving verbal communication through several oral progress reports given during the semester and a comprehensive oral report on one experiment. Students perform three experiments which are drawn from the areas of atomic, condensed matter, classical, and nuclear and particle physics. Those currently available are the following: Zeeman effect, light scattering, optical pumping, thermal lensing, Raman scattering, chaos, magnetic susceptibility, nuclear magnetic resonance, electron spin resonance, X-ray diffraction, Mössbauer effect, neutron activation of radioactive nuclides, Compton scattering, and cosmic ray muons.	U	4, 17, 7	focused
33341	Physics	Thermal Physics I	The three laws of classical thermodynamics, which deal with the existence of state functions for energy and entropy and the entropy at the absolute zero of temperature, are developed along phenomenological lines. Elementary statistical mechanics is then introduced via the canonical ensemble to understand the interpretation of entropy in terms of probability and to calculate some thermodynamic quantities from simple models. These laws are applied to deduce relationships among heat capacities and other measureable quantities and then are generalized to open systems and their various auxiliary thermodynamic potentials; transformations between potentials are developed. Criteria for equilibrium of multicomponent systems are developed and applied to phase transformations and chemical reactions. Models of solutions are obtained by using statistical mechanics and are applied to deduce simple phase diagrams for ideal and regular solutions. The concept of thermodynamic stability is then introduced and illustrated in the context of phase transformations.	U	7, 13, 9	focused
33342	Physics	Thermal Physics II	This course begins with a more systematic development of formal probability theory, with emphasis on generating functions, probability density functions and asymptotic approximations. Examples are taken from games of chance, geometric probabilities and radioactive decay. The connections between the ensembles of statistical mechanics (microcanonical, canonical and grand canonical) with the various thermodynamic potentials is developed for single component and multicomponent systems. Fermi-Dirac and Bose-Einstein statistics are reviewed. These principles are then applied to applications such as electronic specific heats, Einstein condensation, chemical reactions, phase transformations, mean field theories, binary phase diagrams, paramagnetism, ferromagnetism, defects, semiconductors and fluctuation phenomena.	U	9, 6, 17	focused
33350	Physics	Undergraduate Research	The student undertakes a project of interest under the supervision of a faculty member. May include research done in a research lab, extending the capabilities of a teaching lab, or a theoretical or computational physics project. The student experiences the less structured atmosphere of a research program where there is much room for independent initiative. A list of research projects is available. The student must contact the Assistant Head for the Undergraduate Affairs before registering so that student project pairings can be set. Reports on results are required at end of semester.	U	4, 17, 9	focused
33353	Physics	Intermediate Optics	Offer alternative years. Geometrical optics: reflection and refraction, mirrors, prisms, lenses, apertures and stops, simple optical instruments, fiber optics. Scalar wave optics: wave properties of light, interference, coherence, interferometry, Huygens-Fresnel principle, Fraunhofer diffraction, resolution of optical instruments, Fourier optics, Fresnel diffraction. Laser beam optics: Gaussian beams. Vector wave optics: electromagnetic waves at dielectric interfaces, polarized light. The course will use complex exponential representations of electromagnetic waves.	U	9, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
33441	Physics	Introduction to BioPhysics	This intermediate level course is primarily offered to Physics and Biology undergrads (junior/senior) and provides a modern view of molecular and cellular biology as seen from the perspective of physics, and quantified through the analytical tools of physics. This course will not review experimental biophysical techniques (which are covered, e.g., in 03-871). Rather, physicists will learn what sets "bio" apart from the remainder of the Physics world and how the apparent dilemma that the existence of life represents to classical thermodynamics is reconciled. They also will learn the nomenclature used in molecular biology. In turn, biologists will obtain (a glimpse of) what quantitative tools can achieve beyond the mere collecting and archiving of facts in a universe of observations: By devising models, non-obvious quantitative predictions are derived which can be experimentally tested and may lead to threads that connect vastly different, apparently unrelated phenomena. One major goal is then to merge the two areas, physics an biology, in a unified perspective.	U	9, 4, 7	focused
33445	Physics	Advanced Quantum Physics I	Mathematics of quantum theory, linear algebra and Hilbert spaces; review of classical mechanics; problems with classical mechanics; postulates of quantum theory; one dimensional applications; the harmonic oscillator; uncertainty relations; systems with N degrees of freedom, multi-particle states, identical particles; approximation methods.	U	4, 16, 9	focused
33446	Physics	Advanced Quantum Physics II	Classical symmetries; quantum symmetries; rotations and angular momentum; spin; addition of angular momentum; the hydrogen atom; quantum "paradoxes" and Bell's theorem; applications.	U	7, 13, 9	focused
33448	Physics	Introduction to Solid State Physics	This course gives a quantitative description of crystal lattices, common crystal structures obtained by adding a basis of atoms to the lattice, and the definition and properties of the reciprocal lattice. Diffraction measurements are studied as tools to quantify crystal lattices, including Bragg's law and structure factors. Diffraction from amorphous substances and liquids is also introduced. The various types of atomic bonding, e.g., Van der Waals, metallic, ionic, covalent and hydrogen are surveyed. Binding energies of some crystalline structures are calculated. Models of crystal binding are generalized to include dynamics, first for classical lattice vibrations and then for quantized lattice vibrations known as phonons. These concepts are used to calculate the heat capacities of insulating crystals, to introduce the concept of density of states, and to discuss phonon scattering. The band theory of solids is developed, starting with the free electron model of a metal and culminating with the properties of conductors and semiconductors. Magnetic phenomena such as paramagnetism and the mean field theory of ferromagnetism are covered to the extent that time permits.	U	7, 9, 13	focused
33456	Physics	Advanced Computational Physics	This course extends the study of the topics of 33-241 emphasizing practical numerical, symbolic and data-driven computational techniques as applied to a selection of currently active research areas. It is taught by faculty and staff actively engaged in a variety of areas of computational science. Numerical methods may include SVD decomposition, chi-squared minimization, and Fast Fourier Transforms and Monte Carlo simulation of experiments. Applications may include data analysis, eigenvalue problems and others depending on the research activities of the instructors. The students will be expected to become proficient in a specific programming language and to gain the ability to move to other languages and algorithms as their future computationally intensive efforts may require.	U	4, 17, 9	focused
33466	Physics	Extragalactic Astrophysics and Cosmology	Starting from the expanding universe of galaxies, this course lays out the structure of the universe from the Local Group of galaxies to the largest structures observed. The observational pinnacle of the Big Bang theory, the microwave background radiation, is shown to provide us with many clues to conditions in the early universe and to the parameters which control the expansion and fate of the universe. Current theories for the development of galaxies and clusters of galaxies are outlined in terms of our current understanding of dark matter. Observational cosmology continues to enjoy a golden era of discovery and the latest observational results will be interpreted in terms of the basic cosmological parameters.	U	17, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
33467	Physics	Astrophysics of Stars and the Galaxy	The physics of stars is introduced from first principles, leading from star formation to nuclear fusion to late stellar evolution and the end points of stars: white dwarfs, neutron stars and black holes. The theory of stellar structure and evolution is elegant and impressively powerful, bringing together all branches of physics to predict the life cycles of the stars. The basic physical processes in the interstellar medium will also be described, and the role of multi-wavelength astronomy will be used to illustrate our understanding of the structure of the Milky Way Galaxy, from the massive black hole at the center to the halo of dark matter which emcompasses it.	U	7, 13	focused
33499	Physics	Supervised Reading	The student explores a certain area of advanced physics under the supervision of a faculty member. The student must contact a faculty member and the Assistant Head for Undergraduate Affairs before registering.	U	4, 9	focused
33650	Physics	General Relativity	General Relativity is the classical theory of gravity. It is widely recognized as a beautiful theory - equating gravity and the geometry of spacetime leads to a profound conceptual change in the way we regard the universe. The predictions of the theory are relevant to systems as varied as high precision measurements of the earth's gravitational field or the strongly curved space-times around black holes. In this course, we will gradually develop an understanding of the geometries which are the solutions of the Einstein equation, with an emphasis on their relevance to physical situations. We will motivate the theory step by step and eventually introduce the Einstein equation itself. Typical Textbook(s): "Gravity, An Introduction to Einstein's General Relativity" by James Hartle.	G	9, 13	focused
33658	Physics	Quantum Computation and Quantum Information Theory	This course, taught in collaboration with the Computer Science Department, provides an overview of recent developments in quantum computation and quantum information theory. The topics include: an introduction to quantum mechanics, quantum channels, both ideal and noisy, quantum cryptography, an introduction to computational complexity, Shor's factorization algorithm, Grover's search algorithm, and proposals for the physical realization of quantum devices, such as correlated photons, ions in traps, and nuclear magnetic resonance. The course includes a weekly seminar. Typical Textbook(s): "Quantum Computation and Quantum Information" by Nielsen and Chuang.	G	17, 7, 9	focused
33659	Physics	Quantum Hall Effect and Topological Insulators	This course will introduce students to the topic of topological insulators and related phenomena using the Berry phase a unifying concept. In the first half of the semester, we will cover basic concepts such as Berry phase, Dirac fermions, Hall conductance and its link to topology, and the Hofstadter problem of lattice electrons in a magnetic field. Linear response theory will be discussed in relation to the Hall conductance. In the second half, we will move on to explain topological phases of matter such as Chern insulators and two- and three-dimensional topological insulators. Various techniques to calculate the topological indices will be introduced and connection to real materials will be discussed. Numerical studies of various tight-binding models provide intuitive understandings and will be an essential part of this course.	G	4, 9, 12	focused
33755	Physics	Quantum Mechanics I	This course introduces fundamental concepts of quantum mechanics. Applications are made to quantum computing, the harmonic oscillator, the hydrogen atom, electron spin and addition of angular momentum. 3hrs. lecture. Typical Text: Cohen-Tannoudji Quantum Mechanics, volume 1.	G	7, 13, 9	focused
33756	Physics	Quantum Mechanics II	This course focuses on qualitative and approximation methods in quantum mechanics, including time-independent and time-dependent perturbation theory, scattering and semiclassical methods. Applications are made to atomic, molecular and solid matter. Systems of identical particles are treated including many electron atoms and the Fermi gas. Prerequisite: 33-755, Quantum Mechanics I; 33-759 Theoretical Physics. 3 hrs. lecture. Typical Text: Cohen-Tannoudji Quantum Mechanics, volume 2.	G	17, 7, 9	focused
33759	Physics	Introduction to Mathematical Physics I	This course is an introduction to methods of mathematical analysis used in solving physical problems. Emphasis is placed both upon the generality of the methods, through a variety of sample problems, and upon their underlying principles. Topics normally covered include matrix algebra (normal modes, diagonalization, symmetry properties), complex variables and analytic functions, differential equations (Laplace's equation and separation of variables, special functions and their analytic properties), orthogonal systems of functions.	G	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
33761	Physics	Classical Electrodynamics I	This course deals with the static and dynamic properties of the electromagnetic field as described by Maxwell's equations. Among the topics emphasized are solutions of Laplace's, Poisson's and wave equations, effects of boundaries, Green's functions, multipole expansions, emission and propagation of electromagnetic radiation and the response of dielectrics, metals, magnetizable bodies to fields. 3 hrs. lecture. Typical Text: Jackson, Classical Electrodynamics, 2nd Ed.	G	13, 9, 12	focused
33765	Physics	Statistical Mechanics	This course develops the methods of statistical mechanics and uses them to calculate observable properties of systems in thermodynamic equilibrium. Topics treated include the principles of classical thermodynamics, canonical and grand canonical ensembles for classical and quantum mechanical systems, partition functions and statistical thermodynamics, fluctuations, ideal gases of quanta, atoms and polyatomic molecules, degeneracy of Fermi and Bose gases, chemical equilibrium, ideal paramagnetics and introduction to simple interacting systems. 3 hrs. lecture, 1 hr. recitation. Typical Texts: Reif, Statistical and Thermal Physics; Pathria, Statistical Mechanics.	G	13, 6, 9	focused
33767	Physics	Biophysics: From Basic Concepts to Current Research	This course mixes lectures and student presentations on advanced topis in Biological Physics. In the course, students will gain a deep appreciation of the fact that very basic physical and chemical principles underly many central life processes. Life is not only compatible with the laws of physics and chemistry, rather, it exploits them in ingenious ways. After taking the course, students should be able to name examples of such situations for which they can provide a coherent line of reasoning that outlines these connections. They will be able to explain key experiments by which these connections either have been found or are nowadays routinely established, and outline simple back-of-the-envelope estimates by which one can convince oneself of either the validity or inapplicability of certain popular models and ideas. They should also have become sufficiently familiar with the key terminology frequently encountered in biology, such that they can start to further educate themselves by consulting biological and biophysical literature. The course uses Physical Biology of the Cell by Rob Phillips et al. (Garland Science, New York, NY, 2013, ISBN 978-0-8153-4450-6).	G	4, 9, 17	focused
33775	Physics	Introduction to Research 1	Both semesters are designed to give the student opportunity to gain experience in modern experimental techniques either through participation in research laboratories or through formal instruction, depending on the student's background. In the first semester, the student will also learn of the research of the department through lectures by the faculty on their work. All students are required to take the first semester, but those with post-graduate or unusual laboratory experience may not be required to take the second. However, it should be noted that for the M.S. degree, 12 units of laboratory are required.	G	4, 17, 9	focused
33777	Physics	Introductory Astrophysics	Introductory Astrophysics will explore the applications of physics to the following areas: (i) celestial mechanics and dynamics, (ii) the physics of solar system objects, (iii) the structure, formation and evolution of stars and galaxies, (iv) the large scale structure of the universe of galaxies, (v) cosmology: the origin, evolution and fate of the universe.	G	7, 13	focused
33779	Physics	Introduction to Nuclear and Particle Physics	An introduction to the physics of atomic nuclei and elementary particles. This course is suitable as a one-semester course for students not specializing in this area and also provides an introduction to further work in 33-780, 33-78l. Topics included are symmetry principles of strong and weak interactions, quark model, classification of particles and nuclear forces.	G	4, 7, 13	focused
33783	Physics	Solid State Physics	This course is designed to give advanced graduate students a fundamental knowledge of the microscopic properties of solids in terms of molecular and atomic theory, crystal structures, x-ray diffraction of crystals and crystal defects, lattice vibration and thermal properties of crystals; free-electron model, energy bands, electrical conduction and magnetism. Prerequisite: 33-756. 3 hrs. lecture. Typical Text: Ashcroft and Mermin, Solid State Physics.	G	7, 4, 13	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
36200	Statistics	Reasoning with Data	This course is an introduction to learning how to make statistical decisions and "reason with data". The approach will emphasize thinking through an empirical problem from beginning to end and using statistical tools to look for evidence for/against an explicit argument/hypothesis. Types of data will include continuous and categorical variables, images, text, networks, and repeated measures over time. Applications will largely draw from interdisciplinary case studies spanning the humanities, social sciences, and related fields. Methodological topics will include basic exploratory data analysis, elementary probability, hypothesis tests, and empirical research methods. There is no calculus or programming requirement. There will be one weekly computer lab for additional hands-on practice using an interactive software platform that allows student-driven inquiry. This course is the credit-equivalent to 36-201 and will be honored appropriately as a pre-requisite for downstream Statistics courses. As such, this course is not currently open to students who have received credit for 36-201, 36/70-207, 36-220, 36-247, or any 300- or 400-level Statistics course.	U	4, 8, 17	focused
36202	Statistics	Methods for Statistics & Data Science	This course builds on the principles and methods of statistical reasoning developed in 36-200 (or its equivalents). The course covers simple and multiple regression, analysis of variance methods and logistic regression. Other topics may include non-parametric methods and probability models, as time permits. The objectives of this course is to develop the skills of applying the basic principles and methods that underlie statistical practice and empirical research. Learning the Data Analysis Pipeline is strongly emphasized through structured coding and data analysis projects. In addition to three lectures a week, students attend a computer lab twice a week for "hands-on" practice of the material covered in lecture; students will learn the basics of R Markdown and related analytics tools. Not open to students who have received credit for: 36-208/70-208, 36-309. Students who have completed or are enrolled in 36-401 prior to completing 36-202, are not able to take/receive credit for 36-202.	U	4, 8, 9	focused
36204	Statistics	Discovering the Data Universe	Every day we wake up in the data universe, we use the information around us to make decisions. We are constantly evaluating and interpreting data from our environment, in everything from spreadsheets to Instagram posts. At the same time, our own personal data are being observed and recorded--through websites we visit online, our smart devices, and even our interactions with other students and faculty at CMU. Navigating this data universe requires knowledge of what data is and how to use it responsibly. For example, can a plant be a data set? Discovering the truth behind a piece of data, including who made it, what it looks like, and what we can learn from it, is a critical skill. Understanding data can be the difference between being able to distinguish truth from lies; and the key to identifying your data footprint and succeeding in research and in your career. In this course, we will explore the data universe from multiple angles and across several types of data. We will define, find, and analyze data, and most importantly, identify narratives within data to tell stories about the world around us. We will examine data using the following questions: How can we tell multiple stories from the same dataset? What biases can exist in data? And, who creates or decides what data matters enough to collect, preserve, and share?	U	4, 15, 17	focused
36207	Statistics	Probability and Statistics for Business Applications	This is the first half of a year long sequence in basic statistical methods that are used in business and management. Topics include exploratory and descriptive techniques, probability theory, statistical inference in simple settings, basic categorical analysis, and statistical methods for quality control. Not open to students who have received credit for 36-201, 36-220, 36-625, or 36-247. Cross-listed as 70-207.	U	4, 8, 9	focused
36208	Statistics	Regression Analysis	This is the second half of a year long sequence in basic statistical methods that are used in business and management. Topics include time series, regression and forecasting. In addition to two lectures a week, students will attend a computer lab once a week. Not open to students who have received credit for 36-202, 36-626. Cross-listed as 70-208. Students who have completed 36-401 prior to 36-208 will not receive credit for 36-208.	U	4, 8, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
36218	Statistics	Probability Theory for Computer Scientists	Probability theory is the mathematical foundation for the study of both statistics and of random systems. This course is an intensive introduction to probability,from the foundations and mechanics to its application in statistical methods and modeling of random processes. Special topics and many examples are drawn from areas and problems that are of interest to computer scientists and that should prepare computer science students for the probabilistic and statistical ideas they encounter in downstream courses and research. A grade of C or better is required in order to use this course as a pre-requisite for 36-226, 36-326, and 36-410. Not open to students who have received credit for 36-225, 21-325, or 36-700. If you hold a Statistics primary/additional major or minor you will be required to complete 36-226. For those who do not have a major or minor in Statistics, and receive at least a B in 36-218, you will be eligible to move directly onto 36-401.	U	4, 17, 8	focused
36219	Statistics	Probability Theory and Random Processes	This course provides an introduction to probability theory. It is designed for students in electrical and computer engineering. Topics include elementary probability theory, conditional probability and independence, random variables, distribution functions, joint and conditional distributions, limit theorems, and an introduction to random processes. Some elementary ideas in spectral analysis and information theory will be given. A grade of C or better is required in order to use this course as a pre-requisite for 36-226 and 36-410. Not open to students who have received credit for 36-225, or 36-625.	U	4, 9, 8	focused
36220	Statistics	Engineering Statistics and Quality Control	This is a course in introductory statistics for engineers with emphasis on modern product improvement techniques. Besides exploratory data analysis, basic probability, distribution theory and statistical inference, special topics include experimental design, regression, control charts and acceptance sampling. Not open to students who have received credit for 36-201, 36-207/70-207, 36-226, 36-626, or 36-247, except when AP credit is awarded for 36-201.	U	4, 9, 8	focused
36225	Statistics	Introduction to Probability Theory	This course is the first half of a year long course which provides an introduction to probability and mathematical statistics for students in economics, mathematics and statistics. The use of probability theory is illustrated with examples drawn from engineering, the sciences, and management. Topics include elementary probability theory, conditional probability and independence, random variables, distribution functions, joint and conditional distributions, law of large numbers, and the central limit theorem. A grade of C or better is required in order to advance to 36-226, 36-326, and 36-410. Not open to students who have received credit for 36-217, 36-218, 21-325, 36-700.	U	4, 8, 10	focused
36226	Statistics	Introduction to Statistical Inference	This course is the second half of a year long course in probability and mathematical statistics. Topics include maximum likelihood estimation, confidence intervals, hypothesis testing, and properties of estimators, such as unbiasedness and consistency. If time permits there will also be a discussion of linear regression and the analysis of variance. A grade of C or better is required in order to advance to 36-401, 36-402 or any 36-46x course. Not open to students who have received credit for 36-626.	U	4, 8, 10	focused
36247	Statistics	Statistics for Lab Sciences	This course is equivalent to 36-200 with the exception that 36-247 students take a Lab Sciences-specific laboratory section. This course is an introduction to learning how to make statistical decisions and "reason with data". The approach will emphasize thinking through an empirical problem from beginning to end and using statistical tools to look for evidence for/against an explicit argument/hypothesis. Types of data will include continuous and categorical variables, images, text, networks, and repeated measures over time. Applications will largely draw from interdisciplinary case studies spanning the humanities, social sciences, and related fields. Methodological topics will include basic exploratory data analysis, elementary probability, hypothesis tests, and empirical research methods. There is no calculus or programming requirement. There will be one weekly computer lab for additional hands-on practice using an interactive software platform that allows student-driven inquiry. This course is the credit-equivalent to 36-201 and will be honored appropriately as a pre-requisite for downstream Statistics courses. As such, this course is not currently open to students who have received credit for 36-200, 36-201, 36/70-207, 36-220, or any 300- or 400-level Statistics course.	U	4, 8, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
36290	Statistics	Introduction to Statistical Research Methodology	This course is designed to introduce statistical research methodology--the procedures by which statisticians go about approaching and analyzing data--to early undergraduates. Students will learn basic concepts of statistical learning--inference vs. prediction, supervised vs. unsupervised learning, regression vs. classification, etc.--and will reinforce this knowledge by applying, e.g., linear regression, random forest, principal components analysis, and/or hierarchical clustering and more to datasets provided by the instructor. Students will also practice disseminating the results of their analyses via oral presentations and posters. Analyses will primarily be carried out using the R programming language, but with attention paid to how one would perform similar analyses using Python. Previous knowledge of R is not required for this course. Space is very limited; there will be an application process. The course is currently open to sophomore statistics students only.	U	4, 15, 17	focused
36303	Statistics	Sampling, Survey and Society	This course will revolve around the role of sampling and sample surveys in the context of U.S. society and its institutions. We will examine the evolution of survey taking in the United States in the context of its economic, social and political uses. This will eventually lead to discussions about the accuracy and relevance of survey responses, especially in light of various kinds of nonsampling error. Students will be required to design, implement and analyze a survey sample.	U	8, 4, 1	focused
36309	Statistics	Experimental Design for Behavioral & Social Sciences	Statistical aspects of the design and analysis of planned experiments are studied in this course. A clear statement of the experimental factors will be emphasized. The design aspect will concentrate on choice of models, sample size and order of experimentation. The analysis phase will cover data collection and computation, especially analysis of variance and will stress the interpretation of results. In addition to a weekly lecture, students will attend a computer lab once a week.	U	4, 1, 9	focused
36311	Statistics	Statistical Analysis of Networks	Networks are omnipresent. In this course, students will get an introduction to network science, mainly focusing on social network analysis. The course will start with some empirical background, and an overview of concepts used when measuring and describing networks. We will also discuss network visualization. Most traditional models cannot be applied straightforwardly to social network data, because of their complex dependence structure. We will discuss random graph models and statistical network models, that have been developed for the study of network structure and growth. We will also cover models of how networks impact individual behavior.	U	4, 9, 8	focused
36315	Statistics	Statistical Graphics and Visualization	Graphical displays of quantitative information take on many forms as they help us understand both data and models. This course will serve to introduce the student to the most common forms of graphical displays and their uses and misuses. Students will learn both how to create these displays and how to understand them. As time permits the course will consider some more advanced graphical methods such as computer-generated animations. Each student will be required to engage in a project using graphical methods to understand data collected from a real scientific or engineering experiment. In addition to two weekly lectures there will be lab sessions where the students learn to use software to aid in the production of appropriate graphical displays.	U	4, 9, 17	focused
36350	Statistics	Statistical Computing	Statistical Computing: An introduction to computing targeted at statistics majors with minimal programming knowledge. The main topics are core ideas of programming (functions, objects, data structures, flow control, input and output, debugging, logical design and abstraction), illustrated through key statistical topics (exploratory data analysis, basic optimization, linear models, graphics, and simulation). The class will be taught in the R language. No previous programming experience required.	U	9, 4, 8	focused
36401	Statistics	Modern Regression	This course is an introduction to the real world of statistics and data analysis. We will explore real data sets, examine various models for the data, assess the validity of their assumptions, and determine which conclusions we can make (if any). Data analysis is a bit of an art; there may be several valid approaches. We will strongly emphasize the importance of critical thinking about the data and the question of interest. Our overall goal is to use a basic set of modeling tools to explore and analyze data and to present the results in a scientific report. A grade of C is required to move on to 36-402 or any 36-46x course.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
36402	Statistics	Advanced Methods for Data Analysis	This course introduces modern methods of data analysis, building on the theory and application of linear models from 36-401. Topics include nonlinear regression, nonparametric smoothing, density estimation, generalized linear and generalized additive models, simulation and predictive model-checking, cross-validation, bootstrap uncertainty estimation, multivariate methods including factor analysis and mixture models, and graphical models and causal inference. Students will analyze real-world data from a range of fields, coding small programs and writing reports. Prerequisites: 36-401	U	4, 17, 9	focused
36461	Statistics	Special Topics: Statistical Methods in Epidemiology	Epidemiology is concerned with understanding factors that cause, prevent, and reduce diseases by studying associations between disease outcomes and their suspected determinants in human populations. Epidemiologic research requires an understanding of statistical methods and design. Epidemiologic data is typically discrete, i.e., data that arise whenever counts are made instead of measurements. In this course, methods for the analysis of categorical data are discussed with the purpose of learning how to apply them to data. The central statistical themes are building models, assessing fit and interpreting results. There is a special emphasis on generating and evaluating evidence from observational studies. Case studies and examples will be primarily from the public health sciences.	U	3, 4, 17	focused
36462	Statistics	Special Topics: Methods of Statistical Learning	Data mining is the science of discovering patterns and learning structure in large data sets. Covered topics include information retrieval, clustering, dimension reduction, regression, classification, and decision trees. Prerequisites: 36-401 (C or better).	U	4, 15	focused
36465	Statistics	Special Topics: Conceptual Foundations of Statistical Learning	This class is an introduction to the foundations of statistical learning theory, and its uses in designing and analyzing machine-learning systems. Statistical learning theory studies how to fit predictive models to training data, usually by solving an optimization problem, in such a way that the model will predict well, on average, on new data. The course will focus on the key concepts and theoretical tools, at a level accessible to students who have taken 36-401 and its pre-requisites. The course will also illustrate those concepts and tools by applying them to carefully selected kinds of machine learning systems (such as kernel machines). Students wanting exposure to a broad range of algorithms and applications would be better served by 36-462/662 ("Data Mining"). This class is for those who want a deeper understanding of the principles underlying all machine learning methods.	U	4, 9	focused
36467	Statistics	Special Topics: Data over Space & Time	This course is an introduction to the opportunities and challenges of analyzing data from processes unfolding over space and time. It will cover basic descriptive statistics for spatial and temporal patterns; linear methods for interpolating, extrapolating, and smoothing spatio-temporal data; basic nonlinear modeling; and statistical inference with dependent observations. Class work will combine practical exercises in R, a little mathematics on the underlying theory, and case studies analyzing real problems from various fields (economics, history, meteorology, ecology, etc.). Depending on available time and class interest, additional topics may include: statistics of Markov and hidden-Markov (state-space) models; statistics of point processes; simulation and simulation-based inference; agent-based modeling; dynamical systems theory.	U	4, 15, 8	focused
36490	Statistics	Undergraduate Research	This course is designed to give undergraduate students experience using statistics in real research problems. Small groups of students will be matched with clients and do supervised research for a semester. Students will gain skills in approaching a research problem, critical thinking, statistical analysis, scientific writing, and conveying and defending their results to an audience.	U	4, 17, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
36493	Statistics	Sports Analytics Capstone	This course is designed to give undergraduate students experience applying statistics & data science methodology to research problems in sports analytics. Small groups of students will be matched with clients in the Carnegie Mellon Athletics Department and do supervised projects for a semester. Students will gain skills in approaching a real world problem, critical thinking, advanced statistical analysis, scientific writing, collaboration with clients, communicating results, and meeting expectations with respect to deliverables and timelines. The projects will change and rotate each semester. The course size is limited, and students will submit an application including their project preferences. Students with skill sets matching project needs will be given priority. We will also take into consideration whether or not a student has had a recent prior data science experience with the goal of providing experiences to a broad group of qualified students. Students do not need to be experts in sports analytics or have extensive knowledge in sports.	U	4, 17, 9	focused
36497	Statistics	Corporate Capstone Project	This course is designed to give undergraduate students experience applying statistics data science methodology to real industry projects. Small groups of students will be matched with industry clients and do supervised projects for a semester. Students will gain skills in approaching a real world problem, critical thinking, advanced statistical analysis, scientific writing, collaborating in an industry setting, communicating results, and meeting expectations with respect to deliverables and timelines. The industry clients will change and rotate each semester; available projects will be advertised prior to registration. The course size is limited, and students will submit an application including their project preferences. Students with skill sets matching project needs will be given priority. We will also take into consideration whether or not a student has had a recent prior corporate capstone experience with the goal of providing experiences to a broad group of qualified students.	U	4, 9, 17	focused
36601	Statistics	Perspectives in Data Science I	This course covers the principles and practice of Data Science including data input and cleaning, exploratory data analysis, intermediate R programming, beginning SAS programming, beginning to intermediate python programming, and SQL. For Master's in Statistical Practice students only.	G	4, 12	focused
36602	Statistics	Perspectives in Data Science II	This course is a continuation of 36-601 and covers interactive data visualization with Shiny, advanced R programming techniques, intermediate SAS (macros), web scraping, Hadoop, and Spark. For Master's in Statistical Practice students only.	G	4, 9, 17	focused
36611	Statistics	Professional Skills for Statisticians I	This course covers a variety of professional skills including resumes and cover letters, writing reports, oral presentations, teamwork, and project planning. Consulting skills are developed in the form of a whole-class consulting project. For Master's in Statistical Practice students only.	G	4, 8, 17	focused
36612	Statistics	Professional Skills for Statisticians II	This course is a continuation of 36-611 and covers additional writing and presentation skills, as well as interview skills. For Master's in Statistical Practice students only.	G	4, 17, 8	focused
36617	Statistics	Applied Linear Models	This course covers the theory and practice of linear models in matrix form with emphasis on practical skills for working with real data and communicating results to technical and non-technical audiences. For Master's in Statistical Practice students only.	G	4, 9, 8	focused
36618	Statistics	Time Series and Experimental Design	This course covers fundamentals of experimental design including various ANOVA models, Latin squares and factorial and fractional factorial designs. The time series components covers exponential smoothing models and ARIMA, including seasonal models and transfer function models. Special topics are intermittent. For Master's in Statistical Practice students only.	G	4, 9	focused
36650	Statistics	Statistical Computing	A detailed introduction to elements of computing relating to statistical modeling, targeted to advanced undergraduates, masters students, and doctoral students in Statistics. Topics include important data structures and algorithms; numerical methods; databases; parallelism and concurrency; and coding practices, program design, and testing. Multiple programming languages will be supported (e.g., C, R, Python, etc.). Those with no previous programming experience are welcome but will be required to learn the basics of at least one language via self-study. There are very limited spots for undergraduates; special permission from both advisor and instructor required.	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
36652	Statistics	Statistical Computing II	A detailed discussion of computing elements relating to statistical modeling, targeted to advanced undergraduates and master's students in Statistics. Topics include databases; cloud storage models; data integration concepts; numerical methods; big data analytics frameworks; machine learning models; graphical user interface; low-code application development; and DevOps. The course will focus on using Python programming language. Comparable programming experience in Python -as judged by the instructor- is required. There are very limited spots for undergraduates; special permission from both instructor and advisor required.	G	4, 9, 17	focused
36661	Statistics	Special Topics: Statistical Methods in Epidemiology	Epidemiology is concerned with understanding factors that cause, prevent, and reduce diseases by studying associations between disease outcomes and their suspected determinants in human populations. Epidemiologic research requires an understanding of statistical methods and design. Epidemiologic data is typically discrete, i.e., data that arise whenever counts are made instead of measurements. In this course, methods for the analysis of categorical data are discussed with the purpose of learning how to apply them to data. The central statistical themes are building models, assessing fit and interpreting results. There is a special emphasis on generating and evaluating evidence from observational studies. Case studies and examples will be primarily from the public health sciences.	G	3, 4, 17	focused
36662	Statistics	Special Topics: Methods of Statistical Learning	Data mining is the science of discovering patterns and learning structure in large data sets. Covered topics include information retrieval, clustering, dimension reduction, regression, classification, and decision trees.	G	4, 15	focused
36665	Statistics	Special Topics: Conceptual Foundations of Statistical Learning	This class is an introduction to the foundations of statistical learning theory, and its uses in designing and analyzing machine-learning systems. Statistical learning theory studies how to fit predictive models to training data, usually by solving an optimization problem, in such a way that the model will predict well, on average, on new data. The course will focus on the key concepts and theoretical tools, at a level accessible to students who have taken 36-401 and its pre-requisites. The course will also illustrate those concepts and tools by applying them to carefully selected kinds of machine learning systems (such as kernel machines). Students wanting exposure to a broad range of algorithms and applications would be better served by 36-462/662 ("Data Mining"). This class is for those who want a deeper understanding of the principles underlying all machine learning methods.	G	4, 9	focused
36667	Statistics	Special Topics: Data over Space & Time	This course is an introduction to the opportunities and challenges of analyzing data from processes unfolding over space and time. It will cover basic descriptive statistics for spatial and temporal patterns; linear methods for interpolating, extrapolating, and smoothing spatio-temporal data; basic nonlinear modeling; and statistical inference with dependent observations. Class work will combine practical exercises in R, a little mathematics on the underlying theory, and case studies analyzing real problems from various fields (economics, history, meteorology, ecology, etc.). Depending on available time and class interest, additional topics may include: statistics of Markov and hidden-Markov (state-space) models; statistics of point processes; simulation and simulation-based inference; agent-based modeling; dynamical systems theory.	G	4, 15, 8	focused
36699	Statistics	Statistical Immigration	Students are introduced to the faculty and their interests, the field of statistics, and the facilities at Carnegie Mellon. Each faculty member gives at least one elementary lecture on some topic of his or her choice. In the past, topics have included: the field of statistics and its history, large-scale sample surveys, survival analysis, subjective probability, time series, robustness, multivariate analysis, psychiatric statistics, experimental design, consulting, decision-making, probability models, statistics and the law, and comparative inference. Students are also given information about the libraries at Carnegie Mellon and current bibliographic tools. In addition, students are instructed in the use of the Departmental and University computational facilities and available statistical program packages. THIS COURSE IS FOR PHD STUDENTS IN THE DEPT OF STATISTICS ONLY.	G	4, 10, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
36700	Statistics	Probability and Mathematical Statistics	This is a one-semester course covering the basics of statistics. We will first provide a quick introduction to probability theory, and then cover fundamental topics in mathematical statistics such as point estimation, hypothesis testing, asymptotic theory, and Bayesian inference. If time permits, we will also cover more advanced and useful topics including nonparametric inference, regression and classification. Prerequisites: one- and two-variable calculus and matrix algebra.	G	4, 9	focused
36705	Statistics	Intermediate Statistics	This course covers the fundamentals of theoretical statistics. Topics include: probability inequalities, point and interval estimation, minimax theory, hypothesis testing, data reduction, convergence concepts, Bayesian inference, nonparametric statistics, bootstrap resampling, VC dimension, prediction and model selection.	G	4, 10, 9	focused
36707	Statistics	Regression Analysis	This is a course in data analysis. Topics covered include: Simple and multiple linear regression, causation, weighted least-squares, global and case diagnostics, robust regression, exponential families, logistic regression and generalized linear models; Model selection: prediction risk, bias-variance tradeoff, risk estimation, model search, ridge regression and lasso, stepwise regression, maybe boosting; Smoothing and nonparametric regression: linear smoothers, kernels, local regression, penalized regression, regularization and splines, wavelets, variance estimation, confidence bands, local likelihood, additive models; Classification: parametric and nonparametric regression, LDA, QDA, trees. Practice in data analysis is obtained through course projects. This course is primarily for first year PhD students in Statistics & Data Science; it requires an appropriate background for entering that program.	G	4, 5, 10	focused
36708	Statistics	The ABCDE of Statistical Methods in Machine Learning	This course focuses on statistical methods for machine learning, a decades-old topic in statistics that now has a life of its own, intersecting with many other fields. While the core focus of this course is methodology (algorithms), the course will have some amount of formalization and rigor (theory/derivation/proof), and some amount of interacting with data (simulated and real). However, the primary way in which this course complements related courses in other departments is the joint ABCDE focus on (A) Algorithm design principles, (B) Bias-variance thinking, (C) Computational considerations (D) Data analysis (E) Explainability and interpretability.	G	4, 5, 9	focused
36709	Statistics	Advanced Statistical Theory I	This is a core Ph.D. course in theoretical statistics. The class will cover a selection of modern topics in mathematical statistics, focussing on high-dimensional parametric models and non-parametric models. The main goal of the course is to provide the students with adequate theoretical background and mathematical tools to read and understand the current statistical literature on high-dimensional models. Topics will include: concentration inequalities, covariance estimation, principal component analysis, penalized linear regression, maximal inequalities for empirical processes, Rademacher and Gaussian complexities, non-parametric regression and minimax theory. This will be the first part of a two semester sequence.	G	4, 10, 9	focused
36710	Statistics	Advanced Statistical Theory II	This is a core Ph.D. course in theoretical statistics. The class will cover a selection of modern topics in mathematical statistics, focussing on high-dimensional parametric models and non-parametric models. The main goal of the course is to provide the students with adequate theoretical background and mathematical tools to read and understand the current statistical literature on high-dimensional models. Topics will include: concentration inequalities, covariance estimation, principal component analysis, penalized linear regression, maximal inequalities for empirical processes, Rademacher and Gaussian complexities, non-parametric regression and minimax theory.	G	4, 10, 9	focused
36726	Statistics	Statistical Practice	Students are taught how to structure a consulting session, elicit and diagnose a problem, manage a project, and report an analysis. The class will participate in meetings with industrial and academic clients. For Master's in Statistical Practice students only.	G	4, 9, 17	focused
36750	Statistics	Statistical Computing	A detailed introduction to elements of computing relating to statistical modeling, targeted to advanced undergraduates, masters students, and doctoral students in Statistics. Topics include important data structures and algorithms; numerical methods; databases; parallelism and concurrency; and coding practices, program design, and testing. Multiple programming languages will be supported (e.g., C, R, Python, etc.). Those with no previous programming experience are welcome but will be required to learn the basics of at least one language via self-study.	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
36752	Statistics	Statistical Computing II	A detailed discussion of computing elements relating to statistical modeling. Topics include databases; cloud storage models; data integration concepts; numerical methods; big data analytics frameworks; machine learning models; graphical user interface; low-code application development; and DevOps. The course will focus on using Python programming language. Comparable programming experience in Python -as judged by the instructor- is required.	G	4, 9, 17	focused
36759	Statistics	Statistical Models of the Brain	This new course is intended for CNBC students, as an additional option for fulfilling the computational core course requirement, but it will also be open to Statistics and Machine Learning students. It should be of interest to anyone wishing to see the way statistical ideas play out within the brain sciences, and it will provide a series of case studies on the role of stochastic models in scientific investigation. Statistical ideas have been part of neurophysiology and the brainsciences since the first stochastic description of spike trains, and the quantal hypothesis of neurotransmitter release, more than 50 years ago. Many contemporary theories of neural system behavior are built with statistical models. For example, integrate-and-fire neurons are usually assumed to be driven in part by stochastic noise; the role of spike timing involves the distinction between Poisson and non-Poisson neurons; and oscillations are characterized by decomposing variation into frequency-based components. In the visual system, V1 simple cells are often described using linear-nonlinear Poisson models; in the motor system, neural response may involve direction tuning; and CA1 hippocampal receptive field plasticity has been characterized using dynamic place models. It has also been proposed that perceptions, decisions, and actions result from optimal (Bayesian) combination of sensory input with previously-learned regularities; and some investigators report new insights from viewing whole-brain pattern responses as analogous to statistical classifiers. Throughout the field of statistics, models incorporating random ``noise'' components are used as an effective vehicle for data analysis. In neuroscience, however, the models also help form a conceptual framework for understanding neural function. This course will examine some of the most important methods and claims that have come from applying statistical thinking	G	4, 9, 11	focused
36765	Statistics	Writing in Statistics	There is no one correct way to write. But there are things you can do that tend to make it difficult for a reader to absorb the ideas you are writing about, or make it easier for the reader. Thus, it is important to focus on the reader, and the constraints and habits of mind that most readers (even in the rarefied population of academics who can understand the technical details of your work) bring to the task of reading what you have written. The goals for students in this course are: to understand that writing requires an intellectual investment similar to the investment that you put into other areas of your research, from developing research questions, data collection, and data analysis, to writing and testing algorithms, and formulating and proving theorems; to understand ways of organizing your writing that make it more likely that the reader will interpret and understand your ideas in the way that you intend; and to gain experience writing with these ideas in mind. The course is most suitable for graduate students in statistics who are engaged in a writing project (ADA paper, journal article, thesis work, etc.).	G	4, 17, 9	focused
36795	Statistics	Interdisciplinary Applied Research	This course is the second course of the advanced applied data analysis sequence and is for PhD students in Statistics & Data Science only.	G	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
38101	MCS Interdisciplinary	EUREKA!: Discovery and Its Impact	The MCS first-year seminar "EUREKA: Discovery and Its Impact" will equip new students with foundational knowledge, skills and perspectives that will support their development as emerging scientists. During the seminar, students will be presented with opportunities and experiences designed to help them frame how the MCS curriculum aspires to shape their evolving identities in the areas of scholar, person, professional and citizen, while also engendering a sense of excitement about science and scientific inquiry. The seminar will offer information and strategies that are employed both by successful students and by successful scientists in optimizing their approach to work and life, with a key focus on areas such as cognitive learning skills, research, teamwork, goal setting, time management, innovation, community engagement, ethics, resources and assessment. Additionally, the seminar will introduce first-year students to the learning outcomes and requirements associated with the MCS core curriculum, with a particular emphasis on the self-directed ENGAGE courses and the role of the e-portfolio system in documenting and framing student growth and development.	U	4, 9, 17	focused
38110	MCS Interdisciplinary	ENGAGE in Service	ENGAGE in Service is a 1-unit course (9 hours of work, minimum requirement for a passing grade) designed to promote MCS students' direct engagement with community development and service learning. To fulfill this requirement, students must engage in a minimum of 9 hours of work devoted to a non-profit organization or organizations of their choice, 3 of which must have a direct benefit to the local Pittsburgh community. Students may complete the requirements anytime during their undergraduate years, but must register for the class during the semester that they intend to complete it, no later than their penultimate semester. Coursework includes documentation of service via completion of a form for each eligible activity that includes a time log, a description of the activity, the name and contact information for their supervisor and the supervisor's signature. In addition, during the last semester of the project/course students will prepare a 1-2 page reflective paper on the lessons learned from their immersion in the organization(s) and its (their) work. No pay or other compensation can be received, and, in special cases, students may petition for a waiver if they have completed another service-learning course at Carnegie Mellon.	U	4, 17, 8	focused
38220	MCS Interdisciplinary	ENGAGE in the Arts	ENGAGE in the Arts is part of Mellon College of Science's Core Curriculum. In this 2-unit full-semester course, students will broaden their knowledge of the fine arts, extend their global and cultural awareness, and facilitate the further development of their self-identity. Coursework requires that students attend 8 distinct arts events, 2 of which must engage with a culture different from one's personal cultural background. In choosing events, students should be imbued with an attitude of openness to new ideas and a willingness to try something new. The course requires students to share, reflect, and document their participation in a variety of arts events by engaging with classmates and instructors through MyCORE, where they can upload coursework and find postings for events. Coursework can be completed at any time during students' undergraduate years, but they must register for the class during the semester that they intend to complete it.	U	4, 11, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
38230	MCS Interdisciplinary	ENGAGE in Wellness: Looking Inward	ENGAGE in Wellness: Looking Inward is a 1-unit mini-course that MCS students will enroll in the spring of the sophomore year, designed to give students a holistic understanding of their own personal wellness. The course is structured around the concept of a Wellness Wheel, a model for personal wellness that is used to describe the various areas that students should reflect upon when describing, and ultimately improving, their overall wellness. The MCS Wellness Wheel has nine components: intellectual, physical, emotional, spiritual, environmental, institutional or community, financial, social, and occupational health. During this first course, taken in the first mini of the sophomore year, students will select one of three areas on which to focus: intellectual, emotional or physical health. They will be asked to engage in a recursive, reflective process to assess their own level of wellness in this area, develop short-term goals for the next year and a statement of a longer-term goal in this area, identify possible resources and then choose activities that promote this aspect of wellness. Students should expect to devote 9-14 hours to the development and articulation of their plan in order to earn a passing grade. These hours are tied to completion of the requested assessments and not to the activities students' elect to pursue in fulfillment of their wellness plan. THIS COURSE IS FOR SOPHOMORES ONLY.	U	8, 4, 12	focused
38301	MCS Interdisciplinary	PROPEL	PROPEL: Preparation, Readiness, and Optimization for Professional Excellence in Life - is a 6-unit seminar course that MCS students will enroll in the spring of their junior year. The course will leverage students' deepening disciplinary perspective in service of the development of competencies, skills and perspectives that are necessary to achieve professional excellence in today's society. The course will use traditional career development activities, such as interviewing, resume writing and networking, as a starting point for students to begin the process of reflecting on, and preparing for, their impending transitions into professional life. From there, the course will seek to expand students' conceptualization of the scientific workplace by exploring the interplay of science, innovation, public policy, entrepreneurism and business in professional settings today. The seminar will also equip students with significant insight into the ways in which global policy, societal and political forces, environmental issues and ethical considerations shape and influence the activity and research of working scientists. The course will offer additional experiences for students to refine their multidisciplinary teamwork and communication skills via small group projects focusing on the aforementioned course themes. Finally, "PROPEL" will include a formal academic advising component to ensure that all students are well positioned to complete the MCS core requirements and departmental requirements in the following year. THIS COURSE IS FOR MCS JUNIORS ONLY.	U	4, 9, 8	focused
38304	MCS Interdisciplinary	PROPEL: Science Communication and Social Impact	The MCS seminar "PROPEL," is designed to develop the competencies, skills, and perspectives necessary to achieve professional excellence by honing your skill in communicating with diverse audiences. This course introduces students to frameworks for identifying the linguistic features of scientific argumentation in research papers across a range of scientific disciplines to improve their reading and writing of scientific content. The course also examines the changes in scientific information when it is reported in popular media and the effects these changes have on society's understanding of science. Students will use these changes as a model for writing about scientific research to non-expert audiences. Finally, this course gives students the opportunity to practice oral and visual communication by creating oral presentations for their peers. All reading and writing for this course will focus on climate change and introduce students to the interplay of multiple disciplines on this topic and the broader impact of climate change on society.	U	13, 4, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
38330	MCS Interdisciplinary	ENGAGE in Wellness: Looking Outward	ENGAGE in Wellness: Looking Outward is a 1-unit mini-course that MCS students will enroll in the fall of the junior year, designed to give students a holistic understanding of their own personal wellness. The course is structured around the concept of a Wellness Wheel, a model for personal wellness that is used to describe the various areas that students should reflect upon when describing, and ultimately improving, their overall wellness. The MCS Wellness Wheel has nine components: intellectual, physical, emotional, spiritual, environmental, institutional or community, financial, social, and occupational health. During this second course, taken in the first mini of the junior year, students will select one of three areas on which to focus: spiritual, environmental and institutional or community health. They will be asked to engage in a recursive, reflective process to assess their own level of wellness in this area, develop short-term goals for the next year and a statement of a longer-term goal in this area, identify possible resources and then choose activities that promote this aspect of wellness. Students should expect to devote 9-14 hours to the development and articulation of their plan in order to earn a passing grade. These hours are tied to completion of the requested assessments and not to the activities students' elect to pursue in fulfillment of their wellness plan. This course is intended for juniors only. THIS COURSE IS FOR JUNIORS ONLY.	U	4, 8, 12	focused
38430	MCS Interdisciplinary	ENGAGE in Wellness: Looking Forward	ENGAGE in Wellness: Looking Forward is a 1-unit mini-course that MCS students will enroll in the fall of the senior year, designed to give students a holistic understanding of their own personal wellness. The course is structured around the concept of a Wellness Wheel, a model for personal wellness that is used to describe the various areas that students should reflect upon when describing, and ultimately improving, their overall wellness. The MCS Wellness Wheel has nine components: intellectual, physical, emotional, spiritual, environmental, institutional or community, financial, social, and occupational health. During this third course, taken in the first mini of the senior year, students will select one of three areas on which to focus: financial, social and occupational health. They will be asked to engage in a recursive, reflective process to assess their own level of wellness in this area, develop short-term goals for the next year and a statement of a longer-term goal in this area, identify possible resources and then choose activities that promote this aspect of wellness. Students should expect to devote 9-14 hours to the development and articulation of their plan in order to earn a passing grade. These hours are tied to completion of the requested assessments and not to the activities students' elect to pursue in fulfillment of their wellness plan. THIS COURSE IS FOR SENIORS ONLY.	U	4, 8, 12	focused
39109	CIT Interdisciplinary	Grand Challenge Freshman Seminar: Climate Change	Climate change is considered by many the most serious social, political, and environmental issue of the 21st century. As human activities increase the level of greenhouse gases in the atmosphere, scientists have established the reality of climate change and have estimated its impacts on human society and the natural world. Despite the scientific consensus on its existence, causes, and consequences, a substantial number of Americans and citizens of other countries still question these conclusions and a small but vocal group of doubters continue to challenge the science and scientific consensus on climate change. In spite of some social division over these issues, governments at local, national, and international levels have made concerted efforts to craft policies to address climate change. These policies have shifted over time as the information, attitudes, and technology associated with climate change have evolved. In this course, we will explore the challenges and complexities of climate change by investigating the subject from a variety of angles: scientific, political, rhetorical, cultural, economic, technological, and ethical. Over the course of the semester, well inquire: What is climate change? How do scientists know it is happening? Why is there public debate over it? What solutions are available? And what are the pros and cons of the different solutions?	U	13, 8, 12	focused
39210	CIT Interdisciplinary	Experiential Learning I	The engineer of the 21st century will need to operate effectively in many settings and often with a global perspective. Being curious and constantly looking for inspiration are critical for lifelong learning. This course, designed for all CIT sophomores, requires the student to choose and experience activities for development and growth that are not part of formal course work. Acceptable experiences are listed in the course syllabus on Canvas.	U	4, 8, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
39220	CIT Interdisciplinary	Experiential Learning II	The engineer of the 21st century will need to operate effectively in many settings and often with a global perspective. Being curious and constantly looking for inspiration are critical for lifelong learning. This course, designed for all CIT sophomores, requires the student to choose and experience activities for development and growth that are not part of formal course work. Acceptable experiences are listed in the course syllabus on Canvas.	U	4, 8, 17	focused
39245	CIT Interdisciplinary	Rapid Prototype Design	This course provides an introduction to rapid design through virtual and physical prototyping. The class covers the engineering design process, problem solving methods, interdisciplinary team work, current industrial practice, and manufacturing process capabilities. The course emphasizes hands on learning. Sophomores have priority while registering for this course. Juniors and seniors will be put on the waitlist, then released once sophomores have registered.	U	9, 4, 8	focused
39250	CIT Interdisciplinary	CIT Undergraduate Projects	This course number is to be used for Fall CIT freshman research projects only. Student must complete a CIT Undergraduate Project Approval form (located in Scaife Hall 110) and submit for approval. The form must include a complete description and a signature approval from the research advisor/instructor. If the project is approved, the CIT Undergraduate Studies Office will add the course to the student's fall schedule.	U	4, 17, 9	focused
39251	CIT Interdisciplinary	CIT Undergraduate Projects	This course number is to be used for Spring CIT freshman research projects only. Student must complete a CIT Undergraduate Project Approval form (located in Scaife Hall 110) and submit for approval. The form must include a complete description and a signature approval from the research advisor/instructor. If the project is approved, the CIT Undergraduate Studies Office will add the course to the student's fall schedule.	U	4, 17, 9	focused
39310	CIT Interdisciplinary	Experiential Learning III	The engineer of the 21st century will need to operate effectively in many settings and often with a global perspective. Being curious and constantly looking for inspiration are critical for lifelong learning. This course, designed for all CIT juniors, requires the student to choose and experience activities for development and growth that are not part of formal course work. Acceptable experiences are listed in the course syllabus on Canvas.	U	4, 8, 17	focused
39402	CIT Interdisciplinary	Leadership Development Seminar	This course is designed for CIT seniors and juniors committed to further developing their leadership skills and potential for sustained impact in the future. The course will be substantive and engaging, while less technically challenging, outright, than thought provoking, edifying, and enjoyable, ideally. The course will build on the foundation of six key leadership pillars, identified by CIT to hone a student's professional and personal development to serve others, and to seek out and nurture opportunities to heighten one's capacity as a person and leader who is: VISIONARY, with clear goals for yourself, your organizations and communities, and others in whose lives you are a part, including the broader society; ETHICAL, with core values and steadfastness in the face of competing objectives, and the resilience to deal with conflicts without moral compromise; ENGAGING, with empathy, attentive interpersonal attributes, outstanding formal and informal communication skills, and the capacity to inspire; TACTICAL, with an ability to operationalize big ideas and bring them to fruition, creating the ideal environment for individual and group success; TECHNICAL, based on your own high-level skill set and the ego strength for inclusion of others with complementary realms of expertise; REFLECTIVE, manifesting in the honest appraisal of personal and organizational success against metrics, and the ability to redirect based on assessment.	U	4, 17, 9	focused
39447	CIT Interdisciplinary	CIT Undergraduate Interdisciplinary Design Project	This course is to be used for undergraduate research projects involving a significant interdisciplinary design component. It can be added by permission only through collaboration with the student, project advisor, and the CIT Dean's Office. For projects that are not interdisciplinary in nature, students should refer to the research number specific to the department in which the research is being completed.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
39500	CIT Interdisciplinary	Honors Research Project	Juniors who have an accumulated QPA of at least 3.5 receive an invitation to participate in the program. This course, open by invitation only, will provide the opportunity for close interaction with a faculty member through independent honors research in a number of disciplinary and interdisciplinary areas, as part of the CIT Honors Research Program. Students will work on their projects during their senior year, earning the equivalent of 18-24 units. Students are required to register for CIT Honor Research Project 39-500. To receive CIT College Honors, a student must complete at least 18 units in 39-500 on the same research topic and submit a 1-page executive summary of your research. Lastly, students must present their research findings at the Undergraduate Research Symposium, "Meeting of the Minds" in May. Although "Meeting of the Minds" is open to any undergraduate research initiatives occurring on campus, it is a requirement for College of Engineering Honors Research students.	U	4, 17, 9	focused
39601	CIT Interdisciplinary	Special Topics: Additive Manufacturing Processing and Product Development	Introduction to additive manufacturing (AM) processing fundamentals and applications using Solidworks 3-D CAD software and a variety of polymer and metal AM machines. Includes a brief history of AM processing, a review of and technical fundamentals of current AM processes, a study of the current AM market, and future directions of the technology. Lab Sessions will support an open-ended product development project. Lectures on metals AM will address current research impacting industry. Students will also perform a literature review of papers on the state of the art. Basic Solidworks knowledge required.	G	9, 4, 17	focused
39602	CIT Interdisciplinary	Additive Manufacturing and Materials	This course will develop the understanding required for materials science and engineering for additive manufacturing. The emphasis will be on powder bed machines for printing metal parts, reflecting the research emphasis at CMU. The full scope of methods in use, however, will also be covered. The topics are intended to enable students to understand which materials are feasible for 3D printing. Accordingly, high power density welding methods such as electron beam and laser welding will be discussed, along with the characteristic defects. Since metal powders are a key input, powder-making methods will be discussed. Components once printed must satisfy various property requirements hence microstructure-property relationships will be discussed because the microstructures that emerge from the inherently high cooling rates differ strongly from conventional materials. Defect structures are important to performance and therefore inspection. Porosity is a particularly important feature of 3D printed metals and its occurrence depends strongly on the input materials and on the processing conditions. The impact of data science on this area offers many possibilities such as the automatic recognition of materials origin and history. Finally the context for the course will be discussed, i.e. the rapidly growing penetration of the technology and its anticipated impact on manufacturing.	G	9, 4, 8	focused
39648	CIT Interdisciplinary	Rapid Design and Prototyping of Computer Science	This course deals with rapid prototyping, manufacture, and applications of a new generation of wearable computers, with head-mounted display. The design of wearable computers is a multidisciplinary process including: Electronic design, mechanical design, software development, and human-computer interaction. Two classes of wearable computers will be further developed: embedded, custom designed VuMan series, and general purpose Navigator series. Electronic design includes the custom designed computer board, electronic interfacing, and power supply. Industrial designers and mechanical engineers team to design and manufacture with in-house facilities a variety of conformable/lightweight housings. A software development environment and user interface builders support software and application development. Current applications include: Global Position Sensing, Hypertext documents, speech recognition, wireless communications, and digital imaging.	G	9, 8, 4	focused
39660	CIT Interdisciplinary	Masters EST&P Project	This project course is designed for EST&P students who are working on an independent investigation on a project related to energy with the advice and approval of the program advisor and/or affiliated faculty member. Summary report, presentation or poster on work accomplished must be submitted at completion of semester. Once you have determined a suitable topic area, found an engineering faculty member who has agreed to supervise the project work, send the EST&P project approval form to the EST&P director for enrollment. Variable units. Restricted to EST&P students	G	7, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
39699	CIT Interdisciplinary	Career & Professional Development for Engineering Masters Students	This professional development course is designed to engage, educate and empower engineering Masters Students to create and manage career opportunities, as well as to develop the professional skills necessary to be successful in a job search and internship/first year of employment. Open to College of Engineering masters students, this seminar style course will support professional development in the following areas: self-assessment/awareness, resume creation, personal introduction development, job search planning, interviewing, networking, career fair success, entrepreneurship, and internship/employment readiness, etc. Assignments will be actionable and relevant to the job search, enabling students to immediately apply classroom learning. Assignments and active classroom participation will determine pass/fail grade.	G	4, 8, 17	focused
42101	Biomedical Engineering	Introduction to Biomedical Engineering	This course will provide exposure to basic biology and engineering problems associated with living systems and health care delivery. Examples will be used to illustrate how basic concepts and tools of science & engineering can be brought to bear in understanding, mimicking and utilizing biological processes. The course will focus on four areas: biotechnology, biomechanics, biomaterials and tissue engineering and biosignal and image processing and will introduce the basic life sciences and engineering concepts associated with these topics.	U	9, 1, 4	focused
42200	Biomedical Engineering	Sophomore BME Research Project	Research projects for sophomores under the direction of a regular or adjunct BME faculty member. Arrangements may also be made via the Associate Head of BME for off-campus projects provided that a regular or adjunct BME faculty member agrees to serve as a co-advisor. The nature of the project, the number of units, and the criteria for grading are to be determined between the student and the research advisor. The agreement should be summarized in a two-page project description with sign-off by the research advisor and a copy submitted for review and filing with the BME Department. A final written report of the results is required. Units may vary from 9 to 12 according to the expected time commitment, with one unit corresponding to 1 hour of research per week. One (but not more than one) semester of research, if registered for at least 9 units, may be counted as a restricted elective course toward the BME additional major.	U	4, 17, 15	focused
42201	Biomedical Engineering	Professional Issues in Biomedical Engineering	This course exposes students to many of the issues that biomedical engineers face. It provides an overview of professional topics including bioethics, regulatory issues, communication skills, teamwork, and other contemporary issues. Outside speakers and case studies will describe real world problems and professional issues in biotechnology and bioengineering, and progress toward their solution. Prerequisite or co-requisite: 42-101 Introduction to Biomedical Engineering	U	4, 9, 2	focused
42202	Biomedical Engineering	Physiology	This course is an introduction to human physiology and includes units on all major organ systems. Particular emphasis is given to the musculoskeletal, cardiovascular, respiratory, digestive, excretory, and endocrine systems. Modules on molecular physiology tissue engineering and physiological modeling are also included. Due to the close interrelationship between structure and function in biological systems, each functional topic will be introduced through a brief exploration of anatomical structure. Basic physical laws and principles will be explored as they relate to physiologic function. Prerequisite or co-requisite: 03-121 Modern Biology, or permission of instructor.	U	3, 9, 4	focused
42203	Biomedical Engineering	Biomedical Engineering Laboratory	This laboratory course is designed to provide students with the ability to make measurements on and interpret data from living systems. The experimental modules reinforce concepts from 42-101 Introduction to Biomedical Engineering and expose students to four areas of biomedical engineering: biomedical signal and image processing, biomaterials, biomechanics, and cellular and molecular biotechnology. Several cross-cutting modules are included as well. The course includes weekly lectures to complement the experimental component. Prerequisites: 42-101 Introduction to Biomedical Engineering and 03-121 Modern Biology. Pre-med students should register for 03-206. Priority for enrollment will be given to students who have declared the Additional Major in Biomedical Engineering.	U	4, 9, 2	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
42300	Biomedical Engineering	Junior BME Research Project	Research projects for sophomores under the direction of a regular or adjunct BME faculty member. Arrangements may also be made via the Associate Head of BME for off-campus projects provided that a regular or adjunct BME faculty member agrees to serve as a co-advisor. The nature of the project, the number of units, and the criteria for grading are to be determined between the student and the research advisor. The agreement should be summarized in a two-page project description with sign-off by the research advisor and a copy submitted for review and filing with the BME Department. A final written report of the results is required. Units may vary from 9 to 12 according to the expected time commitment, with one unit corresponding to 1 hour of research per week. One (but not more than one) semester of research, if registered for at least 9 units, may be counted as a restricted elective course toward the BME additional major.	U	4, 17, 15	focused
42302	Biomedical Engineering	Biomedical Engineering Systems Modeling and Analysis	This course will prepare students to develop mathematical models for biological systems and for biomedical engineering systems, devices, components, and processes and to use models for data reduction and for system performance analysis, prediction and optimization. Models considered will be drawn from a broad range of applications and will be based on algebraic equations, ordinary differential equations and partial differential equations. The tools of advanced engineering mathematics comprising analytical, computational and statistical approaches will be introduced and used for model manipulation.	U	4, 9	focused
42400	Biomedical Engineering	Senior BME Research Project	Research projects for sophomores under the direction of a regular or adjunct BME faculty member. Arrangements may also be made via the Associate Head of BME for off-campus projects provided that a regular or adjunct BME faculty member agrees to serve as a co-advisor. The nature of the project, the number of units, and the criteria for grading are to be determined between the student and the research advisor. The agreement should be summarized in a two-page project description with sign-off by the research advisor and a copy submitted for review and filing with the BME Department. A final written report of the results is required. Units may vary from 9 to 12 according to the expected time commitment, with one unit corresponding to 1 hour of research per week. One (but not more than one) semester of research, if registered for at least 9 units, may be counted as a restricted elective course toward the BME additional major.	U	4, 17, 15	focused
42401	Biomedical Engineering	Foundation of BME Design	This course sequence introduces Biomedical Engineering students to the design of useful biomedical products to meet a specific medical need. Students will learn to identify product needs, how to specify problem definitions and to use project management tools. Methods to develop creativity in design will be introduced. The course sequence is comprised of two parts: 42-401 is offered in the Fall semester and provides the students the opportunity to form project teams, select and define a project, create a development plan, and complete an initial prototype. 42-402 is offered in the Spring semester is a full semester course and completes the plan that was developed in the fall semester. This course culminates in the completion of multiple prototypes, a poster presentation, and a written report. Prerequisite: Senior standing in Biomedical Engineering. Co-requisite: 42-101.	U	4, 9, 17	focused
42402	Biomedical Engineering	BME Design Project	This course sequence introduces Biomedical Engineering students to the design of useful biomedical products to meet a specific medical need. Students will learn to identify product needs, how to specify problem definitions and to use project management tools. Methods to develop creativity in design will be introduced. The course sequence is comprised of two parts: 42-401 is offered in the Fall semester and provides the students the opportunity to form project teams, select and define a project, create a development plan, and complete an initial prototype. 42-402 is offered in the Spring semester is a full semester course and completes the plan that was developed in the fall semester. This course culminates in the completion of multiple prototypes, a poster presentation, and a written report. Prerequisite: 42-401	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
42437	Biomedical Engineering	Biomedical Optical Imaging	Biophotonics, or biomedical optics, is a field dealing with the application of optical science and imaging technology to biomedical problems, including clinical applications. The course introduces basic concepts in electromagnetism and light tissue interactions, including optical properties of tissue, absorption, fluorescence, and light scattering. Imaging methods will be described, including fluorescence imaging, Raman spectroscopy, optical coherence tomography, diffuse optical spectroscopy, and photoacoustic tomography. The basic physics and engineering of each imaging technique are emphasized. Their relevance to human disease diagnostic and clinical applications will be included, such as breast cancer imaging and monitoring, 3D retinal imaging, ways of non-invasive tumor detection, as well as functional brain imaging in infants. NOTE: 42-437 is intended for undergraduates only. Pre-requisite: 33-107 Physics II for Engineering Students or permission of the instructor.	U	3, 4, 9	focused
42444	Biomedical Engineering	Medical Devices	This course is an introduction to the engineering, clinical, legal and regulatory aspects of medical device performance and failure. Topics covered include a broad survey of the thousands of successful medical devices in clinical use, as well as historical case studies of devices that were withdrawn from the market. In-depth study of specific medical devices will include: cardiovascular medicine, orthopedics, and general medicine. We will study the principles of operation (with hands-on examples), design evolution, and modes of failure. Additional lectures will provide basic information concerning biomaterials used for implantable medical devices (metals, polymers, ceramics) and their biocompatibility, mechanisms of failure (wear, corrosion, fatigue, fretting, etc.). The level of technical content will require junior standing for MCS and CIT students, a degree in science or engineering for non-MCS or non-CIT graduate students, or permission of the instructor for all other students.	U	4, 9, 3	focused
42610	Biomedical Engineering	Introduction to Biomaterials	Understanding the fundamentals of biomaterials structure-function relationships pertaining to material functions and to cell and tissue environments will be a prime goal. The course will be composed of lectures, readings, projects and technical writing assignments. The synthesis, characterization and functional properties of organic and inorganic biomaterials and the processes involved in their use in tissue engineering and regenerative medicine will be discussed. Fundamental issues related to the utility of biomaterials, including biomechanics, transport, degradability, biointerfaces and biocompatibility, stability, fate in the body will be covered, along with some of the basic approaches to characterization. Clinical applications for biomaterials and new directions in design and synthesis to achieve better biocompatibility will be emphasized.	G	2, 9, 17	focused
42611	Biomedical Engineering	Engineering Biomaterials	This course will cover structure-processing-property relationships in biomaterials for use in medicine. This course will focus on a variety of materials including natural biopolymers, synthetic polymers, and soft materials with additional treatment of metals and ceramics. Topics include considerations in molecular design of biomaterials, understanding cellular aspects of tissue-biomaterials interactions, and the application of bulk and surface properties in the design of medical devices. This course will discuss practical applications of these materials in drug delivery, tissue engineering, biosensors, and other biomedical technologies. Pre-req: formal coursework in thermodynamics, kinetics, or physical chemistry.	G	9, 4, 12	focused
42612	Biomedical Engineering	Tissue Engineering	This course will train students in advanced cellular and tissue engineering methods that apply physical, mechanical and chemical manipulation of materials in order to direct cell and tissue function. Students will learn the techniques and equipment of bench research including cell culture, immunofluorescent imaging, soft lithography, variable stiffness substrates, application/measurement of forces and other methods. Students will integrate classroom lectures and lab skills by applying the scientific method to develop a unique project while working in a team environment, keeping a detailed lab notebook and meeting mandated milestones. Emphasis will be placed on developing the written and oral communication skills required of the professional scientist. The class will culminate with a poster presentation session based on class projects. Pre-requisite: Knowledge in cell biology and biomaterials, or permission of instructor	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
42613	Biomedical Engineering	Polymeric Biomaterials	This course will cover aspects of polymeric biomaterials in medicine from molecular principles to device scale design and fabrication. Topics include the chemistry, characterization, and processing of synthetic polymeric materials; cell-biomaterials interactions including interfacial phenomena, tissue responses, and biodegradation mechanisms; aspects of polymeric micro-systems design and fabrication for applications in medical devices. Recent advances in these topics will also be discussed.	G	9, 12	focused
42620	Biomedical Engineering	Engineering Molecular Cell Biology	Cells are not only basic units of living organisms but also fascinating engineering systems that exhibit amazing functionality, adaptability, and complexity. Applying engineering perspectives and approaches to study molecular mechanisms of cellular processes plays a critical role in the development of contemporary biology. At the same time, understanding the principles that govern biological systems provides critical insights into the development of engineering systems, especially in the micro- and nano-technology. The goal of this course is to provide basic molecular cell biology for engineering students with little or no background in cell biology, with particular emphasis on the application of quantitative and system perspectives to basic cellular processes. Course topics include the fundamentals of molecular biology, the structural and functional organization of the cell, the cytoskeleton and cell motility, the mechanics of cell division, and cell-cell interactions. Pre-requisites: 21-260 Differential Equations, or 06-262 Mathematical Methods of Chemical Engineering, or 18-202 Mathematical Foundations of Electrical Engineering. Advanced undergraduate or graduate student standing is required. Prior completion of 03-121 Modern Biology is suggested but not required. Proficiency in basic computation such as MATLAB programming is expected.	G	4, 9, 17	focused
42624	Biomedical Engineering	Biological Transport and Drug Delivery	Analysis of transport phenomena in life processes on the molecular, cellular, organ and organism levels and their application to the modeling and design of targeted or sustained release drug delivery technologies. Coupling of mass transfer and reaction processes will be a consistent theme as they are applied to rates of receptor-mediated solute uptake in cells, drug transport and biodistribution, and drug release from delivery vehicles. Design concepts underlying advances in nanomedicine will be described.	G	9, 11, 1	focused
42630	Biomedical Engineering	Introduction to Neural Engineering	Neural engineering sits at the interface between neuroscience and engineering, applying classical engineering approaches and principles to understand the nervous system and its function. Modern neural engineering techniques have been used to measure neural activity using tools based on light, electricity, and magnetism. The same tools for measurement can be redirected to modulate neural activity, and manipulate how an organism perceives, thinks, and acts. The course objectives are to familiarize students with a range of neural engineering approaches to investigating and intervening in the nervous system, emphasizing quantitative understanding and fundamental engineering concepts. The course will pair lectures and discussion with projects involving real neural data (Matlab-based exercises). Example projects could include finding visual responses in EEG data, or determining how groups of individual neurons interact based on spiking data. Overall, the goal is to give the student a deep understanding of select topics in neuroscience and the application of quantitative neural engineering approaches to these topics. This course is intended for advanced undergraduate and entering graduate students. Familiarity with linear algebra, signal processing, and introductory Matlab programming is helpful. This course is suitable for students coming from diverse backgrounds: (1) Students with non-engineering backgrounds seeking quantitative skills, and wanting to learn an engineering approach to neuroscience problems, and (2) students with engineering or other quantitative backgrounds who are seeking ways to apply their skills to scientific questions in neuroscience.	G	4, 9, 7	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
42631	Biomedical Engineering	Neural Data Analysis	The vast majority of behaviorally relevant information is transmitted through the brain by neurons as trains of actions potentials. How can we understand the information being transmitted? This class will cover the basic engineering and statistical tools in common use for analyzing neural spike train data, with an emphasis on hands-on application. Topics may include neural spike train statistics (Poisson processes, interspike intervals, Fano factor analysis), estimation (MLE, MAP), signal detection theory (d-prime, ROC analysis, psychometric curve fitting), information theory, discrete classification, continuous decoding (PVA, OLE), and white-noise analysis. Each topic covered will be linked back to the central ideas from undergraduate probability, and each assignment will involve actual analysis of neural data, either real or simulated, using Matlab. This class is meant for upper-level undergrads or beginning graduate students, and is geared to the engineer who wants to learn the neurophysiologist's toolbox and the neurophysiologist who wants to learn new tools. Those looking for broader neuroscience application (eg, fMRI) or more focus on regression analysis are encouraged to take 36-746. Those looking for more advanced techniques are encouraged to take 18-699. Prerequisites: undergraduate probability (36-225/227, or its equivalent), some familiarity with linear algebra and Matlab programming	G	4, 9, 11	focused
42632	Biomedical Engineering	Neural Signal Processing	The brain is among the most complex systems ever studied. Underlying the brain's ability to process sensory information and drive motor actions is a network of roughly 10^11 neurons, each making 10^3 connections with other neurons. Modern statistical and machine learning tools are needed to interpret the plethora of neural data being collected, both for (1) furthering our understanding of how the brain works, and (2) designing biomedical devices that interface with the brain. This course will cover a range of statistical methods and their application to neural data analysis. The statistical topics include latent variable models, dynamical systems, point processes, dimensionality reduction, Bayesian inference, and spectral analysis. The neuroscience applications include neural decoding, firing rate estimation, neural system characterization, sensorimotor control, spike sorting, and field potential analysis. Prerequisites: 18-290; 36-217, or equivalent introductory probability theory and random variables course; an introductory linear algebra course; senior or graduate standing. No prior knowledge of neuroscience is needed.	G	4, 9	focused
42648	Biomedical Engineering	Cardiovascular Mechanics	The primary objective of the course is to learn to model blood flow and mechanical forces in the cardiovascular system. After a brief review of cardiovascular physiology and fluid mechanics, the students will progress from modeling blood flow in a.) small-scale steady flow applications to b.) small-scale pulsatile applications to c.) large-scale or complex pulsatile flow applications. The students will also learn how to calculate mechanical forces on cardiovascular tissue (blood vessels, the heart) and cardiovascular cells (endothelial cells, platelets, red and white blood cells), and the effects of those forces. Lastly, the students will learn various methods for modeling cardiac function. When applicable, students will apply these concepts to the design and function of selected medical devices (heart valves, ventricular assist devices, artificial lungs).	G	4, 3, 9	focused
42649	Biomedical Engineering	Introduction to Biomechanics	The purpose of this course is to achieve a broad overview of the application of mechanics to the human body. This includes solid, fluid, and viscoelastic mechanics applied to single cells, the cardiovascular system, lungs, muscles, bones, and human movement. The physiology of each system will be reviewed as background prior to discussing mechanics applications within that system. There are no firm prerequisites, but statics, fluid mechanics, and biology are helpful.	G	3, 9, 4	focused
42674	Biomedical Engineering	Special Topics: Engineering for Survival: ICU Medicine	Special Topics: Engineering for Survival: ICU Medicine The overall learning objective of this class is to expose students to acute care medicine and the fundamentals of acute illness. The lectures review the structure and function of different body systems. Typical modes of failure (disease) are then described and illustrated with examples using actual de-identified cases based on over 30 years of experiences in the intensive care unit (ICU) by Dr. Rosenbloom. Field trips are made to a local critical care and emergency medicine simulation facility at the University of Pittsburgh. An optional opportunity to participate in ICU rounds is also available. Requirements: Junior standing and higher	G	4, 3, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
42675	Biomedical Engineering	Fundamentals of Computational Biomedical Engineering	This goal of this course is to enable students with little or no programming background to use computational methods to solve basic biomedical engineering problems. Students will use MATLAB to solve linear systems of equations, model fit using least squares techniques (linear and nonlinear), interpolate data, perform numerical integration and differentiation, solve differential equations, and visualize data. Specific examples for each topic will be drawn from different areas of biomedical engineering, such as bioimaging and signal processing, biomechanics, biomaterials, and cellular and biomolecular technology.	G	9, 4	focused
42676	Biomedical Engineering	Bio-nanotechnology: Principles and Applications	"Have you ever wondered what is nanoscience and nanotechnology and their impact on our lives? In this class we will go through the key concepts related to synthesis (including growth methodologies and characterizations techniques) and chemical/physical properties of nanomaterials from zero-dimensional (0D) materials such as nanoparticles or quantum dots (QDs), one-dimensional materials such as nanowires and nanotubes to two-dimensional materials such as graphene. The students will then survey a range of biological applications of nanomaterials through problem-oriented discussions, with the goal of developing design strategies based on basic understanding of nanoscience. Examples include, but are not limited to, biomedical applications such as nanosensors for DNA and protein detection, nanodevices for bioelectrical interfaces, nanomaterials as building blocks in tissue engineering and drug delivery, and nanomaterials in cancer therapy."	G	3, 9, 4	focused
42678	Biomedical Engineering	Medical Device Innovation and Realization	The increasing pace of medical discoveries and emerging technologies presents a unique and exciting time for medical devices. Medical devices range from biomaterials that stimulate the body to repair itself to drug eluting stints to robotic surgical systems. Because they seek to improve and prolong human health, there are unique requirements and challenges for medical device development compared to most other industries. This class will look at how medical device innovation is currently practiced as well as the drivers which govern it, such as the FDA, intellectual property, reimbursement, and funding. By the end of this course, students should be able to: (1) obtain a broad understanding of medical devices; (2) identify new product opportunities; (3) understand the drivers that affect medical device development; and (4) develop strategies to address those drivers within the overall medical device development plan.	G	9, 4, 17	focused
42682	Biomedical Engineering	Bioinstrumentation and Measurement	This course aims to build the understanding of basic concepts and applications of instrumentation used for biomedical research and patient care. The course will follow a fast track, using a flipped format to cover components ranging from simple resistors, capacitors, transistors, sensors, actuators, to operational amplifiers and microcontrollers, using a combination of lectures, guided tutorials, lab exercises, and term projects. Students will gain hands-on skills of how to integrate components into functional instruments, based on physiological measurements such as temperature, humidity, oxygen concentration, blood pressure, and EKG signals. MATLAB programming will be used throughout the course. The course is designed for advanced undergraduate and graduate students with a knowledge in basic physics of electricity and magnetism.	G	4, 9, 7	focused
42683	Biomedical Engineering	Introduction to Machine Learning for Biomedical Engineers	This course introduces fundamental concepts, methods and applications in machine learning and datamining. We will cover topics such as parametric and non-parametric learning algorithms, support vector machines, neural networks, clustering, clustering and principal components analysis. The emphasis will be on learning high-level concepts behind machine learning algorithms, and applying them to biomedical-related problems. This course is intended for advanced undergraduate and graduate students in Biomedical Engineering or related disciplines. Students should have experience with high-level programming language such as Matlab, basic familiarity with probability, statistics and linear algebra, and should be comfortable with manipulating vectors and matrices.	G	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
42684	Biomedical Engineering	Principles of Immunoengineering and Development of Immunotherapy Drugs	This course will provide context for the application of engineering principles to modulate the immune system to approaches problems in human health. Basic understanding of the components and function of the innate and adaptive immune system. Students will leave with a basic understanding of immunology and of the engineering techniques used to develop and characterize immunotherapy systems. Where appropriate, we will discuss how immunoengineering fits into other disciplines of engineering such as mechanical, chemical, and materials science. Because the purpose of immunoengineering is disease treatment, we will discuss, the therapy pipeline, development of clinical trials and the FDA approval process. Immunotherapy will also be assessed within different disease contexts including cancer, infectious disease, allergies, prosthetics and implants, neuro and musculoskeletal disorders.	G	3, 4, 9	focused
42685	Biomedical Engineering	Biostatistics	This course introduces statistical methods for making inferences in engineering, biology and medicine. Students will learn how to select the most appropriate methods, how to apply these methods to actual data, and how to read and interpret computer output from a commonly used statistical package. The topics covered are descriptive statistics; elementary probability; discrete and continuous random variables and their distributions; hypothesis testing involving interval (continuous and discrete) and categorical (nominal and ordinal) variables, for two and three or more treatments; simple and multiple linear regression; time-series analysis; clustering and classification; and time-to-event (survival) analysis. Students will also learn how to write the statistical component of a "Results" section for a scientific paper and learn about the limitations of the statistical analyses. Basic familiarity with probability and probability distribution preferred but not required.	G	4, 9, 8	focused
42691	Biomedical Engineering	Biomechanics of Human Movement	This course provides an overview of the mechanical principles underlying human movement biomechanics and the experimental and modeling techniques used to study it. Specific topics will include locomotion, motion capture systems, force plates, muscle mechanics, musculoskeletal modeling, three dimensional kinematics, inverse dynamics, forward dynamic simulations, and imaging-based biomechanics. Homework and final class projects will emphasize applications of movement biomechanics in orthopedics, rehabilitation, and sports.	G	9, 17, 4	focused
42693	Biomedical Engineering	Special Topics in Integrated Systems Technology: Micro/Nano Biomedical Devices	Biomedical devices constantly call for innovations. Micro/nano fabrication not only miniaturizes devices and instruments, but also can enable new biomedical devices and significantly boost device performance. This course introduces fundamental micro/nano fabrication technologies and related materials of biomedical devices. The biomedical background and design principles of various biomedical devices will be presented. Both diagnostic and therapeutic devices will be discussed, including point-of-care diagnostic devices, biosensors, DNA sequencers, medical implants, prosthetic devices, drug delivery systems, medical robots, etc.	G	9, 12	focused
42694	Biomedical Engineering	Engineering Principles of Medical Devices	Medical devices are apparatuses widely used in diagnosis, treatment and prevention of human diseases. The invention and adoption of medical devices is one of the major driving forces for the revolution in modern healthcare. This course takes a systematic and quantitative approach for the design and implementation of medical devices. We will mainly focus on three major medical device categories: bioelectrical devices, biomechanical devices, and medical devices enabled by emerging technologies. For each category, domain knowledge and fundamental principles will be introduced, and detailed design, implementation, and performance analysis will be studied. Analytical equations and simulation tools will be used when appropriate. The course will prepare students with a solid foundation to further study, research, and work in medical device related fields. Pre-requisite or Co-requisite: 42-202 and (21-120 or 21-122 or 21-259) and (33-141 or 33-142) or permission of instructor	G	4, 9, 3	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
42696	Biomedical Engineering	Special Topics: Wearable Health Technologies	This course will provide an overview of emerging wearable health technologies and give students hands-on experience in solving ongoing technical challenges. The wearable sensing field is experiencing explosive growth, with exciting applications in medicine. New lightweight devices will make it easier to monitor health conditions in real time, automatically import data into health informatics systems, and provide haptic feedback with humans in the loop. We will review several aspects of these technologies, including hardware, software, user experience, communication networks, applications, and big data analytics. Students will be paired with a company for a semester-long project that tackles timely computational challenges. Programing experience, in any language, is a pre-requisite.	G	4, 9, 8	focused
42737	Biomedical Engineering	Biomedical Optical Imaging	Biophotonics, or biomedical optics, is a field dealing with the application of optical science and imaging technology to biomedical problems, including clinical applications. The course introduces basic concepts in electromagnetism and light tissue interactions, including optical properties of tissue, absorption, fluorescence, and light scattering. Imaging methods will be described, including fluorescence imaging, Raman spectroscopy, optical coherence tomography, diffuse optical spectroscopy, and photoacoustic tomography. The basic physics and engineering of each imaging technique are emphasized. Their relevance to human disease diagnostic and clinical applications will be included, such as breast cancer imaging and monitoring, 3D retinal imaging, ways of non-invasive tumor detection, as well as functional brain imaging in infants.	G	3, 9, 15	focused
46751	Computational Finance	Accelerate Leadership	MSPM students are required to participate in leadership training through the Tepper School Accelerate program. The Accelerate Leadership Center offers one-to-one coaching, a series of leadership workshops and Leadership Development Certification for students to create action plans that advance their personal and professional leadership goals. The Accelerate Leadership Center offers a premier leadership development experience and enhances high-performance analytical skills with essential leadership and communication behaviors.	G	4, 8, 17	focused
46752	Computational Finance	MSPM Capstone Project	The Capstone project is structured to cover many of the ongoing challenges that product managers, and the companies that employ them, face at any stage of a products lifecycle in partnership with an industry sponsor. Our MSPM graduate students work in teams (minimum 2 students). Paired with faculty mentors and their industry partners, teams produce product requirements, provide customer discovery, discover product/market fit, complete competitive research, create product marketing communications analysis, construct forecasts, generate pricing research and analysis, and other product management activities for an industry partner's existing or new products This 15-week course runs from August to December and gives each student two educational opportunities: 1. Put into practice the theory and learning from foundational courses 2. Obtain relevant and hands-on experience working on an industry-facing project	G	4, 9, 17	focused
46972	Computational Finance	MSCF Investments	MSCF Investments gives students a foundation for quantitative portfolio management and for understanding market price determination. Key concepts include risk measurement, risk-reward trade-offs, portfolio optimization, benchmarking, equilibrium asset pricing, market efficiency, and pricing anomalies. Specific portfolio management tools include mean-variance optimization, CAPM and APT asset pricing, factor models (e.g., Fama-French), momentum strategies, and performance evaluation. The course will present essential theories and formulas and will also review important institutional and empirical facts about equity, bond, and commodity markets.	G	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
46977	Computational Finance	MSCF Studies in Financial Engineering	This is a course about using Financial Engineering to solve practical risk management and trading problems and about the sales process for selling derivative deals. The focus is on designing and pricing derivative securities to trade on and hedge customized risk exposures - particularly those involving non-linear, path-dependent, and/or multi-variable exposures to interest rates, equity prices, credit events, and commodity prices, -pitching these exotic securities to clients, and managing any associated risks. The valuation tools used to price these derivatives are Risk Neutral Valuation and Monte Carlo Simulation. The course also highlights practical issues about model calibration, model risk, and static and dynamic hedging. The highlight of the course is a series of in-class team case presentations. While pricing and hedging techniques are important, so too are practical issues such as deciding which risks to share contractually and knowing how to pitch a derivative deal. The in-class presentations are a chance to practice standing in front of a client or boss and sell/explain complicated structured products.	G	8, 9, 10	focused
47757	Tepper School of Business	Structural Models & Quantitative Methods	This course focuses on empirical structural models and their applications in Marketing, Economics, and Information Systems. The goal is to help students build up necessary toolkits and provide hands-on experience of applying structural models to empirical researches by combining theories, numerical methods, and applications. The topics that will be covered include static discrete choice models, demand estimation using aggregate data (BLP), single-agent dynamic discrete choice models, static and dynamic discrete games, and their applications including storable good and durable good demand, price discrimination, product innovation, and two-sided platforms. The course will also discuss research methodologies related to computational methods (e.g., function approximation, numerical integration) and econometric analysis. The techniques can be applied to Marketing, Economics (IO, Public, and Labor) and Information Systems.	G	9, 10, 4	focused
47770	Tepper School of Business	Strategic Queueing Models	This course is designed to introduce students to contemporary research topics in Operations Management built on a queueing framework. Queueing theory, the intrinsically dynamic and stochastic study of flow systems, will be used to model how waiting times depend on demand volume and service capacity. The course will cover topics in queueing theory with a focus on higher level decisions (e. g., system design/network planning) and strategic behavior. It will help to assess standard queueing models in an economic environment. This will allow students to study issues such as the quality of service and the pricing of products with different qualities. The course will acquaint students with a range of models, their analysis and main results. Examples include observable vs. unobservable queues, total system value maximization vs. provider revenue maximization, priorities and their implications, state dependent pricing, incentive-compatibility in queueing systems, time-based competition, and operation of online marketplaces. Moreover, some important applications will be studied via fluid limits and heavy traffic analysis. Prerequisites: Although there are no formal course requirements, some prior exposure to analytical tools is essential. The course assumes fairly basic knowledge of mathematical tools, including probability and optimization.	G	8, 4, 9	focused
47776	Tepper School of Business	Advanced Stochastic Models	We will be exploring advanced topics in stochastic processes and queueing theory, potentially including stochastic orderings, heavy tails, conservation laws, approximation techniques, queue decomposition, limiting analysis (fluid, heavy traffic), coupling, and perfect simulation. I am also open to discussing other topics suggested by the class. Each topic will first be presented in terms of the technique being introduced and then in terms of the application of that technique to solving problems in operations, services, or computer science.	G	15, 14, 11	focused
47779	Tepper School of Business	Quantum Integer Programming	This course is primarily designed for students interested in integer programming and the potential of near-term quantum computing for solving combinatorial optimization problems.	G	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
47834	Tepper School of Business	Linear Programming	Linear programming lies at the basis of modern optimization theory. This course focuses primarily on linear programming theory and algorithms, leaving beyond the scope of its practical applications. The main topics to be covered include modeling examples and expressive power of linear programs, polyhedral sets and their geometry, theory of systems of linear inequalities and duality, classical linear optimization algorithms (simplex and network simplex), and decomposition approaches for large-scale optimization. If time permits polynomial time solvability of linear programs, extensions to conic optimization problems, conic duality, and an introduction to interior point methods are topics of interest in the given order.	G	10, 9, 1	focused
47835	Tepper School of Business	Graph Theory	This is a graduate-level course on introductory graph theory. The theory of graphs has found wide applicability in a variety of areas ranging from Engineering to Molecular Biology. The objective of this course is to introduce basic concepts in the theory of graphs and develop problem-solving ability and mathematical maturity in this area.	G	4, 9	focused
47836	Tepper School of Business	Advanced Graph Theory	This is a graduate-level course on advanced graph theory. This is a follow-on course building from the graph theory course.	G	4, 9	focused
47841	Tepper School of Business	Applications of High-Dimensional Statistics	Modern data in settings such as e-commerce, healthcare, and operations management are almost always complex and in high dimension. Recent computational and algorithmic advances have led to exciting opportunities to leverage this data for analysis and decision making indeed, these opportunities have already come to fruition in the form of recommender systems, personalized medicine, and pricing. A critical component of this progress has been a set of probabilistic and statistical tools aimed specifically at high-dimensional settings, including concentration inequalities, minimax theory, and random matrix theory; these tools are precisely the subject of this course. In many applications, including the aforementioned examples, the data are most naturally represented as a set of matrices or tensors. This course will be largely focused on these settings: we will cover algorithms and major results for matrix estimation, and see recent results in the burgeoning field of tensor estimation. The ultimate goal of the course is to prepare students to apply these same tools in their own research.	G	10, 4, 9	focused
47842	Tepper School of Business	Algorithms for Massive Data Science	Data sets have grown to an astonishing size and companies like Yahoo, Google and Twitter are processing up to a petabyte of data every day. There is an opportunity to discover more and better information by processing large data sets. While this opportunity exists, current computational methods frequently fail to scale to data sets of enormous size. Due to this, new methods are being developed to handle the ever increasing size of data sets. This course will focus on a subset of recent algorithmic developments for handling large data. The course will introduce algorithms for massively distributed models of computation. These models are designed to capture frameworks such as Spark, Hadoop and MapReduce used for deploying algorithms in a data center. The course will cover streaming algorithms, an alternative approach where the methods do not store the entire data set in memory. This will be primarily a theoretical course focusing on algorithm design. Applications discussed will be motivated by real world challenges.	G	9, 4, 8	focused
47884	Tepper School of Business	Mechanism Design	This course is an advanced class on theory and applications of mechanism design. Theoretically, the course focuses on recent development in mechanism design: on topics such as robust mechanism design, mechanism design with multiple dimensions of heterogeneity, and behavioral mechanism design. The applications include: optimal taxation, optimal selling mechanisms, auctions, etc.	G	9, 17, 8	focused
47958	Tepper School of Business	Economining I	This is a seminar class intended to explore recent advances in machine learning to combine with economic and consumer behavioral theories to embark on impactful social science and business research.	G	8, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
48025	Architecture	First Year Seminar: Architecture Edition I	The main objective of this first-year seminar course is on how students learn, develop, and make decisions as they transition into architecture education. The goal of this course is to promote academic success and encourage connections within the SoA and the University at large. Teaching and learning strategies will be introduced to help support the transition into architecture and the development of independent critical thinkers. Students will be introduced to campus resources that support their academic/social/personal integration into the campus community. Topical areas to be covered in the seminar will include teaching and learning strategies in architecture education, academic development, career planning, mentorships, academic and personal support services, and the aspects of professional practice in architecture. "	U	4, 17, 1	focused
48026	Architecture	First Year Seminar: Architecture Edition II	The first year seminar (part 2) introduces students to opportunities at Carnegie Mellon University and beyond. The goal of this course is to encourage students to pursue their interests inside and outside of the School of Architecture by introducing a range of opportunities, including study abroad experiences, internships, academic minors/additional majors, and graduate study. The introduction of the study abroad process and travel options will encourage students to consider a study away experience into their academic curriculum. Students will explore their additional academic interests by identifying their psychological preferences through the Myers-Briggs Type Indicator and matching these preferences with academic minors/additional majors at CMU. The presentation of the Intern Development Program (IDP) will engage students in considering future plans for earning IDP hours and understanding the process of securing an architectural internship. Students will be introduced to the process of developing an independent research project. Additional topical areas to be covered in the seminar will include an evaluation of the previous semester, scholarship/academic funding opportunities, graduate studies, and schedule planning for upcoming semesters.	U	4, 17, 8	focused
48095	Architecture	Spatial Concepts for Non-Architecture Majors	This course serves as an introduction to the spatial concepts of architecture for students from other disciplines. The course is focused entirely on project design work (this is not an historical survey, technical or lecture course). This course is very hands-on Projects will explore the design and experience of spatial environments through a series of creative investigations. The semester will be broken in to 3 parts:Intro/Exploration and a long term project. In Intro/Exploration, students will have many hands on opportunities to start to build a common language to describe spacial investigations as well as creating them. This will consist of short projects, with each design investigation progressively building upon the previous exploration; these early projects will consist of both individual and group work. They will focus on Making. The second half of the semester will consist of one long term project to be created individually, incorporating students? personal theories of architecture based on an overarching question. Studio work will be supported by group discussion based upon critical review of student work, readings, slide presentations, videos and films. There will also be a few field trips. Students are encouraged to explore their own areas of interest with respect to their work in class. Self-motivation, class attendance and an open mind is mandatory, however, no prior architectural, engineering or artistic experience is required. Students are expected to perform work both inside and outside of class. Students should be prepared to purchase various supplies throughout the course. This course is in partial fulfillment of requirements for an Architecture Minor.	U	4, 9, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
48100	Architecture	Architecture Design Studio: Foundation I	As the first architectural design studio course, the Foundation I studio establishes a fundamental understanding of representation and abstraction to which more of your own thoughts and ideas about spatial thinking can be added. This will involve, by means of the architectural studio, a reiterative investigation into the relationship of technique, form, and meaning through study, invention, testing, and evaluation. During this semester a series of short problems will be given to expose you to the complexities of visual communication and the design act; to develop skills of spatial manipulation; to give you the self-confidence in making valid decisions within set time limits; to develop the skills of graphic presentation necessary for interpreting and communicating your architectural intentions; and above all, to instill the ability to combine insight with the rigorous analytical study in a ?design process? that is efficient, personally effective, and which becomes second nature to you as a working process.	U	4, 9, 17	focused
48105	Architecture	Architecture Design Studio: Foundation II	The 48-105 studio, called Foundation II, is the second studio in CMU?s professional B.Arch program. It builds on the lessons from 48-100 about clear architectural communication and abstract spatial-definition, but adds a greater emphasis on the material and experiential understanding of how architecture is made and used. We continue to emphasize architectural drawing and models (both analog and digital) as the primary means of architectural communication, but also as a method of creatively exploring and rigorously testing fundamental architectural ideas. We investigate, research, analyze, diagram, and apply lessons from local architecture, and great architecture of the past, in studio, and in the parallel survey of architectural history. We introduce the use of ?systems,? ?computational thinking,? and ?rules? in the design process to create order, deal with a range of parameters, and satisfy specific performance criteria. Beginning with more abstract formal design exercises, and ending with the design of a small building, we explore how tectonics, joinery, materials, as well as site, orientation, context, and human use can be harnessed to inspire great design. The design process is still carefully controlled, but students are encouraged to begin to speculate and take careful risks.	U	4, 9, 17	focused
48116	Architecture	Building Physics	This course is composed of two parts related to fundamental building physics concepts, namely, the lighting performance of buildings (first part)and the thermal performance of buildings (second part). In the first part, the course will introduce fundamental lighting principles in the context of performance-based architectural design and diagnostics. The course will cover relevant aspects of lighting environment that affect the physiological and psychological experience of buildings, performance metrics, design and benchmarking methods, and contemporary simulation tools. Topics include a review of physiological and psychological response to the visual environment, analytical and numeric methods for the prediction of lighting conditions in interior spaces, lighting engineering and design methods, and application of computer-aided lighting simulation tools in architectural design. In the second part, the course will introduce fundamental thermal principles in the context of performance-based architectural design and diagnostics. The course will cover relevant aspects of thermal environment that affect the physiological and psychological experience of buildings, performance metrics, design and benchmarking methods, and contemporary simulation tools. Topics include a review of basic theory of heat transfer, thermal dynamics, thermal comfort, analytical and numeric methods for the prediction of building thermal load and energy consumption, and application of computer-aided thermal simulation tools for building thermal design. Demonstration of a set of environmental measurement and sensing devices will also be included in the thermal part of this lecture. DIVA-for-Rhino and ArchSim-for-Grasshopper/Rhino software platforms will be used for lighting and thermal performance simulations	U	7, 13, 12	focused
48175	Architecture	Descriptive Geometry	This course is offered only at Carnegie Mellon's campus. This is a manual construction course for solving problems in three-dimensional geometry through working with two-dimensional planes using basic mechanical drawing tools. The course covers basic concepts of descriptive geometry; solving problems involving lines and planes in space and their spatial relationships; rotations in three dimensions; locating points and tangents on solids and surfaces; intersection of solids; shades and shadows; perspectives; and development of surfaces.	U	9, 17, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
48200	Architecture	Architecture Design Studio: Elaboration I	This studio is an introduction to architectural design stressing concept generation and the development of a rich design process to create evocative spatial experiences through architecture. Building on the explorations of form and space in the 1st year, we investigate in greater depth the role that program, context, and the physical "elements of architecture" play in creating meaningful architecture. We seek to understand design principles underlying the buildings of the past and present, from the broadly theoretical and conceptual, to the real implications of tectonics and sustainability, and apply these ideas with intent and significance. We will focus on developing challenging architectural ideas, profound building details, and effective ways of communicating them in order to explore architecture's potential for creating poetic expressions, appropriate shelter, or exalted experiences, as well as its ability to embody ideas and impart meaning to the world around us.	U	12, 9, 8	focused
48205	Architecture	Architecture Design Studio: Elaboration II	Building on the fall studio, the spring semester is concerned with more in-depth understanding and development of designs for small-scale buildings, now informed by greater knowledge related to materials, fabrication, and the act of construction. Following the "New Materiality" evident in architecture today, and acknowledging the importance of materials and assembly techniques for sustainable design, we seek to explore the aesthetic and experiential meaning of materials (WHY?), and the technical knowledge related to the use of materials and the processes of construction (HOW?). The creative opportunities and design implications of using varied materials, structural systems, fabrication and assembly techniques--both analogue and digital--are elaborated, especially as they determine the artistic, conceptual, poetic, creative, spatial, and experiential aspects of architecture. The studio projects, lectures, and the required building study will focus on the application and integration of knowledge acquired in a parallel "Materials & Assembly" course 48-215.	U	9, 12, 17	focused
48215	Architecture	Materials & Assembly	48-215/ 48-647 introduces and examines the fundamentals between design intent and construction materials, the science of materials (performance) and their assemblies. Learning how materials and techniques inform spatial and form making decisions will be a central theme for the semester. Lectures and discussions will focus on the meaning, aesthetics and techniques related to the use of materials and the process of construction.	U	4, 9, 12	focused
48240	Architecture	Historical Survey of World Architecture and Urbanism I	This course cuts a broad swath through time, geography and cultures, surveying critical episodes in the built environment of Europe, the Middle East, Asia, and the Americas from antiquity through the 19th century. Reflecting the inseparable relation between building and human needs, this course is not only a history of architecture, but also a history through architecture. It examines architectural and urban design as a form of cultural expression unique to its time and place. The design, use, meaning and legacy of a building is conditioned not only by the architect's will or the patron's desire, but also by a web of technological, religious, social, cultural, economic, and political factors of the time. This foundation course is the first in the architectural history sequence, and introduces students to the subject and skills of world architectural history. It is a prerequisite for all subsequent architectural history courses. Student work will include several exams and a final.	U	4, 8, 11	focused
48241	Architecture	Modern Architecture	This survey of modern architectural history lecture course picks up where the historical survey 48-240 leaves off. It focuses attention on the 20th-century, and investigates the web of interwoven ideas and issues that characterize the modern age and ?modernism.? We begin with a look at the "crisis of modernity" that plagued most of western civilization in the late 19th-century, and then survey the major movements of the avant-garde and other responses to modernity, and end with what came to be known as ?Post-Modernism.? We will look more closely at the increasing divide between the ?disciplinary? edge of architecture, and architecture?s increasing ?professionalization? in the last century, focusing on how architecture has influenced culture through experimentation and provocative thinking, even when the primary intent was functional, technological, social, political, etc. Emphasis will be placed on the relationship of buildings to the more general cultural, intellectual, and historical circumstances in which they were created. Special attention will be devoted to the important manifestoes, theoretical, and critical writings that so determined the project of modern architecture.	U	11, 9, 16	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
48300	Architecture	Architecture Design Studio: Integration I	Design Studio III: Building and Site is a required course taught in the third year. The subjects of the Third Year Fall Semester are the reciprocal orders of buildings and landscapes and the development of the building site. The work builds on knowledge gained in prerequisite and co-requisite courses including 48-312 Site Engineering. This course asks students to continue their investigations into the formal and spatial composition and enquiries of previous semesters with a focus on the following concepts: Occupancy: Social and cultural phenomena, dimension/measurement and cycles of time relating to human and non-human occupancy Site assessment: site inventory at many scales Grading and surface manipulation: compatibility of grading with related technical considerations for water management, ground structures, surfacing, plants, and maintenance Road alignment: design of roads and parking to support construction, service and the anticipated occupancies, design of roads to connect to other roads with appropriate sight lines, stack spaces, and turning requirements, layout and sizing of parking spaces for vehicles Stormwater: volume and direction of runoff water on both the undisturbed and developed areas, storm water surface system, Plants: selection of plants and plant communities with consideration for regional, local, and site-specific factors	U	6, 4, 11	focused
48305	Architecture	Architecture Design Studio: Integration II	The basis for the CMU studio course sequence is the expectation that the student retains and applies knowledge gained each semester to the current studio. The spring semester of the third year of architectural studies at Carnegie Mellon University is concerned with the detailed development and refinement of an architectural design as informed by the technical knowledge of structural systems, enclosure systems and the process of construction. The student is expected to articulate concepts and develop designs with more precision and in greater detail than done in previous studios and courses. In addition to criteria related to the development of design skills appropriate to one's sixth semester of the studio sequence, the following criteria are an explicit part of the evaluation of the student work: Aesthetics: The degree to which the design responds to formal issues as articulated in prior design studios. Structural System: The degree to which the proposed building is presented as a statically stable structure which defines the spatial order and satisfies the architectural intentions made explicit in the project. Enclosure System: The degree to which the proposed enclosure system satisfies the design requirements and responds to the physical phenomena of the environment into which it is placed. Material Selection: The degree to which the selected building materials and their implementation are appropriate to the occupancy, articulate the architectural order, and satisfy the physical design requirements. Constructability: The degree to which the proposed building is developed in response to an understanding of the processes of construction. Presentation: The clarity, craft and completeness of the presentation.	U	4, 9, 17	focused
48315	Architecture	Environment I: Climate & Energy in Architecture	This course introduces architectural design responses for energy conservation, human comfort, and the site-specific dynamics of climate. Students will be expected to combine an understanding of the basic laws of comfort and heat flow with the variables of local climate to create energy design guidelines for their own work. The state of the art in building energy conservation and passive heating and cooling technologies will be presented, with take-home readings and assignments. To stress the significance of architectural design decision-making on energy consumption and comfort, full design specifications and calculations will be completed for a residential-scale building. Students will compile a professional energy consultant's report, designing the most viable energy conservation retrofit measures for their client from siting, massing, organization, enclosure detailing, opening control, to passive system integration and management. An overview of world energy consumption in buildings and energy design standards will be challenged by lectures on building energy conservation successes, and emerging demands for a broader definition of sustainability. The course will end with a focus on the design integration of natural conditioning systems and the potentially dynamic interface of mechanical systems in small- and large-scale buildings.	U	15, 13, 7	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
48339	Architecture	IDeATe: Making Things Interactive	In this hands-on design-build class you will learn the skills to embed sensors and actuators (light, sound, touch, motion, etc.) into everyday things (and places etc.) and to program their interactive behavior using a microcontroller. You'll also dive into the fields of VR/AR/MR and experiment with combining these disciplines with physical computing. Through weekly exercises and a term project the class will introduce basic analog electronics, microcontroller programming, projection mapping and virtual reality; as well as exploration into using kinetics and materials to make the things you design perform. Emphasis will be on creating innovative experiences. The graduate edition of this course will require additional work including a paper that can be submitted to a peer-reviewed interaction design conference such as CHI, UIST, or TEI. Students from all disciplines are welcome: but please note that the class demands that you master technical material. Experience in at least one of: programming, electronics, or physical fabrication is strongly recommended.(Participants will provide their own supplies and materials.)	U	9, 4, 17	focused
48355	Architecture	Perspective	Course addresses perspective on the basis of three distinct understandings of perceptual psychology: 1) A Kinesthetic Basis for Perspective, which is built on the drawing pedagogy of Kimon Nicholaides. It aligns with the transactionalist understanding of perception and considers perspective as partly invented and partly discovered truth. 2)The Order of Appearance, which is built on the early work of the perceptual psychologist, J.J. Gibson, and aligns with the ecological position of Gibson and his followers It considers perspective as an absolute truth of the visual field. 3)Perspective Imposed, which aligns implicitly with the position of Gestalt psychology. It treats perspective as an imposed schema. Along the way some use is made of on-going design work for subject material. Work is submitted in 3 portfolio submissions of 3-4 weeks duration each.	U	15, 9, 12	focused
48356	Architecture	Color Drawing	Color Drawing builds knowledge and provides practice in the use of color in depicting architectural surroundings. Media used are pastels on gray backgrounds, colored pencil on white backgrounds and water color. In the interest of speed the principal technique used in watercolor is a moderate dry brush technique. Coursework assumes knowledge of linear perspective and basic use of color. Work consists of in-class exercises and weekend assignments built on these. Students can expect to spend up to 6 hours of work per weekend.	U	6, 4, 12	focused
48359	Architecture	Special Topics: Design Build / Building Systems	In this studio we will consider Thoreau's essayso much of it about his own design/build experiencein today's context. Collectively, we will design a cabin to meet the high standards of sustainability set by Eden Hall. After a round of prototyping, testing, and design development, the studio will create a set of construction documents and shop drawings. Covid and funding allowing, we will begin building the cabin at mid-term, with construction continuing into the summer or fall as required. This studio has a nine credit co-requisite, 48-358 Cabin Building Systems, which is also open to CEE students. Its focus will be on the building systems for the cabin that is being developed in the parallel studio. Topics include energy performance (e.g. production, renewable energy systems, passive and active ways to achieve efficiency, and modeling); integrated structural and engineering systems (e.g. building envelope, water treatment and management, heating and cooling systems, and electrical and lighting systems; and sensing for monitoring and control. The class will have a team-based format that is hands-on and lab-oriented rather than a seminar structure, and it will contribute directly to the build part of the studio.	U	7, 6, 13	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
48367	Architecture	Material Histories	"Materials have histories, and these histories deeply affect the ways they have been used and the meanings they carry" Jessica Sewell and Andrew Scott Johnston recently wrote on Platform. In this seminar we will look at the history of the architecture of the last two centuries by following the thread of the history of materials. Starting from case studies and critical readings, we will discuss the ways in which buildings of the past and the practice of architecture were affected by which materials were available, how they were produced, and the craft required to work them. Materials affect the way we engage with a building sensorially, and at key moments in the history of architecture there were many implications to the architects' material choices. Materials carry cultural meanings connected with complex histories. We will reflect on how architects have interpreted, manipulated, or added to those meanings through their own work. Materials' lifecycles and the networks of extraction, production, transportation, and reuse had an impact on the built environment in the past, just as they do today. We will learn from historical examples to critically assess the consequences of the choices we make as designers. We will highlight how the meanings attached to materials - such as timber, steel, brick, plaster and concrete - changed over time, as construction moved from craft-based to industrialized, and how these stories of change were deeply and at times messily connected with the social, political and ecological context. Finally, we will critically engage with the presence of history as a layer of complexity embedded in the material itself - an effect that is compounded in the practice of reuse of materials with patina, marked from their past use.	U	12, 15, 11	focused
48369	Architecture	TERRA COTTA ASSEMBLIES: Cultural Expression and Climate Change	This seminar speculates that merging communication with environmental performance, a material like terra cotta can be instrumental in returning cultural expression to the building skin (Picon 2013). The ornamental nature of architectural terra cotta facades can not only move us towards a more sustainable future, but also express our milieu: we created problematic climate futures but as designers we also can envision and propose diverse and alternative relationships to our environment. An exploration of the topics that define the ecological turn and how to manifest them through form, technique, and material will be the focus of the seminar which will culminate in a collective project. The group's issues of concern that will be manifested in the design of an architectural ceramic assembly may range from the expression of conditions of scarcity, to patternings for biodiversity, or performances of energy flows, to an indexing of climate change, to mention a few. Following the methods of interaction with fabricators and manufacturers often found in practice, we will be working hands on (but remotely) with the techniques and technologies used in contemporary architectural terra cotta design and fabrication. The seminar will engage the Architectural Ceramic Assemblies Workshop - 2021 (https://archceramicworkshop.com/), sponsored by regional industry partner Boston Valley Terra Cotta, to expose students to contemporary architectural terra cotta workflows from design concept to production. Through regular engagement with the projects and process of participating architectural firms the seminar will provide students exposure to architecture professionals, facade engineers, ceramics engineers and artists, and glaze experts. In consultation with these the group will develop a prototype to be presented in the upcoming Architectural Ceramics Workshop along with the professional teams.	U	13, 9, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
48371	Architecture	American House and Housing, 1850-1975	This architectural history course examines the development of American house and housing choices during the period 1850-1975. A recurring picture of the "American Dream" has typically included the image of a single-family, detached dwelling set within its own green yard in the suburbs. However powerful and durable that image is, the history of house and home in America is actually a far more complex story with many different twists and turns. In the course we will look at both urban and suburban housing choices and cultures, ranging from single family detached dwellings to multi-unit housing, and across a social spectrum income, class, race, and gender. Through the use of occasional field trips, we will use Pittsburgh as a touchstone for understanding broader national trends in the history of American urban and suburban housing. The course is organized as a lecture course supplemented with field trips and discussions based on field trips and primary source readings. The additional time slot on Thursday afternoons will be used only when field trips are scheduled. Student work will include a research paper and several shorter written assignments throughout the semester.	U	5, 11, 1	focused
48374	Architecture	History of Architecture in the Islamic World- A Primer	This course serves as an introduction to the architecture that developed in the Islamic lands over the centuries. The aim of the course is to provide a basic understanding of major epochs and regional variations, examining the social and historical context within which Islamic art and architecture developed. Through lectures, discussion and guided research activities, the students will learn the function and meaning of the most important building types, examine how these types changed over time to adapt to the needs of changing societies, and consider influences and exchanges with other traditions. While the main geographical focus of the course will be on the Mediterranean area, from Moorish Spain to the modern Middle East, the students will have the opportunity to develop independent research projects on other areas of the Islamic world.	U	4, 17, 11	focused
48380	Architecture	Real Estate Design and Development	This course will provide an overview of the real estate development process and explore the interdependence of real estate development and design. The course will introduce real estate development team members, processes, and phases, including feasibility, predevelopment, construction, and marketing. The course will include a substantial financial component that will introduce students to the basic techniques of property valuation, project budgeting, pro forma analysis, sourcing of financing, and investment analysis. Students will study how market demand, tenant requirements, site constraints, zoning restrictions, and available capital affect design solutions. Course work includes classroom learning, independent reading and exercises, guest lectures, and examination of case studies. The semester?s effort culminates in the execution of a team development project based on a current Pittsburgh development project. Teams will complete a basic market analysis, program evaluation, schematic design creation, project cost estimation, pro forma analysis, and evaluation of financial feasibility. Development practitioners will provide a critique of each team?s project to offer ?real world? guidance on student schematic designs and feasibility analysis prior to the final completion of the project.	U	4, 9, 8	focused
48400	Architecture	Advanced Synthesis Options Studio I	Having proven competency in the spectrum of skills determined necessary for tomorrow's architect during the first three years of the program, students in their fourth and fifth year are permitted to select from a variety of studio options, each providing the opportunity to build upon or augment some of those skills with new or more nuanced perspectives. All advanced synthesis studios are open to both years, the vertical integration offering enhanced learning opportunities.The content and focus of each studio is governed by faculty interests, which run the spectrum of architectural pursuits, ranging in scale from the design of a piece of furniture to a city and in approach from a comprehensive and complex building program to a critically-driven speculation. They may also be interdisciplinary in nature, taking advantage of the unique juxtapositions made possible at Carnegie Mellon.	U	4, 11, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
48432	Architecture	Environment II: Design Integration of Active Building Systems	High performance buildings are achieved with designs that effectively integrate passive and active systems. Having been introduced to passive systems in prior semesters, students in 48432/48655 will focus on the active systems typically included in commercial buildings and strategies for their successful integration with passive components. The goal of the Design Integration of Active Building Systems course is to familiarize students with active building systems and integrative design strategies that should result in high levels of occupant comfort in commercial buildings that, in the US, are moving toward net zero energy and net zero carbon emissions Active systems introduced in this class include: Electric lighting Mechanical ventilation Active heating and cooling Water systems for interior and exterior use and water heating, including solar Onsite electricity generation with renewable energy Building transportation systems Active fire protection & smoke control Because of the breadth of this subject area, the course will be futurefocused, concentrating on design approaches and technologies that appear to be wellsuited to a net zero energy and net zero carbon future.	U	7, 13, 6	focused
48440	Architecture	American Regions & Regionalism: An Architectural History of Place, Time, and Cul	Despite the leveling forces of mass culture and globalization, the geographic and social diversity of the U.S. has created distinctive regional mosaics of landscape and architecture. Say New England and images of English Pilgrims, town greens with white framed churches, and industrial mill villages may come to mind. The Southwest conjures different images, perhaps of adobe pueblos, Spanish friars, arid ranches, and the color turquoise. The built environment of the Midwest, the California coast, the Mississippi Delta, and many places in between reflect particular regional identities that have been both unconsciously and consciously created over time. This course examines the historical development of regional patterns in the American built environment. It investigates how and why a regions architectural identity evolved in the ways that it did. To what degree is place something to respond to, to interact with, and to what degree is place something that is created? Our focus will be primarily pre-20th century when the forces of vernacular traditions were stronger, we will also examine more recent trends of regionalism as an aesthetic choice and a theoretical stance.	U	9, 8, 11	focused
48497	Architecture	Pre-Thesis	The primary goal of this mini is to help students formulate a robust proposal for the 5th year Thesis, but it could be used to create a proposal for any grant, scholarship or academic research project. A series of weekly workshops, readings, discussions, and guest lectures will help students move from wide-open initial ideas about issues they are curious about and seek to explore, to the development of a rigorous research process that builds on existing knowledge and attempts to develop new ideas and advances the discipline. The class will explore the difference between design and research in architecture, how different research methods and modes of representation can be leveraged, and how concepts of disciplinarity and "project" can focus a topic. Students will begin to identify precedents, key readings and a research bibliography, an overview of the general topic they will research in depth, a detailed plan for a years worth of independent thesis work, and a well-defined end-product, likely a design proposal. An important task will be to identify advisors who can support, guide, and critique your work, who can act as intellectual collaborators as much as evaluators. This course (or an equivalent approved by the Thesis coordinator) is a pre-requisite for doing a year-long Thesis or semester-long Independent Project in 5th year studio.	U	4, 17, 9	focused
48500	Architecture	Advanced Synthesis Options Studio III	Having proven competency in the spectrum of skills determined necessary for tomorrow's architect during the first three years of the program, students in their fourth and fifth year are permitted to select from a variety of studio options, each providing the opportunity to build upon or augment some of those skills with new or more nuanced perspectives. All advanced synthesis studios are open to both years, the vertical integration offering enhanced learning opportunities.The content and focus of each studio is governed by faculty interests, which run the spectrum of architectural pursuits, ranging in scale from the design of a piece of furniture to a city and in approach from a comprehensive and complex building program to a critically-driven speculation. They may also be interdisciplinary in nature, taking advantage of the unique juxtapositions made possible at Carnegie Mellon.	U	4, 11, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
48531	Architecture	Fabricating Customization: Prototype	Students in this advanced digital fabrication course will leverage the full range of fabrication techniques (digital and analog) in the school of architecture to develop an architectural building component of a previous studio project with high fidelity. The course challenges students to situate their work within a context of materially sensitive built work, while seeking to explore the theme of digital materiality. The course is divided into two modules, the first of which studies significant recently completed built work related to proposed student building components. The second module operates as a laboratory / workshop in which students develop component prototypes through digital and analog methods of fabrication.	U	9, 4, 11	focused
48545	Architecture	Design Fabrication	This course serves as an introduction to digital fabrication methods through an applied overview of the resources available in the School of Architecture's Digital Fabrication Lab. A series of exercises sequence drawing, computer modeling, fabrication, and assembly in a recursive cycle through which students will learn to balance design, intuitive making, as well as material exploration. The discourse between design and fabrication is shifting as the tools they are reliant upon become increasingly more sophisticated. Students will be challenged to strive towards a digital literacy that fosters a critical engagement with the technology, oscillating between virtual simulation and physical reality. Through a structured disposition of fabrication assignments, the nature of the tools will be exploited to rapidly produce and evaluate within an iterative design process. This semester, we will study a selection of paintings by Charles-Édouard Jeanneret. Over the course of three projects, students will apply the concept of transparency, defined by Colin Rowe and Robert Slutzky, as an operative mean and utilize each of the computational tools at hand to exploit the spatial ambiguity in Le Corbusier's paintings - exploring the translation of two-dimensional compositions into three-dimensional spatial organizations. Each project will focus on developing sensibilities specific to each machine's affordances and allow those to inform the process of design, as well as representation. Similar to how Joseph Savina, a wood carver, created sculptures of Le Corbusier's paintings, students will be producing interpretive physical models of his formal relationships.	U	4, 9, 17	focused
48555	Architecture	Introduction to Architectural Robotics	This course provides an introduction to industrial robotics and automated fabrication within the field of Architecture. A series of lectures will cover the basic components, as well as their work flows, needed to design flexible automation - while work sessions will develop skills in hands-on programming, RAPID, work flow simulation, fixtures, and sensors. We will also issue competency-building projects within the lab environment in order to provide students with hands-on experience using the equipment. Upon covering the fundamental software and hardware content, an end-of-semester project will challenge you to apply your newfound knowledge to solve a final prompt. This is a portal course to all sanctioned coursework using the School of Architecture's Robotic Fabrication Lab. Upon successful completion, students will be eligible and prepared to enroll in advanced robotic fabrication courses.	U	4, 9, 8	focused
48558	Architecture	Reality Computing	Reality computing encompasses a constellation of technologies focused around capturing reality (laser scanning, photogrammetry), working with spatial data (CAD, physical modeling, simulation), and using data to interact with and influence the physical world (augmented reality / virtual reality, 3d printing, robotics). This semester the studio will focus on utilizing these technologies to capture places and objects to digitally recreate them for archives, artifacts, and interactive experiences. We will explore and analyze how to optimize these creations for real-time rendering and analyze how these platforms bridge the divide between "virtual" and "real."	U	9, 11, 4	focused
48568	Architecture	Advanced CAD, BIM, and 3D Visualization	This course is designed to introduce a student to 3D software tools, including AutoCAD 3D, Revit Architecture, and 3D Studio MAX. Building information and parametric modeling, materials, lighting, rendering, and animation concepts allow students to create integrated CAD/BIM projects, 3D video animations, and realistic renderings. At the conclusion of this course, students will have projects and animations created and architectural CAD/BIM standards outlined. Students should have some familiarity with basic AutoCAD 2D commands. Those who don't have AutoCAD 2D knowledge can contact the professor to arrange for on-line tutorials that need to be completed before classes begin.	U	4, 9, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
48569	Architecture	GIS/CAFM	A Geographic Information System (GIS) integrates displays, edits, analyzes, and shares spatial data for informing decision making. Industries benefiting from GIS include architecture, business, city planning, defense and intelligence, education, government, health and human services, natural resources, public safety, transportation, utilities and communications, and urban planning/design. GIS topics include map design and outputs, geodatabases, downloading and importing spatial and attribute data, digitizing, geocoding, and advanced spatial, 3D, and network analysis. Other topics such as raster-vector integration and web-based GIS will also be covered. Facilities management is the practice of coordinating the physical workplace with the people and work of the organization. Computer Aided Facilities Management (CAFM) integrates software tools to streamline operations, boost productivity and develop strategic planning goals for an organization. CAFM topics include space management, asset management, building operations, emergency preparedness, environmental health and safety, telecommunications, and real property and lease management. This course prepares students to understand, maintain, and manipulate spatial and organizational data using world leading software applications. By the end of the course, students will have sufficient background to identify spatial characteristics of diverse application areas enabling them to integrate spatial thinking and analysis into their academic research and careers.	U	4, 8, 9	focused
48634	Architecture	Architectural Theory	This graduate history and theory seminar starts with the conviction that Architecture is not only space, materials, technology, structure, form, program, site... but also culturally constructed discourse, meaning, communication, concept, and debate: or theory. Architects must draw from other disciplines, distinguish multiple positions on any issue, take a stance, act on, and be able to discuss, debate, and defend their ideas. The course will begin with the fundamental questions: What is theory in architecture? How has our understanding of architecture and theory evolved historically to get to this point? How will it continue to transform into the 21st century? Where is architecture going? Students will discover how architectural ideas and theories evolve and reoccur, and even the oldest theories have contemporary relevance. The topics covered will vary from year to year to acknowledge the dynamic nature of the program, profession, environment, and global context. The work of the seminar will focus on readings, weekly presentations and discussions about the sources, and a research paper on a theoretical aspect of architecture that might lead to a thesis or grant proposal. Thanks for syllabi. For NAAB clarity, but also for optics, I will ask all my colleagues teaching required courses for the M.Arch to issue a separate syllabus with the correct course number, and if they want, slightly different language about expectations, attendance, etc. I will also ask all faculty teaching required courses to list in their syllabus the SPC that are being demanded in the course... so students and faculty are clear.	G	4, 9, 17	focused
48635	Architecture	Environment I: Climate & Energy	This course introduces architectural design responses for energy conservation, human comfort, and the site-specific dynamics of climate. Students will be expected to combine an understanding of the basic laws of comfort and heat flow with the variables of local climate to create energy design guidelines for their own work. The state of the art in building energy conservation and passive heating and cooling technologies will be presented, with take-home readings and assignments. To stress the significance of architectural design decision-making on energy consumption and comfort, full design specifications and calculations will be completed for a residential-scale building. Students will compile a professional energy consultant's report, designing the most viable energy conservation retrofit measures for their client from siting, massing, organization, enclosure detailing, opening control, to passive system integration and management. An overview of world energy consumption in buildings and energy design standards will be challenged by lectures on building energy conservation successes, and emerging demands for a broader definition of sustainability. The course will end with a focus on the design integration of natural conditioning systems and the potentially dynamic interface of mechanical systems in small- and large-scale buildings.	G	15, 13, 7	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
48641	Architecture	Modern Architecture	This survey of modern architectural history lecture course picks up where the historical survey 48-240 leaves off. It focuses attention on the 20th-century, and investigates the web of interwoven ideas and issues that characterize the modern age and ?modernism.? We begin with a look at the crisis of modernity that plagued most of western civilization in the late 19th-century, and then survey the major movements of the avant-garde and other responses to modernity, and end with what came to be known as ?Post-Modernism.? We will look more closely at the increasing divide between the ?disciplinary? edge of architecture, and architecture?s increasing ?professionalization? in the last century, focusing on how architecture has influenced culture through experimentation and provocative thinking, even when the primary intent was functional, technological, social, political, etc. Emphasis will be placed on the relationship of buildings to the more general cultural, intellectual, and historical circumstances in which they were created. Special attention will be devoted to the important manifestoes, theoretical, and critical writings that so determined the project of modern architecture.	G	11, 9, 16	focused
48711	Architecture	Paradigms of Research in Architecture	This course is both an introduction to important models and methods of academic research particularly as they are related to building design issues and a forum for intellectual curiosity. During the initial ten weeks of the semester, the course presents an overview of the field and covers several models of research as they relate to the building design. These will include models of natural sciences, social sciences, sciences of the artificial, engineering and aesthetics in building design. During the final five weeks of the semester faculty both CFA and CIT will be invited to make presentations about their areas of research and the methods they use. These presentations correspond in many respect to those covered in lectures.	G	4, 9, 17	focused
48721	Architecture	Building Controls and Diagnostics	This course introduces the concepts and methods of building diagnostics. It focuses on the empirical evaluation of the built environment (building components and systems, interactions between building, occupants and environmental conditions) in view of multiple performance criteria (thermal, visual and acoustic performance). Field measurement and assessment techniques will be introduced. The empirical methods of building analysis are commonly used to: describe/specify building components; study the real-time behavior of buildings; detect the causes of building failures; and gather data for model validation. The course will address these issues, both theoretically and practically, through the application of: field measurement techniques; physical modeling methods; and computer-aided building modeling. Computer-aided data processing techniques will be applied for the analysis and interpretation of the results of model and field studies. The role of building performance simulation in the area of building diagnostics will be investigated	G	9, 12, 13	focused
48723	Architecture	Performance of Advanced Building Systems	Advanced Building Systems Integration This is a graduate level course that focuses on commercial building performance achieved through systems integration. In lectures, class discussion, and student projects, we will explore the topic of building performance, the design and technical strategies that support sustainable high performance; the design, construction and operation processes that are likely to produce sustainable high(er) performance buildings; and the current state of theory versus practice. The course assumes a basic understanding of buildings' impact on the environment, of building design and materials performance, and the calculation of building heating and cooling loads. On that foundation, we will examine the concept of systems integration and how this approach can sustain the occupants and the environment far better than conventional design, construction and operation. Although US climate, building conventions and codes will be our reference point, we will broaden our discussion by using examples and data from many other countries. An essential aspect of our exploration will be identifying successful built projects and examining the factors that may have allowed those projects to succeed. If this course meets its objectives, students who successfully complete the material will understand and be able to discuss sustainable building performance characteristics, will understand the systems integration approach and how it differs from conventional approaches to building design, and will know how to positively affect architectural and engineering decisions to support the design, construction and operation of sustainable high performance buildings.	G	13, 9, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
48724	Architecture	Scripting and Parametric Design	This mini-course prepares students for modeling architectural geometry through scripted development of parametric schemes for architecture applications by supplying the basis of understanding parametric geometric construction mechanisms. The course consists of lectures, computer cluster instruction and assignments. This course introduces students to basic scripting for form making. In this course we focus on customizing procedures for generative design via scripting; and on providing an introduction to basic computational algorithms for form making, e.g., fractals, L-systems, cellular simulations, evolutionary and genetic algorithms for shape making. Students are expected to have familiarity with the basics of parametric modeling and the fundamentals of object-oriented programming¿simple basic principles of working with an object-oriented programming language (Python). For practical reasons, the course uses Rhinoceros ®, Grasshopper ® and GhPython and some of the more common built-in plug-ins in the Grasshopper and GhPython environments. Prior exposure to Rhino/Grasshopper is required.	G	4, 9, 15	focused
48725	Architecture	Real Estate Design and Development	This course will provide an overview of the real estate development process and explore the interdependence of real estate development and design. The primary objective of this course is for you, the student, to understand how real estate development, public policy, and finance will affect your professional life when you enter the workforce. The course will introduce real estate development context, team members, processes, and phases. Students will study how market demand, tenant requirements, site constraints, zoning restrictions, and available capital affect development projects. The course will include a financial component that will introduce students to the basic techniques of property valuation, project budgeting, pro forma analysis, sourcing of financing, and investment analysis. We will also touch on societal issues including social equity and international real estate topics. The semester's effort will culminate in the execution of a team development project. The project client will be a nonprofit or government entity. The project will be a real project/site in the city of Pittsburgh. The project components may include a basic market analysis, program evaluation, schematic design, project cost estimates, pro forma analysis, and evaluation of financial feasibility. You will make a final presentation to the class and the client.	G	4, 8, 9	focused
48729	Architecture	Productivity, Health and the Quality of Buildings	Given the growing demand for green buildings by federal and private sector clients, professional practices are ?tooling up? all over the world to deliver high performance, environmentally responsive, ?green? buildings and communities. However, investments in green, high performance building solutions and technologies are still limited by first cost decision-making, and life cycle tools are still largely inaccessible to professionals. A building investment decision support tool ? BIDS? - continues to be developed by the Center for Building Performance and Diagnostics at Carnegie Mellon University, with the support of the Advanced Building Systems Integration Consortium. This cost-benefit decision support tool presents the substantial cost-benefits of a range of advanced and innovative building systems designed to deliver ? privacy and interaction, air quality, ergonomics, lighting control, thermal control, network flexibility, and access to the natural environment - from field case studies, laboratory studies, simulation studies, and other research efforts. This course will explore the relationship of quality buildings, building systems, and land-use to productivity, health, well-being and the environment. The course will engage students in the literature that relates building design decisions to ten cost/performance impacts: energy, facilities management, organizational change, technological change, attraction/retention (quality of life) of employees, individual productivity, organizational productivity, salvage/ waste, tax/ insurance/ litigation, and health.	G	12, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
48739	Architecture	Making Things Interactive (Graduate)	In this hands-on design-build class you will learn the skills to embed sensors and actuators (light, sound, touch, motion, etc.) into everyday things (and places etc.) and to program their interactive behavior using a microcontroller. You'll also dive into the fields of VR/AR/MR and experiment with combining these disciplines with physical computing. Through weekly exercises and a term project the class will introduce basic analog electronics, microcontroller programming, projection mapping and virtual reality; as well as exploration into using kinetics and materials to make the things you design perform. Emphasis will be on creating innovative experiences. The graduate edition of this course will require additional work including a paper that can be submitted to a peer-reviewed interaction design conference such as CHI, UIST, or TEI. Students from all disciplines are welcome: but please note that the class demands that you master technical material. Experience in at least one of: programming, electronics, or physical fabrication is strongly recommended.(Participants will provide their own supplies and materials.)	G	9, 4, 17	focused
48752	Architecture	Zero Energy Housing	Net zero energy construction has gone from concept to policy in just a few years, but built examples are still rare. What does it take, technically, to achieve net zero and what else, beyond technical requirements, advances or impedes a net zero future? 48-752 is a graduate level class that explores net zero energy design and construction in the residential sector. Through case studies and applied projects, we will explore what it takes to achieve quantitative net zero in residential buildings while maintaining occupant comfort and satisfaction. In locations where net zero is now required, we will examine the results of those requirements. At the outset, we will discuss specific definitions of a net-zero building and the implications of each definition. Through case studies, lectures, field trips, outside reading and assignments, we will examine how a net-zero building is achieved, including the use of renewable energy to achieve the net-zero balance. We will apply lessons learned from metered examples to real sites and to new design or renovation projects in Pittsburgh and will use simulation software to test and quantify the impact of our design/renovation strategies. We will also compare our strategies to requirements in US codes and rating systems such as IECC-2012 and LEED for Homes to evaluate their impact in moving the US residential sector toward much higher performance buildings. Although our focus is residential, many of the concepts and strategies we cover have parallels in the commercial sector. Students who enroll in the class must know how to calculate without software heat loss and heat gain for a small building. You are also expected to have a fundamental understanding of residential design and construction, plan reading and mechanical systems; US residential materials and construction methods for net zero will be covered in class.	G	7, 13, 9	focused
48753	Architecture	Intro to Urban Design Media	This course introduces urban design history, theory and methods of analysis and representation. Urban design is examined at multiple scales: city form and networks, neighborhood and block structures, streets, public spaces, and urban building typologies. A wide variety of cities, projects, proposals and methodologies are examined with a special focus on urban sustainability in the contemporary city. Assignments include readings from seminal texts, presentations and discussions, graphic assignments and a final project. A required course for Master of Urban Design students, it is also open to fourth and fifth-year architecture undergraduates as well as graduate students in related programs.	G	11, 4, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
48770	Architecture	Learning Matters, Exploring Artificial Intelligence in Architecture and Design	With the recent blooming of artificial intelligence (AI) and machine learning (ML) came a renewed interest in how these technologies may impact architecture and other creative practices. Learning Matters introduces students to this emerging field, giving them the tools to make their own machine-learning based design tools by adapting state-of-the-art models, developing new models, and understanding how data shapes machine learning processes. The course places a particular emphasis on machine learning interfaces. Similar to other rule-based computational design approaches, users can interact with machine learning models through scripting. However, machine learning demands new approaches to interacting with data. By collecting, selecting, and generating data points, we will explore how bespoke interfaces can elicit new kinds of designing and making processes. Throughout this course, we explore this new field by curating data sets and training models on them. Four fields of machine learning and their potentials in design and making problems will be explored: 1) unsupervised generative models, 2) reinforcement learning, 3) multimodal machine learning, 4) machine learning for robotics. Students will be introduced to the fundamental concepts of each field and get hands-on experience with state-of-the-art research and tools to implement them.	G	4, 9, 17	focused
48783	Architecture	Generative Modeling (GRAD)	This course introduces students to the fundamentals of generative modeling using computer aided design as practiced in the field of architecture. Core competencies will be developed through modeling projects and software intensive labs, while a broader critical framework for conceiving of contemporary and historical parametric practices will be encouraged through periodic lectures. Emphasis will be placed on careful consideration of digital mediums and developing a sense of craft related to digital modeling in the hope that students will become conscientious makers and consumers of digital content. Students will be encourage to understand and apply algorithmic problem solving to the many design constraints encountered in architecture. The course will explore the relationship of parametric workflows to design thinking and will situate contemporary trends in a broader framework of computational design. The course will also forefront complex form-making as a response to bio-mimicry, systems thinking, and mass-customization. Rather than positioning parametric modeling as a disruption of historical architectural design process, the course will encourage students to consider how new tools might augment the discipline's historical commitments to orthographic projection, perspectival drawing, and physical modeling.	G	4, 9, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
48795	Architecture	LEED, Green Design and Building Rating in Global Context	48795, LEED, Green Design and Building Rating in Global Context is a graduate level mini-course that examines building rating system content, strategies, goals and outcomes. The course is organized within the framework of the US Green Building Council's Leadership in Energy and Environmental Design (LEED) Rating Systems, which contains rating system prerequisites and credits in the following categories: location & transportation, site, water, energy, materials, and the interior environmental quality. Within that framework, we explore strategies promoted within LEED (and the new WELL standard) and compare/contrast them with strategies in the rating systems of other countries. We also consider the design of the rating system itself, its implementation, and the national context in which the system was created. The course is designed to develop your understanding of, and hone your critical thought about, sustainable building design and operation. Class lectures address the concepts and environmental issues underlying rating system requirements and credits; present multiple strategies for improved building performance; and to the extent possible, address the impact of specific rating systems and strategies. Students are then challenged to apply this information to specific locations & issues, based on the environmental/energy issues associated with the rating system categories listed above. Although the course provides a foundation for taking USGBC's LEED Green Associate and/or LEED Accredited Professional exam, it is not an exam prep course. Students who successfully complete the course will understand a range of impacts that buildings may have on the environment and on building occupants, will have insights into contextual aspects of sustainability, and will be familiar with a range of strategies that may be used to encourage development of better buildings and communities.	G	6, 12, 7	focused
49300	Integrated Innovation Institute	Integrated Product Conceptualization	The Integrated Product Conceptualization course focuses on introducing students to some of the thinking, basic skills and methods used by industrial design, engineering, and business to generate new consumer product proposals within integrated teams. Teams will progress through three phases 1) identifying opportunities for new products or services, 2) understanding those opportunities through stakeholder research, value opportunity analysis, and competitive landscape assessment, then selecting one of which to focus, 3) conceptualizing the opportunity with the goal of meeting the value proposition. This course will combine lecture and studio activities including the generation of 2D visual representation skills and 3D low-fidelity physical modeling in support of course work. An important part of this course is a design project that is carried out by interdisciplinary teams. In order to effectively contribute to their team, each student should have experience or coursework in at least one of the following: design, the arts, engineering/technology, or business. This course is reserved for junior and senior level students. Freshmen and sophomores will be admitted as space allows and with instructor permission.	U	4, 9, 17	focused
49313	Integrated Innovation Institute	Designing for the Internet of Things	Thermostats, locks, power sockets, and lights are all being imbued with ¿smarts¿ making them increasingly aware and responsive to their environment and users. This course will chart the emergence of the now connected world to explore the possibilities for future products and connected spaces. This introductory, hands-on course invites students to creating connected products without any knowledge of programming, electronics or systems. Students will be introduced to interactive connected technologies through a series of hands on exercises, collaborative projects, in depth discussions, and instructor led tutorials. Topics explored will include awareness, real time sensing and communication, embedded intelligence, and designing experiences for the internet of things. By the end of this course, students will be familiar with the core skills, the considerations involved and design process required to build a connected system. Students will also apply this learning in collaborative groups to realize a prototype-connected product. This course is offered for undergraduate students in IDeATe.	U	4, 9, 7	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
49700	Integrated Innovation Institute	Engineering Design Fundamentals	This course will teach the basic principles and philosophies of engineering design (with emphasis on mechanical engineering). Topics include stress analysis and fracture, heat transfer, kinematics, and systems packaging. Students will learn the issues engineers must consider during design of commonly produced products. Class includes lectures and labs. This course is required for Master of Integrated Innovation for Products & Services (MIIPS) students who do not have an engineering background. This course is intended for MIIPS students; all other students by permission of the instructor.	G	9, 4, 17	focused
49701	Integrated Innovation Institute	Product Design Fundamentals	This course is an introduction to design principles in the context of product development. During the course, students will learn about the design process and the steps designers take from an understanding of user needs to the creation of a fully considered solution that meets those needs and delights the user. Through case histories, lectures, and a variety of hands-on exercises, students are exposed to design thinking and practice. The relationship among design, product development, and business is explored with class projects, readings, discussions, and the analysis of artifacts and process. Additionally, students experience the use of traditional design skills (drawing, mockups, and model making) in the visualization and representation of design concepts and solutions. Techniques include: 1. Conducting observational research, 2. Analyzing information to inform team brainstorming, 3. Planning projects, 4. Developing concept strategies, 5. Generating ranges of solutions 6. Selecting and refining concepts Methods of early prototyping and testing through the use of interactive and experiential mock-ups are emphasized. As individuals, and in teams, students will present and defend their ideas in front of their peers, the instructor and visiting critics. This course is part of the MIIPS degree curriculum; all other students by permission of the instructor.	G	4, 9, 17	focused
49702	Integrated Innovation Institute	Business Fundamentals	The purpose of the class is to introduce basic business management concepts and to provide the motivations to make these topics more relevant as they appear in later more advanced classes. We will cover six basic functional business areas: accounting, finance, marketing, operations, strategy, and managing technology & innovation. In addition to covering theory and applications, the course will use a business simulation to help students to understand how the functional areas tie together. This course is intended for MII-PS students; all other students by permission of the instructor.	G	9, 4, 8	focused
49703	Integrated Innovation Institute	Career Planning for Integrated Innovators	This highly interactive class will work to assist students in uncovering abilities and identifying goals towards a career in product design/development. It will also look at ways to communicate the unique values MIIPS students have and align them with employer expectations. Students will then integrate those things into a career search plan. The class will alternate between lecture/presentations and coaching by experts and students presenting materials for practice and critique during class sessions. This course is intended for MII-PS students; all other students by permission of the instructor.	G	4, 9, 8	focused
49704	Integrated Innovation Institute	Integrated Innovation Institute-Seminar & Workshop Series	The Integrated Innovation Seminar & Workshop Series meets multiple times throughout the fall and spring semester. Seminars will focus on intellectual content from industry leaders in innovation and product development. Workshops will focus on skill building in key areas for integrated innovators. This course is a requirement of the Master of Integrated Innovation for Products & Services degree. The seminar & workshop schedule for each semester will be released on the first day of classes. This course is intended for MII-PS students; all other students by permission of the instructor.	G	9, 4, 17	focused
49710	Integrated Innovation Institute	Visual Processes	In this course graduate students in the Integrated Innovation Institute will learn about a variety of different ways we leverage visual communication techniques and approaches to communicate. We will cover the following: 1. Industrial Design Sketching, 2. Information visualization & dashboards, 3. Graphic User interface design, 4. Executive Summary and Pitch Decks, 5. Visual Brand Language, Templates and Styling 6. Visual Explanations 7. Storyboarding and making simple videos Guests from industry will join us with stories from their work each week, and weekly homework assignments will allow students to demonstrate their understanding of the technique and its application. This course is intended for MII-PS students; all other students by permission of the instructor.	G	9, 4, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
49711	Integrated Innovation Institute	Special Topics: Industrial Design Practice	This course is an elective follow on to the required Product Design Fundamentals course. The course gives students the opportunity to master the skills and techniques needed to visualize and represent product concepts efficiently. Building on the principles introduced in the required course, the emphasis is on the approach and techniques used to realize tangible products (research, sketching, model making, user testing, and presentation). Sharing resources and knowledge during the research phase, students work individually to solve the product design challenge presented by the instructor. Demonstrations and assigned exercises coupled with classroom critiques are used to practice and improve skills throughout the mini. Class meetings will be both in the assigned classroom and in the studio.	G	4, 9, 17	focused
49712	Integrated Innovation Institute	User Research Methods	User Research Methods will teach the basic methods of user research, including one-on-one interviewing and ethnographic techniques. The course will cover research planning, field research, and the analysis of research findings. Although the course will focus on qualitative and primary research, the benefits of quantitative and secondary research will also be addressed. The course includes lectures and discussions, along with readings and research assignments. This course is intended for MII-PS students; all other students by permission of the instructor.	G	4, 17, 1	focused
49713	Integrated Innovation Institute	Designing for the Internet of Things	Thermostats, locks, power sockets, and lights are all being imbued with ?smarts? making them increasingly aware and responsive to their environment and users. This course will chart the emergence of the now ?connected world? to explore the possibilities for future products and connected spaces. This introductory, hands-on course invites students to creating connected products without any knowledge of programming, electronics or systems. Students will be introduced to interactive connected technologies through a series of hands on exercises, collaborative projects, in depth discussions, and instructor led tutorials. Topics explored will include awareness, real time sensing and communication, embedded intelligence, and designing experiences for the internet of things. By the end of this course, students will be familiar with the core skills, the considerations involved and design process required to build a connected system. Students will also apply this learning in collaborative groups to realize a prototype-connected product. This course is intended for MII-PS students only.	G	4, 9, 7	focused
49715	Integrated Innovation Institute	Special Topics: IoT Ecosystems	IoT Ecosystems: Designing Intelligent, Interactive, Internet-enabled Spaces Imagine a room with dozens of internet-enabled objects sensing, sharing and cooperating around data. It gets complex really fast. So how do we design ecologies of interacting objects that actually do useful things? We'll get hands-on with this question as part of this design-build course. Over 7-weeks, we'll collaboratively research, design and realize an interactive ecosystem of networked devices that solves a stakeholder-driven problem. We'll explore the opportunities to deliver rich, adaptive and connected experiences through existing internet of things products as well as new and emerging technologies. Students will be supported in this in this exploration by lectures, readings, design exercises, and guest speakers that introduce foundational theory, strategies, and precedents that inform the design of these complex ecologies. This course is intended for MII-PS (Pittsburgh). There are limited places for graduate students in other programs by instructor permission only. Students outside of the MIIPS program: to help manage the waitlist, please complete this Google Form: https://goo.gl/forms/kNhyD8PZG8te1ORG3	G	4, 9, 15	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
49716	Integrated Innovation Institute	Special Topics: Experience Innovation	Experience innovators create new offerings for businesses with a primary focus on the quality of the human experience rather than the material of that experience. This leads us to blur boundaries between traditional design fields and create holistic offerings. In this course students will first study the nature of experience and then work in small project teams to analyze leading designed experiences and create new ones. Service and experience design frameworks will be used both to analyze current offerings as well as to propose and innovative new experience. Students will be working in familiar and unfamiliar forms including concepts for products, documents, events, spaces, activities, scripts, and software. By the end of this course, students should be able to: Easily distinguish and shift between different perspectives on the same design problem space Leverage Service and Experience design frameworks to explain how an offering unfolds for people Speak articulately about offerings that are made up of systems of products, services and other components. This course is intended for MIIPS Advanced Study students in their final semester; there are limited places for graduate students in other programs by instructor permission only.	G	9, 4, 17	focused
49717	Integrated Innovation Institute	Special Topics: Digital Ethnography	Students will study the basic principles of ethnography and then conduct a 6-week project as a participant observer in a digital setting. This course provides an opportunity to hone and refine skills from the User Research Methods course, and dive deeper into one method. You will plan the research, collect data, analyze and synthesize what was learned and present a research report that identifies not only what was observed but also interpret its meaning and make indications about opportunities to innovate with new offerings. Research topics will be provided, however you may propose a topic. Priority enrollment to III graduate students; students outside the III can register with the permission of the instructor.	G	4, 17, 9	focused
49719	Integrated Innovation Institute	Internet of Things - In Depth	Building on Designing for the Internet of Things, this elective will guide students in the development of a single IoT concept in greater depth. Before the course, students will propose a project they would like to focus on for seven weeks. Then, students will rapidly iterate through the lifecycle of developing a single project. They'll explore the implementation of their product in detail from technology to user experience. Regular guest talks from industry leaders will provide insight into developing market-ready, robust IoT products. Finally, students will engage in weekly critique and work sessions where they can seek instructor support in transforming their concept into tangible product. By the end of the course, students will have realized a refined prototype, along with a proposal for bringing their product to market.	G	9, 4, 17	focused
49720	Integrated Innovation Institute	Product & Brand Management	Product and Brand Management (49-720) is an introductory mini-course (6 Units) designed for MII students who are interested in exploring the concepts, roles and responsibilities associated with both product management and brand management. Through interactive lecture, case discussions, and assignments, you will use a host of planning, development and marketing tools that product and brand managers use. These tools will help you address common strategic, as well as tactical, challenges. You will address such challenges across the product lifecycle to make a product or service successful. And, you will learn how product and brand management compare in industries served, and in career paths. The course will have an emphasis on product management and B2B products, but will also address aspects of brand management and B2C products. Further, the course will build on your knowledge of marketing, engineering, accounting, and manufacturing, showing how product managers and brand managers work cross-functionally and play critical leadership functions to make products and services successful. This course is intended for MIIPS students only.	G	9, 4, 8	focused
49722	Integrated Innovation Institute	Special Topics: Launching New Products	This course focuses on the strategies and methods for building, leveraging, defending, and sustaining inspired new products and brands. During the course we will focus primarily on established consumer products and brands. Although, we will address how our learnings apply to B2B and entrepreneurial product launches. We will also discuss the actions required to bring a product to market, including understanding your target audiences' needs, values and lifestyles and the key elements of a launch plan.	G	9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
49723	Integrated Innovation Institute	Special Topics: The Pricing of Products & Services	Why does it make so much sense for Ubers pricing to dynamically change? Why do automobile manufacturers (e.g. Tesla, Toyota) offer bundles of features in their "technology package" or "signature entertainment package", etc.? When setting prices for Prozac, why did Eli Lilly charge per pill instead of charging more for higher dosages? Determining the price of a product or service is one of the most important marketing decisions. It is also one of the least understood aspects of marketing. While many marketing activities are geared toward creating value for the customer, sound pricing decisions are the fundamental tool for businesses to capture the value they create. In todays competitive environment, even slight adjustments in pricing can lead to large financial gains or losses. This course covers multiple pricing strategies, tactics and their applications as well as some relevant aspects of consumer psychology.	G	9, 8, 12	focused
49724	Integrated Innovation Institute	Special Topics: The Elements of Professional Practice	Drawing inspiration from Strunk and Whites seminal work The Elements of Style, the course The Elements of Professional Practice covers basic guidance and examples for communicating professionally with sponsors, in teams, and about your independent work and progresses to more complicated challenges like teaming, fluid groupings, and conflict resolution. We will use readings, case studies, activities, scenarios, assessments etc., to discuss these and more, especially issues that may arise with ambiguity, shared control, constructive criticism and engagement. One of the main goals is for you to begin/continue forming an authentic, effective professional voice in your business communications as you move into a new phase of your professional life after graduation.	G	17, 8, 9	focused
49730	Integrated Innovation Institute	Design for Manufacturing and Sustainable Design	Design is the first step in the development, manufacture, distribution and life cycle of a product. Design for manufacturing looks at the influences of materials, manufacturing and downstream processes on the overall design of a product and its impact on successful innovation. Downstream influences that will be explored include: material selection, manufacturing processes, assembly, robustness and quality, platform design, product costing and safety. Students will be exposed to the fundamental concepts of Design for "X" and specifically the impact that DfM (design for manufacturing) and DfA (design for assembly) have on product development and how they affect design decisions However, what we design and how we develop it impacts our environment. We will cover various aspects of Sustainable Design from a life cycle perspective in the course. Students will be exposed to the fundamental concepts of Sustainable Design (also known as Design for Sustainability - DfS, EcoDesign, Sustainability Engineering, LCA and others) and specifically the impact that DfS has on product development and how it effects design decisions. This course is intended for MIIPS (Pittsburgh) student status, or permission of instructor.	G	9, 12, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
49733	Integrated Innovation Institute	Designing Smart Systems	Driven by the combination of increased access to data, computational power, and improved algorithms, data science and artificial intelligence technologies have become mainstream. These technologies include machine learning, natural language and speech processing, expert systems. robotics, and vision. Historically, early programs applying these capabilities were designed to operate on their own, on very narrow tasks, based on pre-programmed knowledge. Today, we have the ability to design human-computer systems in which both human and computers act intelligently, adapt to the world and learn from experience, improving their performance over time. How do we design such collaborative systems, taking advantage of the fundamentally different ways in which humans and computers act and learn? How do we build smart systems that achieve their intended goals, with a minimum of unintended side effects? The mini-course will give students the opportunity to address such questions. After an introduction of some basic concepts and techniques in AI and data science (only a basic familiarity with statistics is assumed), the course illustrates both the potential and current limitations of these techniques with examples from a variety of applications. We spend some time on understanding the strengths and weaknesses of human decision-making and learning, specifically in combination with AI systems. Exercises will include close examination of the inputs and outputs of various technologies with the goal of learning to select appropriate technologies for a given problem and anticipate design implications. Each student will also complete a final project that takes a project from start to finish (framing the problem, choosing data sources, exploratory data analysis, basic modeling, communicating results). This course is intended for MIIPS (Pittsburgh) and MS-SM (SV) student status, or permission of instructor.	G	4, 9, 17	focused
49740	Integrated Innovation Institute	Integrated Product Development Methods	This is a project-based, team-based course in which teams will be given an open-ended problem statement. The course will teach them an innovation process which they will implement in their project, leading to a final deliverable of a product concept. This course is restricted to MIIPS students or by permission of the instructor.	G	9, 4, 17	focused
49741	Integrated Innovation Institute	Integrated Product Development Capstone	The IPD course focuses on team--based integrated product development among engineering, business, and design disciplines. The semester course consists of four modules including identifying, understanding, conceptualizing and introducing a product opportunity. Interdisciplinary teams of students in engineering, business, and industrial design learn methods to research the needs, wants and desires of a market opportunity, define product specifications, conceptualize products to meet the users' needs and desires and refine the most promising concept. The result is a resolved form, functional design, and marketing plan. The course also focuses on communication of the project through multiple presentations and reports. This course is intended for MII-PS students; all other students by permission of the instructor.	G	9, 4, 17	focused
49750	Integrated Innovation Institute	Software Product Definition	Students develop and refine a compelling and realistic vision for a new product. They learn to understand user and customer needs, to document those needs, and to envision creative solutions.	G	4, 9	focused
49751	Integrated Innovation Institute	Requirements Analysis	Project teams analyze, document, and plan the management of functional, technical, and business requirements for a software system and then create a product release strategy. Prerequisites: Admission to the Silicon Valley MS Software Management program and Software Product Definition (49750).	G	9, 17, 8	focused
49752	Integrated Innovation Institute	Product Definition and Validation	Students learn techniques for envisioning creative solutions to real problems. They develop and refine a compelling and realistic vision for a new product. They practice techniques to understand and validate user and customer needs, and to identify market opportunities. They analyze, document, and plan the management of functional, technical, and business requirements for a software system and then develop a product release strategy.	G	4, 9, 8	focused
49753	Integrated Innovation Institute	User-Centered Research Methods for Product Innovation	Building great products and services begins with having a deep knowledge of the problem you are solving and the people for whom you are designing. From controlled lab studies to field research, a/b testing to participatory design, learn a host of Human-Computer Interaction research methods and analysis techniques to get you the right insights and on the path to crafting innovative ideas.	G	9, 17, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
49760	Integrated Innovation Institute	Foundations of Software Management	Students apply fundamental methods, models, and frameworks to assess real software companies from a variety of perspectives - marketing, strategy, finance, operations - to understand how businesses organize and make decisions. Working individually and in groups, students develop skills for managing teams and employee performance. Students practice personal leadership.	G	4, 8, 9	focused
49761	Integrated Innovation Institute	Elements of Software Management	Through seminar discussions and individual investigation, students assess real software businesses from marketing, business strategy, financial, and overall business perspectives, applying fundamental methods, models, and frameworks.	G	4, 8, 9	focused
49762	Integrated Innovation Institute	Software Product Strategy	Students analyze market opportunities for a software product, evaluate its technical feasibility, then expand the product definition and create a product roadmap. Prerequisites: Admission to the Silicon Valley Software Management program and Requirements Analysis (49751).	G	4, 9	focused
49763	Integrated Innovation Institute	The Business of Software	Project teams develop a complete business plan for a software product, including revenue and expense models, as well as sales, marketing, and support mechanisms to define the structure of a successful software business.	G	17, 9, 8	focused
49770	Integrated Innovation Institute	Metrics for Software Managers	This course is part of the MSSM curriculum. Priority enrollment for the course will go to students in the SM degree. Students outside of the Integrated Innovation Institute can register if seats are available or per instructor?s permission.	G	4, 9, 17	focused
49771	Integrated Innovation Institute	Process and Project Management	Students define the optimal software development method for a given project, by identifying a set of Agile, Lean and/or disciplined practices suited for the project's specific needs. They also develop project's estimates and multilevel plans based on their recommended method. Prerequisites: Foundations of Software Engineering (18652) or Metrics for Software Managers (49770) or consent of instructor.	G	4, 17, 9	focused
49774	Integrated Innovation Institute	Product Management	While Product Manager has been a key role in the high-tech industry for over 10 years, the Product Management training in this space was relatively limited. This course connects the knowledge and skills students learned from previous Software Management courses, and guides students to leverage this learning to position, design, develop, launch, measure, and grow products, particularly in the internet/software sectors. The course covers a product managers' role and the application of product ideation & positioning, feature design and documentation, product development process, go-to-market, measurement/optimization, and growth.	G	4, 9, 8	focused
49775	Integrated Innovation Institute	The First-Time Manager	This course is intended for experienced software developers who have newly been given management responsibilities. The course addresses management styles, managing people (reviewing, mentoring, hiring, firing), managing teams (task assignments, collaboration, conflict resolution), managing schedules and deliverables, reporting to higher management, working with other groups in the organization, and communicating with clients and partners outside the organization.	G	4, 8, 9	focused
49781	Integrated Innovation Institute	Introduction to Machine Learning	The landscape of software products has changed over the last decade with the advent of data science as an interdisciplinary field, and its broad and deep applicability has created opportunities for delivering interesting and innovative capabilities based on deep understanding of data. This course helps current and future product managers understand the distinction between data-driven and conventional products and learn to identify new product capabilities made possible by quantitative data analysis and modeling. Regular hands-on exercises will expose them to techniques for analyzing data, developing insights, building models, and turning the outcomes from models into end-user value. The course project will require students to go through the life cycle of a data-product and showcase their insight as a product feature. (Previously Data Analytics). Some class sessions in this course will be offered using a Flipped Classroom model where lectures will be distributed as videos for viewing offline, and class sessions are dedicated to clarifications, content review, and course assignments.	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
49787	Integrated Innovation Institute	Architecture & Programming Principles	This course teaches how to build an architecture that stands the test of time and business, how to keep your code manageable and clean, how to ensure longevity of your design, and how to build interoperable systems. You will do hands-on individual design and coding exercises addressing architectural concepts like scalability, reliability and security, development essentials like reusable code, refactoring and technical debt, and current technologies like containers, APIs and data pipelines. Examples and exercises will be provided in Java, but you can write quizzes and assignments in any equivalent major programming language with instructor approval. This course is reserved for students enrolled in the MS in Software Management program only.	G	4, 9, 8	focused
49794	Integrated Innovation Institute	Strategies for Your Software Industry Career	This workshop continues the self-assessment started in the New Student Orientation for the MS-SM program, and continues with career exploration activities. Students who are searching for their first job or internship in the software industry and those who are seeking to make a career shift will benefit from this course. A discover of careers available in today's software industry will be conducted through student research and guest speakers (including alumni) who present a view into their typical workday. Students develop an understanding of the wide variety of companies operating in the software industry, and the various jobs available within these companies. Students also learn how they can apply their skills to non-software companies for whom software systems are a major aspect of business success. The outcomes for students include a personal brand statement that articulates skills valued by employers, discovery of their work preferences and aptitudes, a list of target companies to engage, and a plan to develop the materials (e.g. resume, interview preparation) required to conduct a successful job or internship search based on their new awareness and understanding of specific opportunities they wish to pursue. This course prepares students for 39-699 Career and Professional Development for Engineering Masters Students.	G	4, 8, 9	focused
49795	Integrated Innovation Institute	Special Topics: Artificial Intelligence for Product Managers	The principles and practices around artificial intelligence (AI) is increasingly critical to unlock the value of data, and transform business and ultimately human experience. It is so pervasive today that we use it daily probably without knowing it. This course will present students AI business case studies, the most popular AI techniques, algorithms, application recipes, best practices, and offer hands-on experience in implementing them to solve real-world problems. This course covers the spectrum of real-world AI implementations from natural language processing, speech recognition, facial recognition, landmark detection, and social network analysis to technical depth of popular algorithms, neural network backpropagation methods, probabilistic and non-probabilistic methods. Students will accumulate firsthand experience on Google and Microsoft AI platforms, AI model design and training. This course is designed with the easy-to-follow approach by showing the step-by-step implementation of the core technologies. It presents recipes in major use cases to offer students a leap start on building AI solutions. With the willing-to-learn attitude, students with either technical or business background will succeed in this course.	G	4, 9, 1	focused
49800	Integrated Innovation Institute	Commercializing Intellectual Property	This course focuses on product innovation based on emerging technologies that are ready for commercialization and technology transfer, but have not moved beyond the "research lab". The course will follow a rigorous product innovation process that begins with identifying feasible commercial opportunities, understanding the needs of potential customers and other stakeholders, and developing prototypes that showcase the product concept. The course entails understanding new technologies, conducting customer research, applying product innovation methods, and assessing initial business execution steps. Students enrolled in this course may follow into 49-801, Enterprise Innovation in the spring term. The goal is to focus on an execution plan and turn this into a viable product. In 2014/15, the technologies were based on 4 CMU research areas ready for tech transfer. This course is offered by CIT and the Integrated Innovation Institute. This course is intended for MIIPS (Pittsburgh) and MS-SM (SV) student status, or permission of instructor.	G	9, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
49801	Integrated Innovation Institute	Enterprise Innovation	This course explores how business enterprises are being re-invented for today's digital era. Many firms are approaching a critical inflection point. The combined impacts of technology and globalization have revolutionized the way we operate. Software is transforming the way companies innovate; how they interact with customers and ecosystem partners, the way they collaborate and communicate, how they access and distribute information, and how they co-ordinate and control. Traditional approaches that assume "stability" have given way to "dynamic" recipes. The new imperative is to swiftly navigate changing realities. Flexibility, versatility and the capacity to quickly adapt to evolving situations have become the critical challenges. The course is based on the new edition of Prof. Evans' book "Super-Flexibility for Knowledge Enterprises" (co-authored with Prof. Bahrami from Haas School of Business, UC Berkeley). Specifically, we will focus on the new rules of "super-flexibility" needed for continuous recalibration and adaptation. This course is intended for MIIPS (Pittsburgh) and MS-TV/MS-SM (SV) student status, or permission of instructor.	G	9, 4, 8	focused
49802	Integrated Innovation Institute	Innovation & Entrepreneurship	This course focuses on entrepreneurship and innovation from the vantage point of high-tech companies in Silicon Valley. We will explore these topics in the context of the Creation Phase - focusing on founding a new start-up and raising seed funding; and the Scaling Phase - focusing on growing a venture where startups typically undergo "B", and "C" rounds of funding; We will examine common mistakes and misconceptions in starting a new entrepreneurial business, and meet entrepreneurs, angel investors, and venture capitalists from Silicon Valley to learn, first hand, the challenges of conceiving, creating, and growing a new venture. In the second part of the I&E course, our focus will be on the Consolidation Phase ? when growing ventures evolve into established global corporations We will examine critical pain points facing this group of companies, the impact of organizational complexity, the challenge of managing a multi-business enterprise, and expanding the global footprint. This is the phase when technology companies find it more challenging to innovate and often shift their growth focus to searching for acquisitions. Invited guests will share their experiences and lessons learned, and give us a first-hand perspective on realities facing this critical group of innovative companies. This course is intended for MIIPS (Pittsburgh) and MS-SM (SV) student status, or permission of instructor.	G	9, 8, 4	focused
49804	Integrated Innovation Institute	The Leadership Challenge	This course studies the emerging contexts for leadership - key attributes and skills, key development points, and key actions. Leadership will be discussed in changing contexts such as agile/lean environments, emerging technology such as mobility, big data, and global issues. Other topics include decision making under uncertainty, leadership and followership, acting as a connector in an ecosystem. A leader is someone who will take you somewhere that you didn't think you could go; what does this mean for teams, businesses and you personally? There will be key readings, case studies, and a retrospective. This course is intended for MSTV and MSSM (SV) student status, or permission of instructor.	G	4, 9, 8	focused
49808	Integrated Innovation Institute	Integrated Innovation for Large-Scale Problems	This course focuses on team-based innovation across design, business, engineering and software with the potential for large-scale impact. Students working across geographic locations will take on a complex problem in an emerging field, and methodically come up with unexpected ideas and opportunities to tackle and solve it. The semester will consist of a series of four modules where students will research current signals and market indicators; identify opportunities for innovation; and formulate, prototype, integrate and resolve a solution. Students will work both individually and collaboratively and will learn and apply innovation, entrepreneurship and conceptualization skills in scaling existing products and services into new markets and in evolving new products in existing markets. Students will be supported in this exploration by regular guest talks from leading academics and industry professions who will provide their insights and guidance on developing solutions for complex problems. This studio course will be offered in both the CMU Pittsburgh and Silicon Valley campuses. This course is intended for Integrated Innovation Masters students only; all other students by permission of the instructors.	G	9, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
49809	Integrated Innovation Institute	Leadership Development: Scholarship and Practice	This course includes both the scholarship and the practice of leadership. The content includes an exploration of major theories in the evolving understanding of leadership, the skills associated with the practice of leadership, and the many areas leadership theories, skills and practice intersect. The process of this course includes reading and viewing content, class discussions, group exercises, and ongoing reflection on personal, interpersonal, contextual and cultural complexities. The structure of the course will be built, in part, around the six pillars of change: visionary pillar, engaging pillar, ethical pillar, reflective pillar, tactical pillar, technical pillar.	G	4, 8, 9	focused
49850	Integrated Innovation Institute	Grand Challenge Innovation	This course presents a formal process for innovation. The method is applied to solve hard societal problems. Innovators and entrepreneurs have an opportunity to solve very hard problems required in the twenty first century. This course teaches students how to apply emerging technologies to solve grand challenges through a physical system. Students will learn to identify the grand challenge as an opportunity for new products, understand that opportunity and requirements for a successful solution, conceptualization of product solutions based on those requirements, and proof of concept. Priority will be given to students in the Master of Science in Technology Ventures degree.	G	9, 4, 8	focused
49851	Integrated Innovation Institute	Financial Fundamentals for New Ventures	This course will aid high tech teams in their financing decisions for startup considerations and entrepreneurial management. The course will review the basics of financials such as the balance sheet, the P&L and a cash flow statement. It will then address the creation of pro forma financials to support financing for new business ventures. This will include the development of business management understanding, the relationship between venture finance and business risk evaluation, and the process of valuing of the opportunity. Teams will create a venture pitch for their startup.	G	8, 9, 17	focused
49852	Integrated Innovation Institute	Agile Marketing for New Ventures	This course will cover how to formulate marketing strategies that lead to successful products. It will include how marketing strategies are adapted for high tech innovations and products including addressing strategic market planning, functional expectations and tactical considerations. Topics include: strategic market planning, positioning, types of alliances needed for moving from innovation to product acceptance, breakthrough versus incremental innovation marketing, and measuring marketing effectiveness.	G	9, 17, 8	focused
49853	Integrated Innovation Institute	Product Management	The course covers a product managers role in the application of product ideation and positioning, feature design and documentation, product development process, go-to-market, measurement/optimization, and growth. The course begins with a brief overview of the product management role, and then goes step by step into managing the process of building a product. In each class, students are required to discuss the reading materials, participate in the discussion sessions, and dive into in-class practices. The course will explore the Product Managers role and responsibilities across the product life cycle; techniques to understand and validate customer needs and product success; application of the knowledge and skills needed to research, position, design, develop, launch, optimize, and grow products; new product development and delivery methodologies and their impact on product and customer; and the key attributes of a successful Product Manager (PM) through direct dialogue with Silicon Valley PMs.	G	4, 9, 8	focused
49854	Integrated Innovation Institute	Business Models & Strategy	This course is about the development of executable strategies for entrepreneurial efforts. In order for entrepreneurs to be successful, the ability to create a business model and roadmap for execution is essential. Strategy is about making decisions and having alternatives for courses of actions. This course will focus on effective approaches and measures in order to make things happen under tight time and financial considerations. The course will explore how to apply the tools of strategy and business models in order to deliver new business creation. Topics include applying an evaluation process for the validity of a business concept, understanding the drivers for a strategic roadmap for new business execution, using a toolkit to shape a strategy with scenarios for choices of action, identifying the key measures of success. Through teams, students will form specific approaches for selected new business concepts and share them in class discussions.	G	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
49855	Integrated Innovation Institute	Venture Governance: Boards, Executive Decision-Making, and Communications	The goal of the course is to teach founders of a high tech startup venture the requirements and process to be a director and how to manage their Board of Directors and Advisory Boards. The boardroom is where the governance of the venture occurs. The course will propose frameworks for understanding the complex dynamics among directors, executives, investors and shareholders. The key elements of the work boards do includes: strategic reviews, selecting, evaluating and compensating CEOs and other senior executives, company re-organizations, new director selection, managing top executive succession and dealing with various corporate crises. The role of the Boards is crucial in the value creation phase of a technology ventures trajectory. Conceptual frameworks will be taught to effectively manage this crucial aspect of a ventures governance in real time. This course will cover the following topics: board participation and voting rights, Board of Directors responsibilities and liabilities, advisory board mentoring duties and shareholding vesting, managing Board of Directors, Directors and Officers Insurance and Compensation of Board Members, Board of Directors role during venture scaling, fundraising, firing & hiring CEOs and company officers, board members role during the Merger and Acquisitions transaction and during IPOs, and joining other boards.	G	9, 1, 8	focused
49856	Integrated Innovation Institute	Legal Issues in New Venture Creation	A critical part of creating a new venture is to provide the legal structure for both compliance and to prepare the venture for future success. For startups the legal profile of the company sets up the framework for growth. The course will cover basic legal requirements of incorporation, and additional options that need to be determined by the founders including equity distribution, board structure, employee stock option vesting, triggers for contingencies such as firing or acquisition and other issues. Another critical legal issue for both startups and established enterprises surrounds protecting intellectual property to immunize the companys strategic advantage as it gains velocity in the global market and encounters competition. Students will learn about various Intellectual Property tools and strategies to protect their product innovations and to understand the competitive marketplace, both in the US and globally.	G	9, 4, 8	focused
49857	Integrated Innovation Institute	Dynamic Global Teams	Dynamic teamwork and collaboration is a critical success factor and a major source of competitive advantage and frustration for companies worldwide. Many startups have engineering teams based in low cost parts of the world. Established companies have disturbed teams working in R&D and Engineering in different geographies. Mobile and remote communication technologies have transformed the global business landscape. Super-flexible teams drive and execute entrepreneurship and innovation. This course will focus on profiles of dynamic collaborative teams, what it takes to balance different priorities, create trust and alignment, interact with diverse stakeholders, and perform under time pressures and resource constraints, all under complex, fast-moving and unpredictable global markets. This course will study critical success factors in driving innovation and explore how super-flexibility enables rapid, real time adaptation. The course will describe practical action steps for organizing and managing super-flexible teams, study and apply fundamental findings in cognitive psychology that support adaptability and creativity of teams, introduce methods for training cross-functional teams to excel at innovation, and learn how to use practical tools and techniques that can turn ideas into action.	G	9, 8, 17	focused
49881	Integrated Innovation Institute	Start Up Creation in Practice	For MSTV students with the goal of creating a new start up as they are enrolled in the MSTV degree, they have the option of using up to 24 units of their electives in the practice of creating a new venture (12 units per semester). Similar to an independent study, but focused specifically on new venture creation, students will work on developing their technology-focused idea into a potentially viable company through this course. Students can work individually or through a team with other MSTV students. Each student (team) must have an approved faculty advisor.	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
49882	Integrated Innovation Institute	Artificial Intelligence (AI) Applications	Artificial Intelligence (AI) is a collection of multiple technologies that enable machines to sense, comprehend and act, and learn, either on their own or to augment human activities. AI has introduced new sources of growth, changing how work is done and reinforcing the role of people to drive growth in business. It is one of the hottest technologies that students may encounter in their future jobs. The course leverages the knowledge, experience, and network of the faculty, provides students with the fundamental knowledge, analytical skills, and strategic thinking needed to assess a job opportunity, analyze an application, and discover the business opportunities in the AI applied sectors.	G	4, 8, 9	focused
51101	Design	Studio: Survey of Design	Students will conduct activities that will help them notice design in the world, investigate how it works, and describe their thinking about design, through photography, video capture, sketching, note-taking and modeling. They will work through projects in various ways as a means of 'testing-out' and reflecting on command design approaches. This course is for undergraduate design majors only.	U	4, 9	focused
51102	Design	Design Lab	Introduce concepts and methods to familiarize students with a range of analog and digital modes of working across products, communications, and environments. Students will use desktop modeling and comping methods to familiarize them with a range of basic materials to build confidence in using and manipulating material to represent ideas. This course is for freshman Design majors only.	U	4, 9, 12	focused
51122	Design	Collaborative Visualizing	This course introduces frameworks of notational, exploratory and explanatory sketching using collaborative methods and exercises to cooperatively communicate design ideas. This course is for undergraduate design majors only.	U	9, 4	focused
51132	Design	Introduction to Photo Design	Using a digital camera, students learn how to extend their 'seeing' with the camera, both in the world and in a shooting studio. Through shooting assignments student will understand how to: deconstruct image meaning and aesthetical choices, construction of photographic meaning and aesthetics, an understanding of color and how color delivers meaning, how a photographic studio works, proper digital photographic workflow and contemporary trends in photography. Intended for Design Majors, or permission of the instructor.	U	4, 9	focused
51171	Design	Placing	This course will explore the context in which students study design. Using primarily photography, students compare where they are from to the bioregion of the Ohio Valley of Western Pennsylvania and the history of the steel town, Pittsburgh. Students also learn about the modern Western emergence of design as a profession and discipline, and map the edges of current design practice by interacting with local professionals.	U	4, 9, 17	focused
51172	Design	Systems	This course explores how to understand complex phenomena by creating models of interrelations between components. Students learn soft systems diagramming as well as the systems thinking associated with ecologies, integrative science and socio-technical regimes. Students also learn how to see design as a way of making interventions into leverage points in a system in order to transform its functions.	U	4, 9	focused
51173	Design	Design Center: Human Experience in Design	Design touches, and can profoundly affect, people's lives. But why? And how? This course begins with a broad definition of what design is (and can be). We'll see how design is about the process as much as it is about the final product. We'll look at how the end user interacts with what is designed. And we'll discuss how designers need to think beyond the actual artifact to what lies behind it. We'll touch on design theory, design practice, design responsibility and even some design history. And through a series of guest lectures, explorations of other designers' work, field trips, viewings, class discussions and projects, we'll try to determine just what design is and what designers do.	U	9, 11	focused
51221	Design	Color for Communications, Products, Environments	This course will explore the fundamentals of color through the implementation of various media as they apply to their use in communication and expression in design. While this course does not deal with color theory per se we will spend time on the causes and effects of color interaction, color contrasts, color harmonies and color strategies for the effective use of color in our visual design work. We will use both nature and man made constructs to discuss how color affects what we see and its effect on our visual world. Short exercises and longer- term projects will be the vehicles of our explorations. This course is for Sophomore Design Majors.	U	9, 15	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
51225	Design	Communications Studio I: Understanding Form & Context	Giving form to messages and information using type, color, and images will be the focus of this introductory studio in Communication Design. Understanding the connection between content, intent, and form will be the goal of every project and exercise. Principles of hierarchy, chunking, sequence, clarity, and visual voice will guide work for the screen and the printed page, in dynamic and static forms.	U	9, 17	focused
51227	Design	Prototyping Lab I: Communications	Learn the core methods and tools of visual communication design, with a focus on Adobe CC: particularly InDesign, Illustrator, Photoshop, Prototyping tools, and After Effects. The learning of software ideally will align with the activities conducted in the Communications Studio. This is a requirement for Design sophomores studying Communications.	U	4, 9	focused
51228	Design	Communications Studio II: Designing Communications for Interactions	This design studio focuses on designing communications for interactions. Through projects that vary in scale and complexity, students explore ways of inciting interaction and providing feedback in print and digital mediums to recognize the dynamic attributes of communication design. Communication structures both traditional and emergent serve as the backbone of the course, as they provide opportunities for students to seek and discover patterns in communication design conventions and apply what they learn to their own work to illicit specific types of interaction. Course projects specifically emphasize the importance of narrative structures to communication design. They prompt students to sketch, diagram, and visually weave together layers of information as a means of moving audiences through a sequence of dense content. This process helps students investigate narrative structures as frameworks that shape interactions with communications and impact audience experiences. The course concludes with an introduction to systems design, where students explore designing for interactions across a set of communication pieces. Prerequisite course includes Communications Studio I.	U	4, 9	focused
51229	Design	Digital Photographic Imaging	The objective of this course is to provide students with a practical, technical and theoretical foundation in digital imaging. The primary software for this course is Adobe Photoshop, with which students will explore construction, combination, manipulation, input, and output of image as a means of narrative creation. Through project critique and other discussion, we will also consider the aesthetic and political implications of the emergence of this and other new electronic imaging technologies.	U	4, 9, 16	focused
51231	Design	Calligraphy I	Working with pure unadorned Roman letterforms, this course introduces students to the theory and practice of hand-generated letters, employing a variety of mark-making tools. This course provides an in-depth understanding of the basic principles and techniques of the art of formal writing. Rhythm, texture and composition are achieved through routine, elementary exercises using geometric forms, demanding concentration and manual discipline with the development of hand-eye coordination. The function, use, and harmonious sequencing of letterforms is taught through weekly projects. Awareness of rhythm, texture and letterform structure is achieved through routine exercises. Drills, demonstrations, discussions, individual and class critiques are on-going. Additional related topics and activities introduced in class include books: binding and design. A brief introduction to the historical development of our Western alphabet is provided through film, slides, demonstrations, with discussion of twentieth-century type designs. Students also gain exposure to letter vocabulary, paleography, monoprints, words and punctuation, classical page design, publication design-past and present, and calligraphy's role in design today. Thinking with hands and eyes, the manual placement and spacing of letters practiced in this course awakens sensitivity and judgment in the designer.	U	4, 9, 17	focused
51232	Design	Calligraphy II	This course serves as a continuation and deeper investigation of topics explored in Calligraphy I, where students tackle advanced problems in calligraphy and lettering. The introduction of new hands is to be decided by the student and instructor. Prerequisites: 51231	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
51236	Design	Information Design	This studio course focuses on teaching a basic visual design process from ethnographic research through ideation to finished artifact. Students will work individually and in teams to gain proficiency in applying specific design techniques to information design challenges. Students will attend lectures to gain new perspectives, engage in projects to learn through making, conduct readings to balance theory and practice, participate in critiques to verbalize their views and consider alternate perspectives, join in discussions to develop shared understanding, give presentations to communicate their thinking, and complete tutorials and learn software for additional insight.	U	4, 9, 17	focused
51239	Design	Prototyping Lab II: Communications	Program simple websites as a means of learning basic HTML 5.0 and CSS; prepare documents for digital and print production using Adobe InDesign, Illustrator, Acrobat; learn basics of UX prototyping	U	4, 9	focused
51242	Design	How Things Work: Mechanics and Electronics	This course investigates the basic principles of mechanics and electronics. Through the combination of lectures, investigations, and lab experiments, students develop simplified representations of complex systems. The skills of freehand drawing, mechanical drawing and three-dimensional models are employed and developed during the project sequence. Instructor permission required for non-Design majors.	U	4, 9, 17	focused
51245	Design	Products Studio I: Understanding Form & Context	This mini-semester course takes students through a progression of exercises and projects that investigate how object forms can relate to people through reasons of looks, feel, function, make, and preference. The understanding of context plays a role as the system of internal and external factors and conditions that cause people to interact a particular way. Through how they recognize, handle, move, and perform activity with the form and material of an object. Drawing and physical modeling become essential tools for the planning, development, and communication of these ideas.	U	4, 9, 17	focused
51247	Design	Prototyping Lab I: Products	The course will consist of introductions, demonstrations and solutions to introductory aspects of SolidWorks. Forming foundation skills in CAD-based communication and problem solving will be emphasized.	U	4, 9, 8	focused
51248	Design	Products Studio II: Designing Products for Interactions	Introduce student to 3D semantics, how form communicates meaning, and how to make meaningful objects through appropriate material choices and mechanical manipulation; utilize a range and combination of analog and digital tools for higher fidelity output.	U	9, 4, 8	focused
51249	Design	Prototyping Lab II: Products	Introduce students to high fidelity modeling techniques through a series of machines, processes, and or methods to simulate desired form, scale, and proportions	U	4, 9	focused
51262	Design	Design Center: CD Fundamentals: Design for Interactions for Communications	A one-semester course that introduces non-majors to the field of communication design. Through studio projects, lectures, and demonstrations, students become familiar with the visual and verbal language of communication designers, the design process, and the communicative value of word and image. Macintosh proficiency required.	U	4, 9	focused
51264	Design	Design Center: Product Design Fundamentals: Design for Interactions for Products	In this one-semester studio-like course non-majors are introduced to product design from the product designer's point of view. Through studio projects, lectures, and discussions, students will learn approaches to defining and visualizing product concepts for mass production. Case histories and the analysis of existing products will supplement hands-on experience in developing product concepts. This course is required for all Design minors.	U	4, 9	focused
51265	Design	Environments Studio I: Understanding Form & Context	Learn the basic design processes for experience-driven multi-modal environments, making meaningful physical and virtual experiences through planning, structuring, and explaining/visualizing; utilize a range and combination of analog and digital tools for high fidelity output.	U	9, 8	focused
51267	Design	Prototyping Lab I: Environments	Learn methods for designing interactions in environments through experiencing the space, low-fi prototyping, rapid making, 3D CAD software and video sketching. Express multi-modal aspects of integrated physical-digital-hybrid environments.	U	9, 7	focused
51268	Design	Environments Studio II: Designing Environments for Interaction	Introduce students to the concept of resonant environments that provide meaningful physical and virtual experiences; utilize a range and combination of analog and digital tools for high fidelity output.	U	4, 9, 8	focused
51269	Design	Prototyping Lab II: Environments	Explore simple reactive and interactive programming as a means to support virtual and hybrid digital/physical environments.	U	9, 7	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
51272	Design	Cultures	Explore the sociotechnical aspects of the many identity based differences between people. These differences may be not only cultural, but also related to gender, age, class, race etc. The course will survey critical theories that are useful for understanding how difference both constructs, and is constructed, by systems, practices and things. Students will also explore different frameworks and strategies for exploring questions of difference, and to think critically around the ethical and political implications for design interventions.	U	5, 4, 10	focused
51317	Design	Publication	Students individually develop a specific story that is important to each of them (not their own personal story or a campus story but a story from the outside worldlocal or broader). Then go on to develop, produce and publish this story putting it out into the world in a compelling way. Each publication could take the form of a substantial book, a series of smaller booklets, a film, an interactive experience or a combination of two or more of these. It would include an exploration of ways to disseminate the publication beyond just the classroom and campus. This course would involve important advanced skills pertaining to C typography, color, scale, grid, hierarchy, juxtaposition, pacing, layout, advanced bookmaking (binding, materials, etc.) but E and P students could also find it pertinent to their practice.	U	4, 9, 2	focused
51321	Design	Design Center: Photographic Narrative	Most photographs tell stories. We see photographs in newspapers, magazines, snapshot albums, on the web, in books, and in posters. In these contexts photographs often work with words to convey meaning, whether they are shown with captions, news stories, or just with titles. Photographs can work without words, too, to create purely visual narratives. In this course, students will make a photo narrative and determine how it will be seen. Students may make photo books, for example, or decide that their images will be seen digitally on screen. While students are making photographs, we will explore the rich traditions of photographic story-telling that range from the world-oriented work of photo-journalist W. Eugene Smith to the documentarians such as Walker Evans, Nicholas Nixon, and Alec Soth. We will look at photographers, too, who construct fictional worlds, such as Duane Michals, Cindy Sherman, and Gregory Crewdson. As students make their own narratives, we will look at the interplay between words and photographic images; how images are paced and scaled to create rhythm; how photographs are sequenced to tell stories; and other formal elements involved in creating visual narratives. 12-15 students. Prerequisite-a college level photography course.	U	4, 9	focused
51324	Design	Basic 3D Prototyping	A half-semester laboratory mini-course introducing a range of materials, methods, and workshop techniques by which designers prototype designs in three dimensions. Basic competence in shop techniques is established by bringing to realization a series of simple artifacts. Studio and model shop tools are required; lab fee. Instructor permission required for non-Design majors.	U	9, 4, 11	focused
51330	Design	Communications Studio IV: Designing Communications for Social Systems	As the final course in a sequence of studio courses for Communication Design majors, this one builds on everything learned previously. Apply skills/knowledge learned in researching, developing, evaluating, refining communications to multi-facetted communication challenges that warrant the design of multiple communication pieces that span diverse mediums (in print and digital platforms) and function as a system; learn how to design for futuring (parts of the system yet to be determined) and for co-design where parts of the system are made for growth through contributions from audiences. This course is required of Communication Design majors in the School of Design.	U	4, 9, 8	focused
51331	Design	Advanced Calligraphy I	This course serves a continuation of study in the discipline of calligraphy. (It meets at the same time as Calligraphy I.) Students may take one of two directions in the course. (1) Enlarging their repertoire of scripts, contemporary or traditional, for use in limited areas of work such as book or display work, or (2) Concentrating on more intensive problem solving using a limited repertoire of scripts such as Roman, Italic, Sans Serif. Prerequisites: 51232	U	4, 17, 9	focused
51332	Design	Advanced Calligraphy II	This course serves a continuation of study in the discipline of calligraphy. (It meets at the same time as Calligraphy II.) Students are encouraged to tackle advanced problems or work with the instructor to determine new directions of study. Prerequisites: 51331	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
51333	Design	Design Center: Designing to Collaborate	In Designing to Collaborate, we'll be working on new and better ways to work cooperatively. The class will be a combination seminar and project-based studio in which we will work together to generate, vet, and test ideas to improve collaboration within and across disciplines. We'll be exploring how issues such as values and goals, intimacy and independence, team dynamics, constructive criticism, and others affect the way we work together. Students can expect reading assignments, class discussion, informal (low stakes) writing projects and presentations, and team-based exercises and projects in which we apply our learning.	U	4, 17, 9	focused
51341	Design	How Things are Made	This course will provide a breadth of knowledge for current manufacturing, materials, and processes encountered in the industrial design field. There will be an emphasis on actual production/manufacture methods and not rapid prototyping methods. The class will consist of various lectures, media, electronic tools, and on-site visits to enable an understanding of how mass production affects design and design decisions. Industrial Design Juniors & Seniors or permission of the instructor.	U	9, 8, 12	focused
51343	Design	Products Studio III: Designing for Complex Products Systems	Provide a framework for understanding core practices of the product design profession by placing it in relation to other disciplines and their influences on mass manufacture of goods; students will use a design process to identify problem/s, map a process in which tangible artifacts are made to learn more about the interaction between object, person, space, and context	U	4, 9, 11	focused
51344	Design	Advanced Digital Prototyping	This course is an advanced course using SolidWorks computer modeling. It is a prerequisite for Production Prototyping. This course is intended for undergraduate Design majors.	U	9, 4	focused
51346	Design	Production Prototyping	This course is the 2nd half of Advanced Digital Prototyping, using your work in SolidWorks to produce hard models. This course is for undergraduate Design majors.	U	9, 4, 2	focused
51347	Design	Drawing from Nature	Drawing From Nature This course is about observing and making images of things growing, crawling, flying, swimming etc. Observations will be made firsthand in the field, supported with relevant research in topic areas with the aim of deepening personal understanding of all things biological. Issue surrounding natural forms such as behavior, locomotion, adaptation, the environment and systems will also be investigated. We will work in tandem on refining our abilities in communicating what we discover through the process of drawing. A variety of visualization methods will be covered i.e. analytical drawing, visual notes, and diagramming to name a few. We will be using a variety of basic drawing and digital media to develop our work as we uncover aspects of form, structure and surface. Guest speakers will present work they have done in areas such as botany, biology, and environmental studies to name a few. A majority of the work will be done in the field and will then be developed in the studio. A final project will be assigned that will challenge you to develop a concept along with a compelling form(s) that communicates what you have uncovered about nature to a variety of audiences. This course builds on your experiences from First Year drawing and introduces several more advanced visualization methods. This course is intended for Junior and Senior Design Majors.	U	12, 15, 13	focused
51349	Design	Visual Notation/Journaling	Visual notation is the graphic equivalent of taking written notes. While the camera is a valuable and at times indispensible tool for recording what we see, the camera cannot make visible mental concepts. Nor can it discover and display underlying structures, create hierarchies, explain organizational schema or concepts that are not easily seen or understood. This course is about making visual notes in order to become fluent in your abilities to observe, record and interperate. Through daily entries in a journal you will work in several content areas i.e. mapping, natural and built environments and systems to name a few. A good portion of the work in this class will be conducted in the field using the resources available to us such as the museum, zoo and architectural sites. You will also be challenged to incorporate your notes as tools for communicating design concepts, implementing project development and presentations. The course will rely on the use of a variety of simple drawing tools and electronic media. Several visualization methods will be introduced and the work will build on the drawing experiences from First Year drawing. This course is intended for Junior and Senior Design Majors.	U	9, 17, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
51350	Design	Products Studio IV: Designing Products for Social Systems	Challenge students to build their own design and research process to identify and frame the scale and scope of a problem/opportunity, and place it in relation to the wider system (social, cultural contexts); projects will require synthesizing a range of inputs to develop proposals for future working and living.	U	4, 9, 17	focused
51359	Design	Tools for UX Design	The course intent is to develop appropriate user experience of tools and technology for a projected time frame or context of use. The need to understand people¹s stories, their lives, and how they want to live determines what interfaces, products, and systems should be developed. Student teams will work together to create appropriate user interactions and experiences which are supported by the design of tools and/or technology. This integrated course will utilize rapid prototyping as the basis for the creation of these proposed tools and products. This course is intended for junior, senior, graduate level students, Non-Disclosure Agreement and other legal agreements may be part of the requirements. Proficiency in one or more of these visualization methods: freehand sketching, computer visualization in 2D graphics, motion graphics and/or 3D solid or surface modeling. By Instructor Approval if NOT in Design. Please forward statement of intent to Instructor.	U	4, 9	focused
51360	Design	Environments Studio IV: Designing Environments for Social Systems	Develop high fidelity proposals and demonstrations of multi-modal hybridized physical-digital environments based on rich information content and principles of user experience design.	U	9, 1	focused
51361	Design	HyperSENSE: Augmenting Human Experience in Environments	We make sense of the world using our bodies, and just as we shape environments around us, they also shape our experiences and senses. In this course, we will look at how we can create physical and digital interactions that bridge the gap between humans and built environments to augment our senses. To support our hands-on projects, we will look at both the phenomenology and temporality of human experience and interactions. We will also explore and introduce new roles of computational design and making in embodied sense-making, including human perception and cognition. We will study how we perceive human presence within our space and time. Students in this class will be working in groups to create installations in space controlled by human actions or wearable pieces that augment the body. We will apply methods and practices that form the basis for embodied interaction design. Using research-through-design and iterative design methods, we will create projects that materialize these interactions. Students choose the themes for their final projects. Some possible themes for these projects could be: An installation that materializes a human presence in a remote space; a remote collaboration work tool or a wearable piece that enhances a certain human sense, and/or alters the perception of a specific space. Students also submit a publishable semester paper documenting the theoretical approach, creative process and results. The instructors will help students publish their paper or pictorial in upcoming design conferences if students ask for help.	U	4, 17, 9	focused
51362	Design	Environmental Typography: Experiments in Space, Place & Identity	This course explores the creative opportunities for typography in the physical environment. Through both individual and team projects, we experiment with dimensionality, material, color, and form. Design experiences that consider scale, interaction, and experimental type. Learn theories, concepts, and strategies related to wayfinding. And lastly, give form to identities through color, material, form, and typographic systems.	U	12, 9, 13	focused
51363	Design	Environments Studio III: Designing for Complex Environment Systems	Provide a framework and tools for designing for environments using experience design methods as a means to address the plurality of digital/physical hybrid environments	U	9, 12, 15	focused
51364	Design	Drawing Spaces	The natural and built environment will comprise the subjects of inquiry in this course. We will investigate systems of spatial and physical organization as found in the landscape in various forms and structures from forest to farm and from tent to tenement as examples. The intersection of these systems found in accessible locals will be investigated in the field through on site drawings using simple media and sketchbooks. These studies will then form the basis for the iteration of more developed images depicting environments both existing and imagined. Some time will be spent on observing people and various life forms as they populate and interact within these spaces to various ends.	U	2, 15, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
51367	Design	Design Center: Computational Design Thinking	This course explores computational concepts, methods, and ideas in the context of design. Students will take computational approaches in design process by building their own programmes that generate a variety of solutions. This course encourages exploratory studies of artifacts and playful experiments through self-driven projects. Basic understanding of creative coding and visual communication is expected. Students will use Javascript (p5.js, and Basil.js) for two projects on algorithmic drawing and generative publication. Preference will be given to junior and senior Design students.	U	9, 17, 11	focused
51368	Design	Moving Pictures	The objective of this course is to provide students with a practical, technical and theoretical foundation in video work. Students leaving this class will have gained knowledge of developing a moving picture from start to finish. Students will learn how to storyboard/scamp, plan/scout, produce, and post-produce. Equally importantly students will develop their own visual esthetics through the creation of 4 short videos.	U	4, 2, 9	focused
51371	Design	Futures I	The Futures 1 course focuses on aligning near term design action with longer time horizons aimed at sustainable futures. We introduce the students to Dexign Futures. Dexign is defined as "an experimental type of design that integrates Futures Thinking with Design Thinking." A distinguishing feature of dexign in our usage is the focus on aligning current action with long-term sustainability goals. The course covers different approaches to interpreting the future: from the extrapolations of trend forecasting, through the risk assessments of scenario planning, to attempts to steering the present through backcasting. Students explore the future through utopian and dystopian fictions that are created by authors, filmmakers and themselves. Students also attempt to evaluate futures in terms of their longer-term consequences.	U	12, 9, 4	focused
51372	Design	Persuasion	Examine written argumentation, oral presentations, artifact exhibitions, but also branding and social media. Students learn how to position their design ideas and connect them to the people and organizations that will increase their perceived value to target audiences. A focus of the course is on argument by precedent, where students build the significance of their innovations by situating them historically.	U	4, 9, 1	focused
51373	Design	Futures II	This course, paired with Futures I (51371), is the second half of a semester-long deep dive into foresight/futures for emerging designers. It represents a turn from learning basic concepts and methods in the futures field, toward more advanced, applied approaches at the cutting edge of strategy, co-design, worldbuilding, and transmedia storytelling.	U	4, 9	focused
51374	Design	Preparing for Design Practice	This course helps design students formulate individual plans for their professional practice. In a ramp-up to Confluence, the first third of the course is devoted to self-evaluation, developing/organizing portfolios, writing/designing resumes and cover letters, practicing interviewing skills and creating leave-behinds. After Confluencethrough a series of lectures, guest lectures, workshops, projects and field tripswe explore various aspects of a professional design career as well as other post-graduate opportunities. The course is geared towards Seniors but Sophomores and Juniors applying for internships are also welcome.	U	4, 9, 17	focused
51382	Design	Design Center: Design for Social Innovation	Design for social innovation is a seminar that traces the history and application of design methods to solving social problems. The course will weaver together themes from readings in design, business, public policy, technology, social service, international relations and current events. The course will review examples of successful and failed social innovations from local, regional, national and international contexts. Students will learn the role of governments, technology, funding, infrastructure, mindset, emotion, and cultural factors in addressing problems in the social sector. The course will include a real-world problem-solving component where students (in teams or individually) will write a paper, design an artifact or intervention, propose a project or conduct a short design research study that addresses a real-world problem that impacts a local community.	U	9, 17, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
51385	Design	Design for Service	We all have an idea of what a good service is -- when everything clicks into place, when you feel a little surprised and delighted because of the thoughtfulness and smoothness. And we know what it's like when a service goes wrong -- missed flight connections leading to sleeping on an airport floor, sitting for too long in a doctor's waiting room, a website or app acting tone deaf in a sensitive situation. So what does it take to get a service right? And how can our services best communicate and reflect their interactions with us when they're integrating different streams of data? We will explore the fundamentals of service design in this lecture/studio class. In the first part of the class, we'll begin with a set of modules on tools and practices of service design. Then, you'll put them to use in a group project, in which you design and prototype a service. Our goals (and the objectives of this class) will be to learn service design fundamentals by hypothesizing, experimenting, building, testing our assumptions, sometimes failing, tweaking, and improving. Some great visitors will join us too, in person and virtually, to provide real-world insights about service design.	U	9, 17	focused
51396	Design	Design Center: Design for Climate Change	Nobel Laureate Herbert Simon said "Designers devise courses of action aimed at changing existing situations into preferred ones." We are in the middle of a climate emergency. The United Nations Intergovernmental Panel on Climate Change (IPCC) issued a dire warning in October 2018 with the 1.5oC report conservatively estimated that to avoid the catastrophic effects of climate change rapid decarbonization by at least 40-50% by year 2030 and 100% by year 2050 are needed. Global mass movements are pressuring governments towards towards meaningful change: global student led strikes fashioned on Greta Thunberg, Extinction Rebellion in the United Kingdom, and so forth. Employee solidarity walkouts from major corporations coincided with the student led strikes (e.g., Amazon, Microsoft, Google, Ben and Jerry's). What role might designers take on during our defining existential challenge for the future of humanity and life on this planet? In the Design for Climate Change course, Students explore how to become the agents of change around the challenges of the climate emergency focused on rapid decarbonization. Projects focus on four levels: individual, campus, community, and design practice. This course is open to all kinds of designers ranging from architecture, art, business, computer science, HCII, engineering, psychology and so forth.	U	13, 4, 8	focused
51400	Design	Transition Design	Transition Design: Designing for Systems-Level Change. This course will provide an overview of the emerging field of Transition Design, which proposes societal transitions toward more sustainable futures. The idea of intentional (designed) societal transitions has become a global meme and involves an understanding of the complex dynamics of socio-technical-ecological systems which form the context for many of todays wicked problems (climate change, loss of biodiversity, pollution, growing gap between rich/poor, etc.).Through a mix of lecture, readings, classroom activities and projects, students will be introduced to the emerging Transition Design process which focuses on framing problems in large, spatio-temporal contexts, resolving conflict among stakeholder groups and facilitating the co-creation, and transition towards, desirable, long-term futures. This course will prepare students for work in transdisciplinary teams to address large, societal problems that require a deep understanding of the anatomy and dynamics of complex systems.	U	13, 12, 8	focused
51420	Design	Sensing Place through Color	The world is enhanced by color in every facet of our environment, but we often overlook unimaginable color interactions. The application of color depends mainly upon a trial and error process of selection, comparison, interaction, and evaluation. This course is about learning to look at the world with color filters and exploring ways to utilize color in new and meaningful ways. Through a series of prompts, journaling exercises, and personal experiences, we will reimagine our sense of place through color.	U	4, 12, 15	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
51425	Design	Design Center: Beginning Book Arts Lab	Beginning Book Arts Lab Class. 6units. (This class is a prerequisite for the Advanced Book Arts Workshop Lab Class). This is a class of basic issues regarding hand bookbinding and letterpress printing. It's purpose is to develop a basic structural sense of book forms, of flat format work and of three dimensional forms. Learning hand craft techniques, developing hand skills and the sensitivity to materials are also a goal. Binding projects assigned will target the unique nature of papers, fabrics and archival card-boards. Structural procedures and techniques will be identified with each assigned binding project. The binding projects will be: A hardcover for a paper back book, a single signature book, a multi-signature book with flat spine, and a box construction. The box project is designed and crafted to contain a small letterpress printed class edition, either in book form, or as a set of un-bound pages. The letterpress component teaches the standard issues, unique to the relief process, in press work, handset procedure of cast metal type, page form spacing, lock-up of pages in press, proofing, and production printing. Each semester a small class edition project of text content and image, in two-color registration, is designed, hand set and printed. Image generation can be by hand cut block, assembled type-high forms, or digital process to polymer plate. This class is not to be repeated.	U	4, 9, 17	focused
51426	Design	Beginning Book Arts Lab	Beginning Book Arts Lab Class. 6units. (This class is a prerequisite for the Advanced Book Arts Workshop Lab Class). This is a class of basic issues regarding hand bookbinding and letterpress printing. It's purpose is to develop a basic structural sense of book forms, of flat format work and of three dimensional forms. Learning hand craft techniques, developing hand skills and the sensitivity to materials are also a goal. Binding projects assigned will target the unique nature of papers, fabrics and archival card-boards. Structural procedures and techniques will be identified with each assigned binding project. The binding projects will be: A hardcover for a paper back book, a single signature book, a multi-signature book with flat spine, and a box construction. The box project is designed and crafted to contain a small letterpress printed class edition, either in book form, or as a set of un-bound pages. The letterpress component teaches the standard issues, unique to the relief process, in press work, handset procedure of cast metal type, page form spacing, lock-up of pages in press, proofing, and production printing. Each semester a small class edition project of text content and image, in two-color registration, is designed, hand set and printed. Image generation can be by hand cut block, assembled type-high forms, or digital process to polymer plate. This class is not to be repeated.	U	4, 9, 17	focused
51427	Design	Advanced Book Arts Workshop	Students will be required to plan and design projects that relate to binding, or digital printing, or letterpress printing, or hand-setting of cast metal type. Projects utilizing a combination of all processes can be planned as well. Experimental work, or Artists' Books are also encouraged. In this class structure students will be able to plan and design projects that are complete books, with printed content, or with out content. Other flat structures, and three dimensional containers are examples of general forms that will be categorized as binding work. Students who wish to enroll in this course must have already taken Beginning Book Arts, and must also speak to the instructor directly about project ideas. Emphasis for binding is working independently with a greater level of hand craft and a sensitivity to materials. Emphasis for letterpress printing is to learn in depth, and master, the general mechanical process for doing press work. Emphasis for hand typesetting is on gaining an understanding of the system of cast metal type, and to develop a sensitivity to typographic principles. Instruction will be given on an individual basis through consultation at strategic times throughout the semester. Project evaluation will be based on the success of the project work compared to each student's written project proposal at the start of the semester. The Advanced Workshop in Book Arts can be repeated. For more complex project work this class can be continued for the following semester.	U	4, 9, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
51434	Design	Experimental Form	The Experimental Form Studio looks broadly at the discipline of industrial design with an emphasis on creating new paradigms for interactive objects. This course encourages an exploratory study of physical objects and artifacts and provides a creative and intellectual forum to re-imagine our relationship with objects. Each independently-themed project presents opportunities to consider embedded mechanics & technology, objects as interactive media, and experience-driven design. Experimental Form, at its most basic, is a process that blends play and inquiry in an open-ended way finding the unexpected through tinkering and trying something you don't quite know how to do, guided by imagination and curiosity. In this sense, Experimental Form complements the core ID Studio sequence by providing a playground for intellectual discourse, experimental trial and error, and refining individual processes for designing. This is your sandbox. Prerequisites: Junior standing in industrial design. Junior level communication design with instructor permission.	U	9, 17, 11	focused
51441	Design	Foundation of BME Design	This course focuses on the Product Development scope and framing of a new medical device. Students will work together in an interdisciplinary team with Biomedical Engineering students to identify medical professional or patient needs through behavioral research and participatory research methods. This course deliverable requires the team to propose the problem space and develop a design brief and plan for the following Spring semester to implement. Prerequisite: Junior level design or higher with studio training. Solid modeling or surface modeling recommended.	U	4, 9, 17	focused
51442	Design	BME Design Project	This course is the second in sequence of prototyping and testing a proposed medical device product. The course consists of modules for the development of a project plan, background research, hazard analysis, setting product specifications based on user requirements, detailed design and analysis, prototype development and final documentation and presentation. All products developed will respond to the needs of appropriate market segments; resulting products will be deemed safe, effective, useful, usable and desirable by those segments. Students will produce a form model, functional prototype, marketing plan, and manufacturing plan of their product. Prerequisite: 51-441 (3 units, Fall) Foundations of Biomedical Engineering Design (or permission of the instructor). Junior level design or higher with studio training. Solid modeling or surface modeling recommended.	U	9, 4, 17	focused
51451	Design	Fundamentals of Joinery & Furniture Design	Intensive introduction to traditional joinery techniques and the properties of wood through the use of textbook studies and lab experiments. Emphasis placed on how these techniques and properties influence design decisions. Students will learn how to set up, sharpen and use traditional hand powered tools. This acquired knowledge will be applied in the design and realization of a piece of wooden furniture. Limited enrollment. Lab fee and material purchases required.	U	4, 9	focused
51471	Design	Design Center: Imaginaries Lab: Research through Design	The Imaginaries Lab is a research studio developing design methods to explore and support people's imagining¿both new ways to understand, and new ways to live, in an increasingly complex world. This course, running over three weekends, immerses you in a creative 'research through design' project, including prototyping and using experimental design methods 'in the wild', and in depth. You will learn and develop a variety of tools for conducting innovative forms of research through design, including exploring how people think, understand and imagine complex social and technological concepts, and envision futures, and depending on your expertise or interest, will be able to concentrate on applying particular skills as part of multidisciplinary teams. For example, a project might include speculative design, ethnographic inquiry, physical computing, and novel creative methods. We will aim to turn your work into a published output for a conference or journal, so there is additionally the opportunity to gain experience in this aspect of academic research.	U	9, 4, 17	focused
51480	Design	Design Capstone Project: Service Design & Social Innovation	Learn how to work independently, applying skills/knowledge in Products, Communications, Environments to the research/definition/development/testing of a project that focuses on the design of a service or social innovation that warrants investigation; deepen understanding of service & social innovation design principles and how they are put into practice.	U	9, 17, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
51481	Design	Design Research Studio	"Design Research Studio" represents a particular social frame for design inquiry in this course directed at future needs that are not clearly known. You will be required to use your traditional and contemporary design skills, and the method of Foresight, to conduct quality speculative thinking and gather meaningful insights from future users that lead to valuable design proposals. Truly addressing complex challenges requires expertise across many multidisciplinary domains of practice, therefore, the course work is team based. This is intended to provide you more of an interdisciplinary learning experience that allows, and requires, you to contribute, negotiate and collectively construct and present compelling well-reasoned arguments to the challenge given leveraging your disciplinary orientations to design - products, communications, environments (P,C,E).	U	4, 9, 17	focused
51486	Design	Designing Experiences for Learning	This course focuses on designing experiences that engage people in educational activities that enhance their learning through meaningful, memorable, and enjoyable interactions with information. Throughout the course, students investigate the intersection of design thinking, UI/UX design, cognitive studies, social sciences, instructional design, and educational pedagogy as a way of developing knowledge and skills in designing experiences for learners. Students study topics that are often difficult to grasp and collaboratively build a taxonomy of content types based on common and differentiating characteristics to identify design opportunities. Through readings, projects, and class exercises, students explore how people perceive and process information, what motivates them to learn, and what constitutes an experience. The course introduces students to traditional and emergent learning tools and methods as a means of defining affordances and limitations of various learning approaches and mediums. It also provides students the opportunity to apply what they learn through the design, testing, and assessment of learning experiences that they create.	U	4, 9, 17	focused
51494	Design	Design that Lasts	Never have we wanted, owned, and wasted so much "stuff." Our consumptive path through modern life leaves a wake of social and ecological destruction -- sneakers worn only once, forgotten smartphones languishing in drawers, and abandoned IoT devices promising solutions to problems that don't exist. By what perverse alchemy do our newest, coolest things so readily transform into meaningless junk? This design elective investigates why we throw away things that still work, and shows how we can design products and services that last. This is a studio class, with a substantial theoretical thread woven through it. We will therefore spend about half our time on lectures, readings, and debates, and the other half on studio practice, project coaching tutorials, and group critique. The result, a seven-week journey toward an "experience heavy, material light" design sensibility. A vital and timely new design philosophy that reveals how meaning emerges from designed encounters between people and things, explores ways to increase the quality and longevity of our relationships with objects, and the systems behind them, and ultimately, demonstrates why design can -- and must -- lead the transition to a sustainable future.	U	9, 12, 15	focused
51667	Design	Design Center: Computational Design Thinking	This course explores computational concepts, methods, and ideas in the context of design. Students will take computational approaches in design process by building their own programmes that generate a variety of solutions. This course encourages exploratory studies of artifacts and playful experiments through self-driven projects. Basic understanding of creative coding and visual communication is expected. Students will use Javascript (p5.js, and Basil.js) for two projects on algorithmic drawing and generative publication. Preference will be given to junior and senior Design students.	G	4, 9, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
52190	BXA Intercollege Degree Programs	BXA Seminar I: Building the Wunderkammer	BXA Seminar I introduces first-year and rising sophomore internal transfer students to the field of interdisciplinary work through the concept of the Wunderkammer, the cabinet of wonders. How do we identify and categorize objects? How do we define their position in the world and in a collection? What kind of knowledge is conveyed through context, representation, and juxtaposition? This class considers how interdisciplinary work can be produced, analyzed, justified and--most importantly--contextualized. Students engage with theoretical and practical readings from across disciplines, with particular emphasis on interpretive theory. Weekly readings in aesthetic and critical theory introduce students to a particular vocabulary of analysis, practiced in class discussion and written responses. Students will conceive, research, produce and present a creative final project at the end of the semester.	U	4, 17, 2	focused
52291	BXA Intercollege Degree Programs	BXA Seminar II: Transferring Knowledge	BXA Seminar II is intended for students transferring into a BXA program during their sophomore year or beyond. We'll consider how knowledge is represented across different modes of media--what language, what symbols, what logic guides knowledge acquisition and expression in your varied disciplines? Students engage with theoretical and practical readings from across disciplines, with particular emphasis on interpretive theory. Weekly readings in aesthetic and critical theory introduce students to a particular vocabulary of analysis, practiced in class discussions and written responses. Students will produce written assignments as well as creative responses to the course material.	U	4, 17, 2	focused
52292	BXA Intercollege Degree Programs	BXA Student Advisory Council	This course will provide opportunities for students to promote and refine the mission of the BXA programs. Students will develop and practice leadership skills, including collaboration, communication, and project management. Students will be responsible for planning and running BXA student events, including info sessions, social hours, skills workshops, and alumni events. Students are encouraged to think about how to engage other interdisciplinary scholars and artists as well as how to present their own work and programs to the larger university community.	U	4, 17, 1	focused
52390	BXA Intercollege Degree Programs	BXA Undergraduate Research Project	The BXA Undergraduate Research Project is for students who want to work on a self-designed project with the one-to-one guidance of a faculty advisor. The project should be interdisciplinary in nature, and can be a scholarly and/or creative endeavor. The project may take the form of a written thesis, a compilation of creative works, an outreach project, etc. The project topic must be pre-approved by the faculty member who agrees to supervise the project and assign a letter grade for the course. Projects are to be completed in one semester, may be worth 3, 6, 9, or 12 units of academic credit, and cannot be taken concurrently with the BXA Capstone Project during the senior year. To register, students must submit an "Undergraduate Research Project Proposal Form" signed by both the student and the faculty advisor, along with a proposal, to their BXA academic advisor.	U	4, 17, 8	focused
52391	BXA Intercollege Degree Programs	BXA Junior Portfolio	To better assess the goals and needs of BXA students as they enter their final year and prepare for senior-level projects (e.g. BXA Capstone Project), all students will review their own work and assemble a portfolio during the spring semester of their junior year. Students should work with their BXA advisors and their concentration faculty advisors to assemble a portfolio that represents their academic and creative milestones over the course of their college career. This portfolio also includes reflective written components to allow students to present a narrative of their history with BXA, and identify their goals, visions, ideas and concerns for their future work--both for senior year and beyond. Students should provide an assessment of the areas of intersection between their academic and artistic interests, offer their own specific goals for their academic career, and give a self-evaluation of their performance and opportunities to-date, in light of the programs' broader pedagogical goals.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
52401	BXA Intercollege Degree Programs	BXA Seminar IV: Capstone Project Research	The BXA Capstone gives BXA students the opportunity to demonstrate the extent of their interdisciplinary work over the course of their academic career. The Capstone should include elements that span the student's CFA and SCS concentrations (for BCSA students), CFA and DC concentrations (for BHA students), CFA and MCS concentrations (for BSA students), or CFA concentration and engineering major (for EA additional major students). The project can be either a scholarly or creative endeavor, and may take one of many possible forms (e.g., a written thesis, a compilation of creative work or works, an experiment and report, a computer program or animation, etc.). The BXA Capstone sequence covers both semesters of a student's senior year. In the fall, students are enrolled in 52-401 BXA Seminar IV: Capstone Project Research (9 units), which meets weekly to discuss strategies for managing research, planning the project, and larger theoretical issues related to interdisciplinary work. At the end of the fall course, students will have produced a Capstone Project proposal, an annotated bibliography, and multiple versions of their project pitch. In the spring, students enroll in 52-402 BXA Seminar: Capstone Project Production (9 units), which has no required classroom time. Instead, students spend the semester doing the research and foundational work necessary for the project, as well as meeting with their faculty and BXA advisors as they create their Capstone Project and prepare to present it at the annual Meeting of the Minds Undergraduate Research Symposium held each May. Students will only be enrolled for 18 units when they are unable to complete a two-semester sequence and need to gain special permission by the BXA Director/Academic Advisor. The BXA Capstone sequence is for students in their last two semesters before graduation.	U	4, 17, 9	focused
52402	BXA Intercollege Degree Programs	BXA Seminar V: Capstone Project Production	The BXA Capstone gives BXA students the opportunity to demonstrate the extent of their interdisciplinary work over the course of their academic career. The Capstone should include elements that span the student's CFA and SCS concentrations (for BCSA students), CFA and DC concentrations (for BHA students), CFA and MCS concentrations (for BSA students), or CFA concentration and engineering major (for EA additional major students). The project can be either a scholarly or creative endeavor, and may take one of many possible forms (e.g., a written thesis, a compilation of creative work or works, an experiment and report, a computer program or animation, etc.). The BXA Capstone sequence covers both semesters of a student's senior year. In the fall, students are enrolled in 52-401 BXA Seminar IV: Capstone Project Research (9 units), which meets weekly to discuss strategies for managing research, planning the project, and larger theoretical issues related to interdisciplinary work. At the end of the fall course, students will have produced a Capstone Project proposal, an annotated bibliography, and multiple versions of their project pitch. In the spring, students enroll in 52-402 BXA Seminar: Capstone Project Production (9 units), which has no required classroom time. Instead, students spend the semester doing the research and foundational work necessary for the project, as well as meeting with their faculty and BXA advisors as they create their Capstone Project and prepare to present it at the annual Meeting of the Minds Undergraduate Research Symposium held each May. The BXA Capstone sequence is for students in their last two semesters before graduation.	U	4, 17, 9	focused
52590	BXA Intercollege Degree Programs	BXA Internship	An internship is a supervised professional work experience with clear links to a student's academic goals. BXA students may choose to complete a BXA Internship for elective credit with appropriate individuals or organizations within or outside of Carnegie Mellon University. Junior and senior BXA students in good academic standing are eligible to receive academic credit for one internship. Grading is pass/no pass only. Prior to enrolling in an internship, the student must have a "BXA Internship Agreement Form" signed by their site supervisor and approved by their BXA academic advisor.	U	4, 8, 17	focused
53250	Entertainment Technology Pittsburgh	Immersive Experience Pre-production Process	In this class, students will explore the planning and execution requirements of MR/VR/AR/XR production. They will examine the importance of efficient brainstorming, storyboarding, user journey maps, personas, prototyping, player considerations, various delivery methods, and other guiding principles needed in creating effective, immersive experiences.	U	4, 9, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
53312	Entertainment Technology Pittsburgh	Guest Experience in Theme Park Design	Students will research the history of the Themed Entertainment Industry and study key phases including conceptualization, design, building, management and delivery involved in creating the total themed entertainment experience. The class will focus on the importance of creating the total guest experience. Discussions on story and storytelling will address the different aspects of both franchise and original stories. The class will also examine the role of architecture and technology and how they are crafted to enhance the overall guest experience. The importance of communication and collaboration across all disciplines and the high professional standards required in every phase in the entertainment industry will be explored. The process of managing creativity, risking taking, fostering a culture of team support and trust, developing presentation skills and providing valuable peer-review will all be part of the curriculum. Students will individually complete a variety of short assignment, research and presentations. Students will also work in teams made up of various disciplines and backgrounds. Assignments will include evaluation of experiences in existing theme parks; proposing a concept for a ride or experience deriving inspiration from a list of options provided by faculty; and developing a design project such as an expansion to an existing theme park, a new restaurant, hotel or other architecture added to an existing complex, a new event or attraction which would include a water, sound and light spectacle or a large scale ?Disney? parade event. Students and faculty will jointly choose design assignments based on the needs, interest and composition of the class. The constantly evolving nature of the industry will provide opportunities for topics of discussion which will be identified by both faculty and students.	U	6, 4, 9	focused
53353	Entertainment Technology Pittsburgh	Understanding Game Engines	This course is designed for non-programmers who wish to learn how to use modern game engines such as Unity (which will be the primary tool used for this course). Students will learn the fundamental components and features of game engines (such as objects, inputs, movement, interactions, physics, UI, artwork and animation, sound, and more) and the terminology and theory behind them. Students will attend lectures and participate in example exercises to illustrate these concepts, and put these concepts to practice in their assignment work. This course does not have pre-requisites, but a basic understanding of common code concepts (variables, loops, conditional statements) is recommended.	U	4, 9	focused
53371	Entertainment Technology Pittsburgh	Role Playing Games Writing Workshop	Role playing games (RPGs) are a vibrant and viable popular medium for interactive storytelling. A generation of novelists, screenwriters, playwrights and TV writers came of age playing RPGs. They learned how to tell stories with their friends. Later on they developed those skills and have won Pulitzers, Emmys, Tonys and Oscars. This workshop builds upon a thesis that interactive games share a large portion of dramatic theory DNA with plays, TV and film. Play is performance. The skills developed when creating any time-bound media transfer well to games but must be seen through a different lens - the lens of the player. To do so, we first examine and dissect both RPG story and game design (using pencil and paper examples) seeking an understanding of both system as well as narrative best practices. Once we lay the groundwork, students are divided into three-to-five-person writing teams. Teams use an existing pen-and-paper RPG system to create a set of campaign-style story for that system and that story world. The final product is a hard copy story bible of portfolio-quality. I emphasized this is a writing course, not an RPG design course. Any level of writing experience is welcome, as I provide support and instruction to scaffold in experienced students. More advanced students often find the unique authorial POV of games to be a very different challenge. Experience with and passion for RPGs is a must in this class. To gain final admittance to the class you must submit an original two-page sample original dramatic scene (TV, Screenplay, Stage Play) to the instructor.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
53373	Entertainment Technology Pittsburgh	Dynamic Motion and Game Experience	Making games that rely on human motion is not easy; there is more to making a motion based game than just letting people flail around at random. Depending on the platform and format there will likely be technical and practical problems. These are important to consider; however, on a deeper level there are challenges that involve understanding and interpreting motion in ways that the user can relate to and enjoy. What can be done to make the experiences meaningful to the guest? These and other related concerns represent a challenging problem space for designers of motion based games of all types. In this class students will explore this space in small chunks. Working in interdisciplinary teams students will consult with experts and practitioners in dance, martial arts, sports, stunt performance, etc. Based on information and insights they gain from these people and observations students will construct models of small well defined parts of the dynamic motion systems they are studying. They will use these models to design, build, and analyze small games or interactive experiences. They will have the option to build in a variety of formats from virtual reality to outdoor games. Graduate students register for 53-673.	U	4, 9	focused
53399	Entertainment Technology Pittsburgh	IDeAte Special Topics: Creative Robotics	This experimental course offers unique topics situated at the intersection of robotics research and the arts, with a specific research focus that varies each semester. In this course, students survey the state of an emerging research area, then design and fabricate experimental systems and artworks on the theme. Students are guided through literature search and technical paper analysis to identify opportunities and techniques. The textual study spans contemporary robotics and arts literature. The project component is research-focused and explores novel techniques in design, fabrication, programming, and control. The project sequence culminates in the collaborative design of expressive robotic systems which match technical innovation with a human need or artistic expression. The initial iteration of the course focuses on soft robotics, an emerging discipline centered on devices constructed from compliant materials that incorporate sensing and actuation. The literature survey spans soft robotics and kinetic sculpture. The projects center on fabricating forms that incorporate actuators and sensors using silicone rubber cast into 3D-printed and laser-cut molds. This course is offered by IDeATe and this iteration will satisfy minor requirements for IDeATe Soft Technologies or IDeATe Physical Computing.	U	9, 4, 17	focused
53451	Entertainment Technology Pittsburgh	Research Issues in Game Development: Designing for XR	Extended Reality (or XR) describes the virtual environments generated by the related technologies of Virtual Reality, Augmented Reality, and Mixed Reality. Each generate spatial experiences that hold varying levels of immersion that can enhance or replace our perception of the real world, and each bring their own advantages and limitations. With consumer-grade XR devices now readily available, video game companies are starting to generate content but are faced with the challenge of designing for mediums for which very few standards exist. The class will seek to better understand these technologies, examining the features that differentiate these platforms as well as their capabilities and limitations, and exploring the methods and techniques that trick our brains into believing these environments to be "real". Students will play games and explore apps released for these platforms, dissecting them to discover best practices for designing content for users. Students will apply these learnings by creating brand new XR content. Course work will be performed in collaborative, cross-disciplinary teams as students form their own game studios to tackle design challenges and create games of their very own. These teams will engage in hands-on development for XR platforms, and will have roles for artists, programmers, designers, producers and more. Students from all disciplines are encouraged to join.	U	9, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
53471	Entertainment Technology Pittsburgh	Game Design, Prototyping and Production	Learn to develop video games in a collaborative environment. This course will cover fundamental principles of the design and mechanics of games, rapid prototyping, iterative design processes, and project management. The class will examine business aspects of the industry that impact the design of games, including demographics, economic models, budgets, and marketing. Course work is performed in collaborative, cross-disciplinary teams as students form their own "game studios" to tackle design challenges and create games of their very own. These teams will engage in hands-on development and will have roles for artists, programmers, designers, producers and more. Students from all disciplines are encouraged to join. [Graduate students, please register for 53671]	U	9, 8, 4	focused
53472	Entertainment Technology Pittsburgh	Advanced Game Studio	The Advanced Game Studio is a semester long video game development project. The objective is to provide students with an opportunity to design and deliver a fully realized and refined game, and gain practical working experience with teammates from different backgrounds and disciplines. This year the studio will work collectively as a team to create an interactive VR experience celebrating the 100th anniversary of the Buggy tradition at Carnegie Mellon. This project will have roles available for programmers, artists and animators, sound designers, producers, and more, and students with experience in game development (especially art) are encouraged to apply. Interested students will be asked to interview with the instructor for potential admission to the course. [Students who have already taken 53-472 may instead apply for the cross-listed course 53-399 ETC Special Topics]	U	4, 17, 9	focused
53482	Entertainment Technology Pittsburgh	Advanced Technical Character Animation	Technical Character Animation is a deep dive into the fundamental concepts of character animation and "The Illusion of Life." This course will focus on building a foundation of body mechanics that demonstrate weight, balance, and authenticity. Through a series of strategically designed modules, students will gain a command of the 12 principles of animation, beginning with a ball bounce to more advanced block, spline, and polish workflows. This course is designed to give students exposure to the art of movement as it is done by animators in the fx, film, and game industries.	U	4, 9	focused
53558	Entertainment Technology Pittsburgh	Reality Computing Studio	Reality computing encompasses a constellation of technologies focused around capturing reality (laser scanning, photogrammetry), working with spatial data (CAD, physical modeling, simulation), and using data to interact with and influence the physical world (augmented reality / virtual reality, 3d printing, robotics). This semester the studio will focus on utilizing these technologies to capture places and objects to digitally recreate them for archives, artifacts, and interactive experiences. We will explore and analyze how to optimize these creations for real-time rendering and analyze how these platforms bridge the divide between "virtual" and "real".	U	9, 11, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
53612	Entertainment Technology Pittsburgh	Guest Experience in Theme Park Design	Students will research the history of the Themed Entertainment Industry and study key phases ? including conceptualization, design, building, management and delivery ? involved in creating the total themed entertainment experience. The class will focus on the importance of creating the total guest experience. Discussions on story and storytelling will address the different aspects of both franchise and original stories. The class will also examine the role of architecture and technology and how they are crafted to enhance the overall guest experience. The importance of communication and collaboration across all disciplines and the high professional standards required in every phase in the entertainment industry will be explored. The process of managing creativity, risking taking, fostering a culture of team support and trust, developing presentation skills and providing valuable peer-review will all be part of the curriculum. Students will individually complete a variety of short assignment, research and presentations. Students will also work in teams made up of various disciplines and backgrounds. Assignments will include evaluation of experiences in existing theme parks; proposing a concept for a ride or experience deriving inspiration from a list of options provided by faculty; and developing a design project such as an expansion to an existing theme park, a new restaurant, hotel or other architecture added to an existing complex, a new event or attraction which would include a water, sound and light spectacle or a large scale ?Disney? parade event. Students and faculty will jointly choose design assignments based on the needs, interest and composition of the class. The constantly evolving nature of the industry will provide opportunities for topics of discussion which will be identified by both faculty and students.	G	6, 4, 9	focused
53613	Entertainment Technology Pittsburgh	Experience Design	Experience Design is intended to give Location Based Entertainment (LBE) students knowledge and experience within the realm of designing interactive user based experiences. This hands-on-class will develop experiences within pre-built themed sets to allow the projects to explore the realm of user experience, storytelling, and lighting without having to build physical environments. Hardware and tools knowledge will also be gained through these projects. The class has a regular meeting time that allows for lectures and workshops on specific theories, principles, and tools related to the field of study. Students then work individually or within teams on specific theme based projects to explore concepts covered in class.	G	4, 9, 17	focused
53882	Entertainment Technology Pittsburgh	Technical Character Animation	Technical Character Animation is a deep dive into the fundamental concepts of character animation and "The Illusion of Life." This course will focus on building a foundation of body mechanics that demonstrate weight, balance, and authenticity. Through a series of strategically designed modules, students will gain a command of the 12 principles of animation, beginning with a ball bounce to more advanced block, spline, and polish workflows. This course is designed to give students exposure to the art of movement as it is done by animators in the fx, film, and game industries.	G	4, 9	focused
54101	Drama	Acting I	A knowledge and beginning understanding of the components of acting. Basic exercises, improvisations and prepared work in relaxation, concentration, imagination, communication. The ability to create the reality of a given situation in theatrical terms. Craft fundamentals in preparation for scene study. The beginning development of the students creative resources. This course is open to Drama majors only.	U	4, 9, 17	focused
54102	Drama	Acting I	A knowledge and beginning understanding of the components of acting. Basic exercises, improvisations and prepared work in relaxation, concentration, imagination, communication. The ability to create the reality of a given situation in theatrical terms. Craft fundamentals in preparation for scene study. The beginning development of the students creative resources. This course is for Drama majors only.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54103	Drama	Speech I	(Speech I) The course introduces students to the pronunciation of the sounds of Standard American English pronunciation as presented by Edith Skinner in her textbook SPEAK WITH DISTINCTION. The International Phonetic Alphabet is used to introduce the students to a distinct symbol for each vowel, diphthong and consonant sound. This process will strengthen the student's placement of sounds and will help to illustrate and control regional characteristics. The work is applied to regular individual presentations of various texts. Phonetic transcription is required of class participants throughout the course. Written accuracy of the sounds are required and assigned regularly. This course is open to first year Acting majors who have been accepted to the School of Drama only.	U	4, 9	focused
54104	Drama	Speech I	The Spring course continues to develop the foundational work from the pervious term. This includes the identification and pronunciation of the sounds of Standard American English. Students will study the physical placement and pronunciation of each sound in isolated applications. The International Phonetic Alphabet (IPA) has been introduced and will continue with further diphthong and triphthong sounds and symbols. Further study will involve strong and weak forms of words, linking 'r' sounds and syllabic consonants; students will apply the advanced speech work to challenging extravagant material as well as exercises with commonly mispronounced words.	U	4, 17, 9	focused
54105	Drama	Voice for the Stage I	Introduction to basic speaking voice and Alexander Technique work. Actors explore building a vocal preparation employing the principles of the Alexander for actor's speaking voice through explorations that help develop awareness of the head, neck torso relationship and the movement of the spine; vocal release, breath support, stamina. range, use of resonators and the application to text. Actors learn to identify components of healthy and unhealthy voice usage, basics of vocal anatomy and strategies for maintaining vocal health. Writing exercises are employed to help actors connect the voice to creativity and imaginative, essential for the actor?s development.	U	9, 17, 8	focused
54106	Drama	Voice for the Stage I	Introduction to basic speaking voice and Alexander Technique work. Actors explore building a vocal preparation employing the principles of the Alexander for actor?s speaking voice through explorations that help develop awareness of the head, neck torso relationship and the movement of the spine; vocal release, breath support, stamina. range, use of resonators and the application to text. Actors learn to identify components of healthy and unhealthy voice usage, basics of vocal anatomy and strategies for maintaining vocal health. Writing exercises are employed to help actors connect the voice to creativity and imaginative, essential for the actor?s development.	U	9, 17, 8	focused
54108	Drama	Movement I	This course is designed to continue the physical actor training sequence begun in the previous semester by introducing new methodologies and working vocabularies. This course examines and explores the use of the human body as an expressive artistic instrument of communication. Concepts of the body in relation to Time, Space, Weight, and Energy will be explored. This is a studio course in which learning is experiential. In addition to daily class activities and exercises, assignments will include a written test and solo presentations/performances. Admission to this course fulfills a requirement for first year undergraduate acting and music theatre majors	U	4, 7, 13	focused
54109	Drama	Dramaturgy 1: Approaches to Text	This course is an introduction to dramaturgical analysis of a play; the goal of this course is to provide students with a number of text analysis "tools" to use in understanding plays for production.	U	4, 9	focused
54117	Drama	Design Collaboration Project	This course is intended to provide students with hands-on experience in the process of collaboration on a design for a production. Students in the course will work in teams to design a hypothetical production of a given play.	U	4, 9, 17	focused
54123	Drama	Dance Technique I: Physical Mechanics and Anatomy	This course uses Classical technique (Ballet) to build body placement, alignment and muscular strength and flexibility. Designed to help the student develop a way of learning how to work and train for any dance form. This technique is the basis of the choreography in American musical theater. This course is for Music Theatre majors only. Permission of instructor.	U	4, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54124	Drama	Ballet I	This course continues Classical technique (Ballet) to build body placement, alignment and muscular strength and flexibility. Designed to help the student develop a way of learning how to work and train for any dance form. This technique is the basis of the choreography in American musical theater. This course is for Music Theatre majors only. Prerequisite: 54-123 and permission of instructor.	U	4, 11	focused
54125	Drama	Music Skills I	The students explore the basics of music theory, which includes intervals, rhythm, notation and musical vocabulary. Emphasis is on acquiring these basic skills through sight singing. For School of Drama MT students only.	U	4, 8	focused
54126	Drama	Music Skills II	The students explore the basics of music theory, which includes intervals, rhythm, notation and musical vocabulary. Emphasis is on acquiring these basic skills through sight singing.	U	4, 8	focused
54151	Drama	Stagecraft	The stagecraft class is designed to provide an introductory level of technical training in all the theatrical technical disciplines over the course of two semesters. The intent is to produce people who can capably fill roles on production crews and perhaps serve as an assistant to the head of the crew. Course content will cover materials, tools & equipment, procedures, safety and operations for Carpentry, Props, Paints, Media, Costumes, Lights, Sound, Rigging, and Run Crew. As well as providing opportunity and experience to grow as technicians, this content will also help establish a foundation to begin the process of becoming managers and designers. As craft skills are often best communicated in a master/apprentice environment this course is set up as a mentored practical experience. This course requires significant additional scheduled time on evenings and weekends for crew calls, which are an important element of the course.	U	4, 9, 12	focused
54152	Drama	Stagecraft	The stagecraft class is designed to provide an introductory level of technical training in all the theatrical technical disciplines over the course of two semesters. The intent is to produce people who can capably fill roles on production crews and perhaps serve as an assistant to the head of the crew. Course content will cover materials, tools equipment, procedures, safety and operations for Carpentry, Props, Paints, Media, Costumes, Lights, Sound, Rigging, and Run Crew. As well as providing opportunity and experience to grow as technicians, this content will also help establish a foundation to begin the process of becoming managers and designers. As craft skills are often best communicated in a master/apprentice environment this course is set up as a mentored practical experience. This course requires significant additional scheduled time on evenings and weekends for crew calls, which are an important element of the course.	U	4, 9, 12	focused
54157	Drama	Production Science	Students in the Production Science course are exposed to the very fundamentals, the primitives, of entertainment technology. The intent is to provide the absolutely strongest beginning for all the work to come, to provide a solid foundation for students and instructors to build upon. Production professionals routinely perform organizational tasks. In order to be able to meet that challenge, students will need to build a toolkit of information and procedures. That toolkit will be comprised of knowledge of the kinds of parameters and techniques that are normally selected, the indices that parameters and techniques are evaluated against, and many of the wide range of issues that might point a manager toward one decision or another. There also exists an entire pantheon of information that people typically learn "on the job." Activities and information presented in this course are designed to try to expose students to as much of this on the job type development as possible with the goal of leapfrogging them past the bottom rung of the workplace ladder. Drama Design/Production majors only, or with instructor permission.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54158	Drama	Production Planning	Students in the Basic PTM course are exposed to the very fundamentals, the primitives, of entertainment technology. The intent is to provide the absolutely strongest beginning for all the work to come, to provide a solid foundation for students and instructors to build upon. Production professionals routinely perform organizational tasks. In order to be able to meet that challenge, students will need to build a toolkit of information and procedures. That toolkit will be comprised of knowledge of the kinds of parameters and techniques that are normally selected, the indices that parameters and techniques are evaluated against, and many of the wide range of issues that might point a manager toward one decision or another. There also exists an entire pantheon of information that people typically learn "on the job." Activities and information presented in this course are designed to try to expose students to as much of this on the job type development as possible with the goal of leapfrogging them past the bottom rung of the workplace ladder. PREREQUISITES: Declared Design/PTM focus in the School of Drama FOR: First Year Undergraduate Students	U	4, 9, 8	focused
54162	Drama	Introduction to Costume Design	A rigorous introductory studio course for newly declared School of Drama Costume Design Sophomores in their fourth semester of matriculation. Basics of the design process are covered as well as drawing, sculpture, semiotics, play and character analysis, research and character building are explored. An intensive collaboration project with students of other design disciplines comprises the second half of the course. PREREQUISITES: Basic Design-54-171 and 54-172. All others: interview/portfolio review and instructor permission. FOR: 3rd semester Sophomore Costume Designers and students outside of School of Drama. IDEATE. Prerequisites: 54-171 and 54-172"	U	4, 17, 9	focused
54163	Drama	Production for Non Majors	Basic introduction for non-majors to backstage operations through practical experience handling scenery, costumes, props and lighting. Orientation session offered in fall required prior to taking this class. Contact instructor to register and discuss limited openings	U	4, 16, 17	focused
54166	Drama	Introduction to Sound Design for Theatre	Students explore the basic principles and theories of sound design from technical, psychological and aesthetic standpoints. Course work includes instruction in the controllable properties of sound, practical planning of sound plots, cue creation, and the design process. Prerequisites: Basic Design and Design For The Stage. Drama majors have priority, however this course is also open to Music Technology majors and minors, or with permission of instructor.	U	4, 9	focused
54168	Drama	Acting for Directors I	A knowledge and beginning understanding of the components of acting. Basic exercises, improvisations and prepared work in relaxation, concentration, imagination, communication. The ability to create the reality of a given situation in theatrical terms. Craft fundamentals in preparation for scene study. The beginning development of the students creative resources. This course is for Directing students only.	U	4, 9, 17	focused
54170	Drama	Studiocraft 2	Using the basic skills learned in the first semester, we will develop better and explore the use of basic drafting processes to solve more complex problems. The conventions of drafting do not change with the different types of drawings so line weight, clarity, neatness and organization will continue to be emphasized. We will also begin to discuss ways to improve the cosmetics of draftings. As before, classes will consist mostly of lecture and demonstration. Some class sessions will be dedicated to working on assigned projects, generally one class meeting per project.	U	4, 17, 8	focused
54171	Drama	Basic Design 1	A year-long studio course that explores the principles and elements of design utilizing discreet exercises and projects first semester. Research and reports expose the students to designers, theatres and artists of note in the world. Second semester focuses on the semiotics of the visual and aural aspects of theatrical design. Projects fold in each of the disciplines of scene, costume, lighting, sound and media design. PRE-REQUISITE: Declared Design/PTM focus in the School of Drama. FOR: First Semester Design/PTM Undergraduate Students only .	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54172	Drama	Basic Design 2	A year-long studio course that explores the principles and elements of design utilizing discreet exercises and projects first semester. Research and reports expose the students to designers, theatres and artists of note in the world. Second semester focuses on the semiotics of the visual and aural aspects of theatrical design. Projects fold in each of the disciplines of scene, costume, lighting, sound and media design. PRE-REQUISITE: Declared Design/PTM focus in the School of Drama. FOR: Second Semester Design/PTM Undergraduate Students only	U	4, 9, 17	focused
54184	Drama	Dramaturgy 2: Introduction to Production Dramaturgy	Dramaturgy 2 introduces students to the essential tasks and processes that dramaturgs perform on productions of established plays (i.e., plays whose texts are not changing). Students perform text analysis, conduct research, curate and present information, develop and provide critical feedback on production work in progress, and design pre- and post-performance experiences for an audience. This is a writing-intensive course with a high reading load. Dramaturgy 2 is a prerequisite for higher-level courses in the Dramaturgy curriculum.	U	4, 17, 9	focused
54190	Drama	Special Topics in Playwriting	Section A: Are Quentin Tarantino's films, such as Django Unchained, exploitative or celebratory of black culture? Is a show like Bodyguard reinforcing negative stereotypes about Muslim people or challenging the way that terrorism is viewed the U.K.? If it's a problem for Scarlett Johansson to play a Japanese character in Ghost in the Shell, is it also problematic that David Oyelowoa black Britplays Martin Luther King Jr. in Selma? These are just a few of the sorts of questions we will be asking in this class. We ask these questions not to put down other artists, but to seriously interrogate our own views of representation. In addition to analyzing representation of race/ethnicity in film, TV, and theatre, students will write scenes and (ultimately) one-act plays that incorporate characters from multiple racial identity backgrounds. We are just now at a point in the United States where people of color are being given more space to tell their own stories; this is only the beginning of the process of dismantling stereotypical representations of race. In a diverse nation and a diverse world, we need to better understand one anotherthis class will act as a step in that process. Section B: Playwrights study historic plays to learn the craft of writing. What is lacking in our education as writers because women are missing from our intellectual heritage? In this course we will explore a sampling of the many and diverse female writers who have been left out of the canon. Readings of plays and feminist texts will guide us as we develop our craft as writers and seek a clearer understanding of historical female playwrights: what did they write? Why did history choose not to remember them? What can we gain as writers and theater-makers from remembering them now? Students will write in class every week and will also bring three original short plays, inspired by classic texts, to share in class.	U	5, 4, 16	focused
54192	Drama	Acting Ensemble for Non-Majors	This course offers a practical introduction into the work of an actor through collaboration on composition assignments and scene work with undergraduate or graduate student directors. Each week actors will be cast in a different composition piece, creating a rotating ensemble so that all actors and directors have the opportunity to work with one another at least once and begin to build collaborative relationships. The second half of the semester students are cast in a scene and focus solely on the one scene working with one director. Students are expected to rehearse a maximum of 4 hours outside of class. ******Audition required at the beginning of the semester. Admittance to class by permission of professor. If you are interested, add yourself to the wait list. *****	U	4, 17, 9	focused
54196	Drama	Screenwriting	This course is designed to give writers a variety of tools they can use in writing or rewriting a current project full-length screenplay. There will films assigned to watch and analyze. Either a first draft or a rewritten version of a full length screenplay is to be completed by the end of the semester.	U	17, 4, 9	focused
54203	Drama	Voice and Speech II	The actors take a more concentrated approach to elevated text. The course focuses on the effective production of classical text. The warm up sessions are geared towards preparing the student actors for the extravagant language from Shakespeare?s plays and sonnets. Meter, imagery and further specific text work is also employed to encourage each student to find clear shape in the work. A repertoire of at least five classical monologues will come from the course work.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54204	Drama	Voice and Speech II	The actors take a more concentrated approach to elevated text. The course focuses on the effective production of classical text. The warm up sessions are geared towards preparing the student actors for the extravagant language from Shakespeare?s plays and sonnets. Meter, imagery and further specific text work is also employed to encourage each student to find clear shape in the work. A repertoire of at least five classical monologues will come from the course work.	U	4, 9	focused
54205	Drama	Ballet II	This course is designed to build on the technical foundation, work habits and professional behavior established in Ballet I. The material presented expands the classical dance vocabulary to the next level of difficulty. Course closed: Only for Music Theatre majors in Drama. Prerequisite: Permission of instructor	U	4, 9	focused
54207	Drama	Movement II	This entire term focuses on the Neutral Mask, a completely non-verbal masked movement form, through which actors search for a neutral base, both physically and psychologically, a place of complete presence in the present. The mask allows them to uncover all that is emotional in the body, the "baggage" carried from role to role, and provides techniques to free them from these limitations. Identifications with other forms of energy, the four elements, seasons, materials, colors and plant life give students new insights into the process of character development. The Neutral Mask work is immediately reinforced with applications to scene work in Acting class. Limited to Acting/MT majors only.	U	7, 4, 13	focused
54208	Drama	Movement II	This term is divided between two classic physical forms: Commedia dell'Arte and Clowns. In the first half of the semester students wear the half-masks of the archetypal Commedia characters (Harlequin, Pantalone, et al), to learn their psychology and physicality, improvise on historical and contemporary scenarios, and apply Commedia technique to modern comedy. Commedia dell'Arte gives them the tools to tackle physical comedy from any era, past or present. In the second half of the term students discover their personal Clowns. This clown has nothing to do with the American Barnum & Bailey Circus clown; this is not a character or caricature, but rather a revelation of the clown each student hides under the mask of adulthood. Discovering this clown gives them all a way to laugh at themselves, to uncover what makes each individual uniquely funny; it also lets them see how we only laugh at truth and in the personal material lies universal humor. Inside this freedom is the technique to know what's funny and why, and the ability to apply these rules in comedy."	U	4, 16, 11	focused
54211	Drama	Actor Dance II	This course introduces the basic, fundamental vocabulary of Classical technique (Ballet) to train the body in proper alignment, placement, and muscular strength. Course closed: Only for Acting majors in Drama. Prerequisite: Permission of instructor	U	11, 4	focused
54216	Drama	Technical Solutions from the OSF	This course is an introduction to planning for repertory theater using the Oregon Shakespeare Festival as a model. Students will explore topics including the inherent tensions between time and space created by a rep, interdisciplinary technical design, automation, collaborating with designers, and common rep pitfalls. By course end, students will not only have a working analysis of the inner machinations of a repertory model, but also a deeper understanding of regional theater art making overall.	U	4, 9	focused
54221	Drama	Directing II: Fundamentals	Directing II This is a fall-semester course for 2nd-year Directing students and others with special permission introducing the fundamentals of the director's craft: text analysis; the concept of Action & Change, directors units & transitions) Visual Vocabulary & Staging. Tools including planes, levels, body positions, composition, picturization, emphasis &movement, and the ground plan. Work includes unscripted exercises, scene breakdowns, detailed character analysis, and a final 7 to 10 minute devised performance	U	4, 13, 9	focused
54223	Drama	Tap II	This course trains the student to develop a comfort level to execute percussive sounds, in a variety of percussive rhythmic patterns while applying the technical foundation of alignment and placement from classical technique. Course closed: Only for Music Theatre majors in Drama. Prerequisite: Permission of instructor	U	4, 11, 9	focused
54224	Drama	Tap II	This course continues to technically train the student in a variety of percussive rhythmic patterns. Course closed: Only for Music Theatre majors in Drama.	U	4, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54225	Drama	TD Case Studies	This course will through a weekly round table discussion look at examples of real-world experiences involving technical direction concerns, obstacles, and dilemmas. Each week the class will be given a situation or example that occurred in the past during production of a Pittsburgh Civic Light Opera summer season. The students mediated by the instructor will brainstorm and discuss reactions and solutions to these problems. Realizing that often there are many solutions to the same TD problems depending on any given situation, not only will the discussion look at what was done at the time of the example but how other methods might be weighed against those used. Once the group comes to a consensus on the week's issue the students will be responsible for outlining the process to correct the problem, avoid future similar concerns, or alter the contributing situations. This outline might be in the form of mechanical drawings, excel files, word docs, or actual outlines.	U	4, 9	focused
54230	Drama	Make-Up for Designers	This course is structured as a lecture/demonstration and lab employing and exploring the principles of stage makeup, the variety of materials available and the practical application of these materials. The course is designed to provide the student with a working knowledge of broad-based application procedures, materials and techniques. We will also explore the principles of characterization allowing for the development, planning, and execution of effectual character makeup designs. The student should also be able to determine the stage-worthiness of a makeup application and how light will influence its appearance.	U	9, 4, 17	focused
54231	Drama	Design for the Stage	This course is divided into four minis to introduce the student to the design process for costumes, lighting, scenery and sound. For Drama majors only, or instructor permission	U	4, 9	focused
54232	Drama	Design for the Stage: Lighting	This course is an introduction to the process of lighting design. Students will engage in various hands-on light lab exercises and group projects to explore the physical properties of light in storytelling. Discovery and experimentation are encouraged. Students will begin to build a process for visualizing a play though the principles of design, interpreting a text, and communicating ideas.	U	4, 9	focused
54237	Drama	Scenic Painting I	This is a one semester studio course in the foundations of scenic painting for theater and related fields. Students will complete projects that address the following topics: preparation of and paint techniques for both soft goods and hard covered surfaces, drawing and painting to scale, representing textures in both 2 and 3 dimensions, and color mixing. Subject matter changes often and may include: architecture, natural and man-made textures, drapery, interior/exterior scenes, the human figure, still life objects.	U	4, 9	focused
54238	Drama	Scenic Painting II	This is a studio course in the foundations of scenic painting for theater and related fields. Students will complete projects that address the following topics: preparation of and paint techniques for both soft goods and hard covered surfaces, drawing and painting to scale, representing textures in both 2 and 3 dimensions, and color mixing. Subject matter changes often and may include: architecture, natural and man-made textures, drapery, interior/ exterior scenes, human figure, still life objects.	U	4, 9	focused
54239	Drama	History of Architecture and Decor 1: Ancients to Gothic	This course is a survey of architecture, furniture and interiors from ancient times to the Gothic period. A lecture/slide course, the discussion of architecture is done with reference to social, political and economic history.	U	8, 1, 11	focused
54240	Drama	History of Architecture and Decor 2: Renaissance to the 21st Century	This course will cover the styles and movements of architecture, furniture and to a lesser degree, the decorative arts, from the Italian Renaissance to modern day architecture in the West as well as the major Chinese, Indian and Islamic periods in the East. Discussions will include the social, economic, religious and political history of each period in as much as it helps illuminate the reasoning behind the visual nature of its architecture.	U	8, 1, 16	focused
54242	Drama	Improvisation	This course is for Sophomore Actors only. This course not only sharpens their skills as ensemble performers, but also allows for more playfulness, creativity and exploration, cultivating risk-taking and a certain abandon. The course concentrates on non-verbal psychological improv, helping actors achieve a kind of physical truth and spontaneity, while becoming aware of the importance of the body in conveying information.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54245	Drama	Who Wore What: When, Where, and Why	This year-long course surveys the development of garments in the Western World from ancient civilizations to the first half of the 20th century. We will look at the progression of the shapes and forms that aesthetically define the clothing of each period, while also exploring the broader relationship of costume to culture and society through history. The course will comprise visual presentations of the art of each period, especially pertaining to representations of clothing, along with research projects, quizzes and exams.	U	17, 11, 4	focused
54246	Drama	Who Wore What: When, Where, Why II	The 2nd part of this year-long course surveys the development of garments in the Western World from ancient civilizations to the first half of the 20th century. We will look at the progression of the shapes and forms that aesthetically define the clothing of each period, while also exploring the broader relationship of costume to culture and society through history. The course will comprise visual presentations of the art of each period, especially pertaining to representations of clothing, along with research projects, quizzes and exams.	U	17, 11, 4	focused
54247	Drama	Dramaturgy 4: In Company	Dramaturgical work in a theatre company extends far beyond individual productions. In this course students get hands-on practice in season planning, writing fundraising text, writing marketing text, and public speaking - all responsibilities that are typically but less visibly part of a dramaturg's job description. This course provides good grounding for a future in artistic leadership. Required for dramaturgy majors; open to non-majors with instructor permission.	U	4, 8, 17	focused
54249	Drama	Stagecraft II	Stagecraft II presents advanced shop skills and beginning department head skills for Scenery, Lighting, and Costumes. This course will require additional time during the evening and on weekends. Prerequisites: Stagecraft I (two semesters) OR Instructor Permission	U	4, 8, 9	focused
54250	Drama	Introduction to Scenic Design	This course will introduce students to the principles and methods of designing scenery using the development of ideas based on a text.	U	4, 9, 17	focused
54252	Drama	Introduction to Lighting Design	Students explore the physical properties of light in various design applications and develop a process of storytelling that involves analysis, research, exploration, questioning, problem solving and implementation of a successful design product. Prerequisite: Design for the Stage, or instructor permission.	U	4, 9, 17	focused
54264	Drama	Intro to Welding (MIG & TIG)	The purpose of this course is to give the student an introduction to and develop practical skills in the MIG (Gas Metal Arc Welding) and TIG (Gas Tungsten Arc Welding) processes. Course will include: comprehensive safety coverage setup, troubleshooting and basic maintenance of all machines basic metal preparation emphasis on identifying proper consumables, machine settings, and determining the success of the welds Work boots/shoes are required for this class.	U	9, 4, 8	focused
54265	Drama	Advanced Fabrication 1	This class sets forth to gain a comprehensive understanding of the various tools found in a well-equipped fabrication shop . Shop safety will be emphasized at all times and rigorously promoted per tool. Understanding the differences between tools and when to choose each will be a constant theme. Exploring the various ways of achieving a certain result but with different tools will be a recurring theme. Since most shops use tools for multiple applications, understanding how various materials relate to various tools will be discussed in detail. For TDs only. The first task will be to do an overview of all of the common tools used for woodworking and metalworking. Then we will go through the shop tool-by-tool and make sure everyone understands what the tool was designed for, how it is used, and how it may be utilized for alternative uses.	U	9, 10, 12	focused
54267	Drama	Conceptual Sound Design	Students explore the unique qualities of audio as a design element and the development of a design process through script analysis. Emphasis on the creative application and utilization of the studio in sound shaping and soundscape design. PREREQUISITE: 54-166 Introduction To Sound Design for Theater, 54-231 Design For The Stage. Drama majors have priority, however this course is also open to Music Technology majors and minors, or with permission of instructor.	U	4, 9, 17	focused
54268	Drama	Organized Sound	Both music and sound design are defined by the presence of a human hand in the organization of sound. This course explores what lies at the intersection of music, technology and sound design. Using compositional techniques in conjunction with the creative application and utilization of studio techniques, field recording, editing and sound manipulation, the student will explore this interstitial landscape. Drama majors have priority, however this course is also open to Music Technology majors and minors, or with permission of instructor.	U	9, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54271	Drama	Technical Management	Required for all sophomore Design and PTM students. This class establishes a set of standards for creative project management and introduces students to several software packages that can be utilized within these tasks.	U	4, 9, 17	focused
54272	Drama	Scenic Fabrication and Installation	The Scenic Fabrication & Installation course consolidates and builds upon material presented in the first semester of Basic PTM and in the three semesters of Stagecraft class. Whether they intend to pursue careers as technicians, engineers, or managers students much understand how scenery is built and what is involved in the assembly of the scenery in the theatre. Throughout the semester students will explore the materials and equipment used by all kinds of professionals in the fabrication industry. Through this exploration students will become conversant with the kinds of properties, and the advantages and disadvantages of many different items. Along with this exploration is a concurrent investigation of entertainment industry accidents. This material is valuable in how it contextualizes the kind of work students will be involved in, and helps to drive home the very real consequences of errors pertaining to scenery. In the classroom and in lab students in this course will develop their knowledge and processes for building scenery. The course has three basic units. The beginning of the semester focuses on building materials and on tool use. Through the center of the semester course material focuses on traditional scenery practices. The end of the semester material addresses rigging systems and scenery rigging practices. Laboratory assignments tied to this course will consist of carpentry assignments in the shop and carpentry and rigging assignments during load in. Occasionally students pursuing a more customized path may have lab assignments in the paint department in the shop and in the electrics department during install. All students may receive apprentice assignments in the scenery office.	U	4, 9, 8	focused
54273	Drama	Technical Direction I	This course is an exploration of techniques and practices of the Technical Director. The class has three main components: classroom presentation of School of Drama production technical direction process, classroom lectures centering on TD process, and project work. Over the course of the semester, students will work on two productions as paper projects. This is an opportunity to have a somewhat less stressful pass through a show, completing estimates, schedules, and drawings designed to help establish a professional foundation for the student as a technical director. All of the course components run concurrently. Prerequisites: 54272 or Instructor Permission	U	4, 9, 17	focused
54281	Drama	Foundations of Drama II	In this course students build on the skills of Foundations I to develop acumen in targeted research in support of production. The students learn the "circles of knowledge" technique to provide evidentiary arguments concerning a play script, its author, the historical contexts in which it was written, the theoretical frameworks that may be applied to its interpretations, its production history, and what knowledge is needed to bring its themes to relevance in a modern production. As in Foundations I, there is a great deal of exposure to significant texts, both artistic and philosophical, from theatre history. Registration for this course is limited to Drama majors. All other majors must request the instructor's permission.	U	4, 11, 9	focused
54284	Drama	Fundamentals of Directing	Fundamentals of Directing is a fall-semester course for Drama Design and PTM sophomores. It is an introductory course that examines some of the basic tools of the director. Emphasis is completely on theatrical work although some elements are applicable to television and film.	U	9, 4	focused
54287	Drama	Introduction to Lighting Design Skills	Students will gain the basic skills and practical experience to use the lighting industry's primary software programs: Vectorworks and Lightwright. The class will be seminar based and allow focused opportunity to acquire the skills to execute some of the assignments in the Introduction to Lighting Design course. This course must be taken simultaneously with Introduction to Lighting Design (54-252).	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54297	Drama	VMD Systems Studio	This course is designed to augment the conceptual background and technical skills of First year Graduate students and newly declared VMD Sophomores, and others interested in learning about media design for theater and installations. The course reviews foundational readings about media, technology and society and explores the skills used in contemporary media work. Through real-world examples, building custom media servers, experimenting with materials and software, rigging multiple types of display systems and visiting artists - students will learn the best practices for bringing their designs to life. A great deal of technical information will be covered including; video compression formats, projector optics, cueing software, projection mapping & custom surfaces, media servers both custom and professional, networking and control protocols, live camera systems, and stage rigging for projection systems. The class will give students a clearer perspective of the field and help them plan a fulfilling course of study, based on their goals and interests. Class projects range from presentations of research to building media installations over at Studio 201. Required for new VMD Sophomores, 1st Year VMD Grads; open to IDeATe and BXA students; others accepted up to class limit.	U	4, 9, 17	focused
54301	Drama	Acting III	This is a two-semester course in Acting for Third-Year Actors & MTs who will explore performance within directed structure in various non-Fourth-Wall forms of Theatre including: Greek Tragedy, the Greek Chorus, Moliere Comedy & Brecht. This is not a course that will aspire to provide any "correct" way to play various "styles". Rather, it is a course in which to acquire new tools & perspectives when working in new theatrical worlds. Goals include: to find the appropriate level of external expression to meet the demands of the particular text & its directed world, & to "fill the Form" believably & passionately; to make active choices within a directed framework; to learn to work within industry standards; to learn the nature of the actor's "homework" in a directed framework; to include the Audience in the work.	U	9, 4, 11	focused
54302	Drama	Acting III	This is a two-semester course in Acting for Third-Year Actors & MTs who will explore performance within directed structure in various non-Fourth-Wall forms of Theatre including: Greek Tragedy, the Greek Chorus, Moliere Comedy & Brecht. This is not a course that will aspire to provide any "correct" way to play various "styles". Rather, it is a course in which to acquire new tools & perspectives when working in new theatrical worlds. Goals include: to find the appropriate level of external expression to meet the demands of the particular text & its directed world, & to "fill the Form" believably & passionately; to make active choices within a directed framework; to learn to work within industry standards; to learn the nature of the actor's "homework" in a directed framework; to include the Audience in the work.	U	9, 4, 11	focused
54305	Drama	Voice for the Stage III	Students explore voice work and various methods in more depth and Alexander alignment/awareness work to enhance vocal freedom and full body support of the voice. Areas include: breath support, vocal release, developing freedom in resonating areas, clarity in articulators, building range and stamina. Emphasis is placed on integration of methods with speaking of text. Writing projects are sometimes explored as a way to free the voice creatively and imaginatively. Voice/Alexander 1 is a pre-requisite to registering in this course.	U	4, 16, 17	focused
54306	Drama	Voice for the Stage III	Students explore voice work and various methods in more depth and Alexander alignment/awareness work to enhance vocal freedom and full body support of the voice. Areas include: breath support, vocal release, developing freedom in resonating areas, clarity in articulators, building range and stamina. Emphasis is placed on integration of methods with speaking of text. Writing projects are sometimes explored as a way to free the voice creatively and imaginatively. Voice/Alexander 1 is a pre-requisite to registering in this course.	U	4, 16, 17	focused
54307	Drama	Movement III	Prerequisite: 54-107, 54-108, 54-207, 54-208, or permission of the instructor. This course introduces students to the basic exercises of physical actor training developed by Tadashi Suzuki and examines more advanced uses of the Viewpoints method of actor training. Physically rigorous, this course challenges not only physical stamina, but also concentration, focus and the actor's sense of discipline. The use of spoken text is incorporated into the exercises in an integration of all the physical aspects of the actor's craft. This course is also designed to complement and inform the actor's entry into rehearsal and performance work. This course is required for all third year Acting majors.	U	4, 7, 13	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54308	Drama	Movement III	This course is designed to expand the student's movement skills to include the basic principles and techniques of unarmed stage combat and an introduction to weapons fighting. As a studio course, activities will consist of learning and performing physical techniques, reading materials pertaining to the subject matter, viewing filmed examples of work, and giving performance presentations.	U	4, 12, 9	focused
54312	Drama	Rehearsal and Performance III	Performance training through projects at different levels of difficulty and staging, directed by students and presented in the studio theatre. The actor has the opportunity to put into practice with his/her peers, in a creative and experimental atmosphere, the principles and techniques developed in the classroom. Note: Tues or Thurs time used as needed for performance critiques.	U	4, 9	focused
54313	Drama	Ballet III	Intermediate ballet. This course is dedicated to honing technical skills, expanding the classical dance vocabulary to the next level of difficulty, and addressing issues of strength, stamina, and endurance. Course closed: Only for Music Theatre majors in Drama. Prerequisite: Permission of instructor	U	4, 8, 9	focused
54314	Drama	Ballet III	Intermediate ballet. This course continues to hone technical skills, expand the classical dance vocabulary to the next level of difficulty, and address issues of strength, stamina, and endurance. Course closed: Only for Music Theatre majors in Drama. Prerequisite: 54-313 and Permission of instructor	U	4, 8, 9	focused
54315	Drama	Jazz III	This course is to expand the versatility of the student dancer to master more complex exercises, in dynamics, direction and rhythm using Jazz styles examined by decades. Understanding the 20th century historical background of the 20's, 30's 40's, 50's 60's and 70's. Course closed: Only for Music Theatre majors in Drama. Prerequisite: Permission of instructor	U	4, 11	focused
54316	Drama	Jazz III	This course continues to expand the versatility of the student dancer to master more complex exercises, in dynamics, direction and rhythm using Jazz styles examined by decades. Understanding the 20th century historical background of the 20's, 30's 40's, 50's 60's and 70's. Course closed: Only for Music Theatre majors in Drama.	U	4, 11	focused
54323	Drama	Tap III	This course expands tap vocabulary and clear precision of execution through moderately difficult and extended combinations. Course closed: Only for Music Theatre majors in Drama. Prerequisite: Permission of instructor	U	9, 4	focused
54324	Drama	Tap III	This course continues to expand tap vocabulary and clear precision of execution through moderately difficult and extended combinations. Course closed: Only for Music Theatre majors in Drama. Prerequisite: 54-323 and Permission of instructor	U	9, 4	focused
54325	Drama	Actor Dance III	This course uses basic and fundamental contemporary Jazz styles, i.e. Latin, Blues, Lyric, African, to technically train the body using isolations and rhythmic patterns. Course closed: Only for Acting majors in Drama. Prerequisite: Permission of instructor	U	11, 4	focused
54326	Drama	Actor Dance III	This course continues to use basic and fundamental contemporary Jazz styles, i.e. Latin, Blues, Lyric, African, to technically train the body using isolations and rhythmic patterns. Course closed: Only for Acting majors in Drama. Prerequisite: 54-325 and Permission of instructor	U	11, 4	focused
54328	Drama	Advanced Digital Sound Design Skills	Sound Design Majors ONLY. Advanced sound creation and manipulation through student designed and constructed software and hardware. Prerequisite: Conceptual Sound Design I.	U	4, 9, 8	focused
54330	Drama	Introduction to Stage Management	This course is intended to provide students an opening to the knowledge and skills of the professional stage manager. It will also illuminate the qualities of a good stage manager specific to personality and human interaction. Within this course we will examine the role of the stage manager throughout the full scope of creating a production, including preparatory work, rehearsal period, technical rehearsal, performance and closing.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54331	Drama	Scenic Design: Explorations	Students will spend the year in an exciting and intensive exploration of the process of Scene Design as well as an examination of the nature of creativity and storytelling. Students will also engage extensively in the skills a professional Scene Designer requires, such as drafting, drawing, model making, painting and general collaborative skills. Students will be expected to deal with in-depth research, scriptual examinations, careful arrangements of space, composition and groundplan, conceptual structure, real life obstacles and the elements of a successful final project. By the end of this course, students will have improved their overall design skills, have some projects they can include in their portfolio and have created new routes toward their creativity. (pre-req, intro to Scene Design)	U	4, 9, 17	focused
54332	Drama	Scenic Design: Boot Camp	A rapid-fire design course for scenic design majors. This course offers the students the opportunity to work on six projects over the course of the semester. These projects may include contemporary, classical and non-linear plays, as well as TV workshop and a new plays collaboration with dramatic writing students. Co-taught by Scenic Design faculty.	U	4, 9, 17	focused
54336	Drama	Musical Theater History	This course is a survey of musical comedy and musical theatre performances throughout history. Often considered a quintessential American theatrical form, we will also consider what "musical theatre" or "musical drama" means beyond the borders of the United States. The course will primarily focus in the time frame of 1860-present. We will examine the historical background, development and evolution of form, as well as impact and proliferation of this performance style. The course will involve lecture-based, discussion-based, and project-based styles of engagement. **No previous knowledge of or practice of "musical theatre" is necessary to succeed in this course.	U	17, 11, 8	focused
54341	Drama	Fundamentals of Costume Design	Multiple studio projects comprise this one semester course that focuses on the principals and elements of design, including color theory, as they relate to Costume Design. Hands-on practical workshops include a Television Workshop component with celebrated CMU alumni, and a dance component that culminates in the second semester Dance/Light Concert. A fabric Identification component rounds out the semester. PRE-REQUISITE: Declared Costume Design Major in School of Drama. All others: Portfolio Review and special permission of teacher required. Drawing For The Theatrical Designer & Figure Drawing may be taken concurrently. FOR: First semester Graduate Costume Design and Costume Production Students, First semester Junior Costume Majors.	U	4, 9, 8	focused
54342	Drama	Costume Design for TV and Film	A mini course in the second semester that explores the aesthetic and technical processes of designing costumes for the screen. The course introduces film-specific practical skills including the fundamentals of analyzing and breaking down screenplays for costume design, what design means during the pre-production and shooting phases of a production, and the aesthetic and technical differences of designing for the camera's eye compared to designing for the human eye. The course will consist of lectures, visual presentations, including viewing of films that illustrate the processes described in class, script break-down assignments, and design process projects. PRE-REQUISITE: Design/PTM Costume major. All others: Portfolio Review and special permission of teacher required. FOR: Second year Graduate Costume Design majors and Senior Costume Design students.	U	4, 9, 8	focused
54346	Drama	Introduction to Costume Construction	This sophomore level course is designed to provide an intermediate level of training in the area of clothing construction. Students will learn how to read patterns, prepare and cut fabric appropriately for construction purposes, and complete a garment employing necessary finishing techniques. Additionally, students will be exposed to the rudimentary skills necessary for basic flat patterning and begin the process of project time management and comprehension of product value.	U	4, 17, 9	focused
54351	Drama	Theatrical Lighting Design	The student's ability to analyze and translate information in the script to descriptive stage pictures is developed in a more in-depth process. Verbal, written and visual communication of ideas is emphasized and explored through texts and lab work. Issues of collaboration with the director and other members of the design team are discussed as part of the design process. Prerequisites: 54252	U	9, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54352	Drama	Musical and Opera Lighting Design	Through hands-on lab exercises and preparation of full lighting design plots, students will study lighting design for Musical Theater and Opera. The class will learn to visually analyze the emotional content of music, explore the various forms of musical performance, learn how to develop a design process, create focus in a large-scale space, and strategies for implementing a design.	U	4, 9, 17	focused
54353	Drama	Structural Design I	Required for all senior undergraduate Technical Direction students. A concentrated training in Structural Design specifically developed for the theater technician. This course teaches the process of Allowable Stress Design for the engineering of scenic structures in wood and steel. Drama majors only, or with instructor permission.	U	4, 9, 8	focused
54354	Drama	Structural Design II	Required for all senior undergraduate Technical Direction students. Upon completion of this two-semester sequence, students are familiar with beam and column design/specification, truss design, tensile systems and structural connections.	U	4, 9	focused
54361	Drama	Production Preparation	Participation in School of Drama productions in design or production roles.	U	4, 9	focused
54362	Drama	Anti-Racist Theater: Core	Core course description: This course aims at instilling in participants a development of an anti-racist theatre ethos and an interrogation of harm reduction, harm prevention and relationship repair.	U	17, 5, 16	focused
54367	Drama	Lighting Design Skills	Students will concentrate on developing the skills necessary for lighting designers to successfully implement their designs in the theatre. Content includes communication, CAD programs, paperwork, focusing the show, programming conventional and moving light consoles, cue writing and expectations and responsibilities of the design assistant.	U	4, 9, 17	focused
54369	Drama	Lighting Management II	Lighting Management II continues the investigation of the role of the department head within a theatrical lighting department, concentrating on skills needed to perform the role within the School of Drama.	U	4, 8	focused
54370	Drama	Dramaturgical Sensibilities	In this course, dramaturgy majors will meet with professionals in the field who have used a dramaturgical sensiblity to build careers in "dramaturgy-adjacent" fields.	U	8, 9, 4	focused
54371	Drama	Production Preparation	Participation in School of Drama productions in design or production roles	U	4, 9	focused
54372	Drama	Theatre for the Ear	Survey of aural storytelling with technology focusing on forms with no visual component. Topics include the history of radio drama to present day, radio sound art, cut-up and tape manipulation, comedy records and podcast dramas. Prerequisites: 54-166 Introduction To Sound Design, 54-267 Conceptual Sound Design 1 Restrictions: The course is open to sound design majors or with permission of the instructor.	U	9, 11, 4	focused
54373	Drama	Draping for the Designer I	This is a semester introduction to the arena of the draper. This course illustrates what the draper's role is in effectively spearheading garment production, emphasizing the collaboration and discussion skills needed to follow a garment's design from page to stage. The course instills a strong foundation in pattern creation skills through the use of the dress or suit stand and fosters a laboratory environment for imaginative solutions in clothing pattern development and garment creation. Additional skills such as application of research, garment fitting procedures, pattern manipulations and refinements and complete construction plans are explored. This class provides tangential learning through a thorough investigation of fabric, its history and identification, sculptural and spatial relationships, strategic planning, development of fine motor skills, and exposure to a broad spectrum of materials and methods that can be adapted to other purposes.	U	4, 9, 17	focused
54375	Drama	IDeATe: Robotics for Creative Practice	Robots come in all shapes and sizes: it is the integration of software and hardware that can make any machine surprisingly animate. This project-oriented course brings art and engineering together to build performance systems using embodied behavior as a creative medium. Students learn skills for designing, constructing and programming automated systems for storytelling and human interaction, then explore the results through exhibition and performance. Technical topics include programmed motion control, pneumatic machine design, closed-loop feedback systems, machine choreography, and human-robot interaction. Discussion topics include contemporary kinetic sculpture and animatronics. This interdisciplinary course is part of IDeATe Physical Computing but is open to any student.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54376	Drama	Entertainment Rigging	This course is a survey of the techniques and practices of theatrical rigging. The course has two main components: permanently installed rigging systems typically found in theatres, and background and technical information concerning the components typically used for stage rigging. Discussion topics include selection criteria for line, hardware, and terminations stressing entertainment industry standards, workplace safety and common industry misconceptions. Time permitting the course will shift from a general discussion of components to their assembly into custom rigging systems & solutions. Instructor's permission only.	U	9, 8, 4	focused
54377	Drama	Production Composition Studio	This course is a laboratory style studio class. It is designed to support the student through the process of composing music for theatrical & film productions and projects. Students will be required to bring ongoing creative work materials to class.	U	4, 9, 12	focused
54378	Drama	Technical Direction II	This course is an exploration of techniques and practices of Technical Designers. The class has four main components: an exploration of the types of strategies used by Technical Designers to arrive at solutions, building an expert vocabulary for discussion of technical design issues, development of actual technical solutions, on paper, in discussion, and in the shop, discussion of any pertinent technical issues for any of the school productions while in development.	U	4, 9, 17	focused
54380	Drama	Music Reading for Production	This class gives the basics of music theory, musical terminology and score reading. Students focus on the difference in various musical scores, ie. piano/vocal, full, hand written scores. Students are guided in classroom listening which a wide variety of music including, opera, musical theatre, ballet, and choral/orchestra works.	U	4, 9	focused
54381	Drama	Special Topics in Drama: History, Literature and Criticism	Every semester, members of the School of Drama's faculty offer seminars on special topics that investigate some aspect of theatre history, dramatic literature, dramatic theory, or a particular author, period, or genre. Like all Dramatic Literature classes, these are academically rigorous, requiring some amount of intensive critical reading and writing. Registration for this course is limited to Drama majors: (Arons) "Contemporary Women Playwrights" - in this course we will read, discuss, and analyze a range of works written by women in the last twenty years. We'll read plays by writers like Sarah Ruhl, Kia Corthron, Lynn Nottage, Madeleine George, Young Jean Lee, Jennifer Haley, Lauren Gunderson, Ann Washburn, ... and more! We will explore their works through in-class discussion, reaction papers, and presentations and activities. (Amodei) "Critical Theory and Performance": What is critical theory? In this introductory class, we will investigate how the frameworks and methodologies derived from theories are useful in discussing and making art. The goal of this class will be for students to learn the skills necessary to engage with the larger theoretical discussions bound up with contemporary drama and art. This will be achieved through a blend of reading, writing, discussion and artmaking. Topics include: Postdramatic Theater, Queer Theory, Marxism and its inheritors, Performance Studies, Modernism-to-Postmodernism, Precarity, Land Art and Failure. Some authors we will cover are: Walter Benjamin, Adrian Piper, Theodore Adorno, Judith Butler, Isabell Lorey and José Esteban Muñoz. Come get excited about theory and let's make it more accessible together!	U	4, 5, 13	focused
54383	Drama	Introduction to Digital Media	Software Covered: AutoCAD, Photoshop, Illustrator, InDesign, Sketchup, Vray for Sketchup Concepts Covered: 2D Graphics, Architectural Drafting, 3D Modeling & Rendering, Hybrid Representation Limited to Drama students: Scenic Design Juniors, 1st Year Graduate Students	U	4, 9, 11	focused
54386	Drama	Scenic Design Skills: 3D Model Making	In this mini students explore a variety of three-dimensional media techniques as they learn to build models for the Scenic Designer. Students will investigate many aspects of model-making, from basic structural ideas to complex organic and architectural forms, furniture, and advanced techniques such as scale painting, soldering and carving. Through these methods, students will develop a better understanding of space and objects in space in the theatre.	U	4, 2, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54389	Drama	Composition for Theatrical Sound Design 1	Composition for Theatrical Sound Design 1 This course will concentrate on developing compositional skills for use in theatrical sound design. The full length of this course is designed to take place over two semesters. The rst semester will examine the building blocks of composition such as rhythm, modes, harmony and counterpoint. The second semester will focus on more advanced skills in composition within a theatrical context. Through projects distributed throughout the semester you will practice the skill-based techniques of music notation, orchestration, synthesis, sequencing, and the creation and utilization of sample-based instruments. This course will also cover textual analysis as it applies to both the inspiration for composition and to the more direct challenge of setting music to text.	U	4, 9, 8	focused
54390	Drama	Composition for Theatrical Sound Design 2	This course will concentrate on further developing compositional skills for use in theatrical sound design. The full length of this course is designed to take place over two semesters. This is the second semester and builds on compositional techniques such as writing melody, harmony, counterpoint and orchestration techniques. The second semester focuses particularly on more advanced skills in composition within a theatrical context. Through projects distributed throughout the semester students practice the skill-based techniques of music notation, orchestration, synthesis, sequencing, working with instrumentalists and the creation and utilization of sample-based instruments. This course will also cover textual analysis as it applies to both the inspiration for composition and to the more direct challenge of setting music to text.	U	4, 9, 17	focused
54392	Drama	Scenic Design Skills: 2D Drawing and Rendering	This mini offers practice in two-dimensional drawing and rendering for the theatre.	U	4, 9, 8	focused
54398	Drama	Special Topics in Sound Design	A one semester course covering various rotating topics including the history and critical theories of film sound design, the history of sound recording and technology, Foley sound, recording and editing techniques, and 5.1 audio. Prerequisites: 54-166 Introduction To Sound Design for Theater, 54-267 Conceptual Sound Design. Restrictions: The course is open to Drama sound design majors and minors, Music Technology majors and minors or by permission of the instructor.	U	9, 4, 11	focused
54399	Drama	Decoding Media	Media technologies are designed to do a lot with very little effort. This creates a problem of abundance for artists trying to use these technologies in creative ways. One can relatively quickly pull images off the internet and project them huge onstage, but what does it mean? Decoding is the term I'm using to help you keep control of your process and create meaningful (not just dazzling) imagery for the stage. The entire theatrical process can be considered as a series of decodings and re-encodings, first decoding the text/idea (by the creative team), re-encoding (the design) and finally decoding by the audience. This class is designed to give students a solid foundation in contemporary media design skills while simultaneously providing an examination of the function of theater historically and the ways media technologies fill those needs today. Early assignments focus on students use of media in their everyday lives, by keeping media journals and bringing in media objects for examination. Later classes focus on taking ideas from this research and applying them in conceptual stage designs for an ancient Greek play and then a controversial adaptation from the 1990's by Sara Kane. Students learn how to go from textual analysis to a visual interpretation and staging with media. The class takes students through the process of initial creative brainstorming, to communication tools (concept sketches, digital renderings, 3D models), onto specifying a design through CAD documentation, projection optics calculations and final design presentations.	U	4, 9, 17	focused
54400	Drama	Staging Media	Staging Media is a practical, process-oriented class, focused on building the skills to go from a conceptual design to an actual completed show. We cover how to create, rehearse with and stage meaningful media designs. Through real-world examples, students will learn the best practices for bringing their designs to life. Students are expected to master a wide range of material. Required for new VMD Juniors, 1st Year VMD Grads; others by permission.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54405	Drama	Digital Narratives	Digital Narratives combines options from the School of Drama in a new configuration: through working collaboratively across disciplines, students investigate multimedia approaches to contemporary theater and new ways of storytelling. Directors, designers, actors, and dramaturgs work in groups to generate original ideas, images, texts, and material in a workshop environment. These working groups create projects over the course of the semester which are shown in informal presentations. The emphasis is on process, not product -- devising an interdisciplinary performance requires a keen focus on combining creative invention with a rigorous structure of concept development -- both of which are explored here. We also examine the work of several significant contemporary theater artists whose work approaches collaboration across a variety of disciplines. Artists have included: Ariane Mnouschkine, Dumbtype, Complicite, Ralph Lemon, Robert LePage, and more. Students learn to define and distinguish these artist's approaches through viewing video excerpts, readings, and discussion. This class is an opportunity to explore avenues outside of traditional production modes and beyond each student's individual discipline. We focus on the process of creating a theatrical language which truly integrates disciplines.	U	4, 9, 16	focused
54407	Drama	Movement IV	Movement IV is a cross-option course, wherein Sophomore Designers build masks for the Senior Actors to use in the creation of a movement mask piece based on a classic text. The course gives Senior Actors an opportunity to create an original ensemble performance piece, bringing up to 30 masks to life, using skills learned in the previous classes in mask work (Neutral Mask, Commedia dell'Arte, character and larval masks). Due to the necessity of working as an ensemble in the creation of this piece, the students must work together in various roles: as actors, of course, but also as directors, writers, musicians, dramaturges and stage managers; this course offers a rare chance for students to experiment with actor-created theatre, as well as, because it is cross-option, an opportunity for actors and designers to work together to create masks which are able to be brought to life through movement, that are comfortable, offer enough visibility, are secure during activity, etc. A unique learning laboratory for designers and actors to interact involving both artistic and practical issues related to the creation and use of these masks as theatrical metaphor. Limited to Senior Actors/MTs.	U	4, 8	focused
54412	Drama	Rehearsal and Performance IV	Participation outside of class requirements in departmental productions. Putting into practice the techniques acquired over the years of training and exploring the development of a performance played before the public over two weeks.	U	4, 17, 8	focused
54415	Drama	Broadway Dance Styles	This course is designed to provide the student with a practical and historical knowledge of the dance repertoire in American Musical Theater using the original choreography from prominent Broadway choreographers. Course closed: Only for Music Theatre majors in Drama. Prerequisite: Permission of instructor	U	4, 11	focused
54416	Drama	Broadway Styles	This course continues to provide the student with a practical and historical knowledge of the dance repertoire in American Musical Theater using the original choreography from prominent Broadway choreographers. Course closed: Only for Music Theatre majors in Drama.	U	4, 11	focused
54431	Drama	Scenography	A core design class between scenic designers, costume designers, media designers, and directors collaborating to create projects on paper. This class allows students to experiment away from the pressure of a realized production. The course encourages students to cross traditional boundaries in their own work and to focus on the idea of world building for their projects. This class often includes guest designers and directors.	U	4, 9	focused
54432	Drama	Scenic Design: Design for Spaces	A3: Design for Live Spaces: Scenic Design is a course that focuses on creating design within the format of live performance. The projects will be varied and will include new works, existing texts and other innovative forms of live design within the community. A4: Design for Screen Spaces: Scenic Design is a course that focuses on design for the screen. The projects may alternate between TV and Film design depending on the year. Industry professionals will be part of the course experience, giving students real-time knowledge. Projects will build towards a portfolio of work for use in the industry. This course focuses on developing the design tools in areas such as: research, collage assembly, model making, storyboards and creation of a short reel amongst other things.	U	9, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54438	Drama	Acting IV	Introduces students to Comedy Improv performance; gives students an improv vocabulary; increases students freedom on stage; stimulates students sense of play; and increases students awareness of rhythm/timing/build/fall/recovery.	U	4, 16	focused
54441	Drama	Costume Design for Dance	A mini exploring the design elements specific to the aesthetic and performance requirements of dance. The course will examine the design of costumes at significant points in the history and evolution of dance, from classical ballet to a wide range of modern genres. Coursework will consist of lectures, visual presentations, viewing of filmed footage of notable dance performances, and research and design projects. PRE-REQUISITE: Design/PTM Costume major. All others: Portfolio Review and special permission of teacher required. FOR: Second year Graduate Costume Design majors and Junior Costume Design students.	U	4, 9, 17	focused
54442	Drama	Costume Design for the Classics	This Mini 3 focuses on a range of playwrights and classic theatre genres from among Moliere, Brecht and Shakespeare. Special attention is paid to process, research, critical thinking, character development, style, nuts and bolts and the honing of each individual designer's skills. PRE-REQUISITE: Design/PTM Costume major. All others: Portfolio Review and special permission of teacher required. FOR: First year Graduate Costume Design majors and Junior Costume Design students. Prerequisite: 54-341	U	4, 17, 9	focused
54444	Drama	Draping for the Designer II	Draping for the Designer II is a continuation and development of the proficiencies established in Draping for the Designer I. This course emphasizes the draper's role in the creation of period women's wear: its history, unique pattern challenges, specific construction techniques, and how to manage its creation in the workroom. The synthesis of historical understanding with requirements for the performing arts is underscored. Through the patterning, fitting and making of a multi-layer, historic costume each student undertakes interrelated projects that allow for the application of research, development of complex patterns, composition of complete construction plans and fostering of effective teamwork. To take this class, the student needs to have taken either 54-373 Draping for the Designer I or 54-814 Draping for the Graduate Designer I or to have a background in draping and gain permission from the instructor.	U	5, 4, 11	focused
54446	Drama	Professional Preparation	An introduction to the issues and conventionally held practices for the development of responsible self-employment by design-oriented professionals. Discussions investigate the challenges of conducting business within the competitive marketplace of performance-based industries. This is a micro mini that will meet on Jan 14, Jan 21, and Jan 23.	U	9, 8, 1	focused
54447	Drama	Figure Drawing	Costume Majors have priority, then Design Majors. This course explores the realistic and expressive depiction of the human form primarily in two dimensional media. Working primarily from the live model, exercises will be undertaken that address gesture, proportion, movement, anatomy and structure, composition and expressive form. Students will experience a variety of media and formal approaches to the figure, working from nude, draped, and clothed male and female models. A primary goal of the class is to develop the ability to create the human figure from imagination, based on intensive empirical study of the forms and structures of the human body from life.	U	4, 5, 9	focused
54452	Drama	Architectural Lighting Design	The study of Architectural Lighting Design for interior and exterior spaces.	U	17, 9, 11	focused
54453	Drama	Production Management Workshop	Investigates the organization, planning and interpersonal skills required to successfully manage a live theatrical production. Course is discussion based on 1) participants experience in laboratory productions in the School of Drama, 2) current practical examples of experiences of professional production managers, and 3) contemporary management texts. Topics covered include: Budgeting, Scheduling, Communication, and Project Management. Permission of instructor required.	U	4, 17, 9	focused
54457	Drama	Directing: Production IV	SENIOR DIRECTING PROJECT: This is a 90-minute, public, fully-designed presentation directed by a 4th-Year Directing student with the following goals: to publicly realize a playwright's purpose for a live audience; to tell an entire theatrical story with a beginning, progression & ending; to work as a team with actors & design team to shape a cohesive & coherent theatrical presentation; to extend practical understanding of Theatre as a collaborative process; to synthesize & apply prior studies at Carnegie Mellon.	U	17, 4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54458	Drama	Directing: Production IV	SENIOR DIRECTING PROJECT: This is a 90-minute, public, fully-designed presentation directed by a 4th-Year Directing student with the following goals: to publicly realize a playwright's purpose for a live audience; to tell an entire theatrical story with a beginning, progression & ending; to work as a team with actors & design team to shape a cohesive & coherent theatrical presentation; to extend practical understanding of Theatre as a collaborative process; to synthesize & apply prior studies at Carnegie Mellon.	U	9, 4, 17	focused
54464	Drama	PTM Professional Practice	A seminar about issues surrounding a career as a technical manager. In a series of presentations and discussions students will encounter tools and strategies for job seeking and personal promotion. Guest lecturers will present materials on professional obligations like insurance and taxes and non-salary compensation like retirement and health benefits.	U	4, 1, 8	focused
54467	Drama	Costume Design with Music	A rigorous second semester exploration of costume design for musicals and opera that engages students in aesthetic and practical techniques applied toward these two genres. Special attention paid to music skills, process, research, designing for principals and chorus, swatching, nuts and bolts and the honing of each designer's individual skills. PRE-REQUISITE: Design/PTM Costume major. All others: Portfolio Review and special permission of teacher required. FOR: First year Graduate Costume Design majors and Senior Costume Design students.	U	4, 9, 17	focused
54468	Drama	Theater Management	The course examines theatre enterprises, focusing on both existing and emerging business models for producing or presenting theatre organizations from Broadway to Omaha. Theatres are uniquely responsive to their audiences and ecosystems, hence, the course will investigate how the business works - internally and externally. While programming (plays) are at the core of the theatrical exchange, this course will focus its attention on the institutional frameworks that provide the financing, staffing and audiences to those works. The course will be organized in a seminar structure. Lecture will occur to deliver core concepts but the course emphasizes discussion, individualized investigations and creative projects.	U	9, 8, 15	focused
54470	Drama	Costume Rendering	PRE-REQUISITES: Drawing for the Theatrical Designer, Major in Design Option of School of Drama FOR: Graduate and Undergraduate Design Costume Majors only. Instructor Approval required. DESCRIPTION: this fast-paced course focuses on techniques and exercises specific to the development of refined and versatile costume renderings. A variety of mediums and methods are explored including colored pencil, marker, ink, Doctor Martin's dyes, watercolor and acrylic as well as transfer drawings, resists and the use of other techniques. Color, texture, pattern, nude and clothed human models are carefully studied and rendered. Students also apply course techniques to development of designs for production and portfolio preparation.	U	4, 9, 17	focused
54473	Drama	Drawing for Theatrical Designers	This semester-long basic drawing course focuses on developing hand-eye coordination through discreet exercises that allow the theatre student multiple entry points into drawing. Developed for theatrical design students, accurate drawing of proportion while viewing first hand subjects and research images is stressed. Marker and pencil use only. Rigorous practice required. PRE-REQUISITE: Design/PTM major. All others: Portfolio Review and special permission of teacher required. FOR: First semester Graduate Design and Production Students, First semester Junior Costume Majors, other Design/PTM students by consent of instructor.	U	4, 9, 17	focused
54476	Drama	Media Creation Studio	Advanced topics in media creation for the stage. Students will use camera and software based tools to develop content for stage and installation.	U	9, 4	focused
54477	Drama	Technical Direction III	Required for all senior undergraduate Technical Direction students. This "capstone" course is the second semester of a sequence requiring application of concepts from earlier courses including Standard Scenery Construction, Production Planning, Structural Design, Stage Machinery Design and Technical Design 1. This is a project-based course requiring weekly presentation of solutions to various "unusual" technical challenges, drawn from actual production experiences. Thorough documentation (shop drawings, budgets, build schedules, etc.) is a requirement for each project.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54480	Drama	Technical Direction IV	The purpose of this class is to prepare Technical Directors as Technical Designers, specifying the engineering and fabrication of discrete scenic elements in a production context. Upon completion of this course, students should be able to: Understand how elements function to support production Recognize the limitations of standard approaches Develop unique approaches to technical challenges where appropriate Work with an ever-expanding body of methods, materials and hardware Integrate knowledge from prior PTM coursework Develop effective drawings and prototypes Iterate technical designs to achieve optimization	U	4, 9, 12	focused
54486	Drama	Understanding Textiles	Understanding Textiles is a half-semester introduction to the textiles used for the performing arts. This course begins with an overview of the historical development of textile technology and the role cloth plays in world economies. Next it examines weaving structures and how they impact suitability for particular applications. Techniques for identifying fibers, weaves and fabric density are learned. The course culminates with a project that uses all the explored skills, a fabric in history swatch book. Each student takes an era of history, researches cloth production at that time, finds period appropriate swatches, accurately identifies them and suggests uses for each. These individual chapters are combined into a large resource book, a copy of which each participant keeps for future reference.	U	4, 9, 8	focused
54491	Drama	Concert Lighting Design	Students will explore lighting design for concert touring. Emphasis will be on the conceptual development, design process, music analysis, methods of rendering ideas and strategies for implementation of designs. The course will demonstrate methods of working with the tools, vocabulary and technology available to the concert lighting designer.	U	9, 4, 17	focused
54493	Drama	Business of Acting	This course introduces the (advanced) actor to various aspects of the professional world. Emphasis is placed on the audition and interview process for casting directors, talent agents and personal managers. Each student will present either an individual or small group project chosen from a wide ranging list of topics which include performers unions, various production contracts, New York and regional theater season,s professional publications and web sites. Occasional tests are administered on the subject of current Broadway and Off-Broadway seasons. Registration for this course is limited to Drama majors only.	U	9, 8, 4	focused
54497	Drama	Directed Study in Design and Production	An opportunity to pursue a predefined design project outside of the standard curriculum under the guidance and direction of a School of Drama faculty member. By special permission only.	U	4, 17, 9	focused
54503	Drama	Directors' Practicum	A mini-semester course introducing career paths and professional tools for directors.	U	4, 17, 8	focused
54505	Drama	Ear Training	Ear Training for sound designers and audio technologists. Introduction and development of skills and techniques for discerning, measuring and expressing the physical qualities of sound with accuracy and sensitivity. Topics include recognizing frequencies (1/3 octave and dual-octave) and analyzing effects and processing (pitch, amplitude, time domain and timbral). This course is open to Drama Sound Design majors/minors, Music Technology major/minors or by permission of the instructor.	U	4, 9, 8	focused
54509	Drama	Theatrical Sound System Design 2	Intensive course exploring the theory, art and technology of large scale sound system design for entertainment, specifically live theater productions. Prerequisites: Intro to Sound Design for Theatre and Production Audio, OR permission of instructor.	U	9, 4	focused
54516	Drama	Fabric Painting	This course is structured as a lecture/demonstration and lab employing the principles of fabric painting/printing techniques, fabric painting/printing materials and the practical use of these techniques and materials. The student should learn the basic concepts behind each of the covered processes, the materials and alternate methods involved with each process, and introductory concepts behind pattern registration. Additionally, the world of breakdown and distressing is covered in an ongoing exercise that spans the duration of the semester.	U	4, 9, 12	focused
54519	Drama	Acting for the Camera	This course presents the skills necessary to work as an actor in the film and television industry. We will put into practice proficiencies and techniques acquired during previous training, adapt those tools, and learn the new skills required when working for the camera.	U	4, 9, 8	focused
54520	Drama	Acting for the Camera	This course teaches the skills necessary to work as an actor in the film and television industry. Incorporating the proficiencies and techniques acquired during previous training, we'll learn and practice the additional skills required to work on camera.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54522	Drama	Plays and Pitches	Plays and Pitches teaches students to identify and develop productions they would like to execute, to describe those productions vividly and clearly, and to present themselves and their ideas in an artistically professional manner and context. This course equips students with the practices and skills they need to advance towards readiness for the Senior Capstone project required of BFA directors, and which they will use in their future professional lives.	U	4, 17, 8	focused
54525	Drama	Entertainment Lighting Programming	Students learn and practice programming techniques on the grandMA2 series of lighting control consoles. Advanced programming techniques are explored, including media server control and user-defined commands for the console. Different applications are introduced, but the primary focus is on programming for live music performance.	U	4, 9	focused
54527	Drama	Automated Lighting Workshop	In the spring semester of the 2019/2020 academic year the Automated Lighting Workshop course will consist of seven distinct modules. The first will focus on the operation and maintenance of equipment that falls into the category of automated lighting. The second module will focus on the programming of media servers using lighting consoles. This year Eos Family consoles and MBox will be used. The third module will concentrate on the development of previsualization skills using LightConverse software. In the fourth portion of the class students will engineer the automated lighting rig that will be used for the summer and fall of 2020 in the Wells Video Studio. The fifth module will be a continuation of programming on the Hog4 console, concentrating on preparing students for the national Hog Factor competition. Module six will be an introduction to the Vx76 line of control consoles. In the seventh module students who have experience on the GrandMA2 line of consoles may continue the development of skills on that platform.	U	4, 9, 8	focused
54534	Drama	Costume Crafts: Theatrical Footwear	This introductory course serves to instruct the student in the language, materials and processes of designing, creating and adapting footwear for the stage.	U	4, 12, 9	focused
54539	Drama	Fabric Dyeing I	-This course is designed to provide the student with an introductory level of instruction for a broad range of fabric dyeing and painting techniques. -Students should gain an understanding of the various dye classes and their safe use in dyeing fabric for the theatre. -The student should gain a full comprehension of the processes of each of these classes, including common terminology, and be able to correctly enumerate steps in the processes. -The student should be able to match the appropriate product to the demands of the project. -The student should gain skills necessary to manipulate the dye process to achieve desired results including exercising their understanding of color theory. -The student should gain a basic understanding of several specialty dye techniques that could excite further exploration.	U	4, 17, 9	focused
54587	Drama	Dramaturgy Production	Working as a dramaturg on a School of Drama production in the senior year.	U	4, 9, 17	focused
54714	Drama	Graduate Costume Rendering	PRE-REQUISITES: Drawing for the Theatrical Designer, Major in Design Option of School of Drama FOR: Graduate and Undergraduate Design Costume Majors only. Instructor Approval required. DESCRIPTION: this fast-paced course focuses on techniques and exercises specific to the development of refined and versatile costume renderings. A variety of mediums and methods are explored including colored pencil, marker, ink, Doctor Martin's dyes, watercolor and acrylic as well as transfer drawings, resists and the use of other techniques. Color, texture, pattern, nude and clothed human models are carefully studied and rendered. Students also apply course techniques to development of designs for production and portfolio preparation.	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54729	Drama	Graduate Automated Lighting Workshop	In the spring semester of the 2019/2020 academic year the Automated Lighting Workshop course will consist of seven distinct modules. The first will focus on the operation and maintenance of equipment that falls into the category of automated lighting. The second module will focus on the programming of media servers using lighting consoles. This year Eos Family consoles and MBox will be used. The third module will concentrate on the development of previsualization skills using LightConverse software. In the fourth portion of the class students will engineer the automated lighting rig that will be used for the summer and fall of 2020 in the Wells Video Studio. The fifth module will be a continuation of programming on the Hog4 console, concentrating on preparing students for the national Hog Factor competition. Module six will be an introduction to the Vx76 line of control consoles. In the seventh module students who have experience on the GrandMA2 line of consoles may continue the development of skills on that platform.	G	4, 9, 8	focused
54756	Drama	Graduate Theatre for the Ear	Survey of aural storytelling with technology focusing on forms with no visual component. Topics include the history of radio drama to present day, radio sound art, cut-up and tape manipulation, comedy records and podcast dramas. Prerequisites: 54-767 Graduate Conceptual Sound Design 1 & 54-768 Graduate Conceptual Sound Design 2 OR 54-791 Playwriting I. Restrictions: The course is open to Graduate Sound Design majors, Graduate Dramatic Writers or with permission of the instructor.	G	9, 4, 11	focused
54766	Drama	Graduate Introduction to Sound Design for Theatre	Students explore the basic principles and theories of sound design from technical, psychological and aesthetic standpoints. Course work includes instruction in the controllable properties of sound, practical planning of sound plots, cue creation, and the design process. Restrictions: Open to all Graduate Drama Majors, CFA graduate students or with permission of instructor.	G	4, 9	focused
54780	Drama	Graduate Fabric Painting	This course is structured as a lecture/demonstration and lab employing the principles of fabric painting/printing techniques, fabric painting/printing materials and the practical use of these techniques and materials. The student should learn the basic concepts behind each of the covered processes, the materials and alternate methods involved with each process, and introductory concepts behind pattern registration. Additionally, the world of breakdown and distressing is covered in an ongoing exercise that spans the duration of the semester.	G	4, 9, 12	focused
54819	Drama	Graduate Figure Drawing	Costume Majors have priority, then Design Majors. This course explores the realistic and expressive depiction of the human form primarily in two dimensional media. Working primarily from the live model, exercises will be undertaken that address gesture, proportion, movement, anatomy and structure, composition and expressive form. Students will experience a variety of media and formal approaches to the figure, working from nude, draped, and clothed male and female models. A primary goal of the class is to develop the ability to create the human figure from imagination, based on intensive empirical study of the forms and structures of the human body from life.	G	4, 5, 9	focused
54832	Drama	Graduate Scenic Design: Design for Spaces	A3: Design for Live Spaces: Scenic Design is a course that focuses on creating design within the format of live performance. The projects will be varied and will include new works, existing texts and other innovative forms of live design within the community. A4: Design for Screen Spaces: Scenic Design is a course that focuses on design for the screen. The projects may alternate between TV and Film design depending on the year. Industry professionals will be part of the course experience, giving students real-time knowledge. Projects will build towards a portfolio of work for use in the industry. This course focuses on developing the design tools in areas such as: research, collage assembly, model making, storyboards and creation of a short reel amongst other things.	G	9, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
54884	Drama	Graduate Digital Narratives	Digital Narratives combines options from the School of Drama in a new configuration: through working collaboratively across disciplines, students investigate multimedia approaches to contemporary theater and new ways of storytelling. Directors, designers, actors, and dramaturgs work in groups to generate original ideas, images, texts, and material in a workshop environment. These working groups create projects over the course of the semester which are shown in informal presentations. The emphasis is on process, not product -- devising an interdisciplinary performance requires a keen focus on combining creative invention with a rigorous structure of concept development -- both of which are explored here. We also examine the work of several significant contemporary theater artists whose work approaches collaboration across a variety of disciplines. Artists have included: Ariane Mnouschkine, Dumbtype, Complicite, Ralph Lemon, Robert LePage, and more. Students learn to define and distinguish these artist's approaches through viewing video excerpts, readings, and discussion. This class is an opportunity to explore avenues outside of traditional production modes and beyond each student's individual discipline. We focus on the process of creating a theatrical language which truly integrates disciplines.	G	4, 9, 16	focused
54905	Drama	Graduate Ear Training	Ear Training for sound designers and audio technologists. Introduction and development of skills and techniques for discerning, measuring and expressing the physical qualities of sound with accuracy and sensitivity. Topics include recognizing frequencies (1/3 octave and dual-octave) and analyzing effects and processing (pitch, amplitude, time domain and timbral). This course is open to Drama Sound Design majors/minors, Music Technology major/minors or by permission of the instructor.	G	4, 9, 8	focused
54939	Drama	Graduate Entertainment Lighting Programming	Students learn and practice programming techniques on the grandMA2 series of lighting control consoles. Advanced programming techniques are explored, including media server control and user-defined commands for the console. Different applications are introduced, but the primary focus is on programming for live music performance.	G	4, 9	focused
54964	Drama	Graduate Scenic Design: Moving the Musical	This course will explore methods of designing a musical, emphasizing the ways in which the movement of the scenic units informs the design and helps the audience understand the story being told.	G	4, 9	focused
54972	Drama	Graduate PTM Professional Practice	A seminar about issues surrounding a career as a technical manager. In a series of presentations and discussions students will encounter tools and strategies for job seeking and personal promotion. Guest lecturers will present materials on professional obligations like insurance and taxes and non-salary compensation like retirement and health benefits.	G	4, 1, 8	focused
54997	Drama	Graduate Sound Design For Interactive Environments	This course will examine the process, execution and implementation of sound design for interactive and non-linear storytelling paradigms. Emerging trends in immersive theater, gaming, installation art and multi-media place unique demands on the sound designer both in terms of content and delivery. The student will explore how these demands effect the fundamental processes of design, development of content and flexible delivery systems. Through a combination of directed readings, exploration of current & emerging trends, and project assignments the student will be encouraged to experiment and explore design modes and methodologies that support this flexible method of storytelling.	G	4, 17, 9	focused
54998	Drama	Graduate Special Topics in Sound Design	A one semester course covering various rotating topics including the history and critical theories of film sound design, the history of sound recording and technology, Foley sound, recording and editing techniques, and 5.1 audio. Prerequisites: 54-867 Conceptual Sound Design. Restrictions: The course is open to Drama sound design majors and minors, Music Technology majors and minors or by permission of the instructor.	G	9, 4, 11	focused
57015	Music	Violin Studio Performance Class	Once a week throughout the semester a "violin studio performance class" takes place. A studio class is a most important performance opportunity as it is a step between the studio lessons and the concert stage. Students perform the repertoire they are working on in front of the class and Prof. Forough. Along with comments from the class, Prof. Forough works one on one with each student. The repertoire performed can be solo pieces or accompanied pieces. This class is for violin majors who are studying with Prof. Forough. Other students may audit the class.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
57022	Music	Clarinet Studio Performance Class	The purpose of this class is to have performance before an audience (studio class members) to ease performance anxiety. The class meets once a week, is not for credit and is not mandatory. In addition to playing, the class listens to recordings of various styles of clarinet playing.	U	8, 10	focused
57100	Music	Convocation	A weekly meeting for all music students that features lectures, concerts, and other presentations related to professional development.	U	4, 17, 8	focused
57101	Music	Introduction to Music Technology	This course gives an overview of music technology through practical information and several hands-on projects. Concepts such as MIDI and digital audio are introduced and specific topics are covered in detail including sequencing, music notation, digital recording, mixing, and production. Throughout the course, students are required to complete several projects and create musical compositions in styles of their own choosing. The student is not graded on the "musicality" of these compositions, but instead on how well they meet the stated project goals by correctly using specific equipment and/or computer programs.	U	4, 9, 17	focused
57109	Music	Elective Studio (Guitar Class)	Using classical and jazz guitar methods, this course is designed to provide a basic set of techniques that will allow students to pursue the avenue of guitar playing that most interests them. While emphasis will be on developing skills in playing the guitar, a basic understanding of the principles of music theory as applied to the guitar will also be acquired. While few students will find it possible to master all of the materials presented, an exposure to the many possibilities of musical expression available on the guitar and an understanding of basic music theory will help to broaden the students' perspective and make future musical experiences, such as listening and performing, more rewarding. Each student is expected to have his/her own instrument. A guitar in good working condition is essential. An acoustic classical or steel string is preferred, an electric with a small battery operated amp is acceptable. Students having no previous training on the guitar will find this class most valuable.	U	4, 7, 9	focused
57110	Music	Elective Studio (Voice Class)	Students enrolled in group voice will gain an understanding of basic vocal technique and a variety of singing styles. Students will learn about proper breathing, tone production and posture. Vocal styles will include pop, jazz, musical theater and classical. Students will also explore harmonization, improvisation and audition techniques for the singer. This class is geared towards the beginning student.	U	4, 9	focused
57111	Music	Movement and Dance I	The CMU School of Music movement curriculum is designed to expose students to various styles and genres of contemporary and traditional forms of dance and movement. Students will increase their technical proficiency and personal artistry in dance in order to expand their physical skills as vocal performance artists. Courses will: Improve students' posture and strength, Increase proficiency in dance vocabulary, Increase ability to recognize, interpret and execute choreography, movement and staging direction, Enhance kinesthetic awareness and physical confidence and Improve overall health. With a focus on creativity and expression in movement, these courses concentrate on using the body as a tool in the creative process. Throughout "Movement and Dance I - IV", courses will include movement fundamentals, modern dance, ballet, partnering, dance composition/improvisation; as well as mini-courses in dance forms which can include stage combat, Flamenco dance, pilates and ballroom dance.	U	4, 9, 8	focused
57112	Music	Movement and Dance II	The CMU School of Music movement curriculum is designed to expose students to various styles and genres of contemporary and traditional forms of dance and movement. Students will increase their technical proficiency and personal artistry in dance in order to expand their physical skills as vocal performance artists. Courses will: Improve students' posture and strength, Increase proficiency in dance vocabulary, Increase ability to recognize, interpret and execute choreography, movement and staging direction, Enhance kinesthetic awareness and physical confidence and Improve overall health. With a focus on creativity and expression in movement, these courses concentrate on using the body as a tool in the creative process. Throughout "Movement and Dance I - IV", courses will include movement fundamentals, modern dance, ballet, partnering, dance composition/improvisation; as well as mini-courses in dance forms which can include stage combat, Flamenco dance, pilates and ballroom dance.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
57149	Music	Basic Harmony I	This course deals with common-practice harmony. It includes triads and their inversions, tonality and modality, non-harmonic tones, cadences, and the basic concepts of modulation. Section assignment is determined by a placement test. It includes work on fundamentals for inexperienced students.	U	4, 9	focused
57150	Music	Basic Harmony II	This course deals with common-practice harmony. It includes triads and their inversions, tonality and modality, non-harmonic tones, cadences, and the basic concepts of modulation. It includes work on fundamentals for inexperienced students.	U	4, 9	focused
57151	Music	Counterpoint in Theory and Application	In Counterpoint in Theory and Application, students begin by learning the traditional five species of counterpoint in a tonal context. They then build on this foundation, learning to analyze music in terms of the underlying counterpoint and to apply this analysis to performance, and producing original tonal compositions in two voices.	U	4, 15, 14	focused
57161	Music	Eurhythmics I	Dalcroze Eurhythmics is a unique approach to music learning based on the recognition that meaningful rhythmic movement experience, associated with ear-training and improvisation, reinforces understanding of music concepts, enhances musicianship, and focuses awareness on the physical demands of artistic performance. All concepts are experienced in a musical context. Rhythm reading, notation, analysis, and improvisation are integral to the course. Eurhythmics I covers basic binary and ternary metric units and rhythm patterns in relation to these metric units within simple and compound meters.	U	4, 9	focused
57163	Music	Eurhythmics III	Eurhythmics is a unique approach to music learning developed by the Swiss composer and educator Emile Jaques-Dalcroze (1865-1950). Dalcroze discovered that meaningful rhythmic movement experiences away from their instrument allows students to focus awareness on the physical demands of artistic performance while demonstrating knowledge and understanding of the expressive/interpretive as well as the theoretical aspects of music. Sight reading, conducting, notation, analysis and improvisation are integral to the course. Eurhythmics III Course Content: Divisive vs Additive rhythm, Metric transformation, Irregular subdivisions of metric units, Cross rhythms of 3 against 4, 3 against 5, 4 against 5.	U	4, 6	focused
57164	Music	Eurhythmics IV	Eurhythmics is a unique approach to music learning developed by the Swiss composer and educator Emile Jaques-Dalcroze (1865-1950). It is a process for awakening, developing and refining innate musicality through rhythmic movement, ear training and improvisation. Through rhythmic movement, students demonstrate knowledge and understanding of the expressive/interpretive as well as the metrical/structural aspects of music. Sight reading, conducting, notation, analysis and improvisation are integral to the course. Eurhythmics IV Course Content: More complex rhythmic problems encountered in composed music, Changing meters and changing metric units within a composition, Rhythm reading of patterns using small note values, Messiaen rhythm techniques.	U	4, 7	focused
57171	Music	Introduction to Music Technology (self-paced)	This course gives an overview of music technology through practical information and several hands-on projects. Concepts such as MIDI and digital audio are introduced and specific topics are covered in detail including sequencing, music notation, digital recording, mixing, and production. Throughout the course, students are required to complete several projects and create musical compositions in styles of their own choosing. The student is not graded on the "musicality" of these compositions, but instead on how well they meet the stated project goals by correctly using specific equipment and/or computer programs. This is a self-paced version of 57-101. Material will be covered during weekly class sessions, though students are expected to make time in the evenings or weekends to work on their projects in either the MTC (MM119A) or some other cluster. Students with prior experience may pass out of certain classes and projects by providing teacher with equivalent work (pending teacher approval). In addition to the required projects, there is a final exam which is administered during the last class session.	U	4, 9, 17	focused
57173	Music	Survey of Western Music History	This course surveys the development and contexts of European art music and its global adaptation. While keeping in view the chronology from Gregorian chant to the present, this survey emphasizes key personalities and issues, particularly issues relating to period style and interpretive decisions in performance.	U	17, 8, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
57180	Music	Basic Solfege I	This course improves the student's ability to analyze music aurally and to sing at sight in traditional meters and tonalities using the "fixed do" system. Solfege is the integration of the three cognitive skills: reading music, hearing music, and writing what one hears. Section assignment is determined by a placement test. It includes work on fundamentals for inexperienced students.	U	4, 17, 8	focused
57181	Music	Solfege I	This course improves the student's ability to analyze music aurally and to sing at sight in traditional meters and tonalities using the "fixed do" system. Solfege is the integration of the three cognitive skills: reading music, hearing music, and writing what one hears. Section assignment is determined by a placement test.	U	4, 17, 8	focused
57183	Music	Solfege III	Continues 57-182 Solfege II. Students are given assignments of classical music written in the treble, bass, soprano, alto, and tenor clefs. Writing consists of two-part contrapuntal dictations.	U	4, 17, 14	focused
57185	Music	Advanced Solfege I	This course improves the student's ability to analyze music aurally and to sing at sight in traditional meters and tonalities using the "fixed do" system. Solfege is the integration of the three cognitive skills: reading music, hearing music, and writing what one hears. Section assignment is determined by a placement test. It includes advanced work for experienced students and those with perfect pitch.	U	4, 17, 8	focused
57188	Music	Repertoire and Listening for Musicians	This course is the required co-requisite listening component for Survey of Western Music History (57-173). In this course, students listen critically to essential music which has stood the test of time and to superior performances. It features 2-3 hours of listening per week.	U	4, 11, 9	focused
57189	Music	Introduction to Repertoire and Listening for Musicians	One of the most important ways of achieving musical excellence is to listen. In this course, students listen critically to essential music which has stood the test of time and to superior performances. This on-line course features listening and discussion in a virtual coffee shop atmosphere. 2-3 hours of listening per week. Midterm and final listening tests. Proficiency requirement for freshman music majors.	U	4, 9	focused
57190	Music	Repertoire and Listening for Musicians I	One of the most important ways of achieving musical excellence is to listen. In this course, students listen critically to essential music which has stood the test of time and to superior performances. This on-line course features listening and discussion in a virtual coffee shop atmosphere. 2-3 hours of listening per week. This semester introduces full scores for chamber and orchestral music. Midterm and final listening tests. This course contains midterm and final listening tests. Proficiency requirement for freshman music majors. Other students admitted with instructor's permission.	U	4, 9	focused
57191	Music	Keyboard Studies	All undergraduate music students are required to take four semesters of keyboard studies during their freshman and sophomore years. The emphasis of this course is to develop a practical keyboard facility, which includes keyboard theory and technique, sightreading, solo and ensemble repertoire, transposition, and a variety of creative activities such as harmonization and improvisation.	U	4, 9	focused
57193	Music	Collaborative Piano Skills I	A required course for first year piano majors. The skills include sightreading, basic keyboard harmony, transposition, and improvised accompaniments for popular or musical theater songs from either a piano reduction or a lead sheet. The students participate in collaborative situations such as juries, recitals, and class presentations. The presentations are critiqued by the instructor and by other students.	U	4, 9, 8	focused
57209	Music	The Beatles	This course will focus on the phenomenon of the Beatles. Their songs will be studied, with analysis of the musical and lyrical content and structural elements. What musical styles do the songs address? What were their musical influences? In what ways did their music change over the years? Also, the music's social context will be studied. Why were the Beatles so popular and influential? What exactly caused Beatlemania? How did the group form, grow, and end? The Beatles are the most famous rock group in history; the reasons for this are as much cultural as musical, and we'll study the two elements simultaneously. Open to all undergraduate students.	U	4, 11, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
57211	Music	Movement and Dance III	The CMU School of Music movement curriculum is designed to expose students to various styles and genres of contemporary and traditional forms of dance and movement. Students will increase their technical proficiency and personal artistry in dance in order to expand their physical skills as vocal performance artists. Courses will: Improve students' posture and strength, Increase proficiency in dance vocabulary, Increase ability to recognize, interpret and execute choreography, movement and staging direction, Enhance kinesthetic awareness and physical confidence and Improve overall health. With a focus on creativity and expression in movement, these courses concentrate on using the body as a tool in the creative process. Throughout "Movement and Dance I - IV", courses will include movement fundamentals, modern dance, ballet, partnering, dance composition/improvisation; as well as mini-courses in dance forms which can include stage combat, Flamenco dance, pilates and ballroom dance.	U	4, 9, 8	focused
57212	Music	Movement and Dance IV	The CMU School of Music movement curriculum is designed to expose students to various styles and genres of contemporary and traditional forms of dance and movement. Students will increase their technical proficiency and personal artistry in dance in order to expand their physical skills as vocal performance artists. Courses will: Improve students' posture and strength, Increase proficiency in dance vocabulary, Increase ability to recognize, interpret and execute choreography, movement and staging direction, Enhance kinesthetic awareness and physical confidence and Improve overall health. With a focus on creativity and expression in movement, these courses concentrate on using the body as a tool in the creative process. Throughout "Movement and Dance I - IV", courses will include movement fundamentals, modern dance, ballet, partnering, dance composition/improvisation; as well as mini-courses in dance forms which can include stage combat, Flamenco dance, pilates and ballroom dance.	U	4, 9, 8	focused
57221	Music	Italian Diction	A study of the fundamentals of Italian diction and development of legato vocal style through the analysis of grammatical usage, word construction, vowel colorization, and consonant articulation. Included are in-class performance evaluations, listening assignments, critiques, and private coachings.	U	17, 9, 8	focused
57223	Music	German Diction	In-depth study of German diction - development of legato vocal style in German through the analysis of grammatical usage, word construction, vowel colorization and consonant articulation. Included are in-class German diction evaluations, peer assessment, and emphasis on competency in using the International Phonetic Alphabet.	U	17, 9, 8	focused
57227	Music	Jazz Instrumental Ensemble	This ensemble incorporates a comprehensive approach to Big Band performance and study. The music performed is drawn from all eras of big band repertoire with occasional programs of specific composers and genres. The ensemble is carefully coordinated with the Jazz Vocal Ensemble and major ensembles in order to challenge and prepare students for professional music career opportunities. The ensemble performs on the regular School of Music concert series (2-3 shows per semester) and for on-campus events. Admission of undergraduate and graduate students is by competitive audition and placement is by the director. Grading is based on attendance, preparation, and consistent progress.	U	4, 17, 8	focused
57230	Music	Baroque Ensemble	Carnegie Mellon Baroque is a performing ensemble of 15-25 players consisting of winds, strings and keyboard. Students in this ensemble explore the orchestral and chamber music of the 18th Century. The Ensemble performs on modern instruments, incorporating performance practice ideals of the Baroque era. Throughout the rehearsal process, students are encouraged to study original source materials and arrive at historically informed and musically satisfying performances.	U	4, 17, 9	focused
57232	Music	Chamber Music: Guitar	Provides an opportunity for students to play in small ensembles, advised by faculty coaches. The performers will develop effective rehearsal techniques, explore chamber music repertoire, deal with issues of intonation and balance, and arrive at interpretive conclusions that are stylistically sound, yet individualistic and creative.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
57234	Music	Performance for Composers	This course is for composition majors who choose to fulfill the performance elective requirement in the junior year by completing an independent performance project in the fall semester. Examples of projects can include producing a recital of his/her compositions, or pursuing other performing interests, such as writing music for a School of Drama production. Registration by composition faculty permission only.	U	4, 17, 9	focused
57236	Music	Performance for Composers	This course is for composition majors who choose to fulfill the performance elective requirement in the junior year by completing an independent performance project in the spring semester. Examples of projects can include producing a recital of his/her compositions, or pursuing other performing interests, such as writing music for a School of Drama production. Registration by composition faculty permission only.	U	4, 17, 9	focused
57240	Music	Acting I	The basics of acting will be established throughout the first year following the guideposts described in Audition, by Michael Shurtleffís. Structured improvisations, monologues, scene work, songs, and arias will provide a platform for the development of stage presence and effective communication. Each semester will finish with a group project that provides an opportunity for the students to begin to work together as a cast.	U	4, 17, 9	focused
57273	Music	Piano Pedagogy I	This course offers an historical overview of piano pedagogy including its significant developments over the past forty years. Topics covered include beginning piano techniques, the sequencing of concepts and materials, common problems among beginning pianists, practicing, motivation, and parental involvement. Current representative beginning piano methods will be surveyed.	U	16, 4, 9	focused
57274	Music	Piano Pedagogy II	Beyond the beginning years: this course covers piano pedagogy of intermediate and early advanced level students. Topics include "What is a good piece?" Standard literature and technical development repertoire lists will be studied. The business of piano teaching and the instruction of college keyboard skills for non-piano majors will be discussed.	U	4, 8, 9	focused
57276	Music	Piano Pedagogy IV	Continuation of 57-275. Early advanced literature, analysis, teaching, and performance will be covered.	U	4, 9	focused
57283	Music	Music History I	This class will be an in-depth analytical study of music of the Medieval, Renaissance, and Baroque Periods. It will emphasize selected genres and forms by representative composers in order to trace the evolution of musical style and to clarify the main characteristics of these periods, to set the musical developments in broader cultural contexts, and to apply this knowledge to practical decisions made by today's musician.	U	11, 17	focused
57284	Music	Music History II	This class will be an in-depth analytical study of music of the Classical and Romantic periods. It will emphasize selected genres and forms by representative composers in order to trace the evolution of musical style, to clarify the main characteristics of these periods, to set the musical developments in broader cultural contexts, and to apply this knowledge to practical decisions made by today's musician.	U	11, 17	focused
57285	Music	Music History III	This class will be an in-depth analytical study of music from the 20th and 21st centuries. It will emphasize selected genres and approaches by representative composers in order to trace the various threads of musical style, to clarify the main characteristics of the period's music, to set the musical developments in broader cultural contexts, and to apply this knowledge to the lives and musical practices of musicians today.	U	11, 17	focused
57294	Music	Beginning Piano Test	This is the keyboard proficiency test which is a requirement for all music performance, music composition, music technology, and music theory minors.	U	9, 4	focused
57300	Music	Advanced Bagpipe and Drum Band	The Pipe Band at Carnegie Mellon is a competitive Grade 3 band in the Eastern United States Pipe Band Association. The band competes at various Scottish festivals and Highland Games during the school year. The band also performs at university activities throughout the year. These include Convocation, Homecoming, Spring Carnival, and Commencement. Other engagements are Spring Concert at CMU and the St. Patrick's Day Parade in Pittsburgh. The band has also played as an opening act for the Pittsburgh Steelers and a Rod Stewart concert.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
57301	Music	Bagpipe History	This course covers all types of bagpipe music, including Ceol Mor and Ceol Beag, and studies the prominent composers from MacCrimmon to the present day. Students compose their own material in all time signatures commonly used. The course covers Piobaireachd, Marches, Strathspeys, Reels, Hornpipes, and Jigs, as well as harmony and the ability to write out tunes from repetitive listening.	U	4, 11	focused
57306	Music	World Music	A study of major musical traditions from around the world, including classical music from Asia (broadly defined) and the Middle East, as well as traditional musics in Africa, Europe, and the Americas. This course will examine music in its socio-cultural context, and will demonstrate how learning about music from diverse cultures increases cross-cultural understanding. This course will engage with readings, listening examples, multi-media presentations, in-class discussions, music-making activities, and special guests (virtual and in person).	U	4, 17, 11	focused
57307	Music	Bagpipe Theory	This course prepares students for 57-302, Bagpipe Construction. All aspects of Bagpipe Theory are covered, including time signatures, grand staff, musical rudiments, musical terms and definitions, and writing of simple tunes from memory.	U	4, 17, 9	focused
57331	Music	Principles of Education	This course introduces students to the art and science of being an educator. Content includes views of the academic and social structure of the school, physiological & social characteristics of learners that influence instruction, widely recognized research on learning & teaching, and appropriate & effective class preparation and teaching strategies.	U	4, 1, 17	focused
57332	Music	Introduction to Conducting	This course develops the basic skills needed to conduct instrumental ensembles or a small orchestra. It is primarily focused on conducting technique, body language and body coordination and communication. It also deals with learning and translating an instrumental or orchestral score into actual music. The goal is to achieve a clear and communicative technique upon which an artistic interpretation can be built. The student works periodically with a pianist or a small chamber ensemble.	U	4, 9, 8	focused
57334	Music	Fundamentals of Marching Band	A marching band, due to its visibility and high degree of student involvement, is an integral part of secondary school music programs. The well-schooled music education graduate must have knowledge of this unique form of music performance. This course, designed primarily for those seeking a career in teaching, will accommodate students with no experience and others who have participated in marching band. Among the many areas of concentration will be: philosophy, show charting, marching fundamentals and commands, logistical awareness, and budget formulation. Observation of and active assistance with Carnegie Mellon Kiltie Band will be part of the course content.	U	4, 16, 8	focused
57336	Music	Instrumental/Choral Conducting	This course is a continuation of Introduction to Conducting. The course offers a more detailed conducting technique, adding those subjects related to choral conducting. This is followed by the study and the analysis of interpretation from the point of view of the conductor and ends stressing a set of important practical items, including the psychological attitude and the leadership a conductor must develop as well as the organization and achievement of a fruitful rehearsal technique. The students work periodically with a pianist, a soloist or a chamber ensemble on traditional works and on their own compositions in the case of composition majors.	U	4, 17, 8	focused
57337	Music	Sound Recording	Sound Recording (57337, 57947) centers around the Vlahakis Recording Studio in the College of Fine Arts: how the studio works, and how to record various types of music. The method of instruction is to learn by doing, and the goal is to achieve professional-sounding results. Equipment includes a complete 24-track Pro-Tools system, professionally designed control room that can accommodate up to 24 people, outboard preamps and other gear, and an interesting array of microphones. All recording is direct to hard disc. Grading is based on recording projects, class attendance, mastering studio hardware and software, and several quizzes.	U	9, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
57338	Music	Sound Editing and Mastering	The raw recording is just the first step in the process of creating a professional finished audio product. "Editing" is the art of piecing together different takes to make one final 'good take.' "Mastering" is the art of polishing the 'good take' to perfection--balancing all the instruments and tracks, adding special effects, setting final levels. If 'recording' seems like an high-energy activity--involving engineers, musicians, producers--'editing and mastering' are the necessary counterparts--long tedious hours of solitary confinement honing the skills of the mastering engineer. Those taking this course are expected to have significant music skills: actively playing a musical instrument (or composition), and/or the ability to read a piano score at the least, and a full orchestra score from any recent century, including our own, at the most. Class attendance is essential; work outside of class is necessary.	U	7, 4, 13	focused
57339	Music	Acting III	This course will build upon the foundation laid in the first year, with a more concentrated look at scene work, an audition workshop that focuses on cold readings as well as monologues, and a character-development project that works to identify specific issues that inhibit freedom on stage. More in-depth work on songs and arias will lead into a musical scene project. The semester will close with a classical text project in which the students will work with verse.	U	4, 16, 17	focused
57344	Music	Experimental Sound Synthesis	This is a course that will guide students into the world of experimental approaches to music and sound production, with particular emphasis in some of the key practices and concepts developed in the 20th and 21st centuries. We will examine a variety of ways in which sound works are made and perceived; understanding the historical perspectives and critical viewpoints of each approach through the application of hands-on practicum. The topics covered in the course are divided into three large areas: the art of sound, the use of technology in the production of sound works, and the creation of interdisciplinary sound installation. Students from different disciplines will work together to collaborate on the designing, prototyping and execution of a series of ambitious projects in response to the topics covered in class.	U	4, 9, 17	focused
57347	Music	Electronic and Computer Music	This course builds on the concepts learned in Introduction to Music Technology (57-101) and gives added knowledge in the areas of composition using digital and analog devices as well as various computer programs. Building computer models of both analog and digital synthesizers as well as drum machines, loop players and various other sound processing effects will be covered in detail. Students will be required to produce several projects throughout the course demonstrating their understanding of various concepts in electronic music. More emphasis is placed on the overall quality of the end musical product than in 57-101 in order to prepare students for music production in a professional setting.	U	9, 4, 2	focused
57349	Music	Supervised Theory Teaching	This course provides teaching skills in theory for students who have already completed the theory program at Carnegie Mellon University or who have demonstrated theory competence. The students will attend all sessions of the assigned theory class and will assist the professor by correcting homework, delivering a short lecture, developing a class syllabus and tutoring individual students. The work is done under direct supervision and advice from the regular professor who is always present in the class. Enrollment limited to a maximum of two students per class.	U	4, 8	focused
57355	Music	Secondary Guided Teaching	This course enables students to apply instructional strategies in local secondary school music classes. School visits provide opportunities to work with band, choral, & orchestral ensembles and general music classes. Seminar discussions with the cooperating teachers familiarize students with both school-wide and classroom management issues that affect teaching, learning, motivation, and the administration of music programs.	U	4, 17, 9	focused
57358	Music	Introduction to Electronic Music	This course will allow students to produce original works of electronic music composition in response to strategic listening assignments presented within their historical context. Students will learn critical listening and analytical skills, and be assessed on their electronic music production as well as on their ability to articulate context and structure. This course is for undergraduate music students. Other students may register for it with the permission of the instructor.	U	4, 9, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
57360	Music	Brass Methods	This music education course develops basic brass playing and teaching techniques for beginning and intermediate instrument classes. The course includes training in beginning band program design, aural & visual diagnosis of individual and ensemble playing problems, and methods of accelerating music reading independence in young players. The course requires two off-campus field teaching experiences in local schools. Each field teaching experience will require about 3 hours to complete -- students should allow enough time in their schedules to complete this requirement.	U	4, 9, 3	focused
57361	Music	Percussion Methods	This class gives the non-percussion major a background in the fundamentals of teaching percussion. The main focus of the course is snare drum. The students spend most of their time learning the basic concepts of beginning snare drum so they will be prepared to teach beginning students of any grade level. Much time is devoted to proper stance, grip, and stroke in order to insure a good foundation for a beginning student. Also covered are the various mallet instruments, timpani, and all small hand percussion. Students will learn about purchasing proper equipment for the various levels of learning in common school programs.	U	4, 3, 9	focused
57362	Music	Woodwind Methods	This music education course develops basic woodwind playing and teaching techniques for beginning and intermediate instrument classes. The course includes training in beginning band program design, aural & visual diagnosis of individual and ensemble playing problems, and methods of accelerating music reading independence in young players. The course requires two off-campus field teaching experiences in local schools. Each field teaching experience will require about 3 hours to complete -- students should allow enough time in their schedules to complete this requirement.	U	4, 9, 3	focused
57363	Music	String Methods	String Methods prepares music educators for work in the public schools. A major portion of class time will be applied to violin and cello techniques. Upon completion of the course, the student will be expected to demonstrate the technical skills of a second year beginning string student. Students will also be introduced to various method books, string supplies, and repairs.	U	4, 9, 8	focused
57364	Music	Conducting Practicum	This course provides applied conducting experience for the conducting minor.	U	4, 17, 9	focused
57370	Music	Stage Direction	This course provides an internship working with a middle or high school music theater production. Students may participate in coaching, direction, and choreography. In addition, they keep a journal of their experience and submit a final paper describing what they have learned from working with the teachers or professional directors who were responsible for the production. It is suggested that this course be taken during the spring semester when most music theater productions are scheduled.	U	4, 17, 9	focused
57374	Music	Music in the Urban School	This course will involve workshops with nationally known instructors in eurhythmics, world drumming, contemporary popular music, and classroom management. The course will require attendance at workshops, classroom observations and closely supervised teaching experiences. Schools involved are all inner city schools with a poverty level of 75% or above. This course is offered as the result of a grant received from the Federal Department of Education by the School of Music, the Pittsburgh Public Schools, and the Wilkinsburg School District.	U	4, 1, 11	focused
57376	Music	Music in the Secondary School	This course covers a variety of topics related to the development and the management music programs in secondary schools. Emphasis is placed on the leadership, classroom management, general music & performance course content, and routine administrative planning.	U	4, 17, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
57377	Music	Psychology of Music	Music cognition is an interdisciplinary approach to understanding the mental processes that support musical behaviors, including perception, comprehension, memory, attention, and performance. Like language, music is a uniquely human capacity that arguably played a central role in the origins of human cognition. This course is survey of current approaches to and theories about the perception and cognition of music. Topics covered include psychoacoustics; the cognitive neuroscience of music; relationships between music and language; the nature of musical knowledge; and debates about aesthetics, evolutionary psychology, and musical universals. At the end of this course a student should be able to identify key theories and hypotheses in music cognition as they relate to memory, emotion, physiology, neurology, acoustics, language, and evolution. They will be able to comparatively evaluate hypotheses and place them in an intellectual context. These objectives will be achieved though critical reading, discussions, and written exercises. There are no prerequisites for this course. It will be helpful for you to know some basic elements of music theory (such as the names for chords, Roman numerals, and so on), but some extra help will be available to cover these topics. Some notational basics will be covered in the first lecture.	U	4, 17, 15	focused
57381	Music	Collaborative Piano I	This class is the first in a series of hands-on courses which allow the student to accumulate experience accompanying in a professional venue. Students will be assigned to a vocal and/or instrumental studio and will have the opportunity to coach repertoire with a professional accompanist. Assignments may include playing for instrumental juries.	U	4, 9	focused
57391	Music	Keyboard Studies (Music Ed)	This course develops piano skills necessary for work in the elementary and secondary schools. Special emphasis is placed on transposition, score reading, harmonization and sight-reading. This course is required for all music education majors.	U	4, 8, 1	focused
57392	Music	Keyboard Studies (Music Ed)	Continues 57-391 Keyboard Studies V. This course is required for all music education majors.	U	4, 1	focused
57393	Music	Keyboard Studies Test (Music Ed)	This is the keyboard proficiency test which is a requirement for all undergraduate music majors who are music education minors.	U	4, 1	focused
57404	Music	String Quartet: A Social History	The string quartet is at once a medium and a genre, even a form which for more than two hundred years has had a special, unparalleled place in Western music. This course examines the development of the string quartet - from its function as an intimate and conversational social setting for amateurs, to its role as a secret repository of composers' most daring thoughts. The string quartet repertoire under discussion spans the first attempts at string quartet writing in the 17th Century, to serialism and microtonal disintegration in the 1960s, to contemporary Pop-Rock fusion experiments. This course also deals with the social and personal histories of four individuals who freed themselves from hegemonic orchestral rules in favor of an instrumental democratic microcosm. The program analyzes great music performed by the greatest quartets.	U	17, 1, 8	focused
57405	Music	Concerto: Virtuosity and Contrast	The Concerto, one of the most popular forms of music, is also a dramatic form, a drama of contrast between the strength of one body of sound and another (volume), between one type of sound and another (tonal distinction), between the individual and the masses, and finally, between the "Solo" virtuoso and the less gifted "Tutti" players. The goal of this course is to examine the greatest concerti written for all instruments; from Vivaldi's "Concerto for Two Mandolins" to John Adams's "Grand Pianola Music," and much more, while dealing with the social and personal histories of unforgettable virtuosi and the concerti that became their "Battle Horses." The program analyzes great concerti performed by the world's greatest soloists and orchestras.	U	1, 4	focused
57408	Music	Form and Analysis	This course provides a working understanding of all styles and genres of Western classical and contemporary repertoire. Students will explore various aspects of the compositional process, from basic organizational structures to the details of individual musical phrases. They will learn to see and to hear the most important compositional features of a piece of music and will develop a deeper understanding of the music they perform, conduct, and compose.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
57409	Music	Puccini's Operas	Standing between the 19th and 20th Centuries, Puccini witnessed extraordinary socio-political and cultural shifts sweeping across Europe. His operas reflect such changes through their gradual stylistic adherence to modernity. From theatrical and literary plots to complex relationships with poets, publishers, impresarios, singers, conductors, and political censors, Puccini's operas offer excellent grounds for interdisciplinary dialogue and cultural analysis.	U	16, 11	focused
57417	Music	Major Vocal Performance Ensemble	There are two choral ensembles. Concert Choir is a select ensemble of approximately 40 voices of superior vocal/musical talent and experience in the choral idiom. Performance requirements are more stringent than those of the Repertory Chorus. Repertory Chorus is an ensemble of undetermined size. Emphasis is placed on vocal technique and development, musical skills in the rehearsal with minimum performance requirements. Audition required.	U	4, 8, 17	focused
57418	Music	Major Instrumental Ensemble	There are two instrumental ensembles: Orchestra and Wind Ensemble. Rotating seating plans, within and between ensembles, will prevail at the discretion of the Director of Orchestral Studies and the Director of the Wind Ensemble. The instrumental faculty will be consulted. All music majors who are required to enroll in an instrumental ensemble must audition for placement and enroll in Major Instrumental Ensemble. Audition required.	U	4, 7, 9	focused
57421	Music	Exploded Ensemble	Exploded Ensemble is a group dedicated to the performance of music that pushes the boundaries of traditional performance and composition. The ensemble has a strong emphasis on electro-acoustic performance technique, experimental approaches to staging and amplification, and visuals (live video, computer controlled lighting, wearable technology, etc.). The group will perform works by new/experimental/electro-acoustic composers and will create new arrangements of works for which scores may not currently exist - for example, music by rock bands, electronic musicians, and sound artists. The overall goal of the ensemble is to explode the idea of traditional concert music performance. In so doing we shall advance student skills in music performance, music appreciation, and to advance the very important conversation on the future of concert music. Students interested in this course who have not had the prerequisite should contact the instructors.	U	4, 9, 8	focused
57423	Music	Repertoire Orchestra	This course thoroughly acquaints participants with the standard works one would expect to encounter as part of a career as an orchestral player. Assigned repertoire will be read each class session. All students are eligible to register for this course by special permission. Students who are not placed in the Carnegie Mellon Philharmonic are given priority for registration.	U	4, 8, 9	focused
57427	Music	Advanced Seminar in Film Musicology	This course has been designed primarily for advanced students wishing to apply to film scores analytical methodologies pertaining to historical musicology, cultural studies, and genetic criticism. The films screened and the music analyzed in this course follow at first the historical development of cinema. Then, the syllabus focuses on the film music of Ennio Morricone in honor of his 90th birthday and on final presentations of film soundtracks selected by the students. Prerequisites include some knowledge of music history, theory, practice, or the instructor's permission.	U	4, 17, 11	focused
57429	Music	Beginning Piano for Children I	This course is the first of two courses in a year-long internship in the piano teaching of young children, combining class and private instruction: a study of the basic teaching/learning process as applied to piano teaching, covering comprehensive step-by-step presentation in reading, rhythm, ear training, sight reading, technique, and musicianship. Under supervision, students will teach the weekly group class and private lessons. Weekly conferences will be held for learning the presentation of materials for class teaching, analyzing pedagogical problems, and developing communication skills with both young pupils and their parents.	U	4, 17, 9	focused
57431	Music	Italian Literature and Repertoire	The course provides a bibliography of repertoire in the Italian language. Material will include art songs and cantatas and will be presented via individual student performances in class, listening to recordings and group survey of repertoire. Reading and writing assignments will serve to establish historical perspective as well as programming considerations.	U	4, 17, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
57432	Music	French Literature and Repertoire	This course examines French songs for solo voice. Representative works from 18th through 20th centuries will be studied in the context of music history, style and programmatic considerations. Classes consist of individual performance, listening to recordings, and group survey of repertoire. Reading and written assignments establish historical perspective as well as programming considerations.	U	11, 4, 9	focused
57435	Music	German Literature and Repertoire	The course examines German repertoire composed for solo voice. Representative works from the Baroque period through the 20th Century are studied in the context of musical style, vocal demands and programmatic considerations. Repertoire focuses on art songs and cantatas, but also includes certain oratorio excerpts, which are included frequently in recital programs. A bibliography of German repertoire is compiled through individual or group performance of songs, listening to recordings and through research assignments, the latter of which focuses upon the works of specific composers. Reading assignments are included to establish an historical perspective.	U	17, 11, 9	focused
57436	Music	English/Contemporary Literature and Repertoire	The course provides a bibliography of repertoire in the English language. Material will be limited to art songs and will be presented via individual student or group performances in class, and recorded performances. Research assignments will be required for selected anthologies or for works by specific composers. Repertoire will be examined according to vocal requirements, musical style, and programmatic function. The repertoire will consist primarily of works by British and American composers, but works by Russian and Spanish composers will also be included.	U	4, 17, 9	focused
57438	Music	Multitrack Recording	This course builds upon the ideas learned in Sound Recording (57-337), but with an emphasis on close microphone techniques and popular music styles. Students will work in small groups and complete at least two recording projects. $10.00 materials fee.	U	4, 9, 12	focused
57441	Music	Analysis of 19th Century Music	This course will provide students with a variety of tools for the analysis of music from Schubert to Mahler and early Schoenberg. The primary emphases will be on small-scale (chord-to-chord) harmonic organization, on the larger-scale organization of tonal centers, and on form, but other issues will also be explored (e.g. rhythm and meter, text/music relations). The course will sample a wide range of repertoires, including solo piano music, orchestral music, and opera, and it will have a special emphasis on chamber music including the German Lied.	U	4, 9	focused
57442	Music	Analytical Techniques	Analytical Techniques is a "Music Support" course for Juniors and Seniors who have completed the undergraduate core course of study in harmony and counterpoint. This course provides an in-depth knowledge of all styles and genres of Western classical and contemporary repertoire. The course will cover units in harmonic and motivic analysis, Schenkerian analysis, graphic analysis, twelve-tone analysis, set-class theory, rhythmic analysis and other analytical techniques. The primary goal of the course is for students to develop independent skills in analyzing their own repertoire as performers, conductors, composers and teachers.	U	4, 17, 8	focused
57444	Music	Principles of Counterpoint	This course explores the development of Western music composed with multiple independent parts. The first half of the course traces the history of part-writing from medieval organum to the twenty-first century. Emphasis is given to study of pre-Baroque and twentieth-century music, and to the conceptual shifts that occurred moving in and out of the common-practice period. The second half of the course examines, across multiple musical styles, specific contrapuntal techniques such as imitation and ground bass forms. Assignments include both writing exercises and analysis, culminating in a term project on a topic selected by the student.	U	17, 4, 8	focused
57448	Music	Brass Pedagogy	In this course we introduce the "Art of Teaching". In this case, to teach, develop and encourage young brass players just starting an instrument or who are in their early stages of development. Concepts of basic brass pedagogy will involve the following topics: Music as Metaphor; Teaching young students; Listening; Developing a Concept of Sound; Posture; Breathing; Embouchure; Articulation: Single Tonguing, Multiple Tonguing; Mouthpiece playing; The Warm-up; Slurring; Intonation; The Upper Register; Endurance; Vibrato; Dental Braces; Orchestral Playing; Performance Preparation; Taking Auditions Brass students will leave CMU with a basic understanding of the pedagogical needs and requirements of beginning and inexperienced students, so that they may begin private teaching studio upon graduation.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
57449	Music	Beginning Piano for Children II	This course is the second of two courses in a year-long internship in the piano teaching of young children, combining class and private instruction: a study of the basic teaching/learning process as applied to piano teaching, covering comprehensive step-by-step presentation in reading, rhythm, ear training, sight reading, technique, and musicianship. Under supervision, students will teach the weekly group class and private lessons. Weekly conferences will be held for learning the presentation of materials for class teaching, analyzing pedagogical problems, and developing communication skills with both young pupils and their parents.	U	4, 17, 9	focused
57452	Music	Collaborative Project in Music Entrepreneurship	Responding to requests from the Pittsburgh community, Audience Engagement teams spearhead innovative performance projects that serve organizations such as the CMU Philharmonic, Pittsburgh Symphony, Hillman Cancer Center, Carnegie Carnegie Hall, and the Pittsburgh Parks Conservancy, among others. A strong résumé builder, this course offers business connections and professional experience. No prerequisites.	U	3, 9, 17	focused
57454	Music	The Freelance Musician	This course will teach skills that are essential to your success on the stage and beyond, including stage presence, attire and etiquette, public speaking, taking auditions, receptions, programming, and more. Music majors may take this course as individuals or together as, for example, a chamber music ensemble.	U	4, 8	focused
57456	Music	Marketing for Musicians	What is your message? Who is your audience? How do you reach them? These are among the topics we'll explore in this course. Group projects and case studies help us identify the key aspects of one of the most important aspects of any music career. Being a great musician won't do you any good if no one knows you exist! By the end of the semester, students should be able to understand such concepts as branding, marketing, reach and advertising; identify audience segments and target messages to those segments; create compelling marketing materials, including bios, group and program descriptions, websites and flyers; work with teams to try out a variety of marketing strategies in real-world circumstances; learn to capitalize on social media and use it to effectively build and communicate to an audience; learn to write effective and powerful marketing copy (bios, sales pieces, etc.); examine competitors and market leaders to look for opportunities and best practices.	U	4, 9, 1	focused
57457	Music	Mental training for peak performance	Does your best playing happen in the practice room? Would you like to feel more comfortable on stage? Music faculty from every department are collaborating in this course to help you perform at your peak. On the Kresge stage, you will perform regularly for guest musicians, receive feedback and hear about their strategies for overcoming performance anxiety. The course finishes with four weeks of performances for a live audience from CMU's Osher Lifelong Learning program. Musicians include Lorna McGhee, Pete Sullivan, Alberto Almarza, Sergei Schepkin, Craig Knox, Bill Van der Sloot, and many more.	U	4, 9	focused
57459	Music	Score Reading/Keyboard Harmony	This course is a practical, hands-on learning experience. Students learn by doing and observing other students. All work is done at the keyboard. It is for graduate collaborative piano majors, junior and senior composition majors, and junior and senior conducting minors. Other music majors with good keyboard skills can take this course with instructor permission.	U	4, 9, 8	focused
57476	Music	How Music Works: An Affective History	This is an historical survey of (a) aesthetic theories about music and human agency--music's affects and effects, thus its significance and even its very existence--and of (b) actual utilizations of music. Theories range from Aristotle's catharsis to trauma theory and neuromusicology in our time. The applications range from the biblical David's therapeutic harp playing in the court of King Saul (11th C. BCE) to U.S. interrogators in Iraq (21st C. CE); from Vodun and exorcisms in other cultures to MUZAK in our own. In short, it's a chronological survey of what peoples have believed about music's powers and, consequently, how music has been used and abused. The dialectic between theory and applications is reflected in the assignments. This seminar is heavily focused on reading, as well as written and verbal discussion. There is also a long-term field project.	U	17, 11, 16	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
57478	Music	Survey of Historical Recording	The histories of music and technology have long been intertwined. Their symbiosis intensified with the harnessing of electricity in the third wave of the Industrial Revolution. This course will expose you to many of the best practitioners of music. But it will do so with an eye--an ear--towards the media by which we have known them. In short ... The music. The personalities. The media. This seminar is heavy on listening (guided playlists online via Canvas). Writing includes reviews and a researched feature article.	U	9, 17, 7	focused
57480	Music	History of Black American Music	Come and explore the rich musical heritage of Black America. This course will survey the music of Black America beginning with the African legacy and continuing through the music of the Twentieth Century. Class sessions will involve discussions, listening, viewing of films, and reports by students on topics of individual interest. Discussions will involve, historical, cultural and political perspective, as well as the music and composers themselves. Lecturing will be at a minimum. Innovative testing in quiz show format will be used. No prerequisites required. Open to upper level undergraduate students.	U	4, 11, 9	focused
57489	Music	Practice Teaching (Elementary)	Experience in working with elementary students in a public school setting. The teaching is supervised by an experienced public school teacher and members of the CMU music education faculty.	U	4, 1	focused
57490	Music	Practice Teaching (Secondary)	Experience in working with secondary students in a public school setting. The teaching is supervised by an experienced public school teacher and members of the CMU music education faculty. Students may choose a vocal or instrumental emphasis in the secondary placement.	U	4, 1	focused
57558	Music	Observation	This music education offering is an independent study course designed to introduce students to a range of K-12 instructional practices through observation of elementary and secondary school teachers. Students will identify strategies that impact learning in the areas of pedagogy, student motivation, classroom management, and accommodations for special learners. Students complete this course by arranging 20 prescribed classroom observations in local schools - multiple observations may be completed at each school visit. In order to complete the observations in one semester, students should schedule an open 3-hour time block one day per week between 8 am and 3 pm.	U	4, 17, 1	focused
57570	Music	Sound and Music Computing Seminar	The Sound and Music Computing Seminar is a weekly meetingto discuss topics in the areas of computer music, electronic music, musical acoustics, music perception, music technology, music information retrieval, music interfaces, music systems and software, and music theory. Presentations on these various topics are made by graduate students and faculty. The seminar is open to the University and broader community, but students should only enroll if the seminar is part of their degree requirements.	U	4, 9, 17	focused
57610	Music	Internship	A student can receive credit for an unpaid internship in a music related field. The amount of credit is determined by the number of internship hours.	G	4, 8, 17	focused
57671	Music	Chamber Music: String Quartet	Provides an opportunity for students to play in small ensembles, advised by faculty coaches. The performers will develop effective rehearsal techniques, explore chamber music repertoire, deal with issues of intonation and balance, and arrive at interpretive conclusions that are stylistically sound, yet individualistic and creative. A performance is required each semester.	G	4, 9	focused
57672	Music	Chamber Music: Woodwind and Mixed	Provides an opportunity for students to play in small ensembles, advised by faculty coaches. The performers will develop effective rehearsal techniques, explore chamber music repertoire, deal with issues of intonation and balance, and arrive at interpretive conclusions that are stylistically sound, yet individualistic and creative. A performance is required each semester.	G	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
57829	Music	Contemporary Soundscapes	In the late 1960s on Canada's West Coast, composer R. Murray Schafer started the "World Soundscape Project" (WSP). Originally conceived as an inquiry into the growing problem of noise pollution in Vancouver, the Project expanded to encompass the wider study of the relationship between sonic environments and human communities, both historical and present. From a small group of sound researchers making field recordings in natural landscapes and urban areas has grown the modern study of Acoustic Ecology on a global scale, and also the creative practice of Soundscape Composition, in which recorded elements of sound environments are expressively explored through electronic music. Beginning with a history of the WSP, this course surveys aspects of the field of Acoustic Ecology as an aesthetic, political, and ethical phenomenon, with special attention to its relationship with the creative and sound practices of "Soundwalking," "Deep Listening," and Soundscape Composition. This course will also contextualize the WSP within a broader history of music and sound in the background, including Satie's Furniture Music, Muzak®, and coffee shop music. Throughout the course, students will participate in the activity and design of soundwalking, sonic field documentation / recording and sonic-environmental sampling, and the performance of background music. The course will culminate in a soundscape project entailing the composition of a Soundscape work, or the presentation of a creative mapping of aspects of their own sound environments; special guests will provide students with instruction in sound capture and manipulation.	G	13, 12, 4	focused
60101	Art	Transdisciplinary Research Studio I: Risk, Agency, Failure	Concept Studio: The Self and the Human Being is first of a sequence of five studio courses designed to develop a personal approach to generating art and to learning transferable conceptual skills. The topics of the first three Concept Studios are addressed through a sequence of structured, media-independent projects. Open to first-year students admitted to the School of Art, or by instructor permission.	U	4, 12, 9	focused
60105	Art	Critical Theory in Art I	Critical Studies 1 is the first part of a year-long course intended to introduce CMU's students to key readings in the history of artistic theory, studied in relation with the concurrent development of Western art. It is devoted to the period ranging from the 1500s to the end of the 1800s and covers major artwork and theories spanning from the Renaissance to Symbolism and Primitivism. The course is structured as a seminar discussion of theoretical texts, integrated with lectures. Readings will introduce students to the historical and critical background of the themes discussed in class and familiarize them with the varied methodologies and argumentative styles proper to art criticism, critical theory and philosophy. Open to first-year students in the School of Art, or by permission of the instructor.	U	4, 17, 11	focused
60106	Art	Critical Theory in Art II	This is the second part of a year-long course intended to introduce CMU's students to key readings in the history of artistic theory, studied in relation with the concurrent development of Western art. It is devoted to the period ranging from 1900 to 1960 and covers major artwork and theories spanning from Cubism and the historical avant-garde to totalitarian art and 1950s artistic research worldwide. The course is structured as a seminar discussion of theoretical texts, integrated with lectures. Readings will introduce students to the historical and critical background of the themes discussed in class and familiarize them with the varied methodologies and argumentative styles proper to art criticism, critical theory and philosophy. Open to first-year students in in the School of Art, or by permission of the instructor.	U	4, 17, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
60125	Art	IDeATe: Introduction to 3D Animation Pipeline	This class will explore computer animation as it pertains to a professional animation production pipeline. The course is designed to give students exposure to key job descriptions that align to the animation industry. Topics covered include: character design, world building, storyboarding, digital sculpture, look development, rigging, layout, animation, cinematography, lighting, and rendering. These topics are taught in 2-4 week sprints that allow a student to learn the fundamentals of each craft. In a mixture of class lectures, critiques, and training workshops, students will become acquainted with the necessary skills needed to create their own characters and animations. By completion of the course, students will be familiar with industry-standard best practices and ready to take advanced courses related to animation, vfx, and video game related pipelines. This course specifically offers insight on how the craft of animation is always evolving at top studios such as Walt Disney Animation Studios, Pixar, and Industrial Light and Magic.	U	4, 9, 8	focused
60131	Art	3D Media Studio I: Remote Introduction to Sculpture + Digital Fabrication	An introduction to three-dimensional form. Various materials and methods are explored through projects covering a broad range of sculptural concerns. Art majors must complete one topic of 60-131 and a different topic of 60-132 to satisfy the 3DI requirement. Students are required to select two of the following four sections: Digital Fabrication; Small Metals; Assembly and Armature; and Art and Arduino. Materials fee may be required. Open to first-year students in the School of Art, or by instructor permission.	U	4, 9, 11	focused
60133	Art	3D Media Studio II	An introduction to three-dimensional form and fabrication processes. Various materials and methods are explored through projects covering a broad range of sculptural concerns. Art majors must complete one topic of 60-133 mini, and one different topic of 60-134 mini to satisfy the 3DII requirement. For 3D Media II students are required to select two of the following four mini sections: Multiples, Mold making and Casting; 3D Printing and Lasers; Mixed Media Mini-Installation; and More than Mud, Clay Sculpture. Materials fee may be required. Open to first-year students in the School of Art, or by instructor permission. Multiples: Mold-making and Casting - Students will explore basic mold making and casting techniques, understanding safety protocols and best practices using a variety of materials and processes, learning how to create uncanny reproductions of form and surface. 3D Printing and Lasers - An introduction to digital sculpting and model collage, as well as 3D scanning and photogrammetry. Students will also learn how to fabricate their models through processes related to 3D printing and laser cutting, while migrating concepts that deal with the ebb and flow of the digital and reality. Mixed Media Mini-Installation - Students to explore the use, processes and skills of combining a conglomeration of a wide array of materials including; new, found, reused, recycled and natural materials into meaningful, sculptural relationships with site specificity. More than Mud - Clay Sculpture - An introduction to three-dimensional form using the plastic material clay. Sculptural ideas will be developed through sketches and maquettes to full-scale projects. Lectures will be presented on various approaches and techniques of clay artists, as well as other historic and contemporary artists.	U	4, 9, 12	focused
60141	Art	Black and White Photography I	This course will teach you the basic craft of photography from exposure of the negative through darkroom developing and printing to print finishing and presentation. Content includes student presentations, class discussions, shooting assignments, darkroom sessions and class critiques. We will concentrate not only on the technical aspects of photography, but also the aesthetics of seeing with a camera. The course concentrates on photography as a fine art -- what is unique to it and the concerns that are shared with other visual arts, such as composition, tonal values, etc. and aims to equip students with an understanding of the formal issues and the expressive potentials of the medium. Lab fee and 35mm manual camera required. Each student is responsible for the cost of paper and film.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
60142	Art	Digital Photography I	This course explores digital photography and digital printing methods. By semester's end students will have knowledge of contemporary trends in photography, construction (and deconstruction) of photographic meaning, aesthetic choices, and the use of color. Students will learn how digital cameras work, proper digital workflow, RAW file handling, color management and Adobe Photoshop. Through the combination of the practical and theoretical, students will better define their individual voices as photographers. No prerequisites.	U	4, 9	focused
60150	Art	2D Media Studio: Drawing	This course focuses on the language, materials and concepts of drawing as foundation for all the visual arts. Initial emphasis on the development of perceptual, analytical, and structural drawing skills with increasing attention to idea development. Exposure to methods of creating pictorial and illusionistic space; recording the external world of light and form; and making visible the internal world of the heart, the mind, the soul. Experience with line, texture, tone, shape and mass; in a variety of wet and dry drawing media. Open to first-year students in the School of Art, or by instructor permission.	U	4, 9, 8	focused
60160	Art	2D Media Studio: Imaging	A continuation of Two-Dimensional Media Studio: Drawing. Includes an expansion of drawing to include multimedia approaches, painterly issues, digital input/output and work with digital image processing tools. Open to first-year students in the School of Art, or by instructor permission.	U	4, 9, 8	focused
60200	Art	Sophomore Review	Students present their work and their ideas about their work to a faculty committee. A successful review is required for advancement to the junior year. Although this is a non-credit course, it is required of all Art (BFA, BHA, BSA, and BCSA) sophomores.	U	4, 8, 10	focused
60201	Art	Transdisciplinary Research Studio II: Publics	Concept Studio: Space and Time is a continuation of Concept Studio: The Self and the Human Being with a focus on space and time through projects of increasing complexity. Such topics as biological time, historical time, psychological time, celestial time, clock time, and public space, private space, mathematical space, and virtual space are addressed through projects. Open to sophomores in the School of Art, or by instructor permission.	U	4, 9, 16	focused
60202	Art	Transdisciplinary Research Studio III: Futures	Concept Studio: Systems and Processes focuses on the utility, discovery, and the generation of systems and processes through projects. Open to sophomores in the School of Art, or by permission of instructor.	U	4, 17, 11	focused
60205	Art	Critical Theory in Art III	The Duchampian attack on traditional aesthetic categories has been the engine behind the distinctive shifts in postwar art. Photography, performance, conceptual proposals, installation art, film, video, and appropriations from mass culture play an equal part in contemporary visual culture. Duchamp's attack on art as an institution set the tone for other anti-modernist projects to follow which did not accept the "white cube of the gallery" as their sole exhibition space (or measured worth as an artist). His notions of "indifference," (critique of aesthetic judgment), reproducibility, simulation, performativity, artist-as-curator, and interactivity between the spectator and the work of art set the stage for a host of innovative explorations by artists ranging from the Combines of Robert Rauschenberg to the Mod-Spaceships of Mariko Mori. This seminar examines a tumultuous period in contemporary art and culture from 1960 to the mid-eighties, with special excursions into the aesthetics of commodification, phenomenology, materialism, conceptualism, semiotics, abjection, and technology. The impact of social movements and American foreign policies (i.e. Vietnam, Civil Rights, The Women's Movement, Globalism, the Aids Crisis) on the production and reception of contemporary art will also be examined. Open to sophomores in the School of Art, or by instructor permission.	U	5, 3, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
60206	Art	Critical Theory in Art IV	This seminar examines a period in contemporary art from the mid-1980s to the present in which artists and theorists questioned the differences between the politics of representation and, inversely, the representation of politics. Reeling from the AIDS crisis, the continuing and rising conflicts of post-colonial struggles, as well as the growing sense of a radical call for the recognition of, to borrow from Fred Moten, an undercommons-the dematerialization of the object of Art was suddenly not sufficient as the leading critical, aesthetic discourse. The notion of a critical "After-ness," i.e. Post-Modern, Post-Medium, Post-Internet was the desire for a serious recognition of multiple social and aesthetics definitions at the level of institutions (both inside and outside contemporary art). Critiques of the Subject, of Cartesianism, of Whiteness, of Patriarchy, of Cis-Genderism, of Binarism abounded and works of art like Andres Serrano's Piss Christ (1987) or Chris Ofili's The Holy Virgin Mary (1996) were emblematic of the attack many artists staged on intolerance that gave rise to national and international political debates about the role of "Art" in culture and civic life. We are still feeling the effects of these struggles - this seminar will attempt to make sense of this history, examining what has come to be termed the "Culture Wars," of the late 1980s and early 1990s in which issues that had been so hard-fought for in the sixties, i.e. women's rights over their own bodies, protection of the environment, issues of racism (recognition of difference), freedom of speech, separation of Church and State were under threat again. Specific excursions will be made into theories of abjection, intersectionality, precarity, relational aesthetics, and performativity. New media technologies, and especially the centrality of Social Media and Information Cultures, will be a special focus of the final weeks of the course.	U	5, 3, 16	focused
60210	Art	Electronic Media Studio: Introduction to Interactivity	Electronic Media Studio: Introduction to Interactivity is an introduction to software programming and physical computing within the context of the arts. In this course students develop the skills and confidence to produce interactive artworks using audiovisual, networked and tangible media.	U	4, 9, 2	focused
60212	Art	Electronic Media Studio: Interactivity and Computation for Creative Practice	This is an intermediate level course in "creative coding", interactive new-media art, and computational design. Ideal as a second course for students who have already had one semester of elementary programming (in any language), this course is for you if you'd like to use code to make art, design, architecture, and/or games -- AND you're already familiar with the basics of programming, such as for() loops, if() statements, and arrays. This course satisfies the EMS-2 (60-210: Interactivity) requirement for BFA and BXA-Art majors. As with EMS-2, students in this course will develop an understanding of the contexts, tools, and idioms of software programming in the arts. Unlike EMS-2, this course additionally satisfies the computing portal requirement for CFA and Dietrich students pursuing IDeATe minors and concentrations. (Students with no prior programming experience should register instead for 15-104, 15-110, or 15-112.) This is a "studio art course in computer science," in which the objective is art and design, but the medium is student-written software. The course develops skills and understanding of text-based, imperative programming techniques in a variety of popular open-source arts-engineering toolkits, including p5.js (JavaScript), Processing (Java), and openFrameworks (C++), with the aim of applying such skills to interactive art and design, information visualization, generative media, and other creative cultural practices. Rigorous programming exercises will develop the basic vocabulary of constructs that govern static, dynamic, and interactive form. Topics include the computational manipulation of: point, line and shape; texture, value and color; time, change and motion; reactivity, connectivity and feedback; interactive graphics, sound, and simulation; and the incorporation of various modes of input (sensors, cameras) and multimedia output.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
60220	Art	IDeATe: Technical Character Animation	Technical Character Animation is a deep dive into the fundamental concepts of character animation and "The Illusion of Life." This course will focus on building a foundation of body mechanics that demonstrate weight, balance, and authenticity. Through a series of strategically designed modules, students will gain a command of the 12 principles of animation, beginning with a ball bounce to more advanced block, spline, and polish workflows. This course is designed to give students exposure to the art of movement as it is done by animators in the fx, film, and game industries.	U	4, 9	focused
60223	Art	IDeATe: Introduction to Physical Computing	This practical project-based course covers the basic technical skills (including electronics, programming, and hardware) needed to build simple interactive objects with embedded behavior using the Arduino microcontroller. A sequence of projects challenge students to apply their technical skills in creative ways. For the final project, the class works with a local group of older people who serve as design clients; students conjure and build them functioning custom interactive assistive devices of a practical or whimsical nature. Sensor inputs covered include an ultrasonic ranger, thermometer, light sensor, and human inputs like buttons and knobs; outputs to affect the world include actuators such as motors, LED lights, speakers, and haptic feedback devices. This introductory portal course has no technical prerequisites. Readings and guest speakers address topics including design, disability, and aging. See courses.ideate.cmu.edu/60-223/s2018/work for examples of prior student projects. Contact rzach@cmu.edu with any questions about the course. Students are encouraged to also take the micro course 99-353 IDeATe CAD and Laser Cutting.	U	4, 9, 17	focused
60240	Art	Unfolding Environments: The Intersection of Person and Place	In this course students will use photography to develop projects that study our social environments and personal landscapes. This studio explores the ways photography can combine form and concept to derive meaning from place. Students will be assigned two projects for the semester. The first will be a brief study of a familiar space. The second will comprise the remainder of the semester, concentrating on a single location of the student's choosing. Students will photograph and research their chosen place's function, its history, and its relationship to broader concepts and comparative spaces. A series of prompts, readings, lectures, and critiques will help students build their project and develop new ways to approach their subject matter as they create a long-form narrative.	U	4, 17, 1	focused
60241	Art	Black and White Photography II	Black and White Photography II continues developing your technical skills in analog photography by introducing medium and large format cameras and prints. Large format view cameras remain the state of the art in control and quality in both film and digital photography. These cameras as well as unusual panoramic and pinhole cameras will be supplied. This course emphasizes aesthetic development and personal artistic growth through individual tutorials and group critiques, and will help to build professional level photography skills. Additional topics include digital printing and negative scanning, advanced monotone printing methods, and a focus on exhibition and folio presentation.	U	4, 8, 9	focused
60242	Art	Digital Photography II	Digital Photography II combines digital and analog processes in both color and black & white. Students will gain experience with digital workflow, analog to digital conversion, virtual drum scanning and large format digital printing. Topics include trends in contemporary photography, professional practices, project development, narrative and serial work, and portfolio presentation. Students will be expected to develop their own self-directed projects throughout the semester culminating in a cohesive portfolio of their work. Readings, assignments, artist visits, critiques and discussions will give context to the practical work and help develop a wide ranging familiarity with the subjects. Prereq: 62-141 or 62-142 or equivalent or consent of instructor	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
60245	Art	Portrait Photography	Portraiture maintains a unique standing in photography for its direct and collaborative relationship between an individual and a photographer. This course will examine this relationship and the larger contexts which provide the conceptual framework for deriving meaning and understanding from an image of another person. We will study the theoretical and practical aspects of portrait photography in both studio and environmental settings, providing students with an understanding of the genre by developing both technical and conceptual skill sets. Students will utilize analog and digital equipment, learn studio lighting techniques, develop approaches to working with natural light, and explore methods of printing and presentation.	U	4, 12, 13	focused
60250	Art	2D Media Studio: Painting	This course serves as an introduction to technical, conceptual and historical practices of painting. Through a variety of painting experiences and presentations using oil/acrylic media, students progress from observational exercises and exposure to materials and techniques to developing personal processes, imagery and ideas. Class sessions include technical demonstrations, illustrated lectures, personal and group critiques.	U	4, 9, 11	focused
60333	Art	IDeATe: Animation Rigging	Animation Rigging explores processes for building digital skeletons and control systems to drive computer animated forms. This course investigates vital techniques and concepts to create expressive, fully articulated characters for computer animation, film, and game production. Beginning with rigging fundamentals, coursework will advance through various systems and methods that are needed to convey motivated movement and expression in a variety of character forms. Certain key topics include kinematics, joint orientations, driven keys, direct connections, space switching, corrective blend-shapes, custom attributes and graphic user interfaces (GUIs), skinning and deformation. Additionally, coursework provides an introduction to scripting methods for rig creation, including expressions, Python, and MEL. Students will be provided a valuable range of tools that meet production standards for animated film and game creation, as well as a necessary conceptual framework to enable complex problem solving at all levels of rig creation. Anyone interested in the artistic and technical sides of computer animation are encouraged to enroll. Previous experience with Autodesk Maya/3D animation is preferred.	U	4, 9	focused
60350	Art	Professional Development for Creative Practices	This course is intended to expose students to the basic business skills and functions used every day in creative practices and industries. Supporting a creative practice-whether an individual studio practice, temporary collaboration or commission, or an incorporated business or non-profit-all require a foundational knowledge of basic organizational, legal, and financial structures and practices. Students can expect to develop a starting knowledge of business operations, problem-solving skillsets that can be applied to their own practices, and tools for evaluating and taking advantage of new opportunities. Topics covered will include, but are not limited to: basic business structures; intellectual property and artists' rights; agreements, contracts, and employment; generating revenue, tax implications, and financial management; negotiation and compromise; and elements of business strategy development. This course assumes no prior background in business education or administration experience.	U	4, 8, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
60356	Art	Critical Studies: Once Upon A Time: A Survey of International Fairy Tale Film	Fairy tales have been a part of cinema from the beginning. Since George Melies 1899 Cinderella, filmmakers from across the globe have returned to the genre not only for escape into enchanted worlds, but also for social critique, with stories of injustices avenged, class oppression overthrown and gender roles expanded. In this course we will decenter the narrow conception of the genre fixed by Disney and Hollywood directors to examine fairy tale films from around the world. We will encounter the emergence of a renewed poetics and politics of wonder in international films about transformation, wish-fulfillment and reversals of fortune that deliver a situated counterpoint to the hegemony of a colonizing and commercialized poetics of magic. The transformative power of fairy tales can be approached from a variety of angles. We will analyze how stories themselves function as shape-shifters, morphing into new versions of themselves as they are retold and as they migrate into other media. Beyond looking at the films as texts we will consider the affective qualities of how their formal and aesthetic aspects create wonder, delight, humor, apprehension and terror. What are the stakes of the fairy tales varied transformations today, for whom? Films screened may include: Kwaidan (Japan, 1964), Barbe Bleu (Bluebeard, France, 2009), El Laberinto del Fauno (Pan's Labyrinth, Mexico-Spain, 2006), Xala (Senegal, 1975), The Mermaid (China/Hong Kong, 2016), The Juniper Tree (Iceland, 1990), Peau d'Ane (Donkey Skin, France, 1970), Drei Haselnusse fur Aschenbrodel (Three Wishes for Cinderella, Czechoslovakia-GDR, 1973), In The Company of Wolves (UK, 1984), Hansel and Gretel (South Korea, 2007), November (Estonia, 2017), Tropical Malady (Thailand, 2004) and many more.	U	5, 10, 16	focused
60365	Art	Critical Studies: Queer Power in Art Theory	Queer power is a form of (anti-)knowledge that demystifies phallogocentrism and neuters heteronormativity. This class examines how queer theories empower - and can originate in - art making and its history. Over the course of the semester, students discuss recent publications in the field such as Rogers Brubaker's trans: Gender and Race in an Age of Unsettled Identities (2016) and Paul B. Preciado's Testo Junkie: Sex, Drugs, and Biopolitics in the Parmacopornographic Era (2013). Students also investigate recent exhibitions exemplifying oppositional epistemology such as Trigger: Gender as a Tool and a Weapon (The New Museum, 2017-18) and Hide/Seek: Difference and Desire in American Portraiture (National Portrait Gallery, 2011). Interweaving the canons of queer thoughts with newer voices such as Lee Edelman, Tim Dean, and Maggie Nelson, this class contextualizes Paul Mpagi Sepuya, Tschabalala Self, Wu Tsang, and other artists who embody queer power today.	U	5, 4, 10	focused
60388	Art	Critical Studies: Black Utopias	In this course we will examine various utopian visions of Black Americans. Focusing on the 20th century up to present day, the class will research the Afro-futurist and Afro-utopian ideologies found in literature, film, and art, and their opposition to canonical American utopian ideals. We will engage with the ways Zora Neale Hurston's fieldwork inspired Sun Ra's Space Is The Place and Julie Dash's Daughters of The Dust, how real movements like the MOVE house in Philadelphia inspired Octavia Butler to write Parable of the Sower, and more recently, how the oppression from the policing of African Americans can inspire Terence Nance's new series, the Random Acts of Flyness. The course is an exploration of the empowerment and self-determination that African Americans use to visualize a better world for themselves. Students will develop an awareness of how cultural criticism addresses the concept of utopia and how the concerns of this field pertain to African-American expression.	U	4, 17, 5	focused
60397	Art	Critical Studies: Art and Conflict	These are turbulent times we are living through, with unnerving specters of conflict in seemingly irreconcilable political ideologies and environmental threat. What role do we have as artists within this malaise. Can art become a catalyst for meaningful change? This course will consider definitions of 'conflict' and look at artists whose work has responded to conflict, such as war and civil strife, and all manner of disputes from territorial to domestic. We will look internationally at colonial and imperial histories, and consider national struggles from Civil Rights to Black Lives Matter. We will examine how artists have expressed solidarity, observed, or engaged with ideological differences, abuses of power, injustice and the infliction of privilege; through commentary, protest, agit-prop and activism.	U	10, 16, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
60407	Art	IDeATe: Experimental Sound Synthesis	This is a course that will guide students into the world of experimental approaches to music and sound production, with particular emphasis in some of the key practices and concepts developed in the 20th and 21st centuries. We will examine a variety of ways in which sound works are made and perceived; understanding the historical perspectives and critical viewpoints of each approach through the application of hands-on practicum. The topics covered in the course are divided into three large areas: the art of sound, the use of technology in the production of sound works, and the creation of interdisciplinary sound installation. Students from different disciplines will work together to collaborate on the designing, prototyping and execution of a series of ambitious projects in response to the topics covered in class.	U	4, 9, 17	focused
60413	Art	Advanced ETB: Real-Time Animation	An introductory course that explores improvisational strategies for making animation within real-time computer graphics frameworks. Advancements in motion capture technologies, real-time 3D computer graphics engines, and visual programming tools for AV synthesis provide open frameworks for the exploration of animation in spatial and interactive contexts. Studio work will explore real-time animation in a variety of contexts, including screen-based interaction, site-specific installation, and spatial immersion. Conceptual frameworks drawn from the histories of video art, animation, and immersive media design will inform collaborative group work and class discussion. Students without the prerequisite may register by instructor permission.	U	4, 9	focused
60415	Art	Advanced ETB: Animation Studio	Animation Studio explores a variety of techniques and concepts for animation production. Using both 2D and 3D tools, animation will be explored through short assignments designed to develop diverse skills and ideas. For a final project each student will construct an animated short that uses animation as a means of self-expression. The class will engage in discussion and critique of each others work along with examples of historic and contemporary animation. This studio emphasizes production: readings, lectures, and screenings highlight historical contexts for contemporary art and animation practices, forming the foundations for work generated during the course. Screenings include examples of animation in visual art and film practices. Class discussions and group critiques will establish the dialogues surrounding reading and lecture topics, and provide context for art practice.	U	4, 9, 11	focused
60417	Art	Advanced ETB: Moving Image Studio	Moving images are everywhere! In the midst of the Covid-19 pandemic we probably spend more time looking at screens and moving images than ever before. Almost everything from art exhibitions, concerts, live theater, lectures, movies (the list is endless) is experienced on screens large and small. What approaches, experiments, themes and techniques will best serve your moving image media goals? Who is your audience? What communities and discourses do you want to participate in? You will begin to find answers to these questions and more. In Moving Image Studio students will create self-directed moving image experiments and projects. Students may choose from an expansive array of approaches including: narrative, animation, collage, found footage, activism, performance, essay, music video/visual music, documentary, abstract, personal, interactive audio-visual systems, hybrid forms and more. Class time will consist of screenings/discussions of contemporary and historical moving image media, visiting artist presentations, technical and conceptual workshops and tutorials, studio time and presentation and feedback of student work. Additionally we will research and discuss the ever changing contexts for the creation, exhibition and distribution of moving image media. Readings will include theoretical, historical and critical texts exploring the past, present and future of the moving image. Each student will receive an iPhone 11 Cinematography Kit for the duration of the semester. In-depth Smartphone Cinematography workshops and tutorials will be available.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
60419	Art	Advanced ETB: Experimental Game Studio - No More Video Games!	A hands-on game design course focused on innovative and expressive forms of gameplay. In this installment of Experimental Game Design the emphasis is placed on all aspects of remote play: online multiplayer games, streaming culture, MMORPG interventions, transnational gaming communities. If face-to-face activities are still disrupted by the Coronavirus pandemic, the online component will be deeply integrated in the coursework, and will involve workshops in Minecraft, Second Life and Twitch. Topics will include: network protocols for online games, telecommuting tools, source control, streaming, and cloud gaming technologies. The class consists in one long session per week that allows for extended prototyping exercises (mini-jams), technical tutorials, lectures, and in-depth playtesting sessions. Projects are team-based. Some programming experience is required.	U	4, 9, 16	focused
60425	Art	Adv. ETB: (Im)Possible Worlds: 2D Animation, Motion Graphics and Visual Effects	While developing proficiency in Adobe After Effects (and other tools) students will explore the experimental worldbuilding and storytelling possibilities of hybrid moving image media. This course is structured around technical tutorials and workshops, readings and screenings, the creation of collaborative and individual moving image projects, discussion and critique. Some of the themes we will explore include "The Fantastic" as expressed in the genres of horror, science fiction and fantasy. Artists whose work we will look to for inspiration include Jacolby Satterwhite, Shana Moulton, Rachel MacLean, Rachel Rose, Charles Atlas, Sondra Perry, Max Almy, Nam June Paik, Stan Van Der Beek, Zach Blas, Laurie Anderson, Cecile B. Evans, Ryan Trecartin, and many others.	U	4, 9, 7	focused
60430	Art	Advanced SIS: Open Sculpture	Sculpture is perhaps the broadest field among the contemporary visual arts. Through its privileged relationship to the physical world and the viewer's body, sculpture is the glue that connects the intermedia practices of object, installation, interactive art and performance. In this class we build on skills and concepts learned in 3D media 1 and 2 to develop students' individual approach. Students define independent responses to topics proposed through discussion of contemporary sculptors. Emphasis is placed on individual development. Students are encouraged to explore interdisciplinary approaches.	U	4, 17, 9	focused
60431	Art	Advanced SIS: Installation	This course explores a broad range of sculptural issues concerning the practice of Installation Art. Studio focus on relatively large scale works which often involve an ensemble of objects or phenomena in a particular space. Both temporary and permanent works are addressed. Emphasis on research about "place" and the proposal process for a specific context. Various strategies, methods and materials investigated through projects, readings, presentations, discussions and field trips. Exercises and projects assigned initially, but students expected to establish their own projects later in the semester.	U	4, 9, 17	focused
60437	Art	Advanced CP/SIS: Environmental Sculpture	Studio focus on sculpting with the environment. Includes object making, installations and site work with an emphasis on ecological materials, growing systems, environmental impact and related issues. Students required to explore and develop proposal-making skills in order to acquire permission for sites in which to implement projects. Both individual and collaborative projects are possible. Often provide options for collaborative site-specific projects.	U	12, 4, 15	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
60440	Art	Advanced SIS: Special Topic:	Hito Steyerl asked, "Is the internet dead? ...[it is] completely surveilled, monopolized, and sanitized by common sense, copyright, control, and conformism... what happened to the internet after it stopped being a possibility?" This course assumes it is the artist's role to find and create possibilities in all contexts, and investigates what it means to create new possibilities by making physical objects, experiences, sculptures, installations, and systems in an era post-internet. As a project-based experimental lab, this class asks students to navigate back and forth between digital and physical creative tool sets to create new works. We will take inspiration from the history, theory, ideologies and technologies surrounding the internet, as well as from artists, animators, and engineers working on and around the internet today. We will explore issues surrounding automation, digital fabrication, and online maker / fabricator culture as tools to be used, but also as socio-political forces. Other concepts we will explore as a group include the relationship between body and technology; cybernetics, robotics, AI, and the uncanny valley; the relevancy of hand-making and physical construction post-automation; "image-objects;" scripted spaces; the producer-consumer continuum; the divisiveness and productiveness of online subcultures; anonymity; accessibility of information and production tools; and the spatial and temporal effects of inhabiting both digital and physical worlds. If we understand our current epoch as an era dominated by onscreen and networked experiences, this course investigates what it means to embrace, explore, explode, celebrate, negate, critique, reverse, or oppose that through the making of sculpture, broadly defined. This course assumes knowledge of at least very basic 3d modeling, and/or physical computing, and/or coding, and/or 3d media fabrication/construction techniques.	U	9, 4, 11	focused
60451	Art	Advanced DP3: Concepts of Figuration	This course encourages creative exploration of the human image beyond observational figure drawing. We will be thinking of the figure as a symbol to explore narrative, anthropological, cultural, sociopolitical, gender, and dream-life imaging. Through these lenses the figure becomes primary to the understanding of personal or group identity, place, sexuality and gender identification. Figure drawing is open to the use of traditional and extreme image making methods including observational and fictional representations or other conceptual premises relevant to the successful presentation of privately held concerns. Emphasis will be on experimentation with both material and image. The class will consist of studio time, critique, readings, and discussion.	U	5, 10, 9	focused
60452	Art	Advanced DP3: Color	In this advanced course, students will learn to employ a wide range of color theories and color systems through hands-on exercises and studies. Studies will be done primarily in paint, with some use of collage and digital media. These exercises will be aimed at mastering a variety of color approaches that will be applicable to each student's own artistic practice. Students will develop, based on their own interests, a cohesive body of work in which to practice and expand on the skills learned through the directed exercises. Studio work will be augmented by lectures, demonstrations, critiques, readings and critical discussion of writings about color.	U	4, 9, 8	focused
60453	Art	Advanced DP3: Painting	This course is designed to help promote a painter's development, both conceptually and technically. It encourages students to expand their ideas through a diverse set of projects.Through research and studio experimentation, students will explore issues of scale, surface, materiality, process and performativity in painting. They will also consider notions of the "picturesque" and how non-artistic disciplines can inform painting. Lectures and assignments are designed to enrich the painter's conceptual and technical base and to promote creative growth.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
60466	Art	Advanced DP3: Publishing as Artistic Practice (In Quarantine)	This course will look at the history of artist multiples from artist books and zines, mail and subscription based practices, and editioned objects. Students will be introduced to techniques in traditional bookbinding, zine making as well as design and layout an artist book for mass publication. Studio work will focus on materials and processes that can be found and done at home as well as designing projects that utilize print-on-demand product services. We will be looking at contemporary artist's multiples that exist over a wide range of media, from fine art prints, sculptural and digital editions, and even performance and participatory work conceptualized as a multiple. We will discuss the economy and business structure behind independent publishing, looking into contemporary artists who are running their own presses, an emergence of art book and zine fairs, and envisioning alternative distribution opportunities for our artworks.	U	4, 9, 8	focused
60471	Art	Advanced DP3: Photography/Print Workshop	In this course in Photography and Print, students will develop semester-long individual projects in contemporary photography, printmaking, artists' books and/or multiples. Students will work in photography &/or print media, with an invitation to use either studio-based processes (intaglio, lithography, screenprint, photography lab) or work with hand-printing, digital or nontraditional approaches (monotype, stamps, stencils, rubbings, relief, digital photography). This will culminate in a capstone book, supported by the School of Art. Readings, discussion, critique, and visiting artists will enhance our conversation and research. As a workshop, this course is for students who are ready to explore their work more deeply and create ambitious self-driven projects.	U	4, 17, 9	focused
60474	Art	Advanced DP3: Imaging Liveness: photography and performance	Performance art, or the live event, has been a continuous element of art practice throughout most of the 20th century but our evolving technologies of digital recording devices have radically impacted our understanding of performance as a medium of disappearance. With the increased expectation to engage remotely the role of documentation in relationship to the live event has become an inevitability rather than a conscious construction. We are expected to be both a warm flesh body and simultaneously our own image. Considering the proliferation of cameras, the value of photographic representation, it's meaning and potential are critical - from within the glut of image culture it becomes crucial to re-examine our corporeal existence and the repercussions of both having a body and being represented as a body. We will discuss the writing of Peggy Phelan, Andre Lepecki, Fred Moten, Philip Auslander, and Lynne Tillman to deepen our understanding of various historical genres of image construction as they relate to performance and notions of liveness. In this course you will have the opportunity to develop live performances and consider how its documentation can be a transformation of the live event into a work unto itself. We will work collaboratively during in-class workshops; exploring the physical and social aspects of photographic processes in the development of unique event-based photographic methods. Participation in this course will grant you access to a professional digital SLR camera; lens kit, and tripod for the duration of the semester. This course will offer you the time and space to produce new work, take part in advanced critique and research current issues surrounding contemporary photography and performance as they pertain to your individual work. The course will culminate in the production of a printed catalog of student work.	U	9, 17, 4	focused
60490	Art	Advanced CP: Art of Mapping/Mapping as Art	Many artists have used maps as inspiration, and for some, maps are integral to their work. Maps purport to objectively represent territory while revealing the biases of their authors. This course will question conventional notions of objective cartography and look at how artists have creatively and critically used various forms of mapping. As well as geographical and physical space, the course will consider representations of psychological space, social space and conceptual space. Definitions of mapping will be extended to include information visualization, diagrammatic systems, geographic infrastructures, aerial photography, landscape interventions, and journeys through space and time. Following a few initial short assignments, students will devise their own projects later in the semester.	U	4, 9, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
60491	Art	Advanced CP/ETB: Art AFTER The End Of The World	Taught by Prof. Rich Pell (School of Art BSA Faculty Advisor and founder of the Center for PostNatural History). This course will take students on a deep dive into our mythological, scientific and artistic understanding of world-changing catastrophic events, from the earliest human stories up to the present moment. Film and writings, fiction and non-fiction will inform a critical conversation about the important role of artists in these times. Contemporary research in science and critical theory will inform the development of unique self-defined creative practices that embrace our most durable human qualities of joy, empathy, humor, and courage. Field-trips (virtual and/or RL) will fuel group discussion and the development of new artistic works open to any media.	U	4, 7, 17	focused
60493	Art	Advanced CP: Out There - Post-Studio Practice	Since the Dada movement began to erode the importance of institutional validation, artists have consciously chosen to operate outside of a studio context in a variety of ways. The eighties saw the emergence of movements and artist-run organizations intent on removing institutional barriers for art practice, enabling performance, civic engagement, social and political intervention, and myriad other approaches to feed the dialogues surrounding art and culture. This class will consider the philosophical, ideological, aesthetic, and political motivations, which influence such artists and organizations and will look at writers who have provided a corresponding critical framework. Students will engage in research and reading to develop their own project(s), using the class as a space for dialog and development, and the time outside of the class as the space for execution and manifestation.	U	4, 17, 16	focused
60590	Art	Internship	Art Internships are open to all BFA, BHA, BSA and BCSA Art students. Internships may take place with appropriate individuals or organizations within or outside of Carnegie Mellon University. The requirements for an internship are in the School of Art Handbook (available at the School of Art website). Prior to being enrolled for an internship, students must complete an Internship Proposal Form, which defines the goals of the internship. This form must be signed by their site supervisor and approved by the Assistant Head of the School of Art. Forms are available in the bins on the 3rd floor of CFA. Junior and Senior Art majors only.	U	4, 12, 17	focused
62106	Computer Science and Arts	Architecture and the Arts	This interdisciplinary course explores the entangled relationship between architecture and the arts, and their struggle between autonomy and engagement. It will be structured around a series of themes, drawings, and writings that reveal architecture's constantly changing involvement with art, culture, society, and related disciplines The course functions both an introduction to Architecture as Art for a general audience, as well as a critical introduction to architectural thinking and theory for architecture majors. The course will include slide lectures, readings, reading reports, discussions, and a series of research exercises to engage architecture and art more critically, and an exam. We'll examine the common roots, disparate characters, and inter-twined histories of architecture and the arts. We'll investigate not just buildings and art works, but ideas, drawings, images and other representations involved in the construction and reception of architecture that often relate closely to the arts. We'll look at shared terms like composition, rhythm, studio, and form. We'll define architecture in relation to categories such as fine and applied arts, high and low arts, visual and performing arts, and relate these to broad categories such as design, visual culture, and the liberal arts. We'll ask "why" we make architecture and art, rather than "how," and discuss how the human need for expression and meaning can augment the technical and constructed value of mere making or building. We'll debate how the discipline of architecture has been, and can continue to be framed as a fine art, but also act as a service profession, a political tool, a technical expertise, a research endeavor, or as a mode of cultural discourse.	U	9, 16, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
62122	Computer Science and Arts	Digital Media I	This course will engage in an overview of foundational workflows in digital media regarding two-dimensional representation techniques for spatial design processes. The course is divided into two topics with one assignment each: Technical Drawing and 2D Graphics. Students are required to submit work at the end of each class, in addition to self-guided work outside of class times: satisfactory completions of the two assignments, specific Lynda tutorials, final project, and final portfolio are required for the successful completion of the course. Through these deliverables, the course will inquire issues of 2D representation as it pertains to the effective communication of technical and conceptual information in spatial design processes. With digital media, designers now have an arsenal of tools that can subvert and augment traditional means of representation with exponentially greater fidelity and efficiency. Students will have an opportunity to practice these values and favor hybrid approaches that strive to blur the boundaries of analog and digital media, so as to learn how to be versatile in leveraging all forms of media for the design task at hand. Students are required to bring their own laptop computers with AutoCAD, Photoshop, Illustrator, and InDesign installed.	U	4, 9, 17	focused
62125	Computer Science and Arts	Drawing I	62-125 is an introductory course in free-hand architectural drawing. Its central learning objective is building a capacity for visualizing three-dimensional space through hand-drawing. A parallel objective is fostering visual literacy: the ability to use line and tonal values to represent architectural space. Schedule and Content The course is taught in two three-week segments that alternate with the three-week segments of a parallel course Digital Media 1. It concludes with a final project that is shared with 48-100 Introduction to Architecture. The course has three themes that bridge over the two three-week segments. The first focuses on contour and cross contour to describe surface and space. At its completion, it addresses the appearance of architectural space in perspective. Exercises are inspired by the approach of Kimon Nicolaides, The Natural Way to Draw, to these same subjects. The second focuses on the projection of space using both freehand axonometric and perspective drawing. The third is centered on modeling surface and creating space by using tone. A sculptural approach adapted from Kimon Nicolaides is used and at the end applied to drawing architectural sections. This work is preparatory for the final project.	U	4, 17, 9	focused
62141	Computer Science and Arts	Black and White Photography I	This course will teach you the basic craft of photography from exposure of the negative through darkroom developing and printing to print finishing and presentation. Content includes student presentations, class discussions, shooting assignments, darkroom sessions and class critiques. We will concentrate not only on the technical aspects of photography, but also the aesthetics of seeing with a camera. The course concentrates on photography as a fine art -- what is unique to it and the concerns that are shared with other visual arts, such as composition, tonal values, etc. and aims to equip students with an understanding of the formal issues and the expressive potentials of the medium. Lab fee and 35mm manual camera required. Each student is responsible for the cost of paper and film.	U	4, 9	focused
62142	Computer Science and Arts	Digital Photography I	This course explores digital photography and digital printing methods. By semester's end students will have knowledge of contemporary trends in photography, construction (and deconstruction) of photographic meaning, aesthetic choices, and the use of color. Students will learn how digital cameras work, proper digital workflow, RAW file handling, color management and Adobe Photoshop. Through the combination of the practical and theoretical, students will better define their individual voices as photographers. No prerequisites.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
62150	Computer Science and Arts	IDeATe Portal: Introduction to Media Synthesis and Analysis	To view the different section topics, visit https://courses.ideate.cmu.edu/62-150. Technologists, artists, and designers are engaging in new, interdisciplinary modes to consume, create, and reuse media. To do this, they thoughtfully collaborate and critically reflect on media creation, distribution, participation, interaction, and how media affects the audience. In this course, students will challenge themselves to work in these new modal contexts by thinking critically in a genre of exploration. They will formulate the intent of their creative work, articulate relationships to art/design practice and theory, and respond insightfully to creative, media-rich outcomes. The class will introduce core concepts through foundational texts, in-class exercises, collaborative projects, and group critique. Through hands-on media exploration, students will ground concepts such as embodiment, emergence, composition, participatory interfaces, and mediated experiences. Section A will be an Introduction to Textile Media. Section B, will be an Introduction to Mediascapes: 2D to 3D Spatial Environments. Section C will be an Introduction to Digital Storytelling + Archives. For more detail on these sections, please visit https://courses.ideate.cmu.edu/62-150	U	4, 9, 12	focused
62175	Computer Science and Arts	Descriptive Geometry	This is a manual construction course for solving problems in three-dimensional geometry through working with two-dimensional planes using basic mechanical drawing tools. The course covers basic concepts of descriptive geometry; solving problems involving lines and planes in space and their spatial relationships; rotations in three dimensions; locating points and tangents on solids and surfaces; intersection of solids; shades and shadows; perspectives; and development of surfaces.	U	9, 17, 8	focused
62194	Computer Science and Arts	Special Topics in Playwriting	Section A: Are Quentin Tarantino's films, such as Django Unchained, exploitative or celebratory of black culture? Is a show like Bodyguard reinforcing negative stereotypes about Muslim people or challenging the way that terrorism is viewed the U.K.? If it's a problem for Scarlett Johansson to play a Japanese character in Ghost in the Shell, is it also problematic that David Oyelowoa black Britplays Martin Luther King Jr. in Selma? These are just a few of the sorts of questions we will be asking in this class. We ask these questions not to put down other artists, but to seriously interrogate our own views of representation. In addition to analyzing representation of race/ethnicity in film, TV, and theatre, students will write scenes and (ultimately) one-act plays that incorporate characters from multiple racial identity backgrounds. We are just now at a point in the United States where people of color are being given more space to tell their own stories; this is only the beginning of the process of dismantling stereotypical representations of race. In a diverse nation and a diverse world, we need to better understand one anotherthis class will act as a step in that process. Section B: Playwrights study historic plays to learn the craft of writing. What is lacking in our education as writers because women are missing from our intellectual heritage? In this course we will explore a sampling of the many and diverse female writers who have been left out of the canon. Readings of plays and feminist texts will guide us as we develop our craft as writers and seek a clearer understanding of historical female playwrights: what did they write? Why did history choose not to remember them? What can we gain as writers and theater-makers from remembering them now? Students will write in class every week and will also bring three original short plays, inspired by classic texts, to share in class.	U	5, 4, 16	focused
62196	Computer Science and Arts	Screenwriting	This course is designed to give writers a variety of tools they can use in writing or rewriting a current project full-length screenplay. There will films assigned to watch and analyze. Either a first draft or a rewritten version of a full length screenplay is to be completed by the end of the semester. Prerequisite: None.	U	17, 4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
62225	Computer Science and Arts	Generative Modeling	This course introduces students to the fundamentals of generative modeling using computer aided design as practiced in the field of architecture. Core competencies will be developed through modeling projects and software intensive labs, while a broader critical framework for conceiving of contemporary and historical parametric practices will be encouraged through periodic lectures. Emphasis will be placed on careful consideration of digital mediums and developing a sense of craft related to digital modeling in the hope that students will become conscientious makers and consumers of digital content. Students will be encourage to understand and apply algorithmic problem solving to the many design constraints encountered in architecture. The course will explore the relationship of parametric workflows to design thinking and will situate contemporary trends in a broader framework of computational design. The course will also forefront complex form-making as a response to bio-mimicry, systems thinking, and mass-customization. Rather than positioning parametric modeling as a disruption of historical architectural design process, the course will encourage students to consider how new tools might augment the discipline's historical commitments to orthographic projection, perspectival drawing, and physical modeling.	U	4, 9, 11	focused
62240	Computer Science and Arts	Unfolding Environments: The Intersection of Person and Place	In this course students will use photography to develop projects that study our social environments and personal landscapes. This studio explores the ways photography can combine form and concept to derive meaning from place. Students will be assigned two projects for the semester. The first will be a brief study of a familiar space. The second will comprise the remainder of the semester, concentrating on a single location of the student's choosing. Students will photograph and research their chosen place's function, its history, and its relationship to broader concepts and comparative spaces. A series of prompts, readings, lectures, and critiques will help students build their project and develop new ways to approach their subject matter as they create a long-form narrative.	U	4, 17, 1	focused
62241	Computer Science and Arts	Black and White Photography II	Black and White Photography II continues developing your technical skills in analog photography by introducing medium and large format cameras and prints. Large format view cameras remain the state of the art in control and quality in both film and digital photography. These cameras as well as unusual panoramic and pinhole cameras will be supplied. This course emphasizes aesthetic development and personal artistic growth through individual tutorials and group critiques, and will help to build professional level photography skills. Additional topics include digital printing and negative scanning, advanced monotone printing methods, and a focus on exhibition and folio presentation.	U	4, 8, 9	focused
62245	Computer Science and Arts	Portrait Photography	Portraiture maintains a unique standing in photography for its direct and collaborative relationship between an individual and a photographer. This course will examine this relationship and the larger contexts which provide the conceptual framework for deriving meaning and understanding from an image of another person. We will study the theoretical and practical aspects of portrait photography in both studio and environmental settings, providing students with an understanding of the genre by developing both technical and conceptual skill sets. Students will utilize analog and digital equipment, learn studio lighting techniques, develop approaches to working with natural light, and explore methods of printing and presentation. Students will gain knowledge in the development of portraiture through the work of notable figures in the medium's history and contemporary field, including August Sander, Dorothea Lange, Walker Evans, Dawoud Bey, Milton Rogovin, Rineke Dijkstra, Zoe Strauss, Susan Lipper, Justine Kurland, Stefan Ruiz, Larry Sultan, Carrie Mae Weems, Roy DeCarava and Alec Soth. Class discussions, readings and critiques will provide an outline for completing both single and serial image assignments.	U	4, 12, 13	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
62275	Computer Science and Arts	Fundamentals of Computational Design	As analog mechanisms; as metaphors; as bodily extensions or prosthetics; as material systems; as building envelopes; as partners or slaves of humans. This course takes computers outside the box and outlines a journey of discovery revealing computation as the connective tissue encompassing multiple facets of architecture and design culture and experience. Addressing conceptual and practical aspects of the relationship between computation and design, the course explores the fundamentals of generative and rule-based systems for designing and making, environmental simulation and responsiveness, and basic approaches to creative data processing, visualization, and materialization.The course offers a holistic view of computation, exploring the different roles computing plays in the design of our artificial environments. The course is driven by themes, each combining state of the art examples, historical insight, and hands-on computational exploration.	U	9, 12, 13	focused
62314	Computer Science and Arts	The Art of Personal Finance	Money is an inevitable part of our everyday lives. Managing the money we earn and living within our means is essential to ensure that we have the freedom to do what we want to do with our lives. However, even if we successfully eliminate debt and save for the future, true financial freedom will not exist unless we have a plan to guide us on our way. In this course, students will create a simple one-page financial plan that they can use to guide them through their next several years as they cultivate the skills that will ensure their artistic success. Additionally, they will develop the tools needed to support the execution of the plan and create a sourcebook of information they can refer to in the future as their lives (and their financial plans) change. For DRAMA students only.	U	4, 8, 16	focused
62332	Computer Science and Arts	Teaching and Learning	In this course, students will learn about effective strategies for teaching architecture and the built environment. Topics include the cognitive differences between novices and experts, instructional techniques, and goal alignment. As part of the coursework, each student will implement these teaching strategies to design and teach a lesson. Elements of developmental psychology, learning theories, and classroom practices will inform the architectural education lesson. Teaching and learning techniques can be generalized for communication with clients, practice, and the community.	U	4, 9, 12	focused
62360	Computer Science and Arts	Photographers and Photography Since World War II	Invented in 1839, photography was a form of visual expression that immediately attracted a large public following. Starting around 1900, photography was practiced with two dominant strands. One of these firmly believed in the power of photographs to provide a window on the world, and was led by Lewis Hine, whose documentary photographs for the National Child Labor Committee helped to ameliorate living and working conditions for thousands of immigrant children. The other strand adhered to the philosophy of Alfred Stieglitz who adamantly affirmed that photographs were first and foremost reflections of the soul and were art objects, equal to painting, drawing and sculpture. These two schools of thought guided photographers throughout the twentieth century. This course explores in depth the tremendous range of photographic expression since World War II and examines in particular the contributions of significant image-makers such as Helen Levitt, W. Eugene Smith, Robert Frank, Diane Arbus, Garry Winogrand, Charles "Teenie" Harris, Cindy Sherman, Carrie Mae Weems, Nan Goldin, James Nachtwey, and many others. Classes include a slide lecture, student presentation, and video segments that introduce a focused selection of images by major photographers in an attempt to understand their intentions, styles, and influences.	U	4, 10, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
62362	Computer Science and Arts	IDeATe: Electronic Logics && Creative Practice	Activating the Body: Physical Computing and Technology in Performance investigates the fundamentals of electronic computation through performative dialogue with human embodiment. In this advanced studio course, students explore the body and technology as sculptural elements to be manipulated. The course examines the basis of analog and digital computation alongside contemporary, avant-garde, and traditional sculpture, installation, performance, dance, and theater. Students learn the fundamentals of electrical flow and construct functional embodied digital gates, as well as higher-level manipulations of sensors and actuators using the Arduino platform. Major themes in contemporary creative practice are addressed through readings, viewings, field trips, and the creation of original work. Students broaden and deepen conceptual skills and increase the scale, ambition, and finish of creative output. Throughout the semester students complete a series of quick thematic exercises and larger-scale projects; these works are reviewed through individual meetings, group critique, and documentation. The course culminates in an end-of-semester showcase where students exhibit site-specific work on or off campus with the option to participate in the annual Subsurface event.	U	4, 9, 8	focused
62371	Computer Science and Arts	Photography, The First 100 Years, 1839-1939	Photography was announced to the world almost simultaneously in 1839, first in France and then a few months later in England. Accurate "likenesses" of people were available to the masses, and soon reproducible images of faraway places were intriguing to all. This course will explore the earliest image-makers Daguerre and Fox Talbot, the Civil War photographs organized by Mathew Brady, the introduction in 1888 of the Kodak by George Eastman, the critically important social documentary photography of Jacob Riis and his successor, Lewis Hine, the Photo-Secession of Alfred Stieglitz, the Harlem Renaissance of James VanDerZee, the precisionist f64 photographers Ansel Adams, Imogen Cunningham, and Edward Weston, and other important photographers who came before World War II. The class will be introduced to 19th century processes, such as the daguerreotype, tintype, and ambrotype, as well as albumen prints, cyanotypes, and more.	U	1, 9	focused
62418	Computer Science and Arts	Theater Architecture II	CMU's Theater Architecture Program is a multi-disciplinary collaboration of the College of Fine Arts' Schools of Architecture and Drama and Heinz College's Department of Arts Management. Founded in 2008, it is led by Hal H. Hayes, AIA, Studio Professor of Architecture, and Dick Block, Professor and Associate Head of Drama, with participation and collaboration by Drama & Architecture professor Cynthia Limauro and Heinz College associate dean Kathryn Heidemann. The program is an intensive semester comprised of a coordinated design studio in Architecture, a multi-disciplinary theater architecture seminar, live performance attendance, venue tours, research and analysis, and meetings with professionals in the design, construction and operation of theaters and performance production. The curriculum includes research into the history and development of theater building typology, contemporary best practices and future trends of theater architecture, space programming, planning and design of theater buildings. The theaters that are the subject of the design projects are based on real projects and include the active participation of the theaters' artistic and administrative leadership, the professional design teams engaged in the project, public officials and potential users of the proposed facility. Endowed support for the Theatre Architecture Program is provided by CMU Drama alumnus Len Auerbach, ASTC and J.R. Clancy, Inc.. Logistical support and project participation has been provided by Alvin Ailey American Dance Theater, Arup, H3 Hardy Collaborative, HOK, Jazz at Lincoln Center, The Joyce Theater, The New Hazlett Theater, New York City Economic Development Corp., Perkins + Will, Pittsburgh Cultural Trust, Pittsburgh Public Theater, Point Park University, Port Authority of NY and NJ, The Public Theater, Quantum Theater, Related Companies, San Francisco Symphony, Signature Theatre, SOM, Theatre For A New Audience.	U	8, 4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
62471	Computer Science and Arts	Photography/Print Workshop	In this course in Photography and Print, students will develop semester-long individual projects in contemporary photography, printmaking, artists' books and/or multiples. Students will work in photography &/or print media, with an invitation to use either studio-based processes (intaglio, lithography, screenprint, photography lab) or work with hand-printing, digital or nontraditional approaches (monotype, stamps, stencils, rubbings, relief, digital photography). This will culminate in a capstone book, supported by the School of Art. Readings, discussion, critique, and visiting artists will enhance our conversation and research. As a workshop, this course is for students who are ready to explore their work more deeply and create ambitious self-driven projects.	U	4, 17, 9	focused
62475	Computer Science and Arts	ACTIVATED ANAMORPHS: Performative Inhabitables and Interactive Prostheses	This interdisciplinary studio course is centered around the relationship between wearable sculpture, prosthetic apparatus, DIY costume, movement, and identity-based performance. The course emphasizes hands-on experience, the development of visual skills, craftsmanship, conceptual development, and performance techniques. Class time will be spent designing and fabricating performative devices that alter, augment, mask, and transform the body and its inherent abilities. Various lectures, workshops, activities, presentations, and critiques will be included as an integral part of the learning process. Guest instructors from across the College of Fine Arts and outside of the institution will also provide lectures, and workshops that offer students multiple perspectives and techniques. Students will work in a variety of media, unveiling the meanings expressed through materials and investigating new ways to interact with our physical environment(s) through explorations in the adaptation, translation, enhancement, exaggeration, modification, and mutation of the human body. The course will involve student collaboration across disciplines, as well as rehearsals and public performances TBD.	U	4, 8, 9	focused
62478	Computer Science and Arts	IDeATe: digiTOOL	This course serves as an introduction to the fundamental concepts, processes, and procedures to utilize digital and traditional equipment within the IDeATe facilities in Hunt Library. After completion, participating students should leave with a thorough understanding of 3D modeling, 3D printing, laser cutting, engraving, and basic finishing techniques. Students will learn how to operate in a safe, responsible, and efficient manner. This comprehension and experience proves useful for all creative disciplines, and participants are certified for future fabrication equipment access.	U	9, 4, 12	focused
62661	Computer Science and Arts	Interaction and Expression using Pausch Bridge Lighting	Working in cross-disciplinary teams, students will explore light as art, interactive design and programming using a Pharos lighting control system. Students will explore the use of light and interaction using the actual controls within the Randy Pausch Memorial Bridge. Student teams will develop final projects that will be exhibited on the actual Randy Pausch Memorial Bridge.	G	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
62708	Computer Science and Arts	Theater Architecture I	CMU's Theater Architecture Program is a multi-disciplinary collaboration of the College of Fine Arts' Schools of Architecture and Drama and Heinz College's Department of Arts Management. Founded in 2008, it is led by Hal H. Hayes, AIA, Studio Professor of Architecture, and Dick Block, Professor and Associate Head of Drama, with participation and collaboration by Drama & Architecture professor Cynthia Limauro and Heinz College associate dean Kathryn Heidemann. The program is an intensive semester comprised of a coordinated design studio in Architecture, a multi-disciplinary theater architecture seminar, live performance attendance, venue tours, research and analysis, and meetings with professionals in the design, construction and operation of theaters and performance production. The curriculum includes research into the history and development of theater building typology, contemporary best practices and future trends of theater architecture, space programming, planning and design of theater buildings. The theaters that are the subject of the design projects are based on real projects and include the active participation of the theaters' artistic and administrative leadership, the professional design teams engaged in the project, public officials and potential users of the proposed facility. Endowed support for the Theatre Architecture Program is provided by CMU Drama alumnus Len Auerbach, ASTC and J.R. Clancy, Inc.. Logistical support and project participation has been provided by Alvin Ailey American Dance Theater, Arup, H3 Hardy Collaborative, HOK, Jazz at Lincoln Center, The Joyce Theater, The New Hazlett Theater, New York City Economic Development Corp., Perkins + Will, Pittsburgh Cultural Trust, Pittsburgh Public Theater, Point Park University, Port Authority of NY and NJ, The Public Theater, Quantum Theater, Related Companies, San Francisco Symphony, Signature Theatre, SOM, Theatre For A New Audience.	G	8, 4, 9	focused
62718	Computer Science and Arts	Theater Architecture II	CMU's Theater Architecture Program is a multi-disciplinary collaboration of the College of Fine Arts' Schools of Architecture and Drama and Heinz College's Department of Arts Management. Founded in 2008, it is led by Hal H. Hayes, AIA, Studio Professor of Architecture, and Dick Block, Professor and Associate Head of Drama, with participation and collaboration by Drama & Architecture professor Cynthia Limauro and Heinz College associate dean Kathryn Heidemann. The program is an intensive semester comprised of a coordinated design studio in Architecture, a multi-disciplinary theater architecture seminar, live performance attendance, venue tours, research and analysis, and meetings with professionals in the design, construction and operation of theaters and performance production. The curriculum includes research into the history and development of theater building typology, contemporary best practices and future trends of theater architecture, space programming, planning and design of theater buildings. The theaters that are the subject of the design projects are based on real projects and include the active participation of the theaters' artistic and administrative leadership, the professional design teams engaged in the project, public officials and potential users of the proposed facility. Endowed support for the Theatre Architecture Program is provided by CMU Drama alumnus Len Auerbach, ASTC and J.R. Clancy, Inc.. Logistical support and project participation has been provided by Alvin Ailey American Dance Theater, Arup, H3 Hardy Collaborative, HOK, Jazz at Lincoln Center, The Joyce Theater, The New Hazlett Theater, New York City Economic Development Corp., Perkins + Will, Pittsburgh Cultural Trust, Pittsburgh Public Theater, Point Park University, Port Authority of NY and NJ, The Public Theater, Quantum Theater, Related Companies, San Francisco Symphony, Signature Theatre, SOM, Theatre For A New Audience.	G	8, 4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
62775	Computer Science and Arts	ACTIVATED ANAMORPHS: Performative Inhabitables and Interactive Prostheses	This interdisciplinary studio course is centered around the relationship between wearable sculpture, prosthetic apparatus, DIY costume, movement, and identity-based performance. The course emphasizes hands-on experience, the development of visual skills, craftsmanship, conceptual development, and performance techniques. Class time will be spent designing and fabricating performative devices that alter, augment, mask, and transform the body and its inherent abilities. Various lectures, workshops, activities, presentations, and critiques will be included as an integral part of the learning process. Guest instructors from across the College of Fine Arts and outside of the institution will also provide lectures, and workshops that offer students multiple perspectives and techniques. Students will work in a variety of media, unveiling the meanings expressed through materials and investigating new ways to interact with our physical environment(s) through explorations in the adaptation, translation, enhancement, exaggeration, modification, and mutation of the human body. The course will involve student collaboration across disciplines, as well as rehearsals and public performances TBD. This section is open to graduate students only.	G	4, 8, 9	focused
65201	General Dietrich College	Humanities Scholars III	Humanities Scholars Program III: Poetry and Power (Fall 2019) Audre Lorde wrote, "Poetry is not a luxury. It is a vital necessity of our existence." Poetry is often perceived as an elite art, practiced within the confines of academia and understood only by a chosen few. But poetry is grounded historically in an oral tradition and a sense of public ownership. Does poetry have power in our society? What is its social function? How is poetry distinct from other modes of writing and art? Can poetry advance social movements and connect people with perspectives beyond their comfort zones? This course will consider arguments about poetry and its relationship with society. Students will read and discuss poetry both on and off the page, as well as explore arguments about poetry, poetics, and power via essays, literature, performance, media, and community engagement.	U	4, 8, 10	focused
65203	General Dietrich College	Applied Quantitative Social Science II	Applied Quantitative Social Science II is the second course in the QSSS core sequence. Conducted in a seminar format, the course will feature guest lectures from a series of faculty at CMU. Students will discuss ongoing research across the social sciences, and over the course of the semester will develop a research project proposal. Seminar participation is limited to QSSS students.	U	4, 17, 1	focused
66103	Dietrich College Interdisciplinary	HSP First-Year Seminar: Appalachia (for HSP students only)	The Appalachian region - which stretches from Georgia to New York's southern plateau - has a particular place in American history and memory. This course will examine the political, literary, economic and historical narratives that surround the region, as well as examining the role that Appalachia can play as a model for developing regions in other parts of the world. This course fulfills the First-Year Seminar requirement for the Humanities Scholars Program. Enrollment is restricted to first-year HSP students.	U	4, 8, 11	focused
66106	Dietrich College Interdisciplinary	QSSS First-Year Seminar: Applied Quantitative Social Science I (QSSS students)	The QSSS First-Year Seminar provides a fast-paced introduction to a range of methods in the quantitative social sciences. Organized around a set of case studies, the course introduces the language and methods of empirical research through a combination of seminar-style discussions of academic papers, and hands-on lab work using the statistical software R. Students will replicate results from a high-profile labor market discrimination paper, explore agent-based models of neighborhood segregation, and scrape Wikipedia data to examine imbalances in gender representation. Enrollment restricted to first-year QSSS students.	U	5, 10, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
66109	Dietrich College Interdisciplinary	Grand Challenge First-Year Seminar: Climate Change	Many consider climate change to be the most serious social, political, and environmental issue of the 21st century. As human activities increase the level of greenhouse gases in the atmosphere, scientists have established the reality of climate change and have estimated its impacts on human society and the natural world. Despite the scientific consensus on its existence, causes, and consequences, a substantial number of Americans and citizens of other countries still question these conclusions and a small but vocal group of doubters continue to challenge the science and scientific consensus on climate change. In spite of some social division over these issues, governments at local, national, and international levels have made concerted efforts to craft policies to address climate change. These policies have shifted over time as the information, attitudes, and technology associated with climate change have evolved. In this course, we will explore the challenges and complexities of climate change by investigating the subject from a variety of angles: scientific, political, rhetorical, cultural, economic, technological, and ethical. Over the course of the semester, we will inquire: What is climate change? How do scientists know it is happening? Why is there public debate over it? What solutions are available? And what are the pros and cons of the different solutions?	U	13, 8, 12	focused
66118	Dietrich College Interdisciplinary	DC Grand Challenge First-Year Seminar: Thinking With Evidence	In a time of big data and widespread skepticism of science, it is crucial to understand how data and facts can be turned into conclusions, and then into public policy. Using topics from medicine, epidemiology, and public health, this course provides students an introduction into the grand challenge of understanding how evidence is used (and abused) in support of scientific conclusions. Questions of health and disease are particularly important areas for thinking about facts and figures because many life-or-death decisions have to be made on the basis of fragmentary and unreliable evidence. Every trip to the doctor, illness, and vaccination involves a complicated mix of public policy, scientific evidence, and emotional and historical factors. This course helps students understand the sciences and the humanities as united in their desire for rigorous argumentation rather than as competing or incompatible ways of thinking. Moreover, by taking a wide-angle lens to the topic, students will see how and why standards of scientific proof have changed over time, and track what these changes mean for thinking about evidence. Co-taught by a statistician and historian, this course draws on many different disciplines, providing students a broad introduction to reasoning across the humanities and social sciences. Students will be required to participate in written and oral arguments, read scientific articles as well as political, historical, and legal documents, and prepare a capstone project in which they will be asked to weigh real-life evidence and recommend a course of action to the Food and Drug Administration. Other topics may include vaccination controversies, regulation of carcinogens and toxic chemicals, mammography screening standards, and the treatment of infectious diseases in global health settings.	U	3, 4, 6	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
66122	Dietrich College Interdisciplinary	DC Grand Challenge First-Year Seminar: Beyond Earth	Space, as a television series once told us, is the final frontier. But what lies out there? It could be that the billions of rocky planets and moons in the Milky Way are just inert and ready to be terraformed and colonized...but what happens when we encounter life, intelligent or otherwise? In Beyond Earth, co-taught by an astrostatistician and a linguist, students will consider the various rationales for engaging with the rest of the galaxy...and the potential consequences of doing so. Why should one consider leaving the Earth, and where would he or she go? Just to Mars, or to other planetary systems? How long would it take to get to these other systems? The distances involved in space travel are immense, and we cannot rely on warp drives. Inter-generational space travel is a possibility, but who is willing to leave Earth and spend the rest of his or her life on board a spaceship? When one's descendants finally arrive in a suitable planetary system, what happens if they find life? If so, what should they do - communicate with it, control it, or fly away from it? Perhaps these are the wrong questions...perhaps we need to ask if humans have the right to occupy other planets and moons in the first place. But even if we choose not to leave Earth, there will still be the issue of communication: from radio signals to satellites leaving the Solar System to proposed light sails that will be pushed to the nearest stars, we are making ourselves known. Should we do this? And if we send signals into space, how should we design them to make ourselves understood? What should we talk about? Just how should we go about engaging with the rest of our galaxy? By the end of the course, every student will be able to make an informed and dispassionate decision: stay on Earth and improve what we all have, or strike out into the great Beyond?	U	7, 4, 9	focused
66125	Dietrich College Interdisciplinary	DC Grand Challenge First-Year Seminar: Democracy & Data	From gerrymandering to online political ads, data is being used in ways that raise urgent questions about the integrity of democratic elections. But the relationship between democracy and data goes far beyond elections. In a world of constant surveillance, in which vast amounts of data are gathered from our phones, our computers, and from other facets of our lives - and in which new breakthroughs in machine learning and data analytics make such data dramatically more powerful - what does it mean for average citizens to have control over their own lives? What does democracy mean?	U	4, 16, 17	focused
66126	Dietrich College Interdisciplinary	DC Grand Challenge First-Year Seminar: How We Vote	This course investigates the sacred American practice of voting, the cornerstone of American democracy, using the 2020 election cycle as our laboratory. The course uses a multi-disciplinary approach, examining the topic from several different perspectives. We'll investigate social movements to expand the vote, the role of technology, game theory, polling, predictions, electoral mapping, social media, the structures of American governance, and more. Questions include: What is the electoral college? Who gets to vote and why? How well is that vote accounted for? How can voting systems be compromised? Why is it so hard to predict who will win? How do people make decisions? How useful are polling & predictions? What disrupts voting? Why is turnout so low? How does money play a role in the election cycle? Why do we vote the way we do? How is social media changing elections? What are global best practices? Did the founders even intend for a mass democracy? (The answer is no!) Many of you will be first-time, eligible voters in one of the most remarkable presidential campaigns in American history. We'll build your skills as new democratic citizens, of this nation or others, and help you make sense of the history-making U.S. news cycle. A note on partisanship: All political viewpoints are welcome in this class. This is a course on how we navigate and account for political difference in a diverse, disparate nation. This is something we'll practice in class, while we will also study that very process across the nation.	U	4, 9, 16	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
66127	Dietrich College Interdisciplinary	DC Grand Challenge First-Year Seminar: Environmental Justice	Wondering what the "Green New Deal" proposal is about? Does it seem like you have to choose between protecting people and protecting the planet? How does environmentalism connect to struggles over social justice and human rights? This first-year interdisciplinary seminar is an introduction to the Grand Challenge: Environmental Justice. In Giovanna de Chiro's words, the environmental justice movement is working "toward building diverse, dynamic, and powerful coalitions to address the world's most pressing social and environmental crises global poverty and global climate change by organizing across scales and 'seeking a global vision' for healthy, resilient, and sustainable communities." In this seminar, we'll study the history and science behind two interconnected challenges for environmental justice: global climate change and fine-particulate air pollution. Both types of pollution start with combustion of fossil fuels. Particulate air pollution kills roughly 7 million globally each year; these air pollution deaths happen close to the source, with unequal levels of exposure and risk for people according to class and race. Climate change, mostly from carbon dioxide and methane emissions, is spread globally and lasts well beyond our lifetimes, yet the effects are again disproportionately based on class and race. In this course, we'll explore the science, history, ethics, and public perception of these problems, with implications for Pittsburgh and the planet, and for the near- and long-term future.	U	13, 1, 8	focused
66128	Dietrich College Interdisciplinary	DC Grand Challenge First-Year Seminar: Palestinian and Israeli Food Cultures	In a region beset by conflict, how do food cultures allow us to approach cultural intersections and connections? This course is designed to provide students with a historical, cultural, and linguistic understanding of the hybrid nature of Jewish and Arab cultures, and the multiple ethnic contributions to local food cultures in Israel and Palestine. The two instructors, from the fields of Jewish history and Arabic Studies, will introduce students to the history, literature, film, and languages of the region, as well as to critical scholarship on food and foodways in the Palestinian and Israeli context. Students will have the opportunity to engage in cooking either locally or in Philadelphia - subject to travel restrictions - and to learn from Michael Solomonov and Reem Kassis, two award-winning US-based celebrity chefs and authors of Israeli and Palestinian cook books respectively. Throughout the semester we will also host a range of guest speakers who will deliver lectures on our course topic in the classroom and in the community.	U	4, 11, 2	focused
66129	Dietrich College Interdisciplinary	DC Grand Challenge First-Year Seminar: Unreality: Immersive and Spatial Media	Virtual news stories and game worlds are accessible by putting on cardboard goggles, theme parks are engineered to provide convincing multisensory experiences, and workforces are reliant on augmented views of factory floors. Immersive and spatial media constitute a suite of emerging technologies that offer the opportunity to expand arts, entertainment, science, design, commercial enterprises and countless other domains in ways that were previously limited to science fiction. The potential for augmented reality to disrupt our current technological ecosystem is tremendous. Many of these technologies are now 50 years old and just starting to enter the commercial realm. As immersive experiences and augmented realities become more integrated into our work and leisure, do we need to worry about the ways that unreality affect our experiences of reality, or our interactions with each other? How do we know that we can trust our senses to tell us what is real? How do we begin to grapple with the ethical, cultural, social, technological, and regulatory implications of this shift?	U	9, 15, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
66131	Dietrich College Interdisciplinary	DC Grand Challenge First-Year Seminar: Culture, Sports, and Conflict in/and VR	Sports have been celebrated for bringing people together; yet, sports have also been a locus of tensions and conflict that most of us only experience from the sidelines. We understand sports, the people, and their cultural impact through the stories that we tell about them in such places as museums, stadium tours, and Halls of Fame as well as in books, documentaries, and podcasts. Through immersive technologies, these stories are brought to life and bring fans to the heart of the action. In this course, students and faculty together will seek to achieve two main objectives: (1) examine ways in which cultural and societal values are reflected in sports and (2) how Virtual Reality (VR) technology can help design experiences that enhance the users awareness of these issues by engaging with these cultural and societal perspectives. We will first unpack sports stories that are squarely situated at the crossroads of sports and culture(s) (e.g., racism, human rights, and the role of government and/in national politics). Then we will explore the role of VR technology to help craft these narratives. Students, then, will discover what it means to write stories for VR experiences. The course will culminate in students designing an immersive experience about a sports conflict of their choice, which will be developed more fully to be displayed in the Askwith Kenner Global Languages and Cultures Room.	U	16, 4, 9	focused
66204	Dietrich College Interdisciplinary	Film Festival	Students will take on the project of planning and managing a film festival that draws a college- and city-wide audience. Students will collaborate on all aspects of the festival: selecting films, generating and distributing marketing materials, designing and scheduling events, arranging facilities and general logistics, coordinating internal and external public relations, organizing fundraisers, rallying the local communities - in short, all the aspects involved in making the event a spectacular/sensational success! A unique feature of this course-cum-festival will be several directors' participation as guest speakers on the festival theme and other issues informing their films. Previous Film Festivals have covered such topics as: Democracy, Mechanization, Realism, Globalization, Migration, Media and Work. This course is also designed to supplement the study of film with the historical, political and sociological background that students need for critically analyzing the images and ideologies they see on the screen and understand how those images effect our views of the past and present time. NOTE: Interview with course instructor required prior the registration.	U	4, 10, 11	focused
66215	Dietrich College Interdisciplinary	The Innovation Trials	This course will examine some of the most influential intellectual property court battles throughout history and their impact on innovation. This course is geared toward students curious about Americas industrial development and interested in the political and business strategies behind the greatest innovations and technological advances of the past several centuries. The course will answer the who, what, where, when, why and how of a number of legal cases involving various technologies and areas of innovation and place them in their historical context.	U	9, 4, 8	focused
66221	Dietrich College Interdisciplinary	Topics of Law: Introduction to Intellectual Property Law	This course provides students with an overview of patent, trademark, copyright, and trade secret laws. Goals for the course include identifying intellectual property (IP) rights and understanding how to take the necessary steps to protect and enforce those rights. Many recent developments in IP law will also be covered.	U	4, 16	focused
66236	Dietrich College Interdisciplinary	Introduction to Environmental Ideas	By recognizing that environmental problems are themselves complex and require insights from both scientific and social perspectives, the University-wide Minor in Environmental Studies urges students to gain proficiency in different disciplinary habits of thinking about environmental problems. This course fulfills a requirement for the University-wide Minor in Environmental Studies. This course will introduce students from any undergraduate major at CMU to key methods and approaches for inquiry in the framework of Environmental Studies. Students will build up their ability to recognize and apply diagnostic criteria; understand key principles and terms; and take part in an informed discussion about ways of seeing, and creating interventions for environmental problems as social and scientific challenges. There are no pre-requisites for this course. Students will develop skills and apply concepts to different scenarios of environmental crisis. Preference for course registration goes to students already declared for the Minor in Environmental and Sustainability Studies.	U	4, 12, 13	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
66320	Dietrich College Interdisciplinary	Internship	Internships-for-credit allow students to apply course-based knowledge in a non-classroom setting, under joint supervision and evaluation by an on-site supervisor and a faculty sponsor. Approved internships must conform to college guidelines for internships-for-credit, and are available by permission only arranged through the Associate Dean's Office in Baker Hall 154.	U	4, 8, 17	focused
66400	Dietrich College Interdisciplinary	Dietrich College Senior Honors Colloquium	The purpose of this course is to provide students admitted to the Dietrich College Senior Honors Program with a shared set of intellectual and practical sessions that will enhance their senior honors thesis experience. The course will consist of seven bi-weekly 80-minute meetings. Each will be organized around a theme and related topics that are relevant to the senior honors thesis experience, and that take advantage of both the high caliber and interdisciplinary diversity of the course members. Guest visitors will also be a common feature of the course. Topics could include: the meaning(s) of "honors;" getting started and keeping pace: the ebb and flow of an independent research project (including how to recognize and avoid procrastination; forging a successful relationship with your thesis advisor - the myth of the separation of research from writing; writing for publication); ethics in research; "interdisciplinarity," or the "unity of knowledge;" funding for research; preparing for and delivering effective presentations; intellectual property rights, and human subjects policy. Guest speakers invited to address and engage class members in discussion/debate of topics that lend themselves to interdisciplinary discussion and debate (e.g., stem cell research, which calls into play science, ethics, etc.). Course requirements will include mandatory attendance, occasional readings (where appropriate), acting as co-leader for at least one session, and - at course's end - (a) a written, formal preliminary thesis statement and action plan, endorsed by the thesis advisor, and tentatively, (b) a brief oral presentation of the thesis statement and plan to the class + thesis advisors during the last class meeting. All students will participate in critiques of fellow-students' presentations and plans.	U	4, 17, 16	focused
66402	Dietrich College Interdisciplinary	Dietrich Leadership Development Seminar	The Dietrich Leadership Development Seminar is for juniors and seniors in Dietrich College wishing to advance their understanding of leadership theory and practice and to develop their own skills in this regard, while creating a context for their lifelong leadership development. The course is predicated on a six pillar model proposing that ideal leaders must at once be visionary, ethical, engaging, tactical, technical - including sub-expert conversancy in realms beyond their own expertise, and reflective - including both personal mindfulness and assessment against clear metrics. In this context, the course includes a focus on strategic planning, teamwork, cultural awareness, conflict resolution, risk management, sustainability and personal welfare, professionalism, personal financial planning, and ongoing professional development. The course includes an attendance requirement and active engagement in class discussion, assigned readings/videos/podcasts (2 hours/week), self-selected experiential opportunities (2 hours/week), reflective journaling (2 hours/week), three hour-long one:ones per semester with the instructor, special guests who are leaders in various occupational and service domains, a mid-term, a final, and a final presentation. The course includes case studies and role plays to amplify the learning experience. The course is limited to twelve students, with registration based on approval of the faculty member.	U	4, 17, 8	focused
66501	Dietrich College Interdisciplinary	H&SS Senior Honors Thesis I	This is the first semester of a two-semester sequence that culminates in an original, year-long independent research or creative project. The course is open only to students who have been approved for entry into the Dietrich College Senior Honors Program. Thesis topics are selected by faculty and students, and reviewed and approved through the senior honors program application process. Dietrich College senior honors students are also required to participate in the annual Meeting of the Minds Undergraduate Research Symposium, offering either an oral presentation or poster session based on their senior honors thesis	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
66502	Dietrich College Interdisciplinary	H&SS Senior Honors Thesis II	This is the second semester of a two-semester sequence that is the culmination of an original, year-long independent research or creative project. The course is open only to students who have been approved for entry into the Dietrich College Senior Honors Program. Thesis topics are selected by faculty and students, and reviewed and approved through the senior honors program application process. Dietrich College senior honors students are also required to participate in the annual Meeting of the Minds Undergraduate Research Symposium, offering either an oral presentation or poster session based on their senior honors thesis	U	4, 17, 9	focused
66503	Dietrich College Interdisciplinary	Dietrich College Senior Honors Thesis	This course is a one-semester alternative to the two-semester Dietrich College Senior Honors Thesis sequence 66-501/66-502. The course is open only to students who have been approved for entry into the Dietrich College Senior Honors Program, and whose senior honors thesis project has been approved as a one-semester undertaking. Thesis topics are selected by faculty and students, and reviewed and approved through the senior honors program application process. The thesis culminates in an original independent research or creative project. Dietrich College senior honors students are also required to participate in the annual Meeting of the Minds Undergraduate Research Symposium, offering either an oral presentation or poster session based on their senior honors thesis.	U	4, 17, 9	focused
67100	Dietrich College Information Systems	Information Systems First Year Colloquium	This IS Colloquium will provide a broad introduction to the Information Systems Program, an exciting program newly joint between Carnegie Mellon's Dietrich College and Heinz College. The IS Colloquium is open only to first-year IS students and is led by an IS academic advisor who facilitates discussions on the field of IS, the program curriculum, and careers, in addition to co-curricular experiences such as internships and study abroad. Because the flexible nature of the IS program encourages students to explore their own interests, we place an emphasis on highlighting a variety of areas within the field of IS. Guest lecturers will include leaders in IS research including Dietrich and Heinz faculty and IS alumni. Additional speakers include the IS career consultant and various campus representatives. Discussions will include students' progress in their first semester, as well as guidance in course planning, creating student Spring semester class schedules, and their overall four-year plan.	U	4, 17, 8	focused
67102	Dietrich College Information Systems	Concepts of Information Systems	This course is an introduction to the world of Information Systems (IS). It introduces the core concepts of IS and its importance in the modern world around us. The course provides a general overview on the implications of information systems on organizations, by describing what an information system is; presenting some IS applications and discussing the implications of information systems on social and human aspects. The course also provides an initiation to essential information systems skills such as team work and project management.	U	4, 9, 17	focused
67240	Dietrich College Information Systems	Mobile Web Design & Development	The Mobile Web Design and Development course provides a solid web design and development foundation focusing on responsive and user-centered design, and client-side components. Students explore the current standards and best practices of web design. Throughout the course, students work with HTML5, CSS3, Twitter Bootstrap, and Javascript, and learn how the various web components function together. The course utilizes a hands-on approach to guide students through learning and understanding the design and development process. This course is primarily designed for students with minimal technical experience. By the end of the course, students will be able to plan, design, and implement a basic functioning mobile web site/ app.	U	4, 9, 17	focused
67250	Dietrich College Information Systems	The Information Systems Milieux	Information systems (IS) are changing work practices, reshaping organizations, transforming cultures, and giving new meaning to the ways we see the world. This course is designed to help students understand the role of IS in the enterprise and the means by which these systems are created, utilized and maintained. The course will focus on enterprise information architecture including the components of enterprise strategy, business, application, information, and infrastructure layers. This course provides not only a framework for understanding information systems, but also a language to identify their dynamic complexities and interdependencies.	U	9, 4, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
67262	Dietrich College Information Systems	Database Design and Development	Data driven decision making is a core process of organizations. In this class students will study the principles of database management systems, their design, and development. Recent alternatives to the classical relational model will also be examined. This course is a required professional core course and is open only to sophomores in the IS major who have completed 67-250 or equivalent.	U	4, 17, 9	focused
67272	Dietrich College Information Systems	Application Design and Development	This course provides students with the concepts and techniques to design and develop software applications, and to understand the design process. Students will learn the importance of user-centered design and will develop a prototype of a web application as a course project. In the process of developing the application, students will learn how to design and create relational databases, how to acquire competency in new programming languages quickly, how to use the Model-View-Controller pattern to develop software applications, how to ensure technical quality in software development, and how to apply principles of user-centered design. This course is a required professional core course and is open only to sophomores and juniors in the IS major who have completed 67-250 or equivalent.	U	4, 9, 17	focused
67279	Dietrich College Information Systems	Introduction to Geographical Information Systems	Geographical Information Systems (GIS) allow us to visualize information that uses location. Through displaying layers of information in computer generated maps, we can see, analyze, understand and explore spatial patterns and relationships in new and novel ways. People in many different fields use Geographical Information Systems in their work: for visualizing the environment, human development, demographics, traffic and transportation, public health and many more. In this course, students will learn the basics of GIS through hands-on experience with popular mapping tools. Sources of data, principles of coordinate and projection systems and elementary geo-analysis techniques will be included. Upon completion of the course, students will have the background to begin using GIS techniques in their own areas of interest and will be prepared for further study in advanced GIs courses.	U	4, 11, 17	focused
67306	Dietrich College Information Systems	Special Topics: Management of Computer and Information Systems	The course provides the overall knowledge of how Information Technology departments are managed in organizations of all sizes. It is about the technology people, the necessary best practice processes, and how innovation occurs transforming organizations in the way they operate and compete.	U	9, 17, 8	focused
67319	Dietrich College Information Systems	Global Technology Consulting Groundwork	This course is by invitation only for participants in the Technology Consulting in the Global Community program. For information on the program and how to apply, see http://cmu.edu/tcingc.	U	9, 8, 13	focused
67329	Dietrich College Information Systems	Contemporary Themes in Global Systems	Globalization and outsourcing of information systems (IS) is a mainstay of the business environment. The decision to outsource software services to providers in distant places has many risks and thus careful management of critical success factors is essential. Likewise, products and services are being developed and delivered by teams of people in diverse locations working together. Management of these sourcing models and human capital relationships will be an increasingly important skill for students expecting to fully participate in the emerging IS marketplace of the 21st century. This course introduces the effective fundamentals of global project management and the mechanics of sourcing arrangements including offshore outsourcing. Students will also examine the effects of human diversity and cross-cultural considerations in the creation, use and management of information systems.	U	4, 8, 9	focused
67331	Dietrich College Information Systems	Technology Consulting in the Global Community	This course is by invitation only for participants in the Technology Consulting in the Global Community program. Admitted ONLY BY Permission of Instructor	U	9, 4, 8	focused
67338	Dietrich College Information Systems	Information & Grid Design	Whether you create, oversee, or want practice in solving problems through grid systems for websites, responsive applications, slide presentations, or data visualizations, this course provides the skills needed to communicate using the interplay of image, text, and typography in grid environments.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
67352	Dietrich College Information Systems	Electronic Business and Design Thinking	The objective of this course is to give students a good understanding on how e-business is conducted and managed including opportunities, limitations, issues, and risks. E-business applications require certain technological infrastructures and other support mechanism in areas of business-to-consumer, business-to-business, and consumer-to-consumer. Topics will cover the technologies, skills and business concepts that surround the emergence of electronic business and the impacts of applying these information technologies to different commercial processes from both an operational and strategic perspective. The course will also explore the problems surrounding electronic business such as security, privacy, intellectual property rights, legal liabilities and global issues. The course provides a contemporary exposure to concepts and practices associated with a new and dynamic digital environment in the real business world. The information technologies associated with the delivery of Internet sites as well as internal operations will be discussed. After completion of this course, students are expected to have appropriate level of knowledge, skills, and concept of the digital operations in a modern business world.	U	4, 9, 8	focused
67354	Dietrich College Information Systems	Sustainability in the Digital Age	Environmental, economic, and societal challenges are affecting the sustainability of many communities around the globe. Given its multidisciplinary foundation, IS presents an important potential for enabling adaptation and mitigation to these challenges. IS innovation could also play a prominent role in transforming unsustainable problem spaces into sustainable and resilient systems. What is needed is sustainability minded IS professionals to lead such transformation. This course introduces students (future IS leaders) to the fundamentals of sustainability in the 21st century. It includes topics on Green IS, Smart Cities, and the Information Economy. The course invites students to proactively reflect on sustainability issues and their effects on policy and leadership. In such reflection, students are encouraged to consider various case-based scenarios where they evaluate challenges to sustainability and developed innovative, strategic, practical, and rigorously supported IS based solutions.	U	9, 12, 8	focused
67357	Dietrich College Information Systems	Healthcare Analytics and Big Data	The objectives of this course are: (1) to provide a sound understanding of how healthcare analytics helps to re-engineer the complex processes that drive return on investment and lower medical costs and (2) how the big data revolution is accelerating value and innovation in healthcare. Topics in healthcare business intelligence (BI) to be covered include how data quality and data governance improve the quality of healthcare, architectural implications of BI, technology management, and how BI facilitates evidence-based medicine and effective clinical decision support. Besides gaining hands-on lab experience with BI technologies and tools used in real-world healthcare organizations, students will also work on a group project to understand better the challenges that big (and unstructured) data present to traditional clinical database systems.	U	9, 4, 17	focused
67364	Dietrich College Information Systems	Practical Data Science	From empirical, to theoretical, to computational science, we are at the dawn of a new revolution---a fourth paradigm of science driven by data. Like archaeological remnants, data, by its very nature, is a marker of what happened in the past. How can data be used to better understand this past and what is happening in the present? How can data be leveraged to forecast what will happen in the future? Better still, how can data be used to mold what should happen in the future? In this course we will study descriptive, predictive, and prescriptive methods by which data can be used to gain insight and inform actions of people and organizations. The real excitement of data science is in the doing. This is an application oriented course requiring skill in algorithmic problem solving. We will use Python based data science tools. While prior programming experience with Python will be helpful the course will strive to be self-contained. If you have not programmed in Python before, you need to be comfortable programming in some language (e.g., Ruby, R, Java, C++) and will need to come up to speed with the Pythonic way of problem solving.	U	11, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
67373	Dietrich College Information Systems	Information Systems Consulting Project	In this course, students design and implement a usable information system for a client. The client may be affiliated with the university, government, business, or non-profit agency. Students will be assigned to teams to work on these projects, and will produce operational, fully documented and tested, computer-based information systems. The projects will be supervised by CMU faculty and, when possible, by project clients.	U	12, 9, 17	focused
67443	Dietrich College Information Systems	Mobile Application Design and Development	This course provides students with the concepts and techniques to design and develop innovative mobile applications. Students will develop a series of smaller mobile applications in weekly lab sessions (using either iOS or Android frameworks). In addition, student teams will build a larger mobile application, as part of a semester-long project, that fills a demand not effectively met in the current market. In the process of developing these applications, students will gain a strong understanding of mobile application development, mobile-centered design, the process of creating and testing innovative application design, and larger principles of software engineering. In weekly labs, students can choose either the Swift/iOS or Kotlin/Android track to complete course work, but lectures will primarily use Swift to illustrate larger points of software architecture and engineering. This course is open only to juniors and seniors in the IS major who have completed 67-373 or by special permission of the instructor.	U	9, 4, 17	focused
67445	Dietrich College Information Systems	Seminar in IS: Intelligent Agents	The purpose of this seminar is to study users' interactions with and perceptions of intelligent conversational agents and similar systems. This research seminar is intended for junior and senior students in Information Systems and other university departments who wish to engage in research at the intersection of Information Systems, Psychology and Artificial Intelligence. In this course, students will be reading, analyzing and discussing academic papers under this theme. Students will also be working on developing their research proposals with continuous guidance and feedback. This course has four main objectives: 1) build and expand students' research skills through in-depth analysis, critique and discussion of academic papers, 2) develop students' knowledge on current research articles and topics under the theme of users' behavior and interactions with intelligent conversational agents and similar systems, 3) apply a range of frameworks and theories that describe how users perceive and interact with technology, and 4) locate primary and secondary sources of information on course related topics and critique and use them as evidence in students' papers or to create arguments in support of the discussion. Students are expected to have some prior knowledge in Statistics (36-200 and 36-202) or equivalent courses.	U	4, 17, 9	focused
67476	Dietrich College Information Systems	Innovation in Information Systems: Health Care	Healthcare information systems are intended to improve patient outcomes while reducing the cost of clinical care. However, with the highest per person healthcare expenditures, the United States ranks low in healthcare quality compared to other countries. Although healthcare information systems are improving, challenges persist because information workflow, human interface design, and interoperability are not emphasized. In this course, students will learn to solve real-world healthcare information systems challenges in a team-based format. Juniors and Seniors	U	9, 4, 1	focused
67738	Dietrich College Information Systems	Information & Grid Design	Whether you create, oversee, or want practice in solving problems through grid systems for websites, responsive applications, slide presentations, or data visualizations, this course provides the skills needed to communicate using the interplay of image, text, and typography in grid environments.	G	4, 9, 8	focused
67743	Dietrich College Information Systems	Mobile Application Design and Development	This course provides students with the concepts and techniques to design and develop innovative mobile applications. Students will develop a series of smaller mobile applications in weekly lab sessions (using either iOS or Android frameworks). In addition, student teams will build a larger mobile application, as part of a semester-long project, that fills a demand not effectively met in the current market. In the process of developing these applications, students will gain a strong understanding of mobile application development, mobile-centered design, the process of creating and testing innovative application design, and larger principles of software engineering. In weekly labs, students can choose either the Swift/iOS or Kotlin/Android track to complete course work, but lectures will primarily use Swift to illustrate larger points of software architecture and engineering.	G	9, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
69110	Physical Education	Personal Fitness	This course will be a conditioning course prescribed partially by the individual with assistance from the instructor to insure that the desired results will be achieved or at least pursued correctly. Individual goals will be the main concern. Stretching, aerobics, weight training and nutrition will be discussed.	U	4, 3, 17	focused
69151	Physical Education	Introduction to Yoga	This course is designed for the beginning yoga student who wants to gain a solid foundation of yoga poses and the benefits a yoga practice has to offer. The course is also for those who have experience in Yoga and want to practice and improve their basic skills.	U	4, 8, 1	focused
70100	Business Administration	Global Business	The course is for non-Tepper BA students and provides a comprehensive overview of business, including how enterprises determine goals, strategies and operational tactics in competitive markets and the increasingly global environment. It covers different types of businesses - entrepreneurial and corporate, industries, markets, and economies. Students learn about the role of business in society, the various functional areas that make business work, and how companies develop plans and processes to achieve their goals for customers, shareholders, and employees. The course has special emphasis on providing a broad overview of business to augment students' major area of study for their professional development. Declared Tepper BA students are not eligible to enroll.	U	9, 8, 4	focused
70104	Business Administration	Business Leadership Endeavor I	Business Leadership Endeavor (BLE) is a required 3-mini course sequence (70-104,70-204,70-304) offered to undergraduate business students only. BLE 70-104 is the first mini of the BLE course sequence. Each previous mini will serve as a pre-requisite for the next in sequence. BLE introduces students to their leadership journey via four development frameworks: student development, personal development, professional development, and community development. BLE 70-104 will introduce students to the fundamental building blocks required for their development. Students will learn to develop and improve habits, sharpen personal and professional development skills, and develop meaningful networks.	U	4, 8, 17	focused
70106	Business Administration	Business Science	This course is Business Science. It will prepare Tepper Business Majors for the study of business to come. The focus on the class is on the three core "lenses" used to study and advance the science and practice of business. We will study: the mathematics of optimization, economics, and the behavior in and of organizations. These are the foundations of the disciplines of finance, accounting, marketing, ..., that follow in the curriculum. Over the course of the semester, we will tackle complex multifaceted business problems. Think of examples like, bike-share and the "share-economy," international trade and supply chain, AI and the impact on work. For each case, we will work to apply the three lenses. A pillar for the semester is that business problems are not siloed in narrow disciplines, we must draw resources from disciplines across the entire university. The second pillar of our class is solving all problems - across all of society - requires your understanding of business science.	U	4, 8, 9	focused
70110	Business Administration	Business Computing	Students will learn how individuals and organizations use computing technologies to support and improve their businesses. At an individual level, students will build their skills with Microsoft Excel and other personal productivity tools. At an organizational level, the class looks at ways in which businesses of all sizes and types leverage computing technologies to run their businesses more efficiently, make better business decisions, and create new business opportunities. This course is reserved for first-year Business students; others may enroll by special permission from the UBA office only.	U	4, 8, 9	focused
70122	Business Administration	Introduction to Accounting	This course provides the knowledge and skills necessary for the student to understand financial statements and financial records and to make use of the information for management and investment decisions. Topics include: an overview of financial statements and business decisions; the balance sheet, the income statement, and the cash flow statement; sales revenue, receivables, and cash; cost of goods sold and inventory; long-lived assets and depreciation, and amortization; current and long-term liabilities; owners' equity; investments in other corporations; an introduction to financial statement analysis and international issues dealing with financial statements.	U	8, 4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
70201	Business Administration	Professional and Service Projects	This course is designed to improve your effectiveness as a professional and engage you in activities by which you can explore the value of service in professional development. Professional service broadens one' opportunities to improve their skills and knowledge through practice, helps one to develop networks of high social capital, allows one to experience and explore activities vital to the development of leadership abilities, and promotes awareness about community involvement and social responsibility in one's professional life. The primary mechanism to achieve this will be via participation in a semester long group project focused on analyzing an issue/opportunity within an organization of your choice and designing an implementation plan along with recommendations. Course topics will expose you to skills that are needed in order to be successful in the real world.	U	4, 8, 9	focused
70204	Business Administration	Business Leadership Endeavor II	Business Leadership Endeavor (BLE) is a required 3-mini course sequence offered to undergraduate business students only. BLE 70-204 is the second mini of the BLE course sequence. Each previous mini will serve as a pre-requisite for the next in sequence. BLE introduces students to their leadership journey via four development frameworks: student development, personal development, professional development, and community development. BLE 70-204 will help students assemble their fundamental building blocks in a way that supports their continued development. The course will continue to emphasize the importance of strong habits, meaningful networks, and ongoing skill development. Students will begin to connect this development with personal and professional goals.	U	4, 8, 17	focused
70207	Business Administration	Probability and Statistics for Business Applications	Elementary ideas in probability, statistics, and data analysis are presented in the context of their importance to modern business management.	U	4, 9, 8	focused
70208	Business Administration	Regression Analysis	This class focuses on the statistical analysis of the relationship between two or more random variables. In particular, we examine the estimation of the conditional mean of the dependent variable as a function of independent variables using linear regression. We draw on statistical theory to determine the precision of our estimates and to conduct inference about the population, and we examine a number of applications to business, finance, and economics throughout the course.	U	8, 9, 17	focused
70246	Business Administration	Innovation & Entrepreneurial Mindset	This course is designed to introduce students to the theory and frameworks used to develop and implement innovative solutions to societal and entrepreneurial problems. The curriculum incorporates the latest on innovative behavioral traits and frameworks with a highly experiential format to expose undergraduate students to out of the box thinking. For example, the instructor would use the lecture section of the class to explain the behavioral techniques that lead to innovative solutions (based on the Innovator's DNA by Clayton Christensen). Teams of 3-6 students each would then examine a problem and be asked to generate 3 potential solutions and a proposed solution, using the techniques presented. Volunteers from the local Carnegie Mellon and entrepreneurial community will serve as mentors and judges, thereby providing a real world learning and networking experience. Ultimately, the best solution will be selected, using a shark tank format. While the selection of a winning solution will be fun for the class, the students will be graded on their having demonstrated the theory & techniques presented in class. Each week will address a new and important topic related to the innovative & entrepreneurial mindset. Weekly format will include one day of lecture and one day of application of the theory introduced in a fun and competitive format.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
70257	Business Administration	Optimization for Business	This course provides a mathematical foundation for the application of optimization techniques to business problems, as well as the practical implementation of these methods. Mathematical optimization techniques have been applied for decades in the context of logistics, supply chain management, and strategic planning, with great success. In recent years, the application of mathematical optimization has penetrated, and in some cases (re-)defined, many other areas such as the (financial) service industry, analytical marketing, health care, and web-based businesses. In this course, the most important methods and techniques underlying mathematical optimization are studied. These include linear programming, integer programming, and nonlinear programming as basic mathematical methodologies. Based on these, we also consider methodologies for particular problem classes such as network models and traveling salesman problems. During the course we will emphasize mathematical modeling, that is, creating a mathematical description that reflects a given practical problem described in words. Motivated by these mathematical models, we then discuss the necessary mathematical techniques for finding optimal solutions. Lastly, we consider the solution of these problems using optimization software, i.e., we represent the mathematical models in Excel and use Excel Solver to compute an optimal solution.	U	9, 8, 1	focused
70305	Business Administration	Business Leadership Endeavor III	Business Leadership Endeavor (BLE) is a required 3-mini course sequence offered to undergraduate business students. BLE 70-305 is the third mini of the BLE course sequence. BLE introduces students to their leadership journey via four development frameworks: student development, personal development, professional development, and community development. BLE 70-305 will continue to build strong personal and professional skills as students get closer to their professional endeavors. Students will be applying learned skills in and out of the classroom and will begin to see the how the assembled skills are beneficial to themselves and others. This course will emphasize the importance of continued broad growth and lifelong learning.	U	4, 8, 9	focused
70311	Business Administration	Organizational Behavior	This course examines the factors which influence individual, group and firm behavior in the context of the workplace. Topics covered include perception, group behavior, decision making, motivation, leadership and organizational design and change.	U	8, 4, 9	focused
70321	Business Administration	Negotiation and Conflict Resolution	This course will complement the technical and diagnostic skills you have learned in other courses. A basic premise of the course is that, while you will need analytical skills to discover optimal solutions to problems, you will also need a broad array of negotiation skills to implement these solutions and make sure that they are truly effective. Your long-term effectiveness - both in your professional and personal life - is likely to depend on your negotiating abilities. This course will give you the opportunity to develop these skills experientially and to understand the analytical frameworks that underlie negotiations.	U	4, 9, 8	focused
70332	Business Administration	Business, Society and Ethics	This course explores the impact of business on society and society's impact on business. The external forces affecting business entities include legal requirements and legal rights, community expectations, ethical norms and cultural factors.	U	8, 16, 9	focused
70339	Business Administration	FinTech	The financial services industry is a leader in the use of information technology. Firms in banking, securities, investments, insurance and financial marketplaces are among the most information intensive and innovative users of technology. The course will examine the role and potential of technology in this industry. The course begins with a description of the financial markets, specifically equity, foreign exchange, and derivatives, and the systems that enable them. It considers exchanges, ECNs, ATS's Order Management Systems, Straight through Processing, Fix Protocol, and post trading clearance and settlement. It covers the design, evaluation and execution of popular trading strategies that are used by professionals in the various markets. There is increasing interest, in particular, on systematic trading strategies and execution systems because of their scalability and transparency. The course covers both Algorithmic and High Frequency Trading and analyzes issues regarding latency, scalability, and reliability.	U	9, 8, 1	focused
70340	Business Administration	Business Communications	Business Communications develops and sharpens your written, oral, and interpersonal communication, introducing you to common forms of professional writing and speaking in specific business situations. The course explores crucial rhetorical issues that impact your ability to communicate and achieve your objectives as a business leader.	U	9, 17, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
70341	Business Administration	Team Dynamics and Leadership	Organizations have greatly expanded their use of teams to accomplish a wide variety of objectives. Teams develop new products, provide professional services, and start new businesses. Temporary teams are frequently assembled to make difficult decisions, solve cross-functional problems, and generate new ideas. Advances in communication technology allow people dispersed across the globe to collaborate virtually, creating many new opportunities and challenges for leaders of such teams. This course will provide you the knowledge and skills to communicate in teams and to lead them effectively. It will help you better communicate in and lead teams and organizations. You will learn both effective leadership practices as well as how to avoid common leadership mistakes. Our readings reflect both the scientific and practice literatures and class exercises, cases, and projects provide the opportunity to apply what you learn.	U	9, 4, 8	focused
70342	Business Administration	Managing Across Cultures	This course is designed for students who expect to do business in other countries or work with people from other cultures. It provides an intellectual framework for understanding other cultures (and eventually one's own), as well as detailed studies of particular countries. It discusses how culture defines organizations, contracts, personal relationships, attitudes toward authority, time and space, ethics, wealth, and subcultures, and how these affect business. Student teams study a culture of their choice and make presentations, based on interviews and literature research.	U	4, 17, 8	focused
70345	Business Administration	Business Presentations	In this course, students prepare, present, discuss, and critique different oral presentations currently practiced in business. Topics include developing your presence in a professional setting; projecting credibility, professionalism, and authority; and planning presentations to influence business audiences. Assignments and cases will cover informative and persuasive presentations, which will vary from term to term and may include talks such as product pitches, team-driven strategic plans, and state-of-the-company addresses.	U	4, 8, 9	focused
70350	Business Administration	Acting for Business	Perception may or may not be Reality. But Perception is, in fact, what Influences people. This experiential communications course focuses on how you as a Leader can choose to more effectively express yourself & influence others using practical, hands-on tools from Acting in professional, live Theatre. You will choose to effectively Influence your Listeners' perception of you through the use of: "Action"; Assertiveness, Confidence & Expressiveness (ACE); the Visual, Aural & Temporal Communication Tools; and the incorporation of The Seven Steps Of Effective Influence (or core competencies).	U	9, 8, 4	focused
70353	Business Administration	Financial Regulation in the Digital Age	The financial crisis has focused attention on the role of regulation for our financial system and the broader economy. The course will address the foundations of regulation (why regulate?) from various perspectives within the context of a market economy, highlighting the sources of market failure (such as externalities, adverse selection, and natural monopoly) and potential remedies (such as taxes and fees, disclosure, price regulation, guarantees). The conflicting goals among regulators (and why we have multiple regulators) and their impact on the meaning of regulation will be considered along with regulatory competition/arbitrage. Portions of the course will tackle relatively broad questions such as: Why regulate? What is the law of unintended consequences? What is the objective of a policy advocate? Are regulators and regulatory policies a systemic risk? Are our markets rigged? How can regulators enhance the predictability and credibility of their policies? How costly were government guarantees during the financial crisis? Should we bar insider trading? Should regulations be determined and motivated based upon cost-benefit analysis? How can we evaluate the success or failure of particular regulations and whether they have achieved their objectives? How does the Dodd-Frank Act promote financial stability? What basic aspects of the financial crisis did Dodd-Frank not address? (Lecture, 3 hours). Minimum grade standard of "C" applies only to economics courses.	U	8, 4, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
70366	Business Administration	Intellectual Property and E-Commerce	The course is intended to instruct students on the creation of the Internet and the World Wide Web, including the creation of the Domain Naming System. The course will provide an understanding of how the WWW "Web" operates (from its creation to the present), how the laws of various contries interact with the Web; how issues of privacy are addressed and the role of private parties and government in monitoring privacy. The course will examine how intellectual property is created and protected; who owns the property; and the role of ownership of the intellectual property interacts with antitrust laws. The course examines how contracts are formed and administered on the Web by entities created to minimize taxes and personal liability risks for the owners/shareholders of those entities.	U	4, 8, 1	focused
70371	Business Administration	Operations Management	This course is an introduction to production and operations management that covers both manufacturing and services. It deals with strategic issues (design of flexible supply), planning issues (capacity management), and operational issues (inventory management and information). The linkage between strategy and tactics will be emphasized. The students will learn concepts and tools that will help them to manage from the "boardroom" to the "toolroom."	U	9, 4, 17	focused
70374	Business Administration	Data Mining & Business Analytics	Interest in big data analytics has skyrocketed recently. The recent explosion in large-scale high-resolution data enables managers to ask and answer questions regarding businesses and consumers at a whole new level. Managers are faced with data about businesses and consumers that are growing faster than they can be utilized. Data mining enables business to extract useful consumer behavior and preferences from seemingly tremendous and unorganized data, which then can be utilized for data-driven decision-making and competitive advantage. Applications can be found in e-commerce, sales, marketing, finance, operations, etc. In this hands-on introductory class, you will learn the basic concepts and techniques of data mining in addition to when and how they can be applied to improve many aspects of business and consumers' welfare. Throughout the course, we will use R, a powerful open-source statistical language and one of the main tools in data mining and business analytics, fast becoming a mainstream tool. With this tool, you will learn about variety of exploratory and predictive data analytics techniques such as Naïve Bayes classifier, nearest neighbor approaches, decision trees, clustering algorithms, etc.	U	1, 9, 8	focused
70381	Business Administration	Marketing I	An introduction to the nature and fundamentals of marketing and consumer behavior. Topics include an analysis of the economic and psychological factors influencing buyer behavior, marketing research, market segmentation, and the development of marketing programs (new product, price, advertising and distribution decisions).	U	8, 17, 9	focused
70385	Business Administration	Consumer Behavior	Marketing, in particular, begins and ends with the consumer from determining consumer needs to ensuring customer satisfaction. In this course, we will explore the most recent scientific research in marketing, psychology, and behavioral economics on judgment and decision-making. We will develop your ability to understand and influence what people want, how people decide what and when to buy, and whether people will be satisfied or dissatisfied with their decisions. These psychological insights are particularly useful for marketing strategy, brand positioning, and marketing communication decisions, but also yield insight into common biases in judgment and decision making, beyond marketing, to which you would otherwise fall prey. Why people are willing to drive across town to save $5 on a tank of gasoline, for example, when they would not drive a minute to save $5 on a refrigerator. We will discuss some of these applications in class. In addition, we will examine the methodology of market research (specific to consumer behavior) to build the tools you will need to interpret and base decisions on it.	U	9, 8, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
70391	Business Administration	Finance	Firms create value by making good investment decisions. Finance is the field of management science tasked with making this happen. It is a set of tools with which firms identify good investments and decide how to pay for them. Paying for them ultimately involves getting money from households. Therefore, finance also describes the investment decisions of households and the resulting allocation of the economy's resources across firms and time. This course is the introductory finance course in the undergraduate business program. The main topics covered in the course are Financial Markets, Net Present Value, The Objective of the Firm, Discounted Cash Flow, Portfolio Theory and the Cost of Capital, The Efficient Markets Hypothesis, The Capital Structure of the Firm, and Business Valuation. Time permitting, the course will also provide an introduction to option markets and derivative securities. Upon completing the course a student will be able to consider a large and complex business problem, make some assumptions, structure the firms' cash flows in a spreadsheet, calculate the value of different solutions to the problem, and make a decision.	U	8, 9, 4	focused
70395	Business Administration	Funding Entrepreneurial Ventures	So you want to do a startup and you know that you need funding. There are multiple ways to fund a new venture: bootstrapping, economic development, angels, venture capitalists. The question is what are these funders looking for in an early stage investment? What is important to them? How do they decide which companies to invest in and which not? This class looks at funding from the funder's point of view and provides the student with a framework of the investment process: investment criteria, sourcing, selection, due diligence, deal structure, valuation, post investment involvement. Real companies seeking funding are used for the final project in which students will be expected, as investment teams, to make investment decisions and convince their fellow investors (the class) to join them (or not). This is a highly interactive and project class. There will be multiple guest speakers.	U	8, 4, 9	focused
70398	Business Administration	International Finance	International Finance is an elective course designed to give students the opportunity to analyze real-world problems in international capital markets. Topics covered include: exchange rate determination and quoting, international parity relations, foreign exchange hedging strategies using forwards and options, foreign exchange exposure management, international bond market, currency swap market, global equity market, international portfolio risk assessment and performance measurement. Students develop problem solving and communication skills with presentations and critical discussions of case studies.	U	4, 8, 9	focused
70401	Business Administration	Management Game	This course is designed to integrate the managerial concepts and techniques studied earlier in the curriculum and to focus on elements of organizational structure and behavior. Student teams assume the role of top management of firms competing in an international economy simulated by the Carnegie Mellon University Management Game. Each team is responsible to a Board of Directors comprised of alumni of the MBA program and business masters students. Emphasis is placed on the development and implementation of sound organizational decision structures as well as the formulation of effective competitive strategies. The course is reserved for senior-year business majors and additional majors.	U	4, 8, 9	focused
70415	Business Administration	Introduction to Entrepreneurship	This course is an introductory course designed to provide an overview of entrepreneurship, develop an entrepreneurial frame of mind and learn the fundamentals of lean start up development. Students, Sophomore year or higher, interested in founding or contributing to a start-up venture, regardless of areas of discipline (engineering, design, business, computer science, music, drama and more), are welcome. Students can expect to gain a basic understanding of functional areas such as customer discovery, sales, business planning, risk management, venture funding, and more. This class also features "The Apprentice Experience" that affords the students the opportunity to develop, produce and sell a product in a real world and competitive environment. The class is structured in a lecture, followed by applied workshop format. Students will be learning the fundamental tools required for any start up and then applying said tools and techniques to analyze and execute real world business opportunities. Interdisciplinary teams will generate ideas and explore their potential as viable businesses. Numerous student teams have completed this class with real world opportunities. Lectures, guest speakers, case studies, and exercises will also be integrated.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
70416	Business Administration	New Venture Creation	This course exposes students to the nuances of financing new ventures, getting them started legally and marketing their products or services. Students pull together all the ideas and information from different functional aspects of their projects into coherent and persuasive mini-business plans that serve as roadmaps for building their businesses; and useful instruments to find sufficient financing for the new ventures, so that they can convince the outside world that these opportunities are viable, with substantial potential for success.	U	4, 9, 8	focused
70422	Business Administration	Managerial Accounting	The purpose of this course is to prepare students to make sensible business decisions using accounting information. An essential topic in the course is the measurement and allocation of costs to assist decision making in organizations. The course covers standard topics in cost accounting, such as cost behavior and relevant costs, and connect these to broader issues in microeconomics, decision theory, corporate finance, and operations management. Classes contain a mixture of conventional lectures, problem solving, business cases, and simulations.	U	4, 8, 9	focused
70424	Business Administration	Corporate Financial Reporting	This course is designed to strengthen your ability to correctly interpret financial statements and their accompanying disclosures. The course is aimed at anyone whose career might involve working with accounting and other financial data, and should be especially useful for those interested in consulting and financial analysis. Throughout the semester we will discuss the key disclosure rules in the United States, the communication methods available to managers, managers' incentives and ability to exert discretion over reported earnings, and the interplay between a company's corporate strategy and its financial reporting policies and practices. The course emphasizes a number of topics of recent interest to the business community including the quality of earnings, mergers and acquisitions, corporate innovation and R&D, post-employment benefits, executive compensation, and intangible assets.	U	8, 9, 1	focused
70427	Business Administration	Fundamentals of Banking Institutions	What is the main role that banks play in the economy? Are banks safe and trustworthy? What are the main business areas of a modern full service bank and how does it make profit in each area? What are the main risks that they face and how do they manage those risks? How can the public assess the risks a bank faces and measure its performance? Does the regulation governing banking address these risks effectively? The main goal of this course is to examine these and related questions by focusing on the analysis of banks' financial reports. Students will learn how accounting and disclosure rules for financial instruments and institutions convey detailed information that is useful to evaluate their risks and performance. Potential limitations of the current financial reporting requirements facing banks will also be discussed. The course covers crucial topics in modern banking strategy and regulation such as interest rate risk, provision on loan losses, fair value accounting for financial instruments, repos, securitization, capital requirements, and derivative and hedge accounting.	U	8, 4, 10	focused
70428	Business Administration	Financial Statement Analysis	This course is about fundamental analysis using financial statements. We develop and apply technologies for understanding and identifying firm activities that generate shareholder value and for developing valuation benchmarks. The ultimate goal of such analysis is to aid the security valuation and risk analysis exercises. This course is intended to help students establish a good foundation and introduce students the basics of equity and debt analysis techniques. Taking Finance (70-391) before this course is recommended, though not a formal prerequisite.	U	4, 8, 9	focused
70430	Business Administration	International Management	This course uses the case method to examine the strategic and operational issues in management practice and decision-making that are important in operating a business that spans national borders. Topics include political and economic risk assessment, technology transfer, cultural analysis, negotiation, social responsibility, organization structure, supply chain management and trends in foreign direct investment and their impact on developing strategies for entering and becoming successful in international markets.	U	8, 9, 1	focused
70440	Business Administration	Corporate Strategy	This course is designed to provide the student with a general management perspective and an understanding of the total business enterprise. It builds upon previous course work in functional areas and provides insights and analytical tools which a general manager should have in order to plan and implement successful business strategy. The student will analyze complex business problems and formulate realistic strategic solutions. Emphasis is placed on the practical application of business theory by the student in his/her business career.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
70443	Business Administration	Digital Marketing and Social Media Strategy	This course explores issues related to digital and social media marketing. This is a hands-on class where you will use real world data, case studies and participation in Google online marketing challenge. The following topics would be covered in detail: (a) Search Engine Optimization - you will learn how search engines, keyword auctions, and search engine marketing work, and how to optimize your pay per click advertisement efforts; (b) Econo-Mining - you will also learn on how firms are getting or can get useful information from user generated content using text mining and opinion mining capabilities to drive their product development, placement and advertisement decisions. Using real world data you will analyze whether the traditional approaches for driving advertising or product development strategy are in alignment with what you learn from user generated content; (c) Social Media Marketing - you will learn how to design a social media marketing campaign. What are the key ingredients that make such campaigns successful? How do you run a campaign for a viral product; (d) Forecasting Demand Using Publicly Available Online Search Data - you will learn how to build better forecasting models for demand using Google search data (Google Trends and Insights); (e) Wisdom of the Crowds: we will cover how to design crowdsourcing contests, what and how to crowdsource. You will also learn what prediction markets are, how they work, how to design them, when prediction markets are successful and what kinds of questions are best suited for prediction markets.	U	4, 9, 8	focused
70447	Business Administration	Client Consulting Project: Strategic Management of the Enterprise	This is a project course for senior business majors offered in partnership with real-world client companies. Teams of five to six students are given a client to engage with for the semester on a specific consulting project assignment. Students will learn about the challenges of the multi-dimensional and complex issues faced by managers, including learning the concepts and skills to handle ambiguity, perform a persuasive data analysis, and communicate the findings effectively. Students will develop a deeper understanding of how organizations can co-ordinate and leverage synergies across a range of disciplines by effective deployment of technologies and organizational structures and processes. Teams will have an opportunity to work with clients on a wide mix of problems spanning multiple functions, including strategy, operations, technology and marketing. Specifically, teams will address issues such as big data, mobile application strategies, supply chain, digital media, complexity management, health care delivery models and healthcare marketing strategy. Regular meetings with the instructor will be scheduled to guide teams during client engagement and co-ordinate with the executives at their client company. The deliverables will be in the form of a report/prototype and a final presentation to the client's executive team. No classes to attend, but weekly team meetings with times to be determined. The course is for undergraduate business seniors only, and enrollment is by special permission.	U	4, 9, 17	focused
70453	Business Administration	Business Technology for Consulting	In this course, you will learn to how to effectively lead and undertake information system analysis and design projects. In doing so you will develop your 'intellectual toolbox' for business technologies consulting by learning to apply specific tools and techniques such as BPMN and Agile development methodologies. You will practice applying these techniques on a variety of case studies, examples, and a substantial semester-long project. Beyond the concrete analysis and design techniques, you will develop a set of work practices and habits of thought that should serve you well in your consulting career. This will be a very hands-on course in which you will largely learn by doing. Most class sessions will include a combination of some presentation by the instructor, some discussion (possibly of a case study), and exercises to practice working with the day's tools and concepts. Homework assignments, in-class presentations, and a semester-long term project are essential parts of the course.	U	4, 9, 17	focused
70455	Business Administration	Modern Data Management	Data drives modern business. Transactional data systems keep the world's economy operating smoothly by tracking and processing the movement of bits, money, atoms, and attention across the planet. Analytic systems help managers understand and optimize their businesses. Robotic systems (both physical machines and software bots) are automating a tremendous amount of the work that has historically been done by people. In this course you will learn to use a set of data management tools to capture, manage, analyze, and understand data so to help your organization do business better, faster, and cheaper.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
70460	Business Administration	Mathematical Models for Consulting	This course will cover a wide variety of mathematical models and techniques that are used by consultants and lie at the heart of modern decision-support systems. We will discuss the benefits and limitations of different models and follow a practical spreadsheet-based approach to provide hands-on experience with Excel Solver. The course will build on the knowledge you have gained from the prerequisite courses; we will develop your model-building skills, explore some technique-oriented skills such as linear, integer, and nonlinear programming, and experiment with heuristic solution methods. While going through different models and techniques, we will also see real-world examples of how these models are actually used in practical business environments.	U	4, 9, 8	focused
70462	Business Administration	Uncertainty and Risk Modeling	This is a hands-on course on modeling and simulation of business systems under uncertainty. It takes the perspective of the consultant whose job is to analyze existing or potential business processes and provide recommendations for managerial decision-making. Recognizing that most businesses are subject to high levels of variability, risk and uncertainty, it will adopt a stochastic approach to characterize the behavior of business systems and processes, and explore the effects of alternative decisions in this context. Two modeling methodologies will be covered: (i) stochastic modeling, and (ii) stochastic simulation. Examples are drawn from different managerial domains, such as supply chain management, risk management, marketing, and project management. The lectures, homework assignments, exam and term project will focus on modeling, computational, and analytical skills. Computational implementations will be done in Excel using the @Risk add-in (during the first half of the course to build simple simulation models) and the Arena software (during the second half of the course to build more complex models based on discrete-event simulation). Course objectives: 1. Recognize uncertainty in business systems and processes, and their impact on managerial decisions (e.g., demand uncertainty, financial risk, etc.) 2. Model uncertainty and risk quantitatively using probabilistic tools 3. Specify probabilistic distributions for inputs from available data 4. Generate probabilistic distributions for outputs and relevant performance metrics (e.g., average, standard deviation, distribution tails) 5. Develop computational models to simulate complex stochastic processes using appropriate software 6. Communicate outputs of uncertainty analyses and implications for managerial decision- making.	U	4, 8, 9	focused
70467	Business Administration	Machine Learning for Business Analytics	This course introduces students to the machine learning tools and software that drive modern predictive analytics in business settings. Students will gain an understanding of a variety of popular machine learning algorithms including linear and logistic regression, random forests, and neural networks. Each algorithm will be introduced with real-world business applications, and students will learn to implement these algorithms on data. The course is taught in the programming language R (prior programming experience is not required).	U	4, 15, 9	focused
70469	Business Administration	End to End Business Analytics	Deriving value from business data is an integrative process. It requires putting together the virtuous pipeline of using the data to derive descriptive and diagnostic inferences, building explainable predictive models and incorporating them in prescriptive decision making. This course charts this process end-to-end by describing and integrating common tools for modeling uncertainty, machine learning, and optimization in the context of common applications from finance, marketing and operations. The coursework is based on data-driven cases that will have students analyzing data from real business applications to derive their own insights, predictions and decisions and communicating them effectively. The course will prepare students for careers in consulting and any form of business data analysis in any functional area.	U	4, 8, 9	focused
70471	Business Administration	Supply Chain Management	This course will discuss basic issues in supply chain management to answer how a company should design its supply chain and how a company should administer its operations policy to satisfy the company's business strategy. We will also examine how firms interact with other entities within the supply chain, and how one can turn the system/network of entities across the supply chain to its own advantage by capturing economic surplus effectively. Special attention will be paid to analyzing the strengths and weaknesses of supply chains from a strategic, qualitative level. At the same time, we will also learn how to make effective trade-offs in operational decisions from a tactical, quantitative level.	U	8, 9, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
70477	Business Administration	Real Options: Creating Value Beyond NPV	Real options analysis is an approach to the management of operational assets that exploits managerial flexibility in decision-making and combines it with market-driven valuation of cash flows. This approach assumes that managers use all the available information when making decisions. It is thus particularly useful when managing projects that involve dynamic and state-contingent choices among alternatives (options), especially of a strategic nature. Examples include investing in and developing new products or technology, expanding/reducing manufacturing capacity, and suspending/resuming production. The valuation of financial options is the conceptual basis of real options management (but this course does not assume prior knowledge of this topic). Real options analysis extends this fundamental market-driven valuation approach to a much broader spectrum of business applications that feature dynamic decision-making. It thus contrasts the standard net present value rule used by static discounted cash flow analysis. The resulting managerial decisions and asset valuations can be very different when real options analysis is used rather than static discounted cash flow analysis. The course learning objectives are to (i) develop the students ability to take an unstructured problem and implement real options analysis in a structured manner; (ii) integrate market-driven valuation and dynamic decision-making techniques into a practical, yet rigorous, business analytics toolkit; and (iii) provide examples of successful practice and applications in a variety of industries.	U	9, 4, 8	focused
70480	Business Administration	International Marketing	This course is designed to provide students with a basic understanding of global marketing opportunities, key issues, and strategies. It introduces the main characteristics of international markets and addresses the impact of global environmental factors (economic, social, legal, and cultural) on marketing decisions such as market entry, product development, pricing, promotion, and distribution. The objective of the course is to help students acquire knowledge of major international marketing concepts and develop cross-cultural sensitivities and skills that would enable them to identify, analyze, and solve international marketing problems.	U	8, 4, 12	focused
70481	Business Administration	Marketing Research	The purpose of this course is to teach multiple research techniques used in marketing. This course is an applied marketing course that gives insight into how various techniques are used in marketing research firms. There are three projects and a final. The first project is designed to teach students about research survey methods. The second is an experiment in which the whole class is involved. The third, an individual project, is designed to teach quantitative research techniques.	U	4, 17, 9	focused
70482	Business Administration	Pricing Strategy	Pricing is a critical marketing decision which enables a firm to translate customer value into profit. This course provides a first survey of pricing concepts. Instead of discussing pricing in isolation, we focus on the interplay between pricing and other aspects of marketing, such as positioning, branding and advertising. To this end, we provide a formal treatment of pricing concepts in the framework of game theory. Finally, we also discuss non-pricing tools that firms can use in order to capture customer value. Specifically, we cover cases wherein firms generate a profit while keeping their services free, a phenomena that is widely observed among Internet firms. This course has no formal prerequisite, but a willingness to study formal (i.e., mathematical) models is assumed. Any previous exposure to microeconomics analysis and game theory will be helpful.	U	9, 17, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
70483	Business Administration	Advertising and Marketing Communications	"Integrated Marketing Communications (IMC) is a strategic business process used to plan, develop, execute, and evaluate coordinated, measurable, persuasive brand communication programs over time with consumers, customers, prospects, and other targeted, relevant external and internal audiences." (source: Don Schultz). IMC is specifically designed to ensure that all communication strategies and messages are unified and integrated across all channels and, importantly, begin with the consumer/customer. It is critical that marketers understand the limitations of marcom tactics as well as how to best leverage and integrate marcom tactics for the strongest, most consistent and authentic brand voice in the targeted marketplace. The entire IMC process is driven by the customer, and in the case of our discussions in this class, the consumer. The course is designed to help students understand the integrated marketing communications model, the strategy and tools of the marketing mix and what makes an iconic brand. The course is designed in five sections: Part One focuses on understanding brands - iconic brands, terminology and types of branding. Part Two focuses on the understanding of consumer behavior - one of the, if not the most critical part of understanding marketing. Brands are built and defined in the minds of consumers. Part Three focuses on IMC and the framework used by brand management to develop strategy, and understand audience segmentation and brand positioning to drive IMC. Part Four focuses on understanding the IMC tactics available to marketers including advertising, social media and digital marketing, events and public relations. Part five concludes with the deeper study of an iconic brand.	U	4, 9, 17	focused
70484	Business Administration	Data Science for Finance	This course first reviews the fundamentals of Financial Data Science with Python. The course then introduces several financial applications that rely heavily on data analytics, including 1) Algorithmic Trading, 2) Quantitative portfolio management, and 3) "Smart" beta and performance analysis. The class uses tools from statistics, machine learning and natural language processing.	U	4, 8, 9	focused
70485	Business Administration	Product and Brand Management	Product managers are essentially the "CEO" of the product line. Brand and product management provides strategic vision and leadership for the product and service, both 1) understanding the market opportunity and what must be done for successfully delivering on the brand promise and 2) leading across the organization, often without authority, to achieve that success. Product/service success in a dynamic market is subject to many factors, including marketplace needs, reactions and activities of competition, the strategy and change within one's own firm, operating and financial constraints, demand forecast uncertainty, and more. By taking this course, you will learn the principles of product and brand management and understand what it is like and what it takes to be a successful marketing leader.	U	8, 9, 10	focused
70492	Business Administration	Investment Analysis	Investment analysis provides you the concepts and tools used to analyze publicly traded securities, and you will learn how to these tools to real world situations. The course is organized as a tour of the different kinds of securities used in the financial markets. You will analyze how security prices are determined, the relations between the prices of different securities, their risks and returns, and how to choose a portfolio or strategy from different asset classes.	U	8, 9, 4	focused
70493	Business Administration	Valuation and Financial Modeling	This course focuses on valuing companies. Students will learn theoretical valuation frameworks and then apply them practically. The class will cover a range of valuation approaches including discounted cash flow analyses, price multiples, real options and the venture capital method. The class will be very hands-on - we will be building valuation models in excel in-class and in case assignments using real-world data such as company financial statements and stock prices. This is particularly useful for students considering careers in investment banking and private equity. We will focus not just on learning valuation methods but also understanding the assumptions that underlie them. We will ask when such assumptions are trivial and when they can lead to large errors. We will value a variety of companies including Ferrari, WhatsApp and Snap Inc.	U	4, 8, 9	focused
70495	Business Administration	Corporate Finance	Students develop an advanced financial perspective on how firms make investment, financing, and management decisions. The course starts with simple net present value rules and builds the theoretical framework to address more sophisticated issues and problems including risk management, mergers, acquisitions, executive compensation, corporate governance, and dividend payout policies. Theory is supplemented with numerous case study examples.	U	8, 9, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
70499	Business Administration	Internship	Students doing a business-related internship for academic credit may enroll in this course for three units with a pass/no pass grade. Students must submit an internship agreement form to the instructor for approval prior to the start of the internship. A summary writing assignment must be submitted after the internship in order to receive credit. Enrollment with special permission.	U	4, 8, 17	focused
70500	Business Administration	Honors Thesis I	Business students with outstanding academic records may undertake an Honors Thesis. The topic is of the student's choice but must have some original aspect in the question being explored, the data set, or in the methods that are used. It must also be of sufficient academic rigor to meet the approval of a faculty advisor with expertise in the project's area. Students enroll each semester in a 9-unit independent study course with their faculty advisor for the project (70-500 in the fall and 70-501 in the spring). Students and their faculty advisor develop a course description for the project and submit it for approval as two 9-unit courses to the BA department. Enrollment by permission of the BA Program.	U	4, 17, 8	focused
70501	Business Administration	Honor Thesis II	Business students with outstanding academic records may undertake an Honors Thesis. The topic is of the student's choice but must have some original aspect in the question being explored, the data set, or in the methods that are used. It must also be of sufficient academic rigor to meet the approval of a faculty advisor with expertise in the project's area. Students enroll each semester in a 9-unit independent study course with their faculty advisor for the project (70-500 in the fall and 70-501 in the spring). Students and their faculty advisor develop a course description for the project and submit it for approval as two 9-unit courses to the BA Director. Enrollment by permission of the BA Program.	U	4, 17, 8	focused
73060	Economics	Economics: BaseCamp	This short course will launch you into the economics intellectual space and get you thinking like an economist. Through a series of presentations by some of CMU's great economics thinkers you will learn how economic reasoning harnessed to data can lead to better policy design and better business decision making. Presentations may cover the economics of bitcoin and crypto-currency, online market design, financial crises, the future of work, how to become involved in economics research, healthcare, the environment, and other topics. The presentations will be curated by one of CMU's research economists and there will be plenty of opportunities for discussion and debate. The course will also introduce you to the CMU approach to economics and map out the CMU economics major landscape.	U	8, 1, 9	focused
73102	Economics	Principles of Microeconomics	A one-semester course that teaches the fundamentals of microeconomics. Students will learn how microeconomic analysis can explain market successes, market failures, how government intervention might improve outcomes, and the role of asymmetric information. In addition to an investigation of firm behavior and consumer behavior, attention will be paid to: Game Theory, Behavioral Economics, Economics of Time and Risk, Economics of Information, Experimental Economics, and Auctions and Market Design. Students will also learn how to integrate basic data analysis and statistics. Not open to students who have received credit for 73-100. While there are no mathematical pre-requisites for this course, students are encouraged to enroll in 73-102 after they've passed 21-111. (Lecture, 2 hours; Recitation, 1 hour).	U	4, 8, 9	focused
73103	Economics	Principles of Macroeconomics	A one-semester course that teaches the fundamentals of macroeconomics. Students will learn how macroeconomic analysis can explain national economic activity and how government intervention might stabilize an economy. Topics include: defining and measuring national wealth, economic growth, credit markets, unemployment, interest rates, inflation, and the monetary system. Additional emphasis will be paid to: long-term economic development, political economy, financial crises and topics that are central to contemporary macroeconomic debates such as the impact of technological change, migration, and trade on the macroeconomy. Students will access macroeconomic databases, and then use basic statistics to describe and isolate empirical patterns in macro-data. Not open to students who have received credit for 73-100. (Lecture, 2 hours; Recitation, 1 hour).	U	8, 1, 10	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
73111	Economics	Internship I	The goal of this course is for you to reflect critically and constructively on your internship and to help you identify a path that will allow you to build on your internship experiences. By permission of the Undergraduate Economics Program. Open only to declared Economics, Economics and Mathematical Sciences, and Economics and Statistics majors.	U	4, 8, 17	focused
73112	Economics	Internship II	The goal of this course is for you to reflect critically and constructively on your internship and to help you identify a path that will allow you to build on your internship experiences. By permission of the Undergraduate Economics Program. Open only to declared Economics, Economics and Mathematical Sciences, and Economics and Statistics majors.	U	4, 8, 17	focused
73160	Economics	Foundations of Microeconomics: Applications and Theory	Intermediate level microeconomics stresses individual economic decision making in the context of consumer behavior, and firm behavior, and examines in detail how these behaviors interact in competitive market settings to answer the fundamental economic questions of what gets produced, how it gets produced, and who gets the output. These component theories of economic behavior are the building blocks of higher level economic analysis, as well as the basis for examining empirically-motivated deviations from classical economic predictions. As such, most of the course will be methodological in its focus, although many of the problems in the weekly assignments will involve everyday personal and business applications. The experiments we do will also give students hands-on experience with the phenomena that economic theories try to explain. (Lecture, 3 hours: Recitation: 1 hour). Minimum grade of "C" required in all economics pre-requisite courses.	U	8, 4, 9	focused
73210	Economics	Economics Colloquium I	Economics majors meet weekly for discussions about current research by faculty or students, presentations on economics from economists outside academia, and expository talks on selected economics topics not part of the usual curricula. The colloquium provides students with opportunities to grow personally and intellectually by introducing them to campus resources (including special interest to undergraduates such as preparation for graduate school) and using the economic toolbox to examine current economic topics in the press. It is recommended that students take this course during the sophomore year so that economics majors realize the range of resources that exist on campus. (Colloquium, 1 hour)	U	4, 8, 1	focused
73230	Economics	Intermediate Microeconomics	This course is a multivariate calculus-based study of microeconomics. Topics in partial equilibrium analysis include supply and demand, consumer theory, theory of the firm, profit maximizing behavior, monopoly theory, and perfect competition. The course concludes with an introduction to general equilibrium analysis and the welfare laws. (Lecture, 3 hours; Recitation, 1 hour). Minimum grade of "C" required in all economics pre-requisite courses.	U	1, 4, 8	focused
73240	Economics	Intermediate Macroeconomics	Through macroeconomic models built upon microeconomic foundations, insights are developed into economic growth processes and business cycles. Topics include aggregation and measurement, national income, business cycle measurement, economic welfare theorems and social inefficiencies, the effect of government fiscal policy upon employment and productivity, and the relationship between investment, interest rates and economic growth. (Lecture, 3 hours; Recitation, 1 hour). Minimum grade of "C" required in all economics pre-requisite courses.	U	8, 1, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
73265	Economics	Economics and Data Science	This course is at the intersection of economic analysis, computing and statistics. It develops foundational skills in these areas and provides students with hands-on experience in identifying, analyzing and solving real-world data challenges in economics and business. Students will learn the basics of database and data manipulation, how to visualize, present and interpret data related to economic and business activity by employing statistics and statistical analysis, machine learning, visualization techniques. Students will also be taught a programming language suitable for data science/analysis. Databases will include leading economic indicators; emerging market country indicators; bond and equity returns; exchange rates; stock options; education and income by zip code; sales data; innovation diffusion; experimental and survey data and many others. Applications will include analyzing the effectiveness of different Internet pricing strategies on firm sales, the impact of taking online classes on a worker's earnings, the relationship between regional employment and trade policies; constructing investment risk indices for emerging markets; predicting employee productivity with machine learning tools; assessing health (sleep and exercise) improvements associated with wearable technologies (e.g. FitBit). Additionally, the course will provide students with communication skills to effectively describe their findings for technical and non-technical audiences. Minimum grade of "C" required in all economics pre-requisite courses.	U	4, 8, 9	focused
73270	Economics	Professional Communication for Economists	A writing course specifically designed for second-year and third-year Economics majors and additional majors. Students gain experience with technical writing techniques and skills needed for both their eventual professional careers. The course emphasizes both individual and group projects. (Seminar, 3 hours). Minimum grade of "C" required in all economics pre-requisite courses.	U	4, 8, 17	focused
73274	Economics	Econometrics I	This course will provide an introduction to the analysis of economic field data. The first part of the course will discuss how data is generated and how this affects the inferences we can make. In particular, we will look at the difficulties of working with field data and learn how non-random sampling leads to poor inferences. We will then move on to some simple statistical techniques, in particular OLS and its extensions as well as Maximum Likelihood Estimators. We will also learn about the large sample properties of these estimators. At the end of the course, students should be able to understand what inferences can be made with field data and some basic statistical techniques that can be used to uncover patterns in the data. (Lecture, 3 hours; Recitation, 1 hour). Pre-reqs for those entering Fall 2018 and later: (21256 or 21259 or 21268 or 21269) and (73265) and (73230 or 73240). Students pursuing the ECOMTH or MTHECO degrees may enroll in 73-274 after the completion of 36-225. Minimum grade of "C" required in all economics and statistics pre-requisite courses.	U	4, 8, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
73315	Economics	Market Design	In this course, we consider the design of various market mechanisms. We learn the typical causes of market failures and why we need to design new markets. For each topic, we start with a case study of a problem, develop a theory to address it, and consider its possible solutions. The class is roughly divided into three parts: matching, auctions, and further topics. In the first part, we study markets where there is no money and no prices (matching markets). Instead, we have people preferences over possible matching outcomes. Examples include placing doctors in residency positions, assigning students to schools, and assigning kidneys to transplant patients. We will learn algorithms that have desirable theoretical properties and are often used in practice. In the second part, we consider the problem of allocating of single or multiple goods (a house, a painting, or the rights to a natural resource such as oil or timber) using auctions. We discuss how different types of auctions work in theory and practice. We will look at the auctions used in financial markets to sell treasury bills, the auctions used by Google, Microsoft and Facebook to sell advertising, and the auctions used by governments to sell radio spectrum licenses. In the third part, we consider further important topics of market design. We will look into problems of high-frequency trading, digital markets, the allocation of refugees among European countries, and proposals to fix market for carbon pollution permits. An important goal of the course is to show how recent achievements of game theory and mechanism design lead to important practical applications and to inspire you to use these ideas in your life and workplace. (Lecture, 3 hours). Minimum grade of "C" required in all economics pre-requisite courses.	U	4, 13, 8	focused
73328	Economics	Health Economics	This course will teach the student to use economic analysis to understand critical issues in health care and and health policy. We will address issues such as the following: 1. What factors best explain the level and rate of growth of U.S. health expenditures? 2. Does the recent high rate of growth of U.S. health care expenditures make U.S. firms less competitive in international markets? 3. What are some of the likely consequences (intended and unintended) of the proposed reforms to Medicare? 4. Can physicians induce demand for their services? 5. What are the impacts of managed care on the health care system? 6. Do strong affiliations between physicians and health plans hurt competition? (Lecture, 3 hours). Minimum grade of "C" required in all economics pre-requisite courses. Junior standing required.	U	8, 4, 1	focused
73332	Economics	Political Economy	The Political Economy course looks at how groups within society organize for self-governance. The course will begin with an overview of the ways groups of individuals organize for collective action by examining different types of political institutions, the role these institutions play in different contexts, and the economic and strategic micro-foundations that give rise to these institutions. We will then examine the empirical evidence supporting this taxonomy, leading to a more detailed consideration of institutions that moderate social conflicts. The next part of the course examines basic results in social choice theory: the Condorcet paradox, Arrow's Impossibility Theorem, majority rule, median voter theories, and modern treatments of probabilistic voting models that allow for strategic behavior, misrepresentation of preferences, and policy manipulation. From this basis for understanding collective choice mechanisms, we will then examine how institutions foster cooperation, looking in detail at problems of public goods allocation, redistribution of income, the organization of clubs - interest groups and lobbying associations --in the private sector, and the organization of legislative activities in the public sector. In our examination of voting and electoral mechanisms, we will look at practical applications of the theory to problems of gerrymandering, voter suppression, and propaganda that feature prominently in contemporary political discourse.	U	8, 1, 16	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
73338	Economics	Financial Crises and Risk	This course provides an in-depth examination of the causes of financial crises as well as what governments can do to prevent them or at least reduce their cost. The course is designed to to provide an understanding of individual attitudes towards risk and individual decision making about savings and investment under uncertainty, and to use this understanding to evaluate the various economic roles played by financial institutions in helping individuals manage risk, especially those roles which may lead to economic instability and crises. In addition, the course may cover bubbles and swindles, especially when these spillover to the broader macroeconomy; the role of information in banking in normal times and in bank runs; crisis resolution techniques; and the extensive history of attempts to improve regulation so as to reduce the frequency and cost of crises. (Lecture, 3 hours). Minimum grade of "C" required in all economics pre-requisite courses.	U	8, 10, 4	focused
73341	Economics	Within the Firm: Managing through Incentives	We live in an exciting age of information and knowledge when inspiring employees within a firm becomes increasing important. Aligning the objectives of workers, managers, and owners by providing them with appropriate incentives becomes an emerging paradigm in the modern business world. In this course, we learn how to reason about incentives between managers and employees, between managers and owners, and within a team of co-workers. We cover a broad range of topics including objective and subjective performance measurements, relative performance evaluations, relational contracts, and executive compensation. The course relies on business case discussions, rigorous theoretical material, and numerous class activities. (Lecture, 3 hours). Minimum grade of "C" required in all economics pre-requisite courses.	U	8, 4, 9	focused
73347	Economics	Game Theory Applications for Economics and Business	An introduction to the theory of non-cooperative games with an emphasis on economic applications. After an initial examination of two-person, zero-sum games, the notion of a Nash equilibrium in an n-person, non-cooperative game is considered. Existence of and refinements to the equilibrium concept are discussed in the context of both normal and extensive form games. Economic applications may include various topics, including Cournot and Bertrand oligopoly models, general competitive exchange equilibrium, and free rider problems. (Lecture, 3 hours). Minimum grade of "C" required in all economics pre-requisite courses.	U	8, 4, 1	focused
73348	Economics	Behavioral Economics	This course introduces students to behavioral economics which is a subfield of economics that incorporates insights from other social sciences, such as psychology, into economic models and aims to explain the anomalies challenging some of the classical economic models. (Lecture, 3 hours). Minimum grade of "C" required in all economics pre-requisite courses.	U	4, 8, 1	focused
73352	Economics	Public Economics	In this course, students analyze the role of governments in market economies and their impact on the behavior and welfare of citizens. Reasons for government intervention in markets are examined in light of some of the economic challenges faced by modern societies in an increasingly globalized marketplace. Topics include: taxation and expenditure policies, externalities and market failure, social security, public assistance and income redistribution programs. There will also be some coverage of the role of local governments in the economy with respect to such issues as crime, urban development and education. (Lecture, 3 hours). Minimum grade of "C" required in all economics pre-requisite courses.	U	4, 8, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
73353	Economics	Financial Regulation in the Digital Age	The financial crisis and the digitalization of the financial markets have focused attention on the role of regulation for our financial system and the broader economy in recent years. Among the settings that are especially important in the digital economy are electronic trading, big data, algorithms, robo investing, winner-take-all economics, securities offerings, property rights and cyber assets. The course will address the foundations of regulation ("why regulate?") from various perspectives within a market economy, highlighting the sources of "market failure" (such as externalities, adverse selection, and natural monopoly) and potential remedies (such as disclosure, taxes and fees, antitrust prohibitions, privacy requirements, price regulation and guarantees). The conflicting goals among regulators (and why we have multiple regulators) and their impact on the meaning of regulation will be considered along with regulatory competition/arbitrage. Portions of the course will tackle relatively broad questions such as: Why regulate? Why could it be beneficial to restrict permitted algorithms? Are our markets rigged? How suitable are antitrust remedies in the digital era? What is the law of unintended consequences? What is the objective of a policy advocate? Are regulators and regulatory policies a systemic risk? How can regulators enhance the predictability and credibility of their policies? Should we bar insider trading? Should regulations be determined and motivated based upon cost-benefit analysis? How can we evaluate the success or failure of particular regulations and whether they have achieved their objectives? To what extent did the Dodd-Frank Act ensure financial stability?(Lecture, 3 hours). Minimum grade of "C" required in all economics pre-requisite courses.	U	8, 4, 1	focused
73359	Economics	Benefit-Cost Analysis	The evaluation of public private sector projects. The theory of benefit-cost analysis and related techniques, such as cost-effectiveness analysis. Attention is given to such issues as valuing goods and services that are not normally traded in the marketplace (e.g., the value of an individuals life) and the social rate of discount. Applications are considered in detail. (Lecture, 3 hours). Minimum grade of "C" required in all economics pre-requisite courses.	U	4, 8, 9	focused
73365	Economics	Firms, Market Structures, and Strategy	This course is concerned with the economic analysis of industrial markets that are not perfectly competitive. The effects of imperfect competition on firms' decisions (pricing, location, advertising, research and development, among others) are reviewed. Implications of these effects in terms of public policy are also discussed from a variety of perspectives. Finally, applications to actual markets are considered. (Lecture, 3 hours). Minimum grade of "C" required in all economics pre-requisite courses.	U	8, 9, 17	focused
73366	Economics	Designing the Digital Economy	This class analyzes the economics of e-commerce and technology. It will identify the critical features that differentiate the technology ?firms from traditional industries, and examine the implications for business strategy. The class will discuss topics such as network effects, switching costs, and platform markets. To complement the economic theory, we will also consider a case study of a fi?rm each week. These have three aims: to provide applications for the concepts developed in the lectures; to inform you about different industries; and to help develop your written, rhetorical and presentation skills. Minimum grade of "C" required in all economics pre-requisite courses.	U	8, 9, 4	focused
73374	Economics	Econometrics II	The material covered in this course extends from the material covered in Econometrics I (73-274). The course will include both the theory behind the methods and a hands-on analysis of actual data, providing students the tools for both research and industry jobs. Theories and methodologies covered will include: nonlinear regression models, qualitative response regression models, panel data estimators, simultaneous-equation models, and time series. (Lecture, 3 hours; Recitation, 1 hour). Minimum grade of "C" required in all economics and statistics pre-requisite courses.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
73408	Economics	Law and Economics	This course will provide a broad overview of the scholarly field known as "law and economics." The focus will be on how legal rules and institutions can correct market failures. We will discuss the economic function of contracts and, when contracts fail or are not feasible, the role of legal remedies to resolve disputes. We will also discuss at some length the choice between encouraging private parties to initiate legal actions to correct externalities and governmental actors, such aas regulatory authorities. Extensive attention will be given to the economics of litigation, and to how private incentives to bring lawsuits differ from the social value of litigation. The economic motive to commit crimes, and the optimal governmental response to crime, will be studied in depth. Specific topics within the preceding broad themes include: the Coase Theorem; the tradeoff between the certainty and severity of punishment; the choice between ex ante and ex post sanctions; negligence versus strict liability; property rules; remedies for breach of contract; and the American rule versus the English rule for allocating litigation costs. (Lecture, 3 hours). Minimum grade of "C" required in all economics pre-requisite courses.	U	8, 16, 1	focused
73421	Economics	Emerging Markets	The goal of the course is to study the economic and institutional forces that spur or hinder business activity and growth in emerging economies. The course is designed to provide both quantitative and theoretical foundations for the study of emerging markets. On the quantitative side, the course will introduce students to the empirical analysis of the growth forces and obstacles facing emerging markets by providing numerous hands-on opportunities using real-world data. On the theory side, the course will provide an overview of fiscal, trade and exchange rate policies adopted in emerging economies. The course will focus on successful emerging economies such as India, China, S. Korea and Ireland with broader lessons and comparisons drawn from developed countries. The course will also look at distressed economies, such as North Korea and Venezuela analyzing the challenges and opportunities faced by these developing nations today. (Lecture, 3 hours). Minimum grade of "C" required in all economics pre-requisite courses.	U	8, 4, 9	focused
73423	Economics	Forecasting for Economics and Business	Governments forecast economic indicators (e.g., GDP, job growth, etc.); businesses forecast sales; portfolio managers forecast asset return; the list goes on. Accurate forecasts are critical to robust organizational decision-making. This course will introduce students to modern methods for forecasting in economic and business applications. Topics covered include Bayesian, statistical, and online learning approaches to forecast construction and assessment, univariate and multivariate time series models and algorithms, and principled combination of multiple methods and data sources along with subject matter expertise to improve performance. Methods will be motivated by applications in macroeconomics, technology, marketing, and finance, with cases drawn from forecasting processes in a variety of business and government organizations. Students will implement forecasting methods in R, including in a real data forecasting competition.	U	8, 4, 9	focused
73427	Economics	Sustainability, Energy, and Environmental Economics	Topics related to sustainability and the environment are increasingly important to businesses, policymakers, and the general public. This course applies the tools of economic analysis to the problems of environmental protection, natural resource management, and energy production and use. The course will begin by introducing students to how an economist approaches problems of market failure commonly found in environmental contexts. Next, we will explore models that characterize solutions to such environmental issues. We will then address questions regarding measurement, policy design, and, finally, we will apply the tools that we have developed during the semester to the problems of climate change, and the optimal management of non-renewable resources. (Lecture, 3 hours). Minimum grade of "C" required in all economics pre-requisite courses.	U	13, 7, 8	focused
73500	Economics	Tepper College Honors Thesis I	Economics majors with outstanding academic records and intellectual promise will be given the opportunity to undertake original research under the direction of individual faculty members. Research topics are selected by students and approved by faculty. Prerequisites: Senior standing in the Economics Program and permission of the Economics faculty. Minimum grade of "C" required in all economics and statistics pre-requisite courses.	U	4, 17, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
73501	Economics	Tepper College Honors Thesis II	Economics majors with outstanding academic records and intellectual promise will be given the opportunity to undertake original research under the direction of individual faculty members. Research topics are selected by students and approved by faculty. Prerequisites include: Senior standing in the Economics Program and permission of the Economics faculty. Minimum grade of "C" required in all economics and statistics pre-requisite courses, and a minimum grade of "B" required in Tepper College Honors Thesis I.	U	4, 17, 8	focused
76100	English	Reading and Writing in an Academic Context	76-100 is an academic reading and writing course for multilingual students, especially those who are not native speakers of English or who consider English to be their weaker language. The course emphasizes reading comprehension strategies for reading a variety of text types in English (e.g., journalism, textbook selections, popular press arguments, and academic journal articles). Throughout the semester, students use these sources to write summaries and short position papers. The course introduces students to readers' expectations for North American rhetorical style at the sentence, paragraph, and whole text or genre levels. Within the course we discuss explicit genre and linguistic norms for writing in academic English so that writers can connect with their readers. Students who take this course qualify through an online placement test that is administered through the university prior to the fall semester. (All sections are offered MWF). Each 76-100 course is structured by the reading and writing objectives of the course as well as a vocabulary for writing in English, but some courses present different themes (or content) in their readings.	U	4, 17, 9	focused
76101	English	Interpretation and Argument	Interpretation and Argument is a foundational, inquiry-driven writing course that introduces students to a variety of strategies for making compositional decisions in writing and communication. Within the course, students learn genre-based skills applicable to a variety of different fields. Students use a comparative genre analysis method to learn how to use models to take on new writing tasks, including an academic research proposal and a research article that contributes to an ongoing academic conversation. Faculty who teach 76-101 typically select texts, ranging from scholarly texts, journalism, and film, about an issue so that students can identify interesting questions for their own research projects. Students should expect explicit, research-based instruction, practice, and reflection to build knowledge in controlling their writing processes and writing clear, well-supported, reader-oriented arguments. Because the course emphasizes the real stakes of communicating with readers and listeners, students share with their peers both low and high stakes written work within an interactive and collaborative classroom environment. Due to the limits of our schedule, we are unable to meet each student's individual preferences for course topics, but we do offer a wide variety from which to choose. Section descriptions are posted at: http://www.cmu.edu/hss/english/first_year/index.html	U	4, 17, 9	focused
76102	English	Advanced First Year Writing: Special Topics	76-102, Advanced First-Year Writing courses are designed for students who have demonstrated an understanding of academic writing that most incoming freshmen have not. Because of the students' level of preparedness, the First-Year Writing Program provides intensive, advanced courses for students to work closely with senior faculty within the English department. Advanced courses assume that students have established strong reading and synthesizing skills, as well as a demonstrated interest in writing and communication, prior to entering Carnegie Mellon. The course topics shift each semester. Students enroll through special invitation. Class size for 76102 is capped at 19 and there are no prerequisites for the course. Advisors will be notified if their students qualify for the advanced writing courses.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76106	English	Writing about Literature, Art and Culture	This mini course (one of two minis students can choose to fulfill their FYW requirement) uses artistic, literary, and cultural texts (e.g., poetry, short story, lyrics, video clips) to introduce students to a variety of academic reading and writing practices that enable students to engage with texts and write about them with complexity and nuance. Within the course, we will discuss texts and evidence from multiple perspectives. We will examine how literary and cultural scholars write about texts (defined broadly), how they make claims, provide reasoning, and use textual support to argue for particular ways of seeing cultural objects. Throughout the semester, students will draw upon prior strategies and develop new ones for close reading and for critical analysis in order to produce their own thesis-driven arguments about why texts matter. We will consider and write about the extent to which these reading strategies are relevant for other kinds of reading and analysis by comparing texts from a variety of different disciplinary contexts.	U	4, 17, 11	focused
76107	English	Writing about Data	Our lives are increasingly shaped by writing that involves numbers: newspapers routinely report the latest medical fads; politicians support their political agendas with both dubious and credible statistics; parents use data to decide where to buy a house and where to send their kids to school. This course (one of two minis students can choose to fulfill their FYW requirement) focuses upon interpreting and making arguments using mainly numerical data but also qualitative data. We will look at research in a range of disciplinesincluding psychology, education, medicine, engineering, and the sciencesand note how writers select and analyze the data they collect. We will also examine what happens to this research when it is picked up by the popular media. Students will also practice collecting and analyzing their own data and reporting it to suit the needs of various stakeholders. There are two primary audiences for this section. Students in data-driven majors will find the section useful preparation for communicating in their disciplines. Students in other fields will learn how to critique and respond to the many ways that numbers shape our lives. This section presumes a basic ability to calculate averages, percentages, and ratios, but no advanced mathematical or statistical preparation. Instead, this section provides a fascinating look at how numbers and words intersect to create persuasive arguments in academic, professional, and popular contexts. Students will compare and analyze texts that make arguments with data, practice rhetorical strategies for synthesizing and representing data so that by the end of the class, students will apply these strategies to write an original data-driven research proposal.	U	4, 17, 9	focused
76108	English	Writing about Public Problems	If all problems required a simple fix, we could don our Avenger costumes, pick up Thors hammer, and right the worlds wrongs. But most problems arent so simple. Most of the problems we encounter require careful investigation and research so that we might propose solutions that connect with others to make change. In this 76101 class (one of two minis students can choose to fulfill their FYW requirement), we will learn how public problems are defined and argued across a range of texts, including proposals, op-ed genres, and white papers. By analyzing a range of proposal texts, we will identify the different kinds of legwork necessary to write a successful proposal, arguably one of the most challenging aspects of writing a persuasive recommendation for change. We will examine how writers unpack problems rhetorically and use evidence to argue solutions for different stakeholders who may not share common values. We will learn strategies for evaluating and synthesizing data from existing research to use in a proposal argument. By the end of the course, students will write their own proposal that recommends a solution and a feasible plan for solving a real problem.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76203	English	Literature & Culture in the 18th Century	Topics vary by semester. Fall 2020: The Birth of Modern Media Before the internet, English-speaking people got their news and connected with each other through the printed word, live performances on the stage, and the pleasures of visual media. Engraved portraits of celebrities promoted glamor and fashion, and political cartoons helped to shape political parties. The period between 1660 and 1830 saw an explosion of newspapers and visual media, and theaters expanded from seating a few hundred to pleasure palaces accommodating thousands. New media forms, like the modern novel and musical theater, were gobbled up by audiences hungry for innovation. It was an age of experiment in gender and sexuality as well as media, an age in which cross-dressing flourished, and modern ideas of sexual conformityand transgressioncame into being. Race entered European consciousness through the distorting lens of the African slave trade and the growth of consumer desire for merchandise from continents to the east and west of the British Empire. This course will give you the contexts for understanding the impact of media on our lives today. In addition, you will gain skills in critical reading and writing that are applicable to a range of media, such as visual prints, plays, as well as literary texts.	U	5, 9, 16	focused
76210	English	Banned Books	Freedom of expression enjoys an almost sacrosanct position in American politics, and yet there have been repeated attempts in the past century to ban, burn, censor, and suppress a number of controversial books. Students in this course will learn about the historic, institutional, and social contexts in which these censorship controversies arise, as well as the ways in which artists have responded to censorship attempts. We will ask which kinds of work are typically challenged and how attempts at censorship affect our understanding of a banned text and its significance. Readings for this class will include novels such as Toni Morrison's The Bluest Eye, Kurt Vonnegut's Slaughterhouse Five, Judy Blume's Are You There God? It's Me, Margaret, Stephen Chobsky's The Perks of Being a Wallflower, Sherman Alexie's The Absolutely True Diary of a Part-Time Indian, and Alison Bechdel's Fun Home: A Family Tragicomedy. In addition to literature, we will also consider the ways in which other forms of art, such as movies and music, have been challenged and censored. Students in this course will also celebrate the American Library Association's Banned Books Week, which will take place September 22-28.	U	4, 5, 16	focused
76214	English	Understanding Cultural Complexities	In today's society that explores Diversity, Equity, and Inclusion, one can ponder if Arab societies have made progress to achieve DEI towards minorities of religions (Muslims, Christians, Jews), sects (Sunni and Shi'a), ethnicities (Copts, Nubians, Kurds), Palestinians in Israel, homosexuals, and physical disabilities. This course aims to enrich students' understanding of the diversity of Arab countries and histories of intercommunal relations and conflict, explore the progress made in equating minorities to majorities, including them in various sectors, and granting them more rights. We will use readings, films, arts, and music, to engage with students in 4 Arab countries to further their learning.	U	4, 10, 5	focused
76217	English	Literature & Culture of the 20th and 21st Century	Topics vary by semester. Fall 2020: Contemporary American Fiction No one seems to know quite how to define contemporary American fiction. It's clear that fiction has changed since the 1960s and 70s, the heyday of postmodernism, but it's not clear what exactly characterizes the work that has come since. In this course, we will read a selection of American fiction from the 1980s to the present and try to get a sense of its main lines. In particular we'll look at the turn to "genre," the expansion to multicultural authors, and the return to realism. Also, we will consider how it relates to American society. Authors might include Chimamanda Ngozi Adichie, Junot Diaz, Jennifer Egan, Bret Easton Ellis, Jonathan Franzen, Chang-Rae Lee, Emily St. John Mandel, Gary Shteyngart, and Colson Whitehead.	U	5, 10, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76219	English	Law & Blame	How do we use language to accuse and defend? How do we attribute responsibility to specific individuals or institutions and dispute such claims, either by debunking them or shifting the blame? What makes the stories we tell and the arguments we make about responsibility succeed or fail? What unintended consequences can they produce? This course will examine these and related questions through the lens of legal cases in which individuals or institutions are accused of responsibility for harm, from vehicular accident cases to criminal trials. The study of these questions is not only valuable for understanding the legal process, participating in it, or writing about it, but the practice of attributing responsibility is common in many social and institutional contexts beyond law, even in daily conversation. It raises fundamental questions about culture, ethics, and politics evident in the way many legal cases capture public imagination and produce controversy beyond the courtroom.Drawing on readings from rhetoric, linguistics, and legal studies, as well as briefs, opening and closing arguments, direct and cross-examinations of witnesses, physical and documentary evidence, and judicial opinions from legal cases, we will examine the strategies advocates use to attribute responsibility and how the legal system manages such disputes. Students will produce written responses to readings, one short paper analyzing a claim of responsibility and one short paper advocating or disputing responsibility in a specific case, along with a final project that combines analysis with a recommended approach to advocacy. This course meets the Dietrich College Communicating Gen Ed requirement.	U	4, 17, 16	focused
76221	English	Books You Should Have Read By Now	Topics vary by semester. Fall 2020: "Utopias" What does it mean to dream of a perfect world? In 1516, Thomas More coined the term "utopia"to refer to an idealized space of hope, peace, and perfection. The term is borrowed from the Greek and literally means "no place." In short, this place of perfection and hope does not and cannot exist. However, writers through history have continued to invent utopias in literature. In this class, we will trace the creation of fictional utopias across literary genresnovels, plays, and short storiesstarting with Frances Bacon's The New Atlantis (1627) and concluding with Margaret Atwood's The Year of the Flood (2009). We will focus on different kinds of utopias: technological, aesthetic, feminist, and environmental. How has our concept of a perfect world changed through time? How are values, desires, and hope represented in each of these utopias? What is at stake in inventing a paradise-like world?	U	5, 11, 12	focused
76222	English	Creative Writing Matters	This course will explore at least two of the meanings of the word "matters"¿as in "is of importance," and as in "things, concerns." Through reading and writing in various genres, students will discover and discuss how creative writing engages with the world around us while also learning some of the important techniques of writing creatively in various genres, including scriptwriting, fiction, nonfiction, and poetry. The class will read a wide variety of books, and students will have the opportunity to interact with the authors through public readings, classroom visits, and attending a play. In addition, the class will take advantage of other literary events happening around Pittsburgh in order to further examine places where writing comes off the page and engages with the world. Revision will be required and emphasized.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76230	English	Literature & Culture in the 19th Century	Topics vary by semester. Spring 2021: The Arts, Literature, and Social Transformation: From the French Revolution to the rise of the Avant Gardes, art and literature began to play an explosive role in the forces of political change and the struggle for social justice. This course explores the ways in which poetry, the novel, photography, painting, architecture, and early cinema articulated new ideas for social transformation between 1789 and 1914--the long century when capitalism became the world's dominant economic power and the spread of the British Empire created a global context marked by unprecedented inequalities that are still with us today. It was an age of experiment in which Romantic poetry became a means of resistance against the power of class structure, the institution of slavery, and the hierarchies of gender in the work of William Blake, Mary Robinson, and Percy Shelley. Gothic novels like Mary Shelley's Frankenstein invented the genre of science fiction as a protest against the violence of empires, while at the other end of the 19th century, H.G. Wells's The Time Machine used science fiction and the real science of evolutionary biology to protest the inequality of the class system. The Victorian social critic John Ruskin showed how Gothic buildings resisted the imposition of commercial conformity on everyday life. The poet Christina Rossetti offered powerful insights into the relation of sexuality and the marketplace in her classic Goblin Market. Early photography began registering poverty and racial injustice at the same time that the new technologies of visual representation became a medium for the expansion of empire. This course will give you the contexts for understanding the impact of the arts and literature on our lives today. In addition, you will gain skills in critical reading and writing that are applicable to a range of literary texts and visual media.	U	1, 10, 5	focused
76239	English	Introduction to Film Studies	This course is an introduction to the history, technology, aesthetics and ideology of film. Our main focus is the narrative fiction film, but we will also discuss documentaries, avant-garde work and animation. The central organizing principle is historical, but there are a number of recurring thematic concerns. These include an examination of the basic principles of filmmaking, the development of film technology, the definition of film as both art and business, and the history of film as an object of critical and cultural study. The goals of this course are threefold. First, it will provide you with a solid grounding in the key issues and concepts of film studies. Second, it will expand your ability to knowledgeably critique individual cinematic works and their relationship to the larger culture. Lastly, it will provide you with experience in expressing your critiques in essay form. Most films will be viewed during the mandatory, weekly class screening, though several films will be assigned for viewing outside of class (in addition to readings and written assignments).	U	9, 17, 11	focused
76241	English	Introduction to Gender Studies	Biological sex vs. gender roles. Intersectional feminism. LGBTQIA+ rights. Consent. Masculinity and gender roles. #metoo and gender-based violence. Economic inequity. Sexual politics. This course offers students a scholarly introduction to these social and political issues. With interdisciplinary readings both foundational and contemporary, the class will combine theory, literature, and film with texts like law, public policy, and media representations. We will read critically and discuss openly. Readings might include work by Virginia Woolf, Simone de Beauvoir, Judith Butler, Kimberlé Crenshaw, bell hooks, Raewyn Connell, Todd Reeser, Chimamanda Ngozi Adichie, Roxanne Gay, James Baldwin and Marjane Satrapi.	U	5, 16, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76245	English	Shakespeare's Dark Plays	Shakespeare's Dark Plays is an approachable introduction to Shakespeare's Tragedies and Histories. Students will dive deeply into Shakespeare's contexts to explore how and why Shakespeare's darkest plays like Hamlet, King Lear, Macbeth, Othello, Antony and Cleopatra, and Henry V came to be. Students will consider what it might mean to "think like Shakespeare" and will use 21st-century technologies to experience Shakespeare's London. Students will interact with the first-known printed versions of Shakespeare's plays and connect Shakepeare's contexts to our present day by creating adaptations and performances. No questions about Shakespeare are off-limits: why read Shakespeare in the first place? Is Shakespeare a beard for white supremacy? Students will have opportunities to consider the darkest implications of the so-called "Shakespeare industry" and consider what it might mean to decolonize Shakespeare. Students can expect to develop valuable reading and writing habits and to build skills in contextual and historical thinking. The course fulfills many GenEd requirements and can count toward the English Literature and Culture major and the minor in Humanities Analytics.	U	4, 9, 11	focused
76259	English	Film History	This introductory course will focus on the history of the so-called Studio (or "Classic") Era of American film, 1920-1960. On most weeks, we will screen two films that reflect the most important genres and most enduring achievements of the era. We will be concerned with understanding how the studio system produced and marketed these works. By focusing on individual studios (for example, MGM and Warner Bros.) as "test cases," the class will also examine how particular companies produced films of a certain type in terms of such parameters as genre, theme, player, class address, and/or style. Readings will deal with the history of Hollywood, the various films, stars and/or filmmakers considered, as well theoretical/critical issues such as authorship, reception, and high vs. low culture. Students will learn important skills for film history, including reception study, archival research, and contextual analysis. Attendance at an evening screening session will be required. Grades will be based on three papers, a midterm, and a final.	U	4, 17, 9	focused
76260	English	Survey of Forms: Fiction	This course serves as an introduction to the craft of fiction. We will read a wide array of short stories, a novella, and a novel, and study the techniques and elements of literary fiction as they are displayed in the works of established writers. I will expect you to read the assigned works carefully, giving ample time and consideration to these readings, and to come to class prepared to discuss them. You will also be expected to spend a good deal of time on your own writing, to improve upon that work throughout the term, and to provide thoughtful criticism on your classmates' work. By the end of the semester, you should have a solid understanding of the elements of successful literary fiction, be able to write meaningful critiques of such writing, and be able to write and revise a complete short story. At times, the class will be fun, but it will also entail a good deal of effort and time on your part. Overall, you should see this class as an opportunity to develop and share your creative work, and to learn skills and new ways of thinking about writing. Section B: This class introduces you to a variety of literary fiction, and invites you to try your hand at your own writing, while focusing on aspects of the craft. We read and discuss fiction to learn about the craft and about the world of the various stories.	U	4, 17, 9	focused
76261	English	Survey of Forms: Creative Nonfiction	In this course we will analyze the different types of narrative structure, narrative suspense, voice, metaphor, and point of view that make for effective nonfiction writing. We will also examine the difference between good writers and good work, the functions of objective distance from and intimate investment in a subject, as well as the philosophical questions spurred by nonfiction writing. What is the nonfiction writer's role, and how does it differ from that of the fiction writer? Where do the two genres overlap? What gives nonfiction writing integrity? What does the term "creative nonfiction" mean? How have the form and aims of nonfiction writing - from memoir to essays to long-form journalism - evolved for better and for worse?	U	9, 17, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76265	English	Survey of Forms: Poetry	Section A: This course is meant to serve as an introduction to the craft of poetry. We'll look closely at traditional forms in an effort to understand the effects of more formal choices on the page, and we'll examine the craft choices of modern and contemporary poets to expand our understanding of poetic approaches. Our analysis of poetry will begin at the level of the syllable and progress to words, lines, stanzas, series, and collections. You will be required to read both published work and the work of your classmates with a critical eye, to write your own poems, both formal and not, to write several short analysis essays, to write a longer critical essay, and to demonstrate your knowledge on one in-class exam. The most important take-away from this class is the ability to talk knowledgeably and critically about poetry. What you learn here will pave the way for your future as both a writer and a reader.	U	4, 17, 9	focused
76270	English	Writing for the Professions	Writing in the Professions is a writing course specifically designed for juniors and seniors in all majors other than English. The course is appropriate for upper-level students in all CMU colleges, has no writing prerequisites, and assumes that you may not have had much college-level writing instruction past your freshman year. The basic idea of the course is to give you experience in developing the writing skills you will be expected to have as you make the transition from student to professional. The course will cover resume writing, proposal writing, writing instructions, the difference between writing for general and specific audiences, and analysis of visual aids in various texts. The course requires that students work both independently and in groups.	U	4, 3, 17	focused
76271	English	Introduction to Professional and Technical Writing	Professional and technical communicators use words and images to connect people with information. With a strong foundation in rhetoric, this course will sharpen your abilities to communicate information clearly, effectively, and responsibly to real readers, stakeholders, and decision makers. Our assignments and conversations will include a wide range of genres and rhetorical situations you can expect to encounter as a professional and technical communicator, including job application genres, narrative genres like feature articles that blend subject matter interviews with keen observation, research genres like proposals, and team writing genres like technical documentation. A high level goal for the course is to combine theory, methods, and best practices for putting real readers and users of information at the center of our communication strategies. By the end of the course, you will have a portfolio of polished work that you can use to narrate your professional strengths and interests. This course is designed for undergraduates pursuing majors and minors in a writing and communication field, and who want to explore professional and technical communication as a discipline and career area.	U	8, 9, 17	focused
76275	English	Critical Writing Workshop	This course will introduce you to ways of critical thinking and writing about literary and media genres: poetry, drama, fiction and film. Authors may include William Blake, Percy Shelley, Jane Austen, Herman Melville, Emily Dickinson, H. G. Wells, Charlotte Perkins Gilman, T. S. Eliot, Toni Morrison, Tom Stoppard, or Don Delillo. Film directors may include Sergei Eisenstein, Orson Welles, Alfred Hitchcock, Jean-Luc Godard, or others. Students will learn how to interpret print and visual media and how to communicate their interpretations with clarity and self-awareness. To that end, students will write four short to mid-length interpretive papers to workshop in class.	U	5, 4, 10	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76280	English	Gender and Sexuality in Performance	"Performance" describes a wide range of practices, from the everyday to the artistic. Gender and sexuality are key elements in everyday, political, and artistic performances, from the very personalhow you order a latte at Tassa D'Oro, tell a lover goodbye at the airport or comfort a crying childto the very publicperforming a Bach cello suite or an iconic King Lear, staging a demonstration against police violence or marketing a new app. This course will bring performance and theory into a practical partnership to create and critique social and individual narratives. We will also take an intersectional approach to gender and sexuality, mindfully mapping these performances in relation to race, class, and ability. We raise questions such as, How does everyday performance define gender and sexual identity? How do gender and sexuality define everyday performance? How does aesthetic performanceart, theater, film, digital media, poetryintervene in the ways in which gender and sexuality are performed? Readings in theory at the intersection between gender studies, queer theory, intersectional feminism, and performance studies will help us explore these questions. We will also consider a variety of cultural and artistic practices. Since this class will be in a remote format, we will focus on performances that are digitally accessible, both for the performances that we study and those we create for the class. This course counts towards the Gender Studies Minor.	U	5, 16, 10	focused
76284	English	Rhetoric & Storytelling	What are stories and why do we tell them? What purpose do they serve? What makes a story true? What effect do stories have on those who hear them? In this course, we will ask how narratives work rhetorically to shape how we perceive and encounter events, movements, places, and experiences. Students can expect to read and discuss narrative theories and practice employing these theories to analyze story artifacts, such as political speeches, newspaper or magazine articles, podcasts, and oral histories. During the semester, we will explore and analyze the way stories surrounding events like September 11 or movements like #metoo or Black Lives Matter work (or don't) to influence and persuade. Students will consider the stories that infuse recent or local subjects of interest and investigate the effect such narratives have on contemporary contexts. Any student who is interested in developing a critical awareness of the ways storytelling influences and shapes our thinking as well as those who want to enhance their analytical toolkit will benefit from this course. Most remote class sessions will involve guided student discussions of narrative concepts and theories, individual and collaborative activities to analyze story artifacts, and opportunities to reflect. Weekly assignments will include concept notes, short analyses, and other in-class activities to practice course skills. The course will culminate in a final project portfolio where students will explore stories that shape a selected social or cultural theme, event, or movement. This course meets the Dietrich College Communicating Gen Ed requirement.	U	4, 11, 9	focused
76287	English	Sex & Texts	Please see *Content Warning* Below In this course, we will consider how writing and communication serve as means to create, define, and bound our worlds, shaping our ideas about "sex" and "sexuality" at their intersections with gender, disability, race, geographic location, religion, age, and so on. Using a rhetorical perspective, we will interrogate how everyday experiences with and performances of sex and sexuality are tied to legal, medical, corporate, cultural, and historical practices and ideologies. Readings will consist of public, scholarly, and creative genres such as Roxane Gay's Unruly Bodies, Judith Butler's Gender Trouble, Cardi B's "WAP" (feat. Megan Thee Stallion), and the Hulu series Shrill and will address topics including but not limited to bathroom bills, rape culture, the beauty industry, intellectual property, citizenship, and marriage equality. Students in this course will 1) develop a vocabulary for talking about sex and sexuality; 2) examine how sex and sexuality are shaped by public, historical, and cultural norms; and 3) practice analyzing rhetorical elements such as purpose, genre, audience, context, form, and style. Student projects will include weekly discussion posts, two shorter papers, and one creative project. This course meets the Dietrich College Communicating Gen Ed requirement. *Content Warning* Because this course takes up questions of sex and sexuality, we will discuss the body/embodiment and issues related to violence (sexual, racial, intellectual, domestic, linguistic, etc.). While projects will ask students to examine questions of sex and sexuality, students will not be required to write about issues related to violence.	U	5, 16, 10	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76289	English	Billingual & Bicultural Experiences in the US	This course focuses on various aspects of bilingualism and biculturalism in the United States, with particular emphasis on the experiences of those who identify as a speaker of a heritage language and/or member of a heritage culture. Some possible topics to be covered include: the nature of bilingualism and biculturalism; the historical and social contexts of bilingualism in the United States; characteristics of languages in contact and bilinguals' language practices; policies around heritage language maintenance in education; and the connection between language, culture, and identity. This discussion-based course is taught in English and is open to all students, whether they identify as bilingual/bicultural Americans, or are simply interested in the course topic.	U	4, 11, 1	focused
76291	English	Getting Heard/Making a Difference	How can a college student get people to pay attention to a problem, whether it is a personal, social, environmental, ethical, or public issue? In particular, how do people who don't already have what is called "standing"such as the authority or credentials to speakget their community to listen? In this course you will learn how to create real dialogue and carry out effective (not simply adversarial) engagement within a university and later in your professional lives. It introduces you to the rhetorical art of savvy, issue-centered social engagement. Drawing on research, theory, and our own campus investigation, we will try out methods for collecting competing perspectives, for framing a shared actionable problem, and for creating well-supported, persuasive and motivating accounts in proposals, reports, editorials, stories, or media. The theory and strategies we study are designed to create what is called a rhetorical presence for your ideas, to put them into circulation, and help create a more engaged local public. This course meets the Dietrich College Communicating Gen Ed requirement.	U	4, 12, 17	focused
76292	English	Film Production	Experiencing the process of filmmaking from the script to the set and to the editing room, students will develop a personal filmic language to create a short final film, exploring audio and visual forms that will serve the content they developed in their scripts. The focus will be on understanding the various aspect of the film grammar with an emphasis on the basic visual components - using space, tone, line, shape, color, movement and rhythm- and how they are used to visually tell the story. These components are used to define characters, communicate moods, emotions, thoughts and ideas.	U	4, 9	focused
76295	English	Russian Cinema: From the Bolshevik Revolution to Putin's Russia	"Last night I was in the kingdom of shadows," said the writer Maxim Gorky in 1896 after seeing a film for the first time. "How terrifying to be there!" Early film inspired fear and fascination in its Russian audiences, and before long became a medium of bold aesthetic and philosophical experimentation. This seminar-style course surveys the development of Russian and Soviet film, paying equal attention to the formal evolution of the medium and the circumstances¿historical, cultural, institutional¿that shaped it. We will examine Sergei Eisenstein's and Dziga Vertov's experiments with montage in light of the events of the Bolshevik Revolution and the directors' engagement with Marxism; Georgi Alexandrov's and the Vasiliev brothers' Socialist Realist production against the backdrop of Stalinist censorship; Andrei Tarkovsky's and Kira Muratova's Thaw-era films within the broader context of New Wave Cinema; and the works of contemporary directors, including Aleksei Balabanov, Alexander Sokurov, and Andrey Zvyagintsev, in connection with the shifting social and political landscape of post-Soviet Russia. Besides introducing students to the Russian and Soviet cinematic tradition, this course will hone their skills in close visual analysis. No prior knowledge of Russian language or culture is required. The course is conducted in English, but students will have the option to do work in Russian for three extra course units.	U	4, 17, 16	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76300	English	Professional Seminar	This weekly, 3-unit seminar is designed to give professional writing majors an overview of possible career and internship options and ways to pursue their professional interests. Each session will feature guest presenters who are professionals working in diverse communications-related fields such as web design, journalism, public relations, corporate and media relations, technical writing, medical communications, and working for non-profits. The visiting professionals talk about their own and related careers, show samples of their work, and answer student questions. The course is required for first-year MAPW students and is open to all English undergraduates, who are urged to participate in their sophomore or junior years to explore options for internships and careers.	U	4, 17, 8	focused
76301	English	Internship	This course is designed to help you explore possible writing-related careers as you gain workplace experience and earn academic credit. You'll work on- or off-campus as an entry-level professional writer for 8-10 hours per week in a field of interest to you (public relations, journalism, advertising, magazine writing, non-profit, healthcare, etc.). You are responsible for finding an internship. Most of your class time for the course will be completed at your internship site - a minimum of 120 hours (8-10 per week) over the semester for 9 units of credit. As the academic component of the course, you'll keep a reflective journal and meet periodically with the internship coordinator to discuss your internship and related professional issues. You must register for the course before the add/drop deadline of the semester in which you want to do your internship. Before you can register, you must contact the internship instructor listed above to express your interest in the course and to be cleared for registration. Credit for the internship course cannot be retroactively awarded for past internships.	U	4, 8, 17	focused
76302	English	Communication Support Tutoring Practicum	This practicum is restricted to students who have applied and accepted a position as a Global Communication Center tutor. For more information on applying, contact the course instructor. Students in this six-unit mini will learn about best practices in tutoring, gain experience analyzing and responding to a wide range of academic and professional genres, and learn to adapt their tutoring style for different kinds of students. In addition, we will learn to support oral, visual, and collaborative modes of communication alongside more traditional written genres. Assessments include regular hands-on activities, reading responses, and participation in class discussions. Please note that in terms of time commitment, a 6 unit mini is equivalent in weekly workload to a 12 unit full semester course. The mini is half the credits because it requires the same workload but only for half the semester.	U	4, 9, 17	focused
76306	English	Editing and Publishing	Note: Registration in this course is by permission only. Students must contact Prof. Costanzo directly. In this course students will work closely with the editors of Carnegie Mellon University Press to learn many of the facets of producing books. These range from business management and marketing to the elements of editing, book design, and production.	U	4, 9, 8	focused
76307	English	Advanced Editing and Publishing	Note: Registration in this course is by permission only. Students must contact Prof. Costanzo directly. In this course students will work closely with the editors of Carnegie Mellon University Press to learn many of the facets of producing books. These range from business management and marketing to the elements of editing, book design, and production.	U	4, 9, 8	focused
76308	English	Literary Journal Publishing	In this course, students will learn about the landscape of and publication process for literary journals in the United States. We will read a variety of literary journals in print and online, will host guest speakers, and will do a variety of hands-on activities related to editing and publishing. Students will gain experience by working on The Oakland Review, an international literary journal run out of CMU, in capacities as varied as editorial, design and production, or promotion. If you are interested in registering for this course, please go to the Course URL and fill out the questionnaire. Thank you.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76310	English	Advanced Studies in Film and Media	This course will focus on several key technical components of filmmaking and the ways they function within the film text, as well as the ways they can be read as an indication of the underlying ideology of a work. Individual units of the course will concentrate on performance, production design, photography, editing and music. Films will be drawn from a variety of national cinemas from around the world. A primary goal of the course will be the development of skills useful for filmmaking, film analysis and scholarship. Students will engage in focused projects designed to facilitate the pedagogical goals of each unit.	U	4, 9, 8	focused
76311	English	Acting Out in the London Theatre	More Londoners went to the theater between 1660 and 1800 than read novels or newspapers. The theater was THE social media of this formative period in the history of an English-speaking, urban public, and this course explores the power of the theater as a means of both social control and political resistance. Instead of taking a traditional "survey" approach to this period in the English theater, we will study a succession of "nights at the theater," specific performances of plays that happened on particularly eventful evenings when the playwhile significantwas not the only important performance. The farewell turn of a beloved actor, the presence in the house of a visiting African prince, violent protest by audiences against a play, an actoror pretty much anythingcould charge that evening's performance of a play with meaning beyond the script. We will approach plays from this period historically by reading, viewing, and listening to print and visual documents and music that inform the historical moment of the play. Most importantly, we will workshop scripts in class in order to learn from performance how these plays conveyed the power relations of race, class, and gender both then and today.	U	5, 16, 11	focused
76314	English	Data Stories	Every dataset has a story. In the age of big data, it is vital to understand the unlikely casts of algorithms, data miners, researchers, data janitors, pirates, data brokers, financiers, etc. whose activities shape culture. This course will feature a range of "farm to table" data stories, some going back hundreds of years, and introduce students to resources and strategies for contextual research. It will explore cases such as the London cholera epidemic, Google Books, Netflix, the Oxford English Dictionary, the Strava map, and the Queen Nefertiti scan alongside several pieces of art and fiction that capture aspects of data stories typically obscured elsewhere. Research methods introduced will include book history, media archeology, history of information, infrastructure studies, ethnography, narratology, and digital forensics. Students will read scholarly articles, novels, journalism, and popular non-fiction, and they will develop and individualized long-form research and writing projects informed by contemporary developments in data studies, journalism, and art.	U	9, 2, 4	focused
76316	English	Topics in Literature: Watching HBO's The Watchmen	This course is centered on the graphic, social and political universe created by HBO's The Watchmen series. Course viewings/readings will include: the 9-episode HBO series from 2019, the original The Watchmen comic series from the 1980s, and various cultural influences on the HBO series, including the musical Oklahoma, and the 1930s era singing group the Ink Spots, whose hit, "I Don't Want to Set the World on Fire," is featured in the series. The course will include the intro to film studies text, Writing about Movies, and one of the goals of the course will be for students to write original, accessible, and interesting 1000 word essays about the series to be published on a public website.	U	4, 16, 17	focused
76319	English	Environmental Rhetoric	Environmental rhetoric is a place of commitment and contention in which competing discourses celebrate our relationship with the natural world, frame environmental problems, and argue for public action. As we compare the environmental rhetoric of naturalists, scientists, policy makers, and activists, we will trace an American history that has managed to combine mystical celebration with militant critique, and scientific research with public debate. Equally important, this course will prepare you to act as a rhetorical consultant and writer, learning how writers communicate the three "Rs" of environmental rhetoric: relationship with nature, the presence of risk, and the need for response.	U	4, 12, 13	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76325	English	Intertextuality	What do we mean when we say that someone has "twisted" our words, or that our words have been "taken out of context"? Why is Martin Luther King Jr. best remembered for saying, "I have a dream," and not for saying, "War is the greatest plague that can affect humanity"? What are political "talking points" and how are they perpetuated? How does a claim (unfounded or not) become a fact? How does a fact become a myth? These are just some of the questions that we will consider. More specifically, this is a course in how meaning changes as texts created in one context and for specific purposes are repeated, cited, and used in other contexts and for other purposes, sometimes related and relevant, sometimes not. More technically, we'll be focusing on the rhetorical nature of intertextual discourse. Our goal will be to examine the ways that people of all kindsincluding politicians, journalists, and scientistsstrategically draw upon and transform the statements, arguments, and evidence of other people to promote their own viewpoints or purposes. We will begin by investigating scholarship that views language as an extended conversation in which people struggle to have their own voices heard, and other voices countered or even suppressed. Later, we will survey a number of studies that suggest how individuals and organizations recontextualize and reinterpret prior discourse for persuasive ends. More specifically, we will analyze how the micro-features of the language (for example, qualifications, evaluations, and attributions) are used to persuade audiences that certain assertions are (not) factual, that certain speakers are (not) authoritative, and that certain proposed actions are (un)desirable. Ultimately, you can conduct your own research on intertextual rhetoric on a topic of specific interest to your academic or professional goals.	U	4, 16, 17	focused
76326	English	Contemporary Global Literature	In this course, students will read, interpret, discuss and write about novels and short stories written in English in the past ten years by writers originally from Africa, South Asia, East Asia and the Caribbean. While these works represent the "large stories" of economic globalization, refugee migration, and ecological catastrophe, they are crafted around the "small stories" of love, longing, friendship and family.We will talk about both kinds of narratives, tracing the entanglements of one in the other.Students will reflect on the relationship between history, society and culture in a global context, situating the contemporary within the longer trajectories that mark the legacies of colonialism and imperialism. This course is virtual and almost entirely synchronous; barring unexpected situations, attendance is expected for what should be a lively class discussion.	U	10, 8, 4	focused
76329	English	Performing Race in Early Modernity	The earliest known use of the term "white" in reference to Europeans occurs in The Triumphs of Truth, a 1613 play by Shakespeare's contemporary, Thomas Middleton. In addition to suggesting an important connection between race and drama in 17th-century England, this simple historical note raises a range of questions that have a direct bearing on some of the most pressing issues of the 21st century: Where do ideas about race come from? By what processes do the distinctions of racial concepts emerge, evolve, calcify, and mutate? How does the conceptualization of race relate to media? How do racial representations bolster and conduct political power? In this course, we will broach these questions by taking a close look at the race-making function of drama in early modernity, a period when race was an inchoate, incipient concept, caught up with the emergence of colonialism, capitalism, and increasing interconnection between peoples, cultures, and worlds. As we think, read, and converse together, we will endeavor to come to terms with the problems and paradoxes of racial representation in the early modern theater, a forum that offered access to innovative, daring thinking about human equality and ethical responsibility, but was also a site for the perpetuation of hateful stereotypes and exploitative theories of white supremacy. In a wide-ranging survey of drama, historical documents, and contemporary criticism, we will work toward an understanding of how race-based concepts operated in the theater, and how the drama early of modernity continues to influence thinking about race in our own time. This course meets the Dietrich College Reflecting Gen Ed requirement.	U	9, 5, 10	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76337	English	Intersectional Feminism	The concept of intersectionality first appeared in African-American feminist legal theory, but it rapidly spoke to other ideas and movements authored by other women positioned on the margins in the United States and beyond. Now widely disseminated as a feminist practice embraced by many identities, intersectional feminism acknowledges how interlocking power structures produce systematic oppression and discrimination to create distinctive gender identities in terms of such aspects as sexuality, race, ethnicity, class, religion, language (and accent), and neuro- and physical diversity. In this class, we will consider a wide variety of texts that mobilize this movement, including fiction, poetry, memoir, scholarly works, drama, popular media and films. We will consider voices from the "global south," non-Western countries that are speaking back to the economic and political centers of globalization. Pairing analysis with these texts with some examples of praxis, or political practice, we will think through and debate how critiques of power can move toward social change. Students will be encouraged to use these texts and a series of shorter writing assignments about texts to build toward a final project relevant to their own discipline. Readings might include Kimberlé Crenshaw, Audre Lorde, bell hooks, Roxane Gay, Chimamanda Ngozi Adichie, Mona Eltahawy, Erika L. Sánchez, Chandra Talpade Mohanty, Fatima Mernissi and Mari Matsuda, Fatima Mernissi, and Aiwah Ong.	U	5, 10, 8	focused
76338	English	Internship Mini	This course is designed to help you explore possible writing-related careers as you gain workplace experience and earn academic credit. You'll work on- or off-campus as an entry-level professional writer in a field of interest to you (public relations, journalism, advertising, magazine writing, non-profit, healthcare, etc.). You are responsible for finding an internship. Most of your class time for the course will be completed at your internship site. As the academic component of the course, you'll keep a reflective journal and meet periodically with the internship coordinator to discuss your internship and related professional issues. You must register for the course before the add/drop deadline of the semester in which you want to do your internship. Before you can register, you must contact the internship instructor listed above to express your interest in the course and to be cleared for registration. Credit for the internship course cannot be retroactively awarded for past internships.	U	4, 8, 17	focused
76339	English	Topics in Film and Media	Topics vary by semester. Fall 2020: Gender & Pop Culture - Gender and Popular Culture starts with the premise that the bulwark of our gender identities is formed in the domain of popular culture. This course will introduce students to various theoretical and methodological approaches to the study of media and other popular culture as they relate to issues of gender and other axes of difference. Examining a wide range of genres and media, including Harlequin romances, romantic comedies, sentimental melodramas, and contemporary superhero films, the course will illuminate how popular culture scripts the ways we perform our genders. Some of the questions the course will address include: What are the underlying politics of gender in popular culture? What are the ways that contemporary culture mediates our understanding and performance of gender? How does cultural production reproduce gendered stereotypes? How do different genres negotiate gendered identities? The course will take a self-reflexive turn by asking students to examine the role that gender plays in the creation of their taste and pleasure. In pursuing this line of inquiry, the course will encourage students to rethink the assumptions and biases that undergird the binaries of high and low culture.	U	5, 4, 10	focused
76350	English	Critical Theories about Literature	This course studies the long-debated problem of how readers or spectators respond to texts (in print, performances, film, or painting) from ancient rhetoric and tragedy to contemporary mass culture.We will read in a range of critical theories, from thinkers like Aristotle, Plato, and Longinus to recent theorists in poststructuralism, gender studies, Marxism, and affect theory. How have such critics and theorists thought about the nature of the text and of representation--or the relation of authorship to reading, ideas, and affects? What techniques of analyzing literary texts have such theories stimulated? Two papers and vigorous in-class discussion will be required.	U	5, 11, 10	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76351	English	Rhetorical Invention	Rhetorical invention is a discursive approach to the process of inquiry, discovery, and problem solving, or how we decide what to say, what arguments to advance, and what means of persuasion to use in any situation. In other words, it is a rhetorical approach to content generation in any speaking or writing situation. Although invention is centrally important to rhetoricwithout it rhetoric becomes a superficial and marginalized study of style and arrangementfrom the Scientific Revolution and Enlightenment through the mid-twentieth century invention all but disappeared as a topic of rhetorical study, influenced by the view that the content of communication should be exclusively governed by deductive logic and the scientific method rather than rhetorical considerations such as audience, situation, or the history and figurality of language. This repudiation of rhetorical invention fundamentally shaped modern thought and continues to influence the ways we think and communicate today. In this course, we examine the status of rhetorical invention in the development of modern thought and then attend to scholarly efforts to revive a rhetorical understanding of invention from the mid-twentieth century forward, surveying contemporary theories of rhetorical invention including those promoted by postmodern, posthuman, and digital rhetorics. The course is designed to explore the central importance of invention to contemporary rhetorical theory through a pairing of historical and contemporary readings. In addition to regular reading responses, students select a research project examining the history or theory of rhetorical invention.	U	17, 4, 9	focused
76354	English	Watchdog Journalism	The practice of journalism involves covering the news of the day. Investigative journalism uncovers it, digging through public records and data to expose corruption or correct social injustices. The process takes patience and persistence, as well as familiarity with right-to-know laws, to find that gold nugget of information that exposes secrets or becomes the missing piece to a larger puzzle. In this course, students will learn investigative techniques that make the powerful accountable, using government documents, financial filings and databases to spot undetected crime patterns, an unfair housing policy or perhaps questionable spending by a non-profit charity. Investigative journalism has a storied history of exposing wrongdoing and today many of the tools historically used to tell those stories are available to everyone. This course will help budding journalists, researchers and anyone else interested in addressing societal problems find those tools and learn how to use them. This course meets the Dietrich College Deciding Gen Ed requirement.	U	16, 4, 8	focused
76355	English	Leadership, Dialogue, and Change	This course is about an alternative to the "great man" theory of leadership--in which success is built on charisma, power, status, or institutional authority. The alternative model of adaptive leadership, however, depends on an ability to draw a divided community into a dialogue that re-frames the problem and may even call on us to re-interpret our values. We will see this in action, comparing the methods of Martin Luther King to the radical community organizing of Saul Alinsky, or in the influential of African-American cultural critiques of Cornel West and bell hooks, or in the work of students calling for change on campuses. Their work poses a question: how does dialogue work in the rhetoric of making a difference? So in the second half, we will put theory into practice, organizing a CMU Community Think Tank to explore this question: how do college students take effective leadership on public issues raised on campus (e.g., climate change, equity for workers, or the corporate ethics of would-be employers)? How do student advocates give "rhetorical presence" to problems or create counterpublics that actually put ideas into "circulation"? How do departments and faculty support publicly engaged learning in their disciplines? In this project of studying and taking leadership, you will develop skills in framing a shared problem, collecting data across diverse, often competing perspectives, in creating a Briefing Book to guide live Round Table problem-solving dialogues, and in documenting, writing and publishing your Findings on www.cmu.edu/thinktank. As a portfolio project, it will also demonstrate your ability to support problem-solving dialogues across difference in a community or organization.	U	13, 4, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76359	English	User Experience Methods for Documents	This course will be useful for any student who is interested in learning more about user experience methods that are widely used in professions such as designing/writing for new media, technical writing, science and healthcare communication, public media relations, policy and non-profit communication. You will deepen your mastery of the following research skills associated with planning and testing documents: interviewing in context, retrospective interviewing, focus groups, surveys, and think-aloud usability testing of documents. In addition to specific research methods and skills, we will cover issues that pertain to all research methods: How many people do I need to include in my study? How should I select them? Are my results valid? Is what I think I'm finding out reliable? What are the ethical issues in my study? We will use a combination of lecture, discussion, exercises and projects to achieve these objectives.	U	4, 17, 9	focused
76360	English	Literary Journalism Workshop	Normally Literary Journalism demands field work: interviews with people out in the world. I'm not sure how Covid will affect this course. It always has a strong overlap with Creative Non Fiction. Students will write flash non-fiction and longer essays, developing their writing voices, and their ability to see and represent the world they and others inhabit. We'll read literary journalism by a variety of writers, using some of what we read as models. If you like fiction writing and creative non-fiction writing, you'll like this genre: you'll be asked to employ the similar tools of characterization, sense of place, voice, narrative arc, dialogue, etc. I hope you'll be able to go out into the world and find stories as field-researchers, but we'll have to see about that. Usually I have students respond to six writing assignments, along with revisions.	U	4, 17, 9	focused
76364	English	Reading in Forms: Fiction	In this course we're going to be reading and viewing creative works that are set in Brooklyn and that reflect the astonishing diversity and vitality of New York's most populous borough. While we analyze and discuss the assigned readings, we'll have a chance to reflect on the experience of newcomers who've settled in the city and see something of the tensions in the borough, the period of decline and loss of status, and the present boom period, with issues relating to gentrification.	U	16, 11, 9	focused
76367	English	Fact Into Film: Translating History into Cinema	From the very beginning, film has provided a window into the past. But how useful are the images we see through that window? For every person who reads a work of history, thousands will see a film on the same subject. But who will learn more? Can written history and filmed history perform the same tasks? Should we expect them to do so? How are these two historical forms related? How can they complement each other? This course will draw examples from across the history of film in order to examine how the medium of film impacts our understanding of facts and events, the ways that film transfers those facts to the screen, and how that process affects the creation of historical discourse. Films may include such titles as The Fall of the Roman Empire, The Gunfight at the O.K. Corral, Saving Private Ryan, World Trade Center, Enemy at the Gates, Lagaan and Hero.	U	11, 1	focused
76368	English	Role Playing Game Writing Workshop	Role-playing games (RPGs) are a vibrant and viable popular medium for interactive storytelling. A generation of novelists, screenwriters, playwrights and TV writers came of age playing RPGs. They learned how to tell stories with their friends. Later on, they developed those skills and have won Pulitzers, Emmys, Tonys and Oscars. This workshop builds upon a thesis that interactive games share a large portion of dramatic theory DNA with plays, TV, and film. Play is performance. The skills developed when creating any time-bound media transfer well to games but must be seen through a different lens - the lens of the player. To do so, we first examine and dissect both RPG story and game design (using pencil and paper examples) seeking an understanding of both system as well as narrative best practices. Once we lay the groundwork, students are divided into three-to-five-person writing teams. Teams use an existing pen-and-paper RPG system to create a set of a campaign-style story for that system and that story world. The final product is a hard copy story bible of portfolio-quality. I emphasized this is a writing course, not an RPG design course. Any level of writing experience is welcome, as I provide support and instruction to scaffold in experienced students. More advanced students often find the unique authorial POV of games to be a very different challenge. Experience with and passion for RPGs is a must in this class.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76372	English	News Writing	In this course, we will study and learn the fundamental skills of journalistic writing. We will start with the basics - the importance of accuracy, clarity and fairness, writing for audience, striving for objectivity, judging newsworthiness, meeting deadlines. But the key to learning how to write in a journalistic style is to practice those skills so the core class work (and most of your grade) will be based on seven writing assignments due approximately every two weeks throughout the semester. Expect to do some writing each class period. We will learn how to write a story lede (yes, that's how journalists spell it), how to structure a story and how to write different kinds of news stories, from crime news to features to editorials and commentary. We also will learn how to research a news story, conduct an interview and sort through mountains of information to discern what's important so we can write about it in a clear, concise manner.	U	4, 16, 17	focused
76373	English	Argument	This course introduces the fundamentals of argumentation theory and offers guided practice in analyzing and producing arguments. Through analysis, we will learn what an argument is, how to identify one, and what the names and functions of a variety of argument features are. We will also explore the production of argument by pursuing the questions: What are my argumentative goals? How do I build a theory of my audience? What means of persuasion are available for me to achieve my goals? And how should I order the contents of my argument? To answer these questions, we will explore argument in a variety of genres including visuals, op-eds, presidential speeches, and congressional testimonies.	U	4, 9, 8	focused
76374	English	Mediated Narrative	S21: Futuristic Explorations - An Interactive Media Project We are offering the opportunity to travel into the future, build it, and represent it in a creative, critical way. The Futuristic Explorations Mediated Narrative course aims to critically explore the concept of the future, analyze its representations, and create an interactive fictional video based on potential utopian/dystopian areas of human progress and evolution. Students will recreate and represent visions of the future through an interactive media project. Essential to the research and development of the class is the concept of humanity and empathy within a technological social world. Ideas such as: "reality ahead of schedule"; "high tech, low life"; "neon and corporate dystopias"; "cyberpunk", "post-human"; "sustainability", etc, will be analyzed and discussed in class. Concepts of civilization, the cityscape, the individual, the body and the mind will be examined as we have seen technology and society evolve. The idea is to map traditional futuristic themes and styles and find new ways to represent them based on needs and contradictions in our present world.	U	9, 4, 17	focused
76380	English	Methods in Humanities Analytics	The computer-aided analysis of text has become increasingly important to a variety of fields and the humanities is no exception, whether in the form of corpus linguistics, stylometrics, "distant reading," or the digital humanities. In this course, we will build a methodological toolkit for computer-aided textual analysis. That toolkit will include methods for the collection data, its processing via off-the-shelf software and some simple code, as well as its analysis using a variety of statistical techniques. In doing so, the class offers students in the humanities the opportunity to put their expertise in qualitative analysis into conversation with more quantitative approaches, and those from more technically-oriented fields the opportunity to gain experience with the possibilities and pitfalls of working with language. The first part of the term will be devoted to introducing fundamental concepts and taking a bird's eye view of their potential application in domains like academic writing, technical communication, and social media. From there, students will initiate projects of their own choosing and develop them over the course of the semester. The goal is to acquaint students with the strengths and limitations of computer-aided textual analysis and to provide them with the necessary foundational skills to design projects, to apply appropriate quantitative methods, and to report their results clearly and ethically to a variety of audiences. This class requires neither an advanced knowledge of statistics nor any previous coding experience, just a curiosity about language and the ways in which identifying patterns in language can help us solve problems and understand our world.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76384	English	Race, Nation, and the Enemy	Conflicts over racial and national identity continue to dominate headlines in the United States as they often have during the nation's history, from debates regarding the immigration, naturalization, and birthright citizenship of racial minorities to debates regarding racial disparities in access to civil rights. This course explores the discursive practices through which racial and national identities are formed and the frequent conflicts between them, particularly by focusing on the role of enemies, threats to the nation, and sacrifices made on behalf of the nation in American public discourse. Alongside primary sources of public discourse regarding wars, the immigration and citizenship of racial minorities, racial segregation and civil rights, and the criminal prosecutions of dissidents during periods of crisis, we will read secondary sources offering multiple theoretical and disciplinary approaches to the study of racial and national identity formation. Along with regular brief responses to readings, assignments will include a short rhetorical analysis paper and a longer research paper.	U	10, 16, 5	focused
76386	English	Language & Culture	This course is an introduction into the scholarship surrounding the nature of language and the question of how language shapes and is shaped by social, cultural and political contexts. We will begin by studying important literature in linguistics and language theory, both to introduce us to how scholars think about language and to give us a shared vocabulary to use for the rest of the semester. We will then move into case studies and theoretical works exploring the intersections of language use, individual and group identities, and the exercise of power, in its many forms. In particular, we will focus on the relationship between language and culture by asking, in what ways does language influence and constitute social change? How is social change reflected by changes in the way we use language? Over the course of the semester, you will work on applying the knowledge and theoretical tools you gain to your own analysis of a linguistic artifact that you choose.	U	4, 11, 16	focused
76388	English	Coding for Humanists	This introductory course provides humanities students with the foundational knowledge and skills to develop computer-aided research tools for text analysis. Through a series of hands-on coding exercises, students will explore computation as a means to engage in new questions and expand their thinking about textual artifacts. This course is designed for students with no (or very little) coding experience. During the early part of the semester, students will learn basic programming using Python through examples and problem sets that are relevant to text analysis. Then, students will be introduced to a limited set of commonly used Python packages for text analysis, such as natural language processing, statistical analysis, visualization, web scraping, and social media text mining. Students are expected to complete a small final project that examines how evidence-based data-driven insights derived from text analysis would support humanistic research in their area of interest, including (but not limited to) genre studies, rhetorical criticism, authorship attribution, discourse analysis, cultural analysis, social network analysis, spatial/temporal text analysis, and writing assessment. Doctoral students in the Department of English must register for 12 units, and are expected to write a publishable quality paper. Students who are interested in digital humanities scholarship in literary and cultural studies may also consider Professor Warren's seminar: 'Introduction to Digital Humanities.'	U	4, 17, 11	focused
76389	English	Rhetorical Grammar	This is a course in fundamental grammatical structures of English and how these structures fit into the writer's toolkit. This means you will learn a lot about English-language grammar in this course en route to understanding a lot about English language writing. This course is designed for MA students in professional writing and undergraduates who want to improve their grammar, their writing, and their depth of understanding of how improvement in grammar impacts improvement in writing.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76391	English	Document & Information Design	This course provides students who have already learned the foundation of written communication with an opportunity to develop the ability to analyze and create visual-verbal synergy in printed documents. Students will be introduced to the basic concepts and vocabulary, as well as the practical issues of visual communication design through a series of hands-on projects in various rhetorical situations. Assigned readings will complement the projects in exploring document design from historical, theoretical, and technological perspectives. Class discussions and critiquing are an essential part of this course. Adobe InDesign, Photoshop, and Illustrator will be taught in class, and used to create the assigned projects.	U	4, 9, 11	focused
76395	English	Science Writing	This course will teach students how to write clear, well-organized, compelling articles about science, technology and health topics for a general audience. Students will learn how to carry out research on scientific topics using primary and secondary sources, how to conduct interviews, and how to organize that information in a logical fashion for presentation.For writing majors, the course will increase their understanding of scientific research and how to describe it accurately and completely to a general audience. For science majors, this course will teach them how to craft fluid, powerful prose so that they can bring their disciplines to life. The course is not intended just for those who want to become science writers, but for anyone who may have the need to explain technical information to a general audience, whether it is an engineer describing a green building project at a public hearingor a computer programmer describing new software to a firm's marketing staff. Scientists and educators today are increasingly concerned about the public's lack of understanding about scientific principles and practices, and this course is one step toward remedying that deficit.Students will get a chance to read several examples of high-quality science writing and interview researchers, but the primary emphasis will be on writing a series of articles, and rewriting them after they've been edited. The articles will range from profiles of scientists to explanations of how something works. In particular, this year's class will focus on how science and society interact, whether that means the way that science affects marginalized communities or how scientific findings are shaped by ethical debates. Students should expect to see their writing critiqued in class, in a process similar to what journalists routinely go through. The goal will be clarity and verve; the ethos will be mutual learning and enjoyment.	U	4, 17, 9	focused
76396	English	Non-Profit Message Creation	Non-profit organizations support a multitude of causes ranging from the arts to animals to the environment to health care to human rights to scientific research to many great causes in between. Non-profits achieve their missions by advocating on behalf of their organization's cause, raising public awareness about issues surrounding their cause, and fundraising to make their advocacy possible. In this course, students will select a local, Pittsburgh-area non-profit to examine and produce materials based on the organization's needs. Over the course of the semester students will research the organization's persona and values via interviews with chosen organization's staff and analysis of existing communication channels and different forms of content currently used by the organization. Students will use this research and analyses to inform and shape a final project that should meet the specified, needed deliverables from the selected non-profit. Previous example projects include: Revising a newsletter and specifying future best practices for an organization; developing new format and copy for an organization's website; developing a social media campaign for an upcoming event; developing a grant proposal for an organization's project; among many others. Students will have a wide selection of organizations to choose from and know projects associated with the organization at the beginning of the semester, as these will be organized by the professor. At the end of the course, students will have a portfolio ready material and an increased understanding as to how non-profit organizations advance their causes.	U	16, 4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76397	English	Instructional Text Design	This course focuses on the planning, writing, and evaluating of instruction of various kinds, especially instructional texts. It is particularly appropriate for professional and technical writers, but also a good option for anyone interested in fields that involve substantial instruction, such as teaching or employee training. In the first part of the course, we'll examine the recent history of instructional design and the major current theories. Then we'll take a step back and study the concepts of learning upon which these theories are based, with particular attention to their implications for how instruction is structured. You'll find that different learners (e.g., children, older adults) and goals (e.g., learning concepts and principles, learning to apply principles to solve novel problems, learning a procedure, learning to change one's behavior, etc.) require different types of instruction. In the second part of the course, we'll look in detail at models of how people learn from texts and what features (e.g., advanced organizers, examples, metaphors, illustrations, multimedia) enhance learning under what circumstances. We will study and analyze particular types of texts. Some possible examples include an introduction to the concept of gravity; a tutorial for computer software; a self-paced unit in French; adult educational materials in health care; a workshop on sexual harassment in the workplace; or a unit to train someone how to moderate a discussion. We will also look at various methods (concept mapping, think-aloud, comprehension tests, etc.) that are used to plan and evaluate instructional text. You will do a project, either individually or in a small group (2-3), in which you design, write and evaluate instruction.	U	4, 16, 5	focused
76413	English	Book Design: A Cultural History	Today the book is thriving despite earlier predictions of its "death" at the hands of the digital media. What has made the book so powerful a medium over six centuries? This course will take you into the book's makeup, design, and impact over time. We study how the book was made at different times in its historyfor instance, the manuscript book (medieval), the hand-press book (Renaissance and eighteenth century), the machine-made book (1800s to present). We also ask how today's databases like Google Books make us see new dimensions of the print medium that were not visible earlier. Likewise we will study theories of the print medium and the cultural effects of the book among readers and social groups. Students will have hands-on experience with a printing press and the Rare Book archives at Hunt and Hillman libraries. Two papers and shorter assignments will be required. Please note: first-year students are prohibited from registering for this course. Sophomores must obtain instructor permission.	U	4, 9, 11	focused
76415	English	Mediated Power and Propaganda	For most of us, the word "propaganda" triggers a familiar script. We tend to think of totalitarian regimes where the State controls information and prohibits the expression of dissenting views. We also tend to associate propaganda with certain rhetorical techniques - highly emotional words, deceptive representations, and glittering generalities that inhibit rational thought and manipulate public opinion. According to such popular views, propaganda is linked to the dissemination of false information and is antithetical to the norms of democratic society. Our class will challenge these assumptions. First, instead of confining propaganda to authoritarian governments, we will examine how propaganda functions within democratic society. Indeed, we will focus on domestic propaganda in America, especially political propaganda but also propaganda in advertising and public relations. Next, instead of focusing exclusively on deceptive rhetorical techniques, we will ask a more elemental question: What enables propaganda to circulate? Answering this question will force us to consider the routines and values of corporate media as well as the power relations that give some people special access to channels of mass communication. Certainly, we will also examine propaganda messages themselves, attending to manipulative tactics as well as rhetorical strategies used to induce uptake in the mainstream press. We begin our seminar by studying key theories of propaganda, looking at primary texts for various definitions and criticisms of the concept. We will then examine how powerful institutions, especially media organizations, manage the dissemination of propaganda in democracies. Finally, we will consider how to analyze propaganda, generating methodological prerequisites for scholarly study. Ultimately, students will have the opportunity to conduct their own research on propaganda as it relates to their academic and professional goals.	U	4, 17, 16	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76420	English	The Cognition of Reading and Writing: Introduction to a Social/Cognitive Process	Ever wondered how a reader is interpreting a text you wroteand how that compares to what you thought it said? Or how does your own process of writing that text compare to the problem-solving strategies experts draw upon? This course explores reading and writing as a social/cognitive processrevealing conscious and unconscious problem-solving strategies with which readers comprehend and interpret texts, and writers construct and communicate their meaning. To get at the why behind the surprising things readers do with a text, we will draw on the psychology of reading, where socially constructed memory networks, cognitive schemas, and meta-knowledge actively shape interpretation. To uncover readers' interpretations, we put our knowledge to work trying out user-testing methods that help writers build effective audience-based presentations, applications, websites, or guides. We then take the same approach to writers as thinkers, examining the key problem-solving processes, from task representation, to planning, to revision, on which expert and novice writers often differ. Learning to track problem-solving through process tracing methods, will let you carry out two case studies of your own. The first will uncover the (sometimes radical) differences in how a small set of readers actually interpret a text you find significant. The second will be a case study of your own thinking process on a real task you are doing outside this class. Here you are likely to uncover old unconscious habits, problems you had to solve, as well as unrecognized successful strategies, giving you a new reflective insight into your own thinking as a writer. Freshmen prohibited from registering for this course. Sophomores must obtain instructor permission.	U	4, 17, 1	focused
76431	English	Gender Play in Early Modern Drama	The playhouses of early modern London offered access to an astonishing spectacle that would be difficult to find anywhere else in the city: men dressed as women, skillfully reproducing (but also exposing, interrogating, and refining) the significations that structure concepts of gender difference. In addition to this fundamental condition of performance and theatrical experience, the plots of the plays themselves regularly engaged with issues pertaining to gender and sexuality, an interest that runs through the raunchy satires performed by companies of adolescent boys, the innumerable comedies of cross-dressing and mistaken identity, and the equally numerous tragedies centered on problems of inequality and imbalances of power. This course will consider a wide range of drama from the period alongside a selection of readings in sexuality and gender theory, thus bringing early modern dramatists such as William Shakespeare and Thomas Middleton into conversation with contemporary thinkers such as Judith Butler and Sarah Ahmed. The body of core texts will include Twelfth Night, The Merchant of Venice, As You Like It, The Roaring Girl, The Taming of the Shrew, The Tamer Tamed, The Island Princess, The Witch of Edmonton, The Silent Woman, Women Beware Women, and Galatea. Please note: First-year students are prohibited from registering for this course. Sophomore students must obtain instructor permission.	U	5, 10, 4	focused
76439	English	Film Seminar: The Rise of the Art Film	The years between 1945 and 1970 saw an explosion of filmmaking talent around the world. Directors such as Vittorio De Sica (Italy), Jean-Luc Godard (France), Agnes Varda (France), Akira Kurosawa (Japan), Ingmar Bergman (Sweden) and Satyajit Ray (India) completely changed the way narratives looked on screen. Just as important, however, was the fact that American audiences used to the standards and storytelling strategies of the Hollywood studio system were suddenly presented with a variety of international cinemas which collectively came to be known as "art films." This class will examine a broad cross section of such films while also scrutinizing the impact of the "art film" on Hollywood narrative strategies, domestic distribution networks, film criticism and American culture.	U	17, 11, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76450	English	Law, Culture, and the Humanities	"I'm not a lawyer, but..." How many times have you heard this disclaimer, closely followed by a lay analysis of law? This course, an introduction to the cultural study of law for graduate students and advanced undergraduate students, can be seen as an introduction to what goes into the making of such a statement. Where do we get our ideas about law? What do we mean when we say "law"? What counts as law? How does culture influence law, and law, culture? And to what degree should historical context condition any answers we might be tempted to give? Students in the course will study works in a range of genres (novels, plays, poems, judicial opinions, pamphlets) and develop methods for investigating ways that law and culture have been made by one another from the 16th-century to the present. Readings will include influential theoretical accounts of law (Aristotle, Hobbes, Cover, Habermas, Bordieu, MacKinnon, Alexander), canonical texts in Law and Literature (Shakespeare's Measure for Measure, Melville's Billy Budd, Kafka's The Trial) and some "weird fiction" by the novelist/legal theorist China Miéville. As a counterpoint to the fiercely anti-historical "law and economics" movement, however, the course will put special emphasis on rooting intersections of law and culture in rich historical context, considering both local and international legal contexts (sometimes in fairly technical detail) alongside so-called "ephemera" of culture. Students will tackle the especially fruitful "case" of Renaissance Britain before developing final research projects, whether on the Renaissance or another period of their choosing.	U	4, 17, 11	focused
76452	English	Generations and Culture	We frequently hear about generations--the Millennials and their multitasking, Gen X and their minivans, and the Baby Boomers and their self-satisfaction--but generations have usually been ignored in cultural studies. Yet generations have significant impact on cultural tastes, consumer choices, and political views, as a good deal of research shows, and identity, alongside other factors such as race, class, gender, sexuality, ethnicity, and abledness. This course will study the theory of generations, as well as novels and films that tell us about generations. Please note: first-year students are prohibited from registering for this course. Sophomore students require instructor permission.	U	5, 4, 10	focused
76460	English	Beginning Fiction Workshop	This course builds upon survey or introduction courses to exercise the writer's craft in fiction. Several texts will be analyzed, in both the short story and novel forms. We will read closely with a focus on the craft of writing--the voice, point of view, character development, etc. We will develop a vocabulary for speaking about the craft of fiction and hone our skills by reading good fiction, discussing work in class and writing response papers with an eye toward the various aspects of the writing process. We will arrange a schedule in which each student?s work will be reviewed twice via peer review and in-class discussion.	U	11, 17	focused
76462	English	Advanced Fiction Workshop	In this class we will work on how narratives are told. Using masterworks to help guide our writing, we will spend the first part of the semester writing stories that imitate the style or narrative voice of several authors. You will have a story due every week. We will workshop several of these stories concentrating our editorial comments on story, development, character, and voice. Your time after mid-semester will be devoted to rewriting and reworking these exercises into stories.	U	2, 11, 16	focused
76464	English	Creative Nonfiction Workshop	F20: This course will offer you the chance to read and write memoir and short essays. How do stories of your own life connect to the larger world? How might you learn to write about the people and places of your own life in a way that helps you, and your readers, achieve a deeper understanding of the world we share? The class emphasizes the art of close observation as the fuel all writers need to create compelling stories, along with an awareness of particular reading audiences. Every student will investigate one journal or magazine and write a final piece for submission to that venue. Students will create a portfolio of their own creative nonfiction, do oral presentations, read extensively, and deepen their knowledge of the craft of good nonfiction writing.	U	4, 7, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76465	English	Advanced Poetry Workshop	In this course, you will be expected to take your knowledge of the principles and techniques of poetry and utilize them in workshop discussions, written analysis, and the composition of your own poems. In addition, readings of books by visiting poets will be required, Participation in a book-making project, cross-genre writing, and/or a mentoring project with high school students will also be included.	U	4, 17, 9	focused
76467	English	Crime Fiction and Film	This course will be concerned with hardboiled crime fiction in print and on screen. The hardboiled emerges in Ernest Hemingway a distinctive literary style, and about same becomes a formula for pulp crime fiction. The language and attitude of the hardboiled became associated with urban gangsters in films such as The Public Enemy. Newspaper crime coverage beginning in the 1920s becomes increasingly frank in both its language and photographic coverage of crime. These various elements will be the material for a new kind of literature represented Dashiell Hammett, James M. Cain, and especially Raymond Chandler, and for a cycle of films that owe much to their work, film noir. Chandler was responsible for invention of one of most enduring types in American fiction, the hardboiled detective. The course will focus on Chandler and the crime stories after him that make various uses of that type and the formula that has become associated with it. Throughout the course we will consider the social and political contexts in which these cultural forms developed, and what cultural work the hard-boiled performed. We will be especially interested such questions as the function of the misogyny typical of much of it, the different representations of race by white and black artists, the representation of police, whether the hardboiled is best understood as having a working-class affiliation, and the degree to which its various manifestations might be called realist. NOTE: Freshmen are prohibited from registering for this course. Sophomores must obtain instructor permission.	U	16, 5, 11	focused
76474	English	Software Documentation	This course teaches theory, techniques, and best practices for creating software documentation. We will learn to plan, architect, write, and publish audience-appropriate user assistance, while applying concepts and approaches like minimalism, topic-oriented authoring, single-source publishing, content reuse, and metadata. Students will complete homework assignments and larger projects to reinforce principles and provide experience in all phases of the software documentation lifecycle. Readings and class discussion will bridge theory and practice.	U	4, 12, 9	focused
76476	English	Rhetoric of Science	This course explores questions about scientific argument and communication that are of interest to scientists, rhetoric of science scholars, and professional/technical writing practitioners. These include questions like: How are scientific arguments structured? How is scientific information and argument transformed when it moves from research papers to publications for non-specialist audiences? How does the social, historical, and cultural context of science shape the way it is communicated and/or argued? What contributions do visuals make to scientific argument and communication? To investigate these questions, we will be examining a wide variety of real-world communications in and about science as well as texts in rhetoric, history, and philosophy of science.	U	17, 11, 9	focused
76481	English	Introduction to Multimedia Design	There is increasing demand for professional/technical writers who understand multimedia and its communicative possibilities. This class will provide students with the opportunity to develop the ability to create and analyze multimedia experiences that merge text, spoken voice, music, animation and video. Students will be introduced to the basic concepts and vocabulary of motion graphics, as well as the practical issues surrounding multimedia design and digital storytelling through a series of hands-on projects involving various contexts. Students will explore what it means to write for a dynamic medium and how to take advantage of elements of time, motion and sound to help expand their visual communicative skills. The essentials of Adobe After Effects will be taught in order to build the skills necessary to complete assignments, explore multimedia possibilities and foster each student's unique creative voice. Adobe Premiere and Audition will be employed to support specific tasks. Students will also be taught to capture their own original images, video and narration audio to craft the elements of their projects. It is helpful to have some prior basic experience with Photoshop or Illustrator. In-class discussion and critiques are an essential part of this course.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76487	English	Web Design	The World Wide Web is a vast collection of information, far more than we can comfortably handle; even individual websites can pose so much information that they become overwhelming. In this client-facing, project-oriented class, we aim to look at ways to tackle this problem, and design content for the web that is easy to access and digest. We will look at how websites manage and present organized information, with an eye to understanding what works well. We will use methods to learn who is using a website and why, and develop our toolset to test our decisions when implementing a new design. Along the way, we will develop a familiarity with the core web technologies of HTML5 and CSS3, with discussion of graphics, sound, social media, and other tools to enrich our presence on the World Wide Web. Please note: Freshmen are prohibited from registering for this course. Sophomores must obtain instructor permission.	U	9, 17, 1	focused
76491	English	Rhetorical Analysis	Students in this course will learn various approaches to analyzing discourse artifacts from a rhetorical point of view. Early in the course, students will identify an artifact or artifacts they wish to analyze. From there, students will be encouraged to explore their own methods of analysis based on two required books for the course and reviews of literature. For the midterm, students will create an annotated bibliography of five specimens of criticism taken from a single journal. For the final project student will first present and then hand in a polished 15 page piece of criticism based on one or some combination of methods. The presentation and final paper count 50% of the grade, with the mid-term, class attendance, participation, and homework making up the final 25%.	U	4, 17, 11	focused
76496	English	Research Methods in Rhetoric & Writing Studies	This course will be a survey introduction to historical, empirical, text-based, and qualitative methods of inquiry used in the fields of rhetorical and writing studies. We will read broadly to understand the philosophical questions, research traditions, practical applications, and innovative directions that shape the field, exposing students to a range of methods and methodologies. Studies of rhetoric, writing, and literacy have evolved tremendously, and we will examine approaches for how to trace, analyze, and critique the use of meaning making in a variety of cultural, political, workplace, technological, and pedagogical contexts. By the end of the course, students will develop a sense of how to put together an effective research project on their own and design and articulate the research methods and methodologies appropriate to that study. Throughout, we will ask a fundamental question: How does rhetoric, writing, and literacy work and for what purposes? Please note: first-year students are prohibited from registering for this course. Sophomore students must obtain instructor permission.	U	9, 4, 17	focused
76700	English	Professional Seminar	This weekly, 3-unit seminar is designed to give professional writing majors an overview of possible career and internship options and ways to pursue their professional interests. Each session will feature guest presenters who are professionals working in diverse communications-related fields such as web design, journalism, public relations, corporate and media relations, technical writing, medical communications, and working for non-profits. The visiting professionals talk about their own and related careers, show samples of their work, and answer student questions. The course is required for first-year MAPW students and open to all English undergraduates, who are urged to participate in their sophomore or junior years to explore options for internships and careers.	G	4, 17, 8	focused
76702	English	Communication Support Tutoring Practicum	This practicum is restricted to students who have applied and accepted a position as a Global Communication Center tutor. For more information on applying, contact the course instructor. Students in this six-unit mini will learn about best practices in tutoring, gain experience analyzing and responding to a wide range of academic and professional genres, and learn to adapt their tutoring style for different kinds of students. In addition, we will learn to support oral, visual, and collaborative modes of communication alongside more traditional written genres. Assessments include regular hands-on activities, reading responses, and participation in class discussions. Please note that in terms of time commitment, a 6 unit mini is equivalent in weekly workload to a 12 unit full semester course. The mini is half the credits because it requires the same workload but only for half the semester.	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76708	English	Literary Journal Publishing	In this course, students will learn about the landscape of and publication process for literary journals in the United States. We will read a variety of literary journals in print and online, will host guest speakers, and will do a variety of hands-on activities related to editing and publishing. Students will gain experience by working on The Oakland Review, an international literary journal run out of CMU, in capacities as varied as editorial, design and production, or promotion. If you are interested in registering for this course, please go to the Course URL and fill out the questionnaire. Thank you.	G	4, 9	focused
76719	English	Environmental Rhetoric	Environmental rhetoric is a place of commitment and contention in which competing discourses celebrate our relationship with the natural world, frame environmental problems, and argue for public action. As we compare the environmental rhetoric of naturalists, scientists, policy makers, and activists, we will trace an American history that has managed to combine mystical celebration with militant critique, and scientific research with public debate. Equally important, this course will prepare you to act as a rhetorical consultant and writer, learning how writers communicate the three "Rs" of environmental rhetoric: relationship with nature, the presence of risk, and the need for response.	G	4, 12, 13	focused
76729	English	Performing Race in Early Modernity	The earliest known use of the term "white" in reference to Europeans occurs in The Triumphs of Truth, a 1613 play by Shakespeare's contemporary, Thomas Middleton. In addition to suggesting an important connection between race and drama in 17th-century England, this simple historical note raises a range of questions that have a direct bearing on some of the most pressing issues of the 21st century: Where do ideas about race come from? By what processes do the distinctions of racial concepts emerge, evolve, calcify, and mutate? How does the conceptualization of race relate to media? How do racial representations bolster and conduct political power? In this course, we will broach these questions by taking a close look at the race-making function of drama in early modernity, a period when race was an inchoate, incipient concept, caught up with the emergence of colonialism, capitalism, and increasing interconnection between peoples, cultures, and worlds. As we think, read, and converse together, we will endeavor to come to terms with the problems and paradoxes of racial representation in the early modern theater, a forum that offered access to innovative, daring thinking about human equality and ethical responsibility, but was also a site for the perpetuation of hateful stereotypes and exploitative theories of white supremacy. In a wide-ranging survey of drama, historical documents, and contemporary criticism, we will work toward an understanding of how race-based concepts operated in the theater, and how the drama early of modernity continues to influence thinking about race in our own time.	G	9, 5, 10	focused
76754	English	Watchdog Journalism	The practice of journalism involves covering the news of the day. Investigative journalism uncovers it, digging through public records and data to expose corruption or correct social injustices. The process takes patience and persistence, as well as familiarity with right-to-know laws, to find that gold nugget of information that exposes secrets or becomes the missing piece to a larger puzzle. In this course, students will learn investigative techniques that make the powerful accountable, using government documents, financial filings and databases to spot undetected crime patterns, an unfair housing policy or perhaps questionable spending by a non-profit charity. Investigative journalism has a storied history of exposing wrongdoing and today many of the tools historically used to tell those stories are available to everyone. This course will help budding journalists, researchers and anyone else interested in addressing societal problems find those tools and learn how to use them.	G	16, 4, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76755	English	Leadership, Dialogue, and Change	This course is about an alternative to the "great man" theory of leadership--in which success is built on charisma, power, status, or institutional authority. The alternative model of adaptive leadership, however, depends on an ability to draw a divided community into a dialogue that re-frames the problem and may even call on us to re-interpret our values. We will see this in action, comparing the methods of Martin Luther King to the radical community organizing of Saul Alinsky, or in the influential of African-American cultural critiques of Cornel West and bell hooks, or in the work of students calling for change on campuses. Their work poses a question: how does dialogue work in the rhetoric of making a difference? So in the second half, we will put theory into practice, organizing a CMU Community Think Tank to explore this question: how do college students take effective leadership on public issues raised on campus (e.g., climate change, equity for workers, or the corporate ethics of would-be employers)? How do student advocates give "rhetorical presence" to problems or create counterpublics that actually put ideas into "circulation"? How do departments and faculty support publicly engaged learning in their disciplines? In this project of studying and taking leadership, you will develop skills in framing a shared problem, collecting data across diverse, often competing perspectives, in creating a Briefing Book to guide live Round Table problem-solving dialogues, and in documenting, writing and publishing your Findings on www.cmu.edu/thinktank. As a portfolio project, it will also demonstrate your ability to support problem-solving dialogues across difference in a community or organization.	G	13, 4, 8	focused
76772	English	News Writing	In this course, we will study and learn the fundamental skills of journalistic writing as well as discuss topics related to how different media outlets cover news. On the writing side, we will start with the basics - the importance of accuracy, clarity and fairness, writing for audience, striving for objectivity, judging newsworthiness, meeting deadlines. Class discussions will touch on current news events, with the historic presidential election this fall undoubtedly taking center stage. The core class work (and most of your grade) will be based on seven writing assignments due approximately every two weeks throughout the semester. Expect to do some writing each class period. We will learn how to write a story lede (yes, that's how journalists spell it), how to structure a story and how to write different kinds of news stories, from crime news to features to editorials and commentary. We also will learn how to research a news story, conduct an interview and sort through mountains of information to discern what's important so we can write about it in a clear, concise manner.	G	4, 16, 17	focused
76773	English	Argument	This course introduces the fundamentals of argumentation theory and offers guided practice in analyzing and producing arguments. Through analysis, we will learn what an argument is, how to identify one, and what the names and functions of a variety of argument features are. We will also explore the production of argument by pursuing the questions: What are my argumentative goals? How do I build a theory of my audience? What means of persuasion are available for me to achieve my goals? And how should I order the contents of my argument? To answer these questions, we will explore argument in a variety of genres including visuals, op-eds, presidential speeches, and congressional testimonies.	G	4, 9, 8	focused
76784	English	Race, Nation, and the Enemy	Conflicts over racial and national identity continue to dominate headlines in the United States as they often have during the nation's history, from debates regarding the immigration, naturalization, and birthright citizenship of racial minorities to debates regarding racial disparities in access to civil rights. This course explores the discursive practices through which racial and national identities are formed and the frequent conflicts between them, particularly by focusing on the role of enemies, threats to the nation, and sacrifices made on behalf of the nation in American public discourse. Alongside primary sources of public discourse regarding wars, the immigration and citizenship of racial minorities, racial segregation and civil rights, and the criminal prosecutions of dissidents during periods of crisis, we will read secondary sources offering multiple theoretical and disciplinary approaches to the study of racial and national identity formation. Along with regular brief responses to readings, assignments will include a short rhetorical analysis paper and a longer research paper.	G	10, 16, 5	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76788	English	Coding for Humanists	This introductory course provides humanities students with the foundational knowledge and skills to develop computer-aided research tools for text analysis. Through a series of hands-on coding exercises, students will explore computation as a means to engage in new questions and expand their thinking about textual artifacts. This course is designed for students with no (or very little) coding experience. During the early part of the semester, students will learn basic programming using Python through examples and problem sets that are relevant to text analysis. Then, students will be introduced to a limited set of commonly used Python packages for text analysis, such as natural language processing, statistical analysis, visualization, web scraping, and social media text mining. Students are expected to complete a small final project that examines how evidence-based data-driven insights derived from text analysis would support humanistic research in their area of interest, including (but not limited to) genre studies, rhetorical criticism, authorship attribution, discourse analysis, cultural analysis, social network analysis, spatial/temporal text analysis, and writing assessment. Doctoral students in the Department of English must register for 12 units, and are expected to write a publishable quality paper. Students who are interested in digital humanities scholarship in literary and cultural studies may also consider Professor Warren's seminar: 76429/829 'Introduction to Digital Humanities.'	G	4, 17, 11	focused
76789	English	Rhetorical Grammar	This is a course in fundamental grammatical structures of English and how these structures fit into the writer's toolkit. This means you will learn a lot about English-language grammar in this course en route to understanding a lot about English language writing. This course is designed for MA students in professional writing and undergraduates who want to improve their grammar, their writing, and their depth of understanding of how improvement in grammar impacts improvement in writing.	G	4, 17, 9	focused
76791	English	Document & Information Design	This course provides students who have already learned the foundation of written communication with an opportunity to develop the ability to analyze and create visual-verbal synergy in printed documents. Students will be introduced to the basic concepts and vocabulary, as well as the practical issues of visual communication design through a series of hands-on projects in various rhetorical situations. Assigned readings will complement the projects in exploring document design from historical, theoretical, and technological perspectives. Class discussions and critiquing are an essential part of this course. Adobe InDesign, Photoshop, and Illustrator will be taught in class, and used to create the assigned projects	G	4, 9, 11	focused
76796	English	Non-Profit Message Creation	Non-profit organizations support a multitude of causes ranging from the arts to animals to the environment to health care to human rights to scientific research to many great causes in between. Non-profits achieve their missions by advocating on behalf of their organization's cause, raising public awareness about issues surrounding their cause, and fundraising to make their advocacy possible. In this course, students will select a local, Pittsburgh-area non-profit to examine and produce materials based on the organization's needs. Over the course of the semester students will research the organization's persona and values via interviews with chosen organization's staff and analysis of existing communication channels and different forms of content currently used by the organization. Students will use this research and analyses to inform and shape a final project that should meet the specified, needed deliverables from the selected non-profit. Previous example projects include: Revising a newsletter and specifying future best practices for an organization; developing new format and copy for an organization's website; developing a social media campaign for an upcoming event; developing a grant proposal for an organization's project; among many others. Students will have a wide selection of organizations to choose from and know projects associated with the organization at the beginning of the semester, as these will be organized by the professor. At the end of the course, students will have a portfolio ready material and an increased understanding as to how non-profit organizations advance their causes.	G	16, 4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76813	English	Book Design: A Cultural History	Today the book is thriving despite earlier predictions of its "death" at the hands of the digital media. What has made the book so powerful a medium over six centuries? This course will take you into the book's makeup, design, and impact over time. We study how the book was made at different times in its historyfor instance, the manuscript book (medieval), the hand-press book (Renaissance and eighteenth century), the machine-made book (1800s to present). We also ask how today's databases like Google Books make us see new dimensions of the print medium that were not visible earlier. Likewise we will study theories of the print medium and the cultural effects of the book among readers and social groups. Students will have hands-on experience with a printing press and the Rare Book archives at Hunt and Hillman libraries. Two papers and shorter assignments will be required.	G	4, 9, 11	focused
76829	English	Digital Humanities	This course is a "learn by doing" introduction to questions and methods in digital humanities, with special emphases on common tasks in digital history, digital literary studies, library science, and cultural analytics. Students will tackle real-world humanities problems while developing core computational competencies such as those required for gathering data (text mining, APIs), transforming data (OCR, regular expressions, natural language processing, image magick), file management (shell commands), data visualization (matplotlib, arcGIS), and more.	G	4, 11, 9	focused
76831	English	Gender Play in Early Modern Drama	The playhouses of early modern London offered access to an astonishing spectacle that would be difficult to find anywhere else in the city: men dressed as women, skillfully reproducing (but also exposing, interrogating, and refining) the significations that structure concepts of gender difference. In addition to this fundamental condition of performance and theatrical experience, the plots of the plays themselves regularly engaged with issues pertaining to gender and sexuality, an interest that runs through the raunchy satires performed by companies of adolescent boys, the innumerable comedies of cross-dressing and mistaken identity, and the equally numerous tragedies centered on problems of inequality and imbalances of power. This course will consider a wide range of drama from the period alongside a selection of readings in sexuality and gender theory, thus bringing early modern dramatists such as William Shakespeare and Thomas Middleton into conversation with contemporary thinkers such as Judith Butler and Sarah Ahmed. The body of core texts will include Twelfth Night, The Merchant of Venice, As You Like It, The Roaring Girl, The Taming of the Shrew, The Tamer Tamed, The Island Princess, The Witch of Edmonton, The Silent Woman, Women Beware Women, and Galatea.	G	5, 10, 1	focused
76850	English	Law, Culture, and the Humanities	"I'm not a lawyer, but..." How many times have you heard this disclaimer, closely followed by a lay analysis of law? This course, an introduction to the cultural study of law for graduate students and advanced undergraduate students, can be seen as an introduction to what goes into the making of such a statement. Where do we get our ideas about law? What do we mean when we say "law"? What counts as law? How does culture influence law, and law, culture? And to what degree should historical context condition any answers we might be tempted to give? Students in the course will study works in a range of genres (novels, plays, poems, judicial opinions, pamphlets) and develop methods for investigating ways that law and culture have been made by one another from the 16th-century to the present. Readings will include influential theoretical accounts of law (Aristotle, Hobbes, Cover, Habermas, Bordieu, MacKinnon, Alexander), canonical texts in Law and Literature (Shakespeare's Measure for Measure, Melville's Billy Budd, Kafka's The Trial) and some "weird fiction" by the novelist/legal theorist China Miéville. As a counterpoint to the fiercely anti-historical "law and economics" movement, however, the course will put special emphasis on rooting intersections of law and culture in rich historical context, considering both local and international legal contexts (sometimes in fairly technical detail) alongside so-called "ephemera" of culture. Students will tackle the especially fruitful "case" of Renaissance Britain before developing final research projects, whether on the Renaissance or another period of their choosing.	G	4, 17, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76852	English	Generations and Culture	We frequently hear about generations--the Millennials and their multitasking, Gen X and their minivans, and the Baby Boomers and their self-satisfaction--but generations have usually been ignored in cultural studies. Yet generations have significant impact on cultural tastes, consumer choices, and political views, as a good deal of research shows, and identity, alongside other factors such as race, class, gender, sexuality, ethnicity, and abledness. This course will study the theory of generations, as well as novels and films that tell us about generations.	G	5, 10, 17	focused
76854	English	Introduction to Literary and Cultural Studies	Cultural Studies is an intellectual and professional movement identified with the Center for Contemporary Cultural Studies in Birmingham. This movement grew out of literary studies. It is neither identitcal with literary studies, nor opposed to literary studies. It is today one form that the study of literature or other cultural works may take. This course offers a theoretical genealogy of cultural studies, showing how and why its theories and practices emerged and developed. As a genealogy, the course does not assume that cultural studies has an essence or an origin. The texts and topics will reflect the heterogeneity of its emergence and development. The course does, however, embody what we see as several historical changes in cultural studies, from idealism to materialism, from mono to multiculturalism, and from high culture exclusiveness to democratic inclusivity. The course is not designed to teach "approaches," but to explore and interrogate the founding assumptions of the academic project that you are being trained to join. Students should, by the end of the class, have a sense of where cultural studies came from and of the problems and possibilities raised by the theories it continues to invoke.	G	4, 17, 11	focused
76864	English	Creative Nonfiction Workshop	Creative Non-fiction Workshop is a good class to take if you like to tell (write) stories about your own life and the lives of other people, all situated in the world we inhabit, the world that is ours to investigate and celebrate and question. The class will teach you how to write a good story, by focusing on aspects of craft. Class is almost always run as a discussion. We'll read books by authors of creative non-fiction, and learn from them how to work with a variety of forms. Every student will create a portfolio of roughly 25 pages of non-fiction by term's end.	G	4, 7, 17	focused
76867	English	Crime Fiction and Film	This course will be concerned with hardboiled crime fiction in print and on screen. The hardboiled emerges in Ernest Hemingway a distinctive literary style, and about same becomes a formula for pulp crime fiction. The language and attitude of the hardboiled became associated with urban gangsters in films such as The Public Enemy. Newspaper crime coverage beginning in the 1920s becomes increasingly frank in both its language and photographic coverage of crime. These various elements will be the material for a new kind of literature represented Dashiell Hammett, James M. Cain, and especially Raymond Chandler, and for a cycle of films that owe much to their work, film noir. Chandler was responsible for invention of one of most enduring types in American fiction, the hardboiled detective. The course will focus on Chandler and the crime stories after him that make various uses of that type and the formula that has become associated with it. Throughout the course we will consider the social and political contexts in which these cultural forms developed, and what cultural work the hard-boiled performed. We will be especially interested such questions as the function of the misogyny typical of much of it, the different representations of race by white and black artists, the representation of police, whether the hardboiled is best understood as having a working-class affiliation, and the degree to which its various manifestations might be called realist.	G	16, 5, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
76881	English	Introduction to Multimedia Design	There is increasing demand for professional/technical writers who understand multimedia and its communicative possibilities. This class will provide students with the opportunity to develop the ability to create and analyze multimedia experiences that merge text, spoken voice, music, animation and video. Students will be introduced to the basic concepts and vocabulary of motion graphics, as well as the practical issues surrounding multimedia design and digital storytelling through a series of hands-on projects involving various contexts. Students will explore what it means to write for a dynamic medium and how to take advantage of elements of time, motion and sound to help expand their visual communicative skills. The essentials of Adobe After Effects will be taught in order to build the skills necessary to complete assignments, explore multimedia possibilities and foster each student's unique creative voice. Adobe Premiere and Audition will be employed to support specific tasks. Students will also be taught to capture their own original images, video and narration audio to craft the elements of their projects. It is helpful to have some prior basic experience with Photoshop or Illustrator. In-class discussion and critiques are an essential part of this course.	G	4, 9, 8	focused
76893	English	Introduction to Global & Postcolonial Studies	Since the 1978 publication of Edward Said's groundbreaking work Orientalism, postcolonial theory has gained currency as a critical discourse examining global experiences of colonization and decolonization. Since the term "postcolonial" was first invoked to describe the cultural effects of colonization, the field of study has expanded considerably. Today postcolonial studies looks backwards at earlier works on nationalism and cultural identity, gazes forwards towards seemingly dire futures, and unpacks present conjunctures. In this course, we will follow several threads of postcolonial theory to talk about the discursive operations of empire, the politics of representations, the problems of nationalism, the intersections of race, gender and sexuality in a global context, and the effects of colonialism, imperialism and globalization on economies, ecology, climate, and migration.	G	5, 13, 10	focused
76896	English	Research Methods in Rhetoric & Writing Studies	This course will be a survey introduction to historical, empirical, text-based, and qualitative methods of inquiry used in the fields of rhetorical and writing studies. We will read broadly to understand the philosophical questions, research traditions, practical applications, and innovative directions that shape the field, exposing students to a range of methods and methodologies. Studies of rhetoric, writing, and literacy have evolved tremendously, and we will examine approaches for how to trace, analyze, and critique the use of meaning making in a variety of cultural, political, workplace, technological, and pedagogical contexts. By the end of the course, students will develop a sense of how to put together an effective research project on their own and design and articulate the research methods and methodologies appropriate to that study. Throughout, we will ask a fundamental question: How does rhetoric, writing, and literacy work and for what purposes?	G	9, 4, 17	focused
79104	History	Global Histories	Human activity transcends political, geographical, and cultural boundaries. From wars to social movements, technological innovations to environmental changes, our world has long been an interconnected one. Acquiring the ability to understand such transnational and even worldwide processes is an indispensable part of any college education. This course provides students with an opportunity to develop the skills and perspectives needed to understand the contemporary world through investigating its global history. All sections are comparable in their composition of lectures and recitations, required amounts of reading, and emphasis on written assignments as the central medium of assessment. The sections all aim to help students: (1) master knowledge through interaction with the instructors, reading material, and other students, (2) think critically about the context and purpose of any given information, (3) craft effective verbal and written arguments by combining evidence, logic, and creativity, and (4) appreciate the relevance of the past in the present and future. For descriptions of specific sections, see "First Year Experience" at the Dietrich College General Education Website:http://www.hss.cmu.edu/gened/topics-79104.html	U	4, 12, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79198	History	Research Training: History	This course is part of a set of 100-level courses offered by Dietrich College departments as independent studies for second-semester freshmen and first- or second-semester sophomores in the College. In general, these courses are designed to give students some real research experience through work on a faculty project in ways that might stimulate and nurture subsequent interest in research participation. Faculty and students devise a personal and regularized meeting and task schedule. Each Research Training course is worth 9 units, which generally means a minimum for students of about 9 work-hours per week. Prerequisites/restrictions: For Dietrich College students only; minimum cumulative QPA of 3.0 (at the time of registration) required for approved entry; additional prerequisites (e.g., language proficiency) may arise out of the particular demands of the research project in question. By permission of the relevant professor and the Director of Undergraduate Studies. Students sign up for these courses through both the History Department and the Dean's Office.	U	4, 17, 11	focused
79200	History	Introduction to Historical Research & Writing	This course introduces students to methods and materials that historians use to study the past. Its goals are: first, to familiarize students with ways that historians think about their research, how they carry it out, and how they debate findings with other historians; second, to train students in "best practices" for doing historical research in primary and secondary sources. We discuss how to ask questions about the past and develop a one-semester research topic, find appropriate primary and secondary sources, take notes from those sources, and write a paper that answers an original question using skills we have studied. In the Fall 2019 semester, we will use the topic of the history of African slavery in the New World (the US, Caribbean, and Latin America) and the Old World (Africa and the Middle East). Although the institution of slavery dates back to antiquity across many of the world's cultures, the trans-Atlantic slave trade and its legal abolition transformed many of the institutions through which people of sub-Saharan Africa were enslaved in the 18th and 19th centuries. Historians of the Atlantic World and the Islamic World have struggled to define "slavery" and the changing category of "slave" and to understand the experiences of the men, women, and children held in bondage by these institutions. The first part of the class will consist of readings from primary sources such as eyewitness accounts, memoirs, poetry, and film to understand the meanings that participants gave to the experience of slavery. We also read secondary accounts of the way in which historians debate the meaning of "slave" and its transformation over time. Work includes reading and discussing course texts, completing short assignments, sharing writing-in-progress, oral reports to classmates, and a final research paper of 10-15-pages. The topical focus for 79-200 during the Spring 2020 semester will be announced in October 2019.	U	4, 17, 11	focused
79201	History	Introduction to Anthropology	Cultural anthropologists "make the strange familiar and the familiar strange," attempting to understand the internal logic of cultures which might, at first glance, seem bizarre to us, while at the same time probing those aspects of our own society which might appear equally bizarre to outsiders. In doing so, anthropology makes us more aware of our own culturally-ingrained assumptions, while broadening our understanding of the possibilities and alternatives in human experience. This course will use ethnographic writings (descriptive accounts of particular cultures), as well as ethnographic films, to investigate the ways in which diverse societies structure family life, resolve conflict, construct gender relations, organize subsistence, etc. We will assess the advantages and pitfalls of comparing cross-cultural data, analyze the workings of power within and between societies, and consider the politics of cultural representations. We will also discuss the anthropologist's relationship to the people s/he studies, and the responsibilities inherent in that relationship. Throughout the course, students will learn the importance of an historical perspective on culture, looking at how and why societies change, and considering how we, as anthropologists, should assess these changes.	U	5, 10, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79203	History	The Other Europes: The Habsburgs, Communism, & Central/Eastern Europe, 1740-1990	Organized as a combination of lectures and seminar discussions, this course explores the political, intellectual, social, and cultural changes occurring in 19th century and 20th century Central and Eastern Europe. It begins with an examination of the emergence of nationalist movements during the 19th century, to then explore the darker side of romantic nationalisms as they unfolded into the radical political ideologies such as socialism and fascism of the interwar period. We will ask to what extent these earlier histories continued to subtly influence post-1945 Central and Eastern Europe under socialism. The second part of the course will focus on the social and political transformations occurring at distinct moments in the history of the Soviet bloc: the 1950s Stalinization, the 1960s De-Stalinization, the emergence of the more subtle forms of dissent in the late 1970s and the early 1980s, and the revolutions of 1989. Course materials include not only historical and anthropological readings, but also historical documents, memoirs, and documentaries. The assignments include: mandatory attendance of lectures, regular participation in the class discussions, weekly diary entries and two take-home exams (midterm and final). The diary entries aim to make you better understand the mentalities and social and political changes at an individual level, by vicariously experience the events through "your" historical character. At the beginning of the semester, you will be assigned two specific characters that you will "impersonate" throughout the semester (one at the time), bringing in material from lectures and readings to bear on "your" character's own experiences.	U	11, 16, 4	focused
79204	History	American Environmental History	This course examines how people in North America have interacted with their surroundings from the end of the last ice age to the present. Topics include Native American economics, colonialism, westward expansion, industrialization, romanticism, conservation, and environmentalism.	U	15, 12, 8	focused
79211	History	Modern Southeast Asia: Colonialism, Capitalism, and Cultural Exchange	When you hear the term "Southeast Asia," what comes to mind? The Vietnam War? The ruins of the Angkor civilization? Rich culinary traditions? Or perhaps your own ethnic heritage? However you imagine it, Southeast Asia is an incredibly diverse and dynamic region that has long been integral to world affairs and whose importance continues to grow. This course offers a wide-ranging survey of Southeast Asia's peoples, their histories, and some of the issues they face today. Together we will explore the region as a "global crossroads," where the world's religions, economies, cultures, and politics come together in generative, sometimes traumatic, and often surprising ways.	U	11, 8, 9	focused
79213	History	The American Railroad: Decline and Renaissance in the Age of Deregulation	Railroads in the USA are often considered as a subject for nostalgia or public sector failure, an image largely based on passenger service. However, the USA's private sector freight rail industry is considered a model for the world as the result of its renaissance following deregulation in 1980. This is a "stealth" industry whose history and economics are both intertwined and complex. Starting with the development of the first U. S. railroads, students will gain a basic understanding of the industry's history and economics, with special attention to the past half-century. In addition, students will participate in small group research projects in particular areas of special interest -- for example, economic history, industry culture, network economics, utility regulation or transportation policy.	U	8, 11, 9	focused
79218	History	Tiananmen Square and Popular Protest in Modern China	On June 4, 1989, the world watched as tanks rolled into Beijing's Tiananmen Square ending what had been six weeks of student-led protest calling for reform of the Chinese Communist Party and its policies. This was not the first time students had gathered at Tiananmen to demand political change. Exactly seventy earlier, student-led protests launched the May 4th Movement, a social and intellectual revolution that fundamentally changed China and helped birth both the Nationalist Party of Chiang Kaishek and Communist Party of Mao Zedong. This class examines the causes and consequences of popular protest in modern China. While the focus is on the protests of 1919 and 1989, we will also look at other popular protests, including the Cultural Revolution (1966-1969), Democracy Wall Movement (1979), post-Tiananmen protests among workers, farmers, and ethnic minorities (especially Tibetans and Uyghurs), and the current protests in Hong Kong.	U	2, 4, 10	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79219	History	Hong Kong, Taiwan and the Idea of "China"	Starting with the core question, "What is China?", this mini-course explores the recent histories of Hong Kong and Taiwan to investigate questions of identity, nationalism, exceptionalism, and historical memory in "Greater China." While the international community recognizes the sovereignty of the People's Republic of China (PRC) over both Hong Kong and Taiwan, neither has ever been fully included in the modern Chinese nation-state. The agreement that transferred Hong Kong from the British Empire to Chinese control in 1997 enshrined the idea of "One Country, Two Systems," a guarantee that Hong Kong's political, legal, and economic systems would not be altered by China for fifty years. One Country, Two Systems has also been offered as a blueprint for "reunifying" Taiwan with Mainland China after seventy years of mutual hostility. However, in recent years publics in both Hong Kong and Taiwan not only increasingly resist political reunification with the PRC, but more and more identify themselves as citizens of either Hong Kong or Taiwan rather than members of a singular Chinese nation. This has led to mass protests in Hong Kong and calls for true independence in Taiwan.	U	8, 16, 9	focused
79220	History	Screening Mexico: Mexican Cinema, 1898 to Present	This mini-course is a survey of Mexican cinema from its origins in silent film to the present. Some areas of focus will include documentary footage and films of the Mexican Revolution (1910-1920), films of the Mexican "Golden Age" (1930-1960), and "New Mexican Cinema" from the 1990s forward. We will explore cinema as a window on Mexico's changing social, cultural and political dynamics, and as a way to probe such topics as: changing conceptions of Mexican identity; political critique and revolutionary movements; and urbanization, migration and the "drug war" in contemporary Mexico.	U	10, 1, 16	focused
79223	History	Mexico: From the Aztec Empire to the Drug War	This course provides a survey of Mexican history and culture over a variety of periods, from the rise of the Aztec empire, to Spanish conquest and colonization, to national independence, to the Mexican Revolution and contemporary Mexico. A wide range of topics will be addressed, such as: race, ethnicity, and indigeneity; state formation and politics; national identity and the politics of memory; migration and the border; and the drug war. Students will discuss historical and anthropological scholarship on Mexico, but will also consider cultural documents of various kinds, like Mexican music, art, and food.	U	10, 4, 11	focused
79227	History	Modern Africa: The Slave Trade to the End of Apartheid	The course is designed to give students an understanding and appreciation of African history and culture from the "inside out." Though it deals with the period of European expansion in Africa, it is centered on African language/ ethnic groups, villages, and individuals as historical actors who daily make collective and personal decisions to pass down, innovate, and borrow practices, technology, spiritual systems, etc. in the face of social, political, and economic realities. The course is also designed to get students thinking critically about how historians select and interpret sources to construct and reconstruct history at these different levels.	U	4, 8, 9	focused
79231	History	American Civil Rights Movement: From Garveyism to Black Power	This course is centrally focused on African Americans' struggle for political and economic freedom throughout the 20th century in the United States from the Garveyism in the 1920s to Black Power in the 1970s. It will attend to the ways in which gender, and class shaped race relations and activist campaigns. Students will explore the structure and manifestations of racial inequality in the United States; the broad historical forces that shaped opportunities and constraints for freedom struggles; the movement's various philosophies, strategies, demands, and tactics; activism and ideologies of the movement's allies and opponents; interactions between the black freedom movement and other movements challenging exclusion and discrimination; and the legacies of the movement. Students will explore these issues through reading in primary and secondary sources; viewing films and film clips; participating in interactive lectures and active course discussion and debates.	U	5, 10, 16	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79234	History	Technology and Society	How has technology shaped human society? And how have human beings shaped technology in return? This course investigates these questions across history-from stone tools, agriculture, and ancient cities to windmills, cathedrals, and the printing press; from railroads, electricity, and airplanes to atom bombs, the internet, and the dishwasher. In analyzing these tools, we will explore the dynamic relationships between technological systems and the social, political, religious, artistic, and economic worlds in which they emerged. We will also pay particular attention to technology's effects, asking both who benefited from and who was harmed by technological change. By the end of the course, students will be able to reflect critically on how humanity chooses which technologies to exploit and how human societies have been transformed by these choices.	U	2, 9, 8	focused
79236	History	Coming to America: Immigration History and Policy	We often hear the United States described as "a nation of immigrants," and the 2016 presidential election brought debates over immigration to the forefront of political debate with Donald Trump's promises to "build the wall." This mini course will examine how these two, seemingly contradictory ideas about immigration, one ostensibly inclusive and one exclusive, came to exist together in American political thought. We will investigate the history of immigration to the United States from the colonial period to the present day, with an emphasis on the history of immigration policy since its development in the 19th century. In doing so, students will analyze concepts such as Americanization, the melting pot, cultural pluralism, and distinctions between legal and illegal immigration. They will emerge from this class with a clearer understanding of US immigration policy and its changes and continuities over time.	U	10, 4, 16	focused
79237	History	Comparative Slavery	This course will examines the pervasive, world-spanning institution of human slavery. Although the time frame this course deals with is broad - from the rise of complex societies in the ancient world to slavery-like labor systems in the modern era - this class will focus more thoroughly on a few case studies, especially slavery in the Middle East and sub-Saharan Africa, the US, and the Caribbean. These disparate examples will be related to a number of core themes, including race, class, family, gender, religion, national identity and underdevelopment.	U	5, 10, 8	focused
79238	History	Modern African American Film: History and Resistance	This course explores the historical and contemporary impact of resistance on and in African American film during the twentieth and twenty-first centuries. We will consider how filmmakers use narrative and aesthetics to represent, address, and combat anti-blackness, attend to filmmaking itself as a potential act of resistance, and cultivate our own "oppositional gazes" as spectators and critics. The five films we will watch are: · Within Our Gates (dir. Oscar Micheaux, 1920) · Do the Right Thing (dir. Spike Lee, 1989) · Daughters of the Dust (dir. Julie Dash, 1993) · The Watermelon Woman (dir. Cheryl Dunye, 1996) · Moonlight (dir. Barry Jenkins, 2016) Access to the films and any supplemental readings will be provided; unless otherwise stated on the syllabus, students will be expected to carefully study this material prior to each class. Though there will be brief lectures contextualizing each film's production and reception history, the majority of our meeting times will be spent on student-led discussion. Assignments include weekly written responses, a final project, and classroom participation. Because of the nature of the course topic and the content of the films, participation requires extended engagement with fictional depictions of issues including, but not limited to, lynching, sexual violence, police brutality, homophobia, and intraracial antagonism. Students are free to contact me at any point in the term if this becomes an issue.	U	4, 16, 5	focused
79240	History	Development of American Culture	This is an introductory survey of American history from colonial times to the present. The course focuses on cultural history instead of the more traditional emphasis on presidents, wars, and memorizing facts or timelines. The major theme of the course is the changing meaning of freedom over three centuries. Required readings include several short books, historical documents, and a study of the concept of freedom. There is no textbook; background facts and events are covered in lectures to provide students with context needed to think about and understand America's cultural history. Assignments include exams and essays.	U	4, 17, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79248	History	U.S. Constitution & the Presidency	This course explores the changing role and powers of the American Presidency under the Constitution, from the founding era through the twentieth century. After absorbing drafting and ratification debates, we will focus on how particular presidents (Washington, Lincoln, FDR, Nixon) established or expanded the executive power and how particular conflicts (the Civil War, the "Court Packing" plan, Watergate) restructured or restricted the presidency. Readings will include the U.S. Constitution (of course), selections from The Federalist Papers, and three short books: Corey Brettschneider's The Oath and the Office: A Guide to the Constitution for Future Presidents, Daniel Farber's Lincoln's Constitution, and Cass Sunstein's Impeachment: A Citizen's Guide. Grades will be based on three short papers, a final paper, and daily preparedness and participation in group discussion.	U	16, 4, 7	focused
79251	History	COVID-19: What History Can Teach Us	For many, the COVID-19 Pandemic feels like a rupture in time - a disaster unprecedented in scale and impact. Yet one-hundred years ago, the Influenza Pandemic of 1918 killed between 17 million and 50 million people. That virus infected approximately a third of all human beings on the planet -- some 500 million people. Since then, humanity has faced a series of influenza epidemics and other global catastrophes, from world wars to HIV-AIDS. Like COVID-19, those crises were shaped by pre-existing forms of inequality and discrimination based on race, gender, sexuality, religion, nationality, and other forms of identity. Pandemics affect everyone, but not equally. For many of the world's poorest and most oppressed people, the COVID-19 pandemic feels less like a rupture than an escalation of long-standing inequalities. In the United States, the racial disparities of the pandemic reflect the long history of systemic racism. What can we learn from the past about how to cope with our current crisis? How can we confront the inequities and injustices of the world in the midst of such a crisis? This course will offer a historical lens on many of the most urgent and difficult questions that we face as a result of COVID-19. Saturday 11/7 from 12-3pm and 4-6pm EST, Monday 11/9 from 6-8pm EST Tuesday 11/10 from 6-8pm EST Wednesday 11/11 from 6-8pm EST Thursday 11/12 from 6-8pm EST Friday 11/13 from 6-8pm EST	U	10, 3, 5	focused
79255	History	Politics, Religion, and Conflict in 19th and 20th Century Ireland	[Note: students who have already taken this course under its former number 79-255 and former title, Irish History, may not enroll.] This 6-unit mini course surveys Irish history from the earliest human settlements until the present day, with emphasis on the period since the late eighteenth century. Our main objective is to understand the sources of conflict in modern Ireland. In order to do that, however, we will look at a number of topics such as the role of religion in Irish society; the causes of population growth, movement, and decline; changing forms of protest; and the formation of rival myths of the Irish past and its meaning.	U	4, 8, 10	focused
79256	History	Sex, Guns, Rock, and Skinheads: Youth Rebellion in Europe, 1960-1990	Between 1960 and 1990, young Europeans rebelled against the conservatism of their parents and politicians. In 1968, they exploded into the streets in capitalist Paris and socialist Prague. In West Germany and Italy, a minority of left-wing radicals took up the gun to bring former Nazis and Fascists to "justice." Young people demanded and practiced sexual liberation. Young women marched for their emancipation and led the struggle to legalize abortion. Young Europeans also contributed to the liberalization of anti-homosexual laws. The British Beat revolution rocked the world with its innovative music, anti-establishment lyrics, shocking fashions, and wild lifestyles. By the 1980s, youth rebellion had taken on disturbing trends with the emergence of right-wing Skinheads and a surge in drug addiction. The course combines lecture and discussion of readings and films. Students will write three essays (1000 words each) based on class assignments. They will write a final essay (1500-1700 words) based on their own research into the press, fanzines, films, etc. (in place of a final exam).	U	5, 4, 16	focused
79257	History	Germany and the Second World War	This course examines the Second World War from the perspective of the country that was central to it in every way. The course will cover: Hitler's ideology, war plans, and military strategy; the military/technological history of the War in Europe and North Africa; the role of the SS; the Holocaust; the occupation of Europe and Resistance movements; the political, social, and economic history of the Third Reich, including popular opinion, the German Resistance, and the use of slave labor in factories and on farms. Readings will include historical studies, a novel, and a memoir/diary.	U	8, 2, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79258	History	Napoleon	It is said that more books have been written on Napoleon Bonaparte than on almost any other historical figure. In this course, we will explore several themes, including how a revolution dedicated to liberty, equality, and fraternity culminated in the rise of a leader who exercised an authoritarian and personal power. What weaknesses was Napoleon able to exploit in France's fledgling democracy, and how did he build a personal "brand" that allowed him to accumulate power around himself? We will examine his transformation of Europe, but also his actions beyond Europe in Egypt and Haiti. Finally, we will interrogate the notion of "great men" of history, highlighting some of the voices that a focus on Napoleon himself fails to capture.	U	16, 5, 10	focused
79262	History	Modern China: From the Birth of Mao ... to Now	This course is an introduction to major themes in twentieth-century Chinese history, including the transition from empire to nation, revolution, social change and modernization, western and Japanese imperialism, the rise of the party-state, Chinese socialism, economic liberalization and the so-called "Chinese Dream." The first half of the class is devoted to the period between the fall of the imperial system and the founding of the People's Republic of China (1911-1949). If the victory of the Chinese Communist Party and development of the socialist state are to be considered in historical context, it is necessary to first understand the political, cultural, economic and intellectual currents that immediately preceded them. During the second half of the course, we will examine the Maoist period (1949-1976). We will investigate the Chinese Communist Party as both a state-building institution and an engine of social transformation, and consider the tensions these dual roles produced. Finally, we will look at the Reform Period (1978-present), and reflect on a newly robust China's attempts to come to terms with its own recent past and what the consequences might be for both China and the world.	U	8, 11, 1	focused
79264	History	Tibet and China: History and Propaganda	This course is an introduction to the "Tibet Question," the dispute over whether Tibet should be part of China, an independent nation-state, or, as the current Dalai Lama now advocates, something in between. "History" often serves as the battleground on which competing visions of the nation are fought - who should be included and excluded, where "natural" boundaries begin and end. This almost always requires a process of simplification in which inconvenient details are forgotten or repurposed in the service of national agendas. The "Tibet Question" is a telling example. In this class, we investigate the historical relationship between "China" and "Tibet" from the 13th century through the present, and note the ways advocates on both sides of the "Tibet Question" have constructed historical narratives (propaganda) in support of their political positions. We will also discuss the prospects for a political solution and consider the lessons the "Tibet Question" may hold for understanding other outstanding "historical" disputes.	U	11, 16, 17	focused
79266	History	Russian History and Revolutionary Socialism	This course covers an epic set of events in Russian history from the emancipation of the serfs in 1861 to the death of Stalin in 1953. Spanning almost a century of upheaval and transformation, it examines what happened when workers and peasants tried to build a new society built on social justice and economic equality. Learn about Lenin, Trotsky, Stalin, and other revolutionary thinkers and dreamers. The course surveys the revolutions in 1917, the Civil War and the Red victory, the ruthless power struggles of the 1920s, the triumph of Stalin, the costly industrialization and collectivization drives, the "Great Terror," and the battle against fascism in World War II. It ends with the death of Stalin, and the beginning of a new era of reform.	U	16, 10, 1	focused
79270	History	Anti-Semitism Then and Now: Perspectives from the Middle Ages to the Present	This course will examine the history of anti-Jewish hatred and violence from the Middle Ages through the present. The course will focus on representative case studies, texts, and films. These will include pre-modern incidents of "fake news" such as the medieval rumor of "blood libel" that unleashed massacres and mass expulsions of Jews from countless communities. In examining the rise of modern anti-Semitism, we shall focus on debates over Jewish assimilation and citizenship and consider the popular impact of the print media's dissemination of conspiracy theories of Jewish world domination, including the infamous forgery, "The Protocols of the Elders of Zion." We will also examine cases of mass anti-Jewish violence, known as pogroms, in Eastern Europe and Russia, and the genocidal onslaught against European Jewry by the National Socialist regime. Finally, we will discuss the resurgence of anti-Semitism in contemporary Europe and the United States.	U	16, 10, 5	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79272	History	Coexistence and Conflict: Muslims, Christians and Jews in Spain and Portugal	In Medieval Spain and Portugal, Islam, Judaism and Christianity coexisted in a situation distinguished by cooperation and exchange, as well as by friction, rivalry and violence. In this course, we shall explore the complexity of this unique historical encounter, as well as its role in shaping debates over modern Spanish/Portuguese and global identities and historical memory. We shall discuss topics such as: Inter-ethnic collaboration and violence; Jewish-Christian disputations; the exclusion and expulsion of religious and ethnic minorities; as well as Muslim and Jewish presence in present day Spain and Portugal. Historical documents, literary texts, film, musical traditions, as well as contemporary political and cultural debates, will be discussed to enhance familiarity with the topic.	U	16, 10, 5	focused
79275	History	Introduction to Global Studies	We live in an increasingly interconnected world, one in which our everyday actions have repercussions across vast distances. To understand this ever-denser web of connections, we must think beyond simplistic accounts of globalization as a uniformly positive, negative, or homogenizing process. Economic crisis, impoverishment, rising inequality, environmental degradation, pandemic disease, and irredentist movements are just as much a part of the story as are technological innovation, digital communication, global supply chains, cultural exchange, the promotion of human rights, and the rise of cosmopolitan values. This course aims to equip you with a conceptual toolkit for thinking critically and holistically about the many dimensions of globalization. By examining how globalization connects and shapes the everyday lives of people around the world, including our own, we will establish a foundation both for your advanced coursework in Global Studies and for your lifelong education as a globally aware professional and citizen.	U	4, 8, 16	focused
79278	History	How (Not) to Change the World	It's often said that the road to hell is paved with good intentions. What, then, can we learn by excavating some of those pavers and interrogating the theories of change that underlie them? And what can we learn from more successful attempts to enact social change? In this course, we will use the tools of history, anthropology, and critical theory to examine various efforts to 'change the world'. From top-down social engineering to neoliberal 'market citizenship' to grassroots organizing, case studies will challenge us to detect theories of change (even when they are concealed) and evaluate their consequences (intended and otherwise). With those lessons in mind, we will then apply our tools to the theories of change that we enact, often unwittingly, as members of a university. Which roads are we paving and where do they lead?	U	10, 11, 9	focused
79280	History	Coffee and Capitalism	What role has coffee played in connecting people and places to capitalist markets and consumer cultures? What are the economic, social, and environmental consequences of these connections? How did espresso change from an "ethnic drink" to something served at McDonalds? Why do college students (and professors!) hang out in coffee shops? This course will answer these questions and more by using coffee to learn about the history of capitalism, and capitalism to understand the history of coffee. We will follow the spread of coffee and capitalism across the globe, with excursions to places where people grow coffee (Ethiopia, Yemen, Indonesia, Brazil, and Costa Rica), and also where they drink coffee (Seattle, Tokyo, Seoul, New York, and Berlin). In the process, we will confront global problems linked to economic inequality, trade, gender relations, and environmental degradation. Course meetings will combine interactive lecture, group discussions, and mini-presentations. Assignments will include journal responses, ethnographic observations, and writing a short script that tells a story about coffee and capitalism.	U	5, 8, 4	focused
79281	History	Introduction to Religion	Religion can be understood from the "outside," through the academic lenses of history, sociology, psychology, philosophy, etc., and from the "inside," listening to the experiences and reflections of those who practice various faiths. The course will examine major religious traditions from several perspectives, and begin to explore such topics as the relationship between religion and science, faith and reason, and religion in public life. This introduction is designed for students with a general interest in religion, as well as those contemplating a Religious Studies minor.	U	4, 5, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79288	History	Bananas, Baseball, and Borders: Latin America and the United States	This course will use historical documents, film/video, and popular music to examine the tumultuous and paradoxical relationship between Latin America and the United States from the time of independence to the present, with an emphasis on Mexico, Central America, and the Caribbean during the Cold War (1945-1989) and its aftermath (1990s-present). We will literally talk about bananas, baseball and borders; the title also alludes to the key dimensions of the relationship we will study: economic, cultural, and geopolitical. We will learn about the actions of U.S. and Latin American government leaders and diplomats along with many other kinds of people including activists, artists, and journalists; athletes, movie stars, and scientists; and migrant workers, tourists, and drug traffickers. Evaluation will be based on mini-presentations, written analysis of historical documents, and a final project that documents changing relations between the United States and a Latin American country.	U	10, 8, 17	focused
79289	History	Animal Planet: An Environmental History of People and Animals	Why do modern societies go to great lengths to protect some animals and slaughter others? Why do some cultures make pets of animals that other cultures turn into a meal? What are the environmental ramifications of hunting, domestication, and trading animals? What is the connection between human pandemics like COVID-19 and animals? Why are there so many cute animals inhabiting social media? These are some of the questions that we will seek to answer as we trace changes in human--animal relationships over time. We will explore these themes through both texts and visual representations (art, film, photography) of animals. Evaluation will be based on active participation in class discussions, submission of weekly field notes, and a final "curated exhibit" of images of people and animals.	U	15, 12, 13	focused
79290	History	The Slave Passage: From West Africa to the Americas	"The Slave Passage" begins among flourishing, technologically advanced, and globally connected regions of Western Africa before the advent of the trans-Atlantic slave trade. It tells the painful story of African captives during the Middle Passage, piecing together the historical record to recognize their suffering aboard the slaving vessels and their multiple strategies of resistance. Students will study slave narratives, slave ship logs, and autobiographies of former enslaved people, as well as analyze films and theater performances depicting the Middle Passage and New World enslavement.	U	4, 17, 9	focused
79291	History	American Popular Culture and the Entertainment Business: 1800 to the Present	This course will examine one topic in popular culture and entertainment per week, from newspapers to social media including minstrelsy, spectator sports, public parks, and the film industry. The course will consider these industries through the lens of business history, documenting innovation and the development of entertainment as commodities. Guiding questions will be: How did the country's economy, society, and politics structure the development of popular culture? How did performers and entrepreneurs develop industries around new innovations in popular culture? And how did popular culture shape the country's economy, society, and politics?	U	9, 8, 17	focused
79296	History	Religion in American Politics	In a presidential election year, religion will once again figure prominently in American politics. Survey organizations often claim that "religiosity" correlates with conservative politics, but that claim can be highly misleading, as religious people are in fact all over the political map. Thomas Jefferson's mention of a "wall of separation" between church and state reminds us that religious institutions are kept separate from government in America, but religious motivations have always played an important part in our politics. This course will provide an historical perspective on the role of religion in public life from the late 18th century to the present, including religion's influence on political parties and public policies, and the boundaries set by the Constitution on such activity.	U	16, 5, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79297	History	Technology and Work	In recent years, conversations about the relationship between technology and work seem to have been conducted with particular fervor: claims of revolutionary ease and freedom sit side-by-side with dystopian visions of exploitation, surveillance, and alienation. Will technological development lead to a new "sharing economy" or widespread deskilling? Will it bring general prosperity or enrich the few at the expense of the many? These concerns - though especially apparent today - are by no means new. In this course, we will examine their history, focusing in particular on North America and Europe in the past two centuries. We will examine the ways in which new technologies - from the assembly line to the washing machine to the personal computer - transformed what it meant to work, and how workers, their families, and the companies who employed them reacted to these changes. Our historical actors will include famous figures like Henry Ford, but also unnamed women, children, people with disabilities, and racial and ethnic minorities. Throughout, we will pay attention to who benefitted, who was harmed, and what broader economic, cultural, or social purposes these technologies were designed to serve.	U	5, 8, 10	focused
79298	History	Guns in American History: Culture, Violence, and Politics	[Note: students who have taken this course during the Fall 2019 semester as, 79-300, Guns in American History: Culture, Violence, and Politics, may not enroll.] This course will describe and analyze aspects of the development of law and public policy related to guns in the United States from the colonial era to the present. Students will be expected to synthesize perspectives from social history, ethnography, public health, criminology, policy analysis, and legal scholarship. They will also engage the critical examination of popular culture and media representations of gun cultures and gun violence. Particular emphasis will be placed on changing views about the authority of the government to intervene in the production and ownership of guns, as well as the best way to balance individual and collective interests in a pluralistic society. Assignments may include reading quizzes, in-class debates, policy position papers, and film/documentary reviews.	U	4, 16, 1	focused
79300	History	History of American Public Policy	This course will describe and analyze aspects of the development of law and public policy related to guns in the United States from the colonial era to the present. Students will be expected to synthesize perspectives from social history, ethnography, public health, criminology, policy analysis, and legal scholarship. They will also engage the critical examination of popular culture and media representations of gun cultures and gun violence. Particular emphasis will be placed on changing views about the authority of the government to intervene in the production and ownership of guns, as well as the best way to balance individual and collective interests in a pluralistic society. Assignments may include reading quizzes, in-class debates, policy position papers, and film/documentary reviews.	U	10, 8, 1	focused
79303	History	Pittsburgh and the Transformation of Modern Urban America	This course will focus on the transformations, both positive and negative, of Pittsburgh and the Pittsburgh region in the period from 1945 through the present. It will explore the following themes: the redevelopment of the city in the Pittsburgh Renaissance; urban renewal and its consequences; the collapse of the steel industry and its impacts; the development of an Eds/Meds service economy; air, land and water environmental issues; and the city's changing demography.	U	6, 9, 11	focused
79306	History	Fact into Film: Translating History into Cinema	From the very beginning, film has provided a window into the past. But how useful are the images we see through that window? For every person who reads a work of history, thousands will see a film on the same subject. But who will learn more? Can written history and filmed history perform the same tasks? Should we expect them to do so? How are these two historical forms related? How can they complement each other? This course will draw examples from across the history of film in order to examine how the medium of film impacts our understanding of facts and events, the ways that film transfers those facts to the screen, and how that process affects the creation of historical discourse. Films may include such titles as The Fall of the Roman Empire, The Gunfight at the O.K. Corral, Saving Private Ryan, World Trade Center, Enemy at the Gates, Lagaan and Hero.	U	11, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79310	History	U. S. Business History: 1870 to the Present	This course explores the development of American business within its economic, political, and social context from the late nineteenth century to the present. Through the lens of "history of capitalism," readings and discussions will explore the interconnections of State and Market in the twentieth century United States that shaped how, why, and where business transactions occurred. Particular attention will be paid to the institutional, social, technological, environmental, labor, and cultural context in which American commerce developed, from the rise of the modern corporation in the late nineteenth century to the emergence of a true information economy in the twenty-first. Students will encounter primary sources, scholarly secondary readings, business case studies, and cultural artifacts as they explore how business functioned and changed over time in an American context.	U	8, 4, 12	focused
79311	History	PaleoKitchen: Food and Cooking in the Ancient World	From home cooking to haute cuisine, people are passionate about food. But what did people eat in the ancient world? This class will center around the origins of the human diet, including human dietary adaptation to diverse ecological and technological situations; social, cultural, behavioral, and ecological factors which influenced diet in ancient societies; and the origins of cuisines around the world.	U	15, 2, 11	focused
79313	History	"Unwanted": Refugees, Asylum Seekers, and Patterns of Global Migration	What is home? What does it mean to belong, or not belong? What does it mean to be mobile? Is mobility a privilege or a curse? How do experiences of migration, exile, and displacement shift one's understanding of home? This course will examine the modern patterns of migration, mobility, and displacement, with a particular focus on the US and Europe in the 20th and 21st centuries. We will engage with anthropological and historical analyses of global migrations of people, capital, and ideas; social inequalities; and new forms of political control (surveillance, "profiling," militarization of borders, and race-related forms of rejection and violence). The course will rely on seminar discussions and interactive lectures¿a combination of lecture and discussion, which will productively challenge the students to engage with the material in a critical manner and will help them contextualize and enrich the knowledge they gain from the course readings.	U	10, 9, 8	focused
79315	History	Thirsty Planet: The Politics of Water in Global Perspective	Water is necessary for all forms of life on Earth. The purpose of this course is to introduce students to social and political aspects of water, using in-depth case studies that draw on a variety of perspectives. Examples of regional water projects we'll study include traditional tank irrigation in South India; international negotiations along the Nile River; and the U.S. Government in negotiation with native activists and fisheries on the Columbia River. In addition to regional variety, readings will explore a variety of themes, for example, water and gender; water and armed conflict; and water and private companies versus public management. By the end of this course, students should be able to articulate their own answers to these questions: How have global organizations and participants characterized, enacted, and addressed problems of water supply and delivery for those who need it most? How do particular regions reflect global trends in water resource development, and how might these diverge from global trends? How have social and environmental studies in the literature of development come to understand the problem of water? One set of readings is assigned each week. Students should be prepared to discuss each week's readings in a thoughtful way during class meeting time.	U	6, 5, 14	focused
79316	History	Photography, the First 100 Years, 1839-1939	Photography was announced to the world almost simultaneously in 1839, first in France and then a few months later in England. Accurate "likenesses" of people were available to the masses, and soon reproducible images of faraway places were intriguing to all. This course will explore the earliest image-makers Daguerre and Fox Talbot, the Civil War photographs organized by Mathew Brady, the introduction in 1888 of the Kodak by George Eastman, the critically important social documentary photography of Jacob Riis and his successor, Lewis Hine, the Photo-Secession of Alfred Stieglitz, the Harlem Renaissance of James VanDerZee, the precisionist f64 photographers Ansel Adams, Imogen Cunningham, and Edward Weston, and other important photographers who came before World War II. The class will be introduced to 19th century processes, such as the daguerreotype, tintype, and ambrotype, as well as albumen prints, cyanotypes, and more.	U	1, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79317	History	Art, Anthropology, and Empire	This seminar will explore the anthropology and history of aesthetic objects, as they travel from places considered "primitive" or "exotic," to others deemed "civilized" or "Western." First, we will consider twentieth-century anthropological attempts to develop ways of appreciating and understanding objects from other cultures, and in the process to reconsider the meaning of such terms as "art" and "aesthetics." Then we will discuss several topics in the history of empire and the "exotic" arts, including: the conquest, colonization and appropriation of indigenous objects; the politics of display and the rise of museums and world fairs; the processes by which locally-produced art objects are transformed into commodities traded in international art markets; the effects of "exotic" art on such aesthetic movements as surrealism, etc.; and the appropriation of indigenous aesthetic styles by "Western" artists. Finally, we will consider attempts by formerly colonized populations to reclaim objects from museums, and to organize new museums, aesthetic styles, and forms of artistic production that challenge imperialism's persistent legacies.	U	11, 17, 9	focused
79320	History	Women, Politics, and Protest	This course examines the history of women's rights agitation in the United States from the early nineteenth-century to the present. It investigates both well-known struggles for women's equality--including the battles for women's voting rights, an Equal Rights Amendment, and access to birth control--and also explores the history of lesser-known struggles for economic and racial justice. Because women often differed about what the most important issues facing their sex were, this course explores not only the issues that have united women, but also those that have divided themkeeping intersectionality and women's diversity at the center of the course.	U	5, 10, 8	focused
79325	History	U.S. Gay and Lesbian History	US Gay and Lesbian History offers an overview of the changing context and circumstances of sexual minorities in American culture. From early constructions of moral opprobrium, criminal deviance or medical pathology, the LGBT community emerged in the twentieth and twenty-first century as a political constituency and a vital part of contemporary society. Students should be aware that this course will necessarily address issues of intimate relations and sexuality as well as broader historical issues.	U	5, 16, 4	focused
79326	History	Shall We Dance? Culture, Politics, and Movement in the 20th Century	Waltzes and flash mobs, hula and swing, disco and breakdance: this course will examine the history and practice of these and other popular dance movements across the course of the twentieth century. In doing so, we will pay particular attention to the ways in which dance both shaped and reflected major moments of political, cultural, and social change. Dancing bodies were used to justify imperial ambitions, explore new kinds of gender relations, and both uphold and upend racial hierarchies, making dancers key - if underappreciated - participants in the century's tumultuous history. The course will include a mix of lecture and discussion, drawing on scholarly analyses, archival sources, films, literature, images, and live performances. Students will also be asked to explore at least one new dance form for themselves and reflect on the experience.	U	5, 10, 4	focused
79328	History	Photographers and Photography Since World War II	Invented in 1839, photography was a form of visual expression that immediately attracted a large public following. Starting around 1900, photography was practiced with two dominant strands. One of these firmly believed in the power of photographs to provide a window on the world, and was led by Lewis Hine, whose documentary photographs for the National Child Labor Committee helped to ameliorate living and working conditions for thousands of immigrant children. The other strand adhered to the philosophy of Alfred Stieglitz who adamantly affirmed that photographs were first and foremost reflections of the soul and were art objects, equal to painting, drawing and sculpture. These two schools of thought guided photographers throughout the twentieth century. This course explores in depth the tremendous range of photographic expression since World War II and examines in particular the contributions of significant image-makers such as Helen Levitt, W. Eugene Smith, Robert Frank, Diane Arbus, Garry Winogrand, Charles "Teenie" Harris, Cindy Sherman, Carrie Mae Weems, Nan Goldin, James Nachtwey, and many others. Classes include a slide lecture, student presentation, and video segments that introduce a focused selection of images by major photographers in an attempt to understand their intentions, styles, and influences. As available, students will be expected to make one or more visits to photography exhibitions on view in Pittsburgh (locations to be announced at the first class.)	U	4, 10, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79331	History	Body Politics: Women and Health in America	[Note: Students who have taken 66-121, First Year Seminar: Body Politics: Women and Health in America, may not enroll.] This course takes a topical, intersectional approach to the history of U.S. women's health in the nineteenth and twentieth centuries. It is less about governmental politics, although we do some of that. Rather, it sees bodies as cultural texts through which power is built and contested. The course covers topics such as the history of anatomy, menstruation, reproductive rights, body image, mental health, sexuality, violence, childbirth, and menopause. We explore how science and American culture both have constructed these issues over time (some of it is super whacky!), while also examining women's organizing around them. This course is open to all students.	U	5, 16, 4	focused
79335	History	Banned Substances: Drugs, Alcohol, and Tobacco in American History	This course traces the development of laws, policies, and social movements related to alcohol, tobacco, and drug regulation in the United States. By highlighting the ideas proponents and opponents used to justify or oppose prohibition, students will examine how responses to drug and alcohol use has as much to do with ideologies of gender, race, ethnicity, and class as they do with the effects of the substances themselves. This course will also analyze how attempts at prohibition have been historically contingent and explore the ways debates surrounding drug and alcohol use can deepen our understanding of American history. Some topics to be considered include: the proliferation of alcohol abuse in the early Republic, temperance movements, the battle over smoking/cigarettes, the Prohibition movement, criminalization of drugs, the drug war and issues of legalization.	U	5, 16, 4	focused
79345	History	Roots of Rock & Roll	This course is about open source, collaborative innovation and the impact of social and technological change on American music. We will spend the first 8 weeks on early "remix" music (slave songs, Anglo-Appalachian ballads, ragtime, and Depression era blues and country). After studying Bessie Smith, Woody Guthrie, Lead Belly, Hank Williams, and other early artists, we'll spend the last 7 weeks on revolutionaries like Chuck Berry, Bob Dylan, Jimi Hendrix, and Janis Joplin. The format is informal lecture and discussion. Assignments include reading two books plus some articles, weekly music listening, short papers, and a final project. NB: This course may be taken pass-fail (with submission of appropriate form).	U	9, 17, 8	focused
79349	History	United States and the Holocaust	This course will explore challenging historical material related to Hitler, the Nazis and America's response. Issues relating to immigration, refugee status, contrasting styles of political leadership, foreign policy goals, news coverage, anti-Semitism, theories of racial supremacy, decision making, global responsibilities will be considered both in the perspective of then and now as we look both at America and at Europe. This course will prompt you to think not only about the events then, but also about the implications for us today as individuals and as citizens of the world. A film, a meeting with a survivor or child of survivor as well as the inclusion of first hand readings will serve to strengthen the learning impact.	U	10, 4, 5	focused
79350	History	Early Christianity	This course examines the origins of Christianity in historical perspective. Using both Christian and non-Christian sources from the period, we will examine how and why Christianity assumed the form that it did by analyzing its background in the Jewish community of Palestine, its place in the classical world, and its relationship to other religious and philosophical traditions of the time. We will also examine historically how the earliest Christians understood the life and message of Jesus, the debates about belief and practice that arose among them, and the factors influencing the extraordinary spread of the movement in its earliest centuries. This course satisfies one of the elective requirements for the Religious Studies minor.	U	11, 16, 10	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79353	History	'Lock 'em Up': The Imprisonment of Children and Youth, 1820s-2021	[Note: students who have already taken this course under its former number 79-353 and former title, Imprisoning Kids: Legal, Historical, and Moral Perspectives, may not enroll.] Can young lawbreakers be rehabilitated, or should they be removed from society to prevent them endangering others? Since the 1820s, reformers, philanthropists, and state officials in the Western world have wrestled with the question of how to reduce juvenile crime and turn delinquents into good citizens. The institutions and policies they created reflected their conceptions of young criminals, their backgrounds and families, their gender and their race. How did experts develop a body of knowledge about at-risk youth, what practices did they put into place, and what spaces did they build to house and contain the children? How have the children themselves responded, developing a sense of their own identity through compliance with or resistance to reformers' intent? In this course, we will explore ideas, practices, and institutions created to save juvenile delinquents, presented in reports and studies as well as fiction and film. Students will read and view a variety of primary and secondary sources from North America and Europe from the early nineteenth to the late twentieth centuries. Assessment will include participation in class discussion, written assignments, and exams.	U	5, 4, 16	focused
79357	History	Science and the Body	The human body has been always an object of fascination. Across time and space, people have wondered what lurks beneath the skin, why we get sick or remain well, and how to explain human variation. The methods used to investigate these questions have, however, varied widely. In this course, we will explore that diversity - from the dissection of medieval corpses to 19th century phrenology to contemporary biohacking - examining how different communities have sought to study, control, and change their bodies over the past several hundred years. In doing so, we will focus on how these scientific efforts were shaped by the political, cultural, and economic values of their times. We will also pay attention to the profound and often ongoing effects of these experiments, particularly on the people who served - both willingly and unwillingly - as their "human subjects."	U	8, 16, 17	focused
79372	History	The Rise and Fall of Pittsburgh Steel	For over 150 years, the Pittsburgh region was world-renowned for the scale and intensity of its iron and steel manufacturing complex. This mini course will trace the origins, explosive growth, stagnation and ultimate collapse of this remarkable industrial complex. Students will gain an understanding of Pittsburgh's rich industrial history - what makes it "The Steel City," understand the emergence and evolution of iron and steel making technology, appreciate the impact of Pittsburgh's iron and steel industrialization on living and working conditions for workers, and analyze the factors that drove the emergence of Pittsburgh steel then to its decline and collapse. The course is structured loosely around a set of periods in Pittsburgh's history through which key themes are drawn.	U	9, 4, 11	focused
79374	History	Inequality, Social Justice, and the Black Urban Experience: 1930s to 2010s	Since the 2016 Presidential Election, politicians, journalists, and academics have looked upon the white working class as the key to understanding the historic boom and bust cycles of American capitalism. What's left out of this discussion is a crucial component to the American political economy-black workers. African-Americans' contribution to the economy spans four hundred years, from the initial settlement of the American continent down through the present day. Throughout this period, black Americans found the courage and creativity to construct their own complex body of political ideas about the contradictory nature between democracy and capitalism. In effect, black Americans made their own history. The legacy of black workers also teaches us that the understanding of race is intimately intertwined with the understanding of class. Throughout this course, we will talk about a wide spectrum of African-American leaders, intellectuals, organizations and institutions spanning from the Great Depression to the today's post-industrial era. This course is, thus, constructed around the voices and languages used by black people themselves. The key issues to be discussed are the rise of organized labor, urbanization and segregation, and law enforcement.	U	9, 10, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79377	History	Food, Culture, and Power: A History of Eating	How can human societies ensure that everyone has enough food to eat that is good for them and does not trash the planet? This course will start with the assumption that the answer to that question requires not only technological innovations, but also an understanding of the historical evolution of food production and consumption. In other words, why do we eat what we eat? How and why have diets changed over time? What roles do government policy, commodity markets, and cultural practices play in creating opportunities and constraints for changing food systems? After exploring different aspects of these big questions via in-class discussions of readings, video, and guest lectures, students will pursue individual research projects focused on some aspect of food policy during the second half of the semester. Evaluation based on in-class participation, writing reflections, and research paper.	U	4, 9, 11	focused
79379	History	Extreme Ethnography	Observation, participation and direct experience of "the field" are hallmarks of anthropological ways of knowing, and their representation has played a foundational role in ethnographic writing both past and present. Yet reflexive and postmodernist explorations of these topics have triggered contentious debates over the nature of anthropology as a scientific or humanistic enterprise, and over its ethical, political and epistemological value. In this seminar, we will approach such questions through an exploration of the extremes of ethnographic fieldwork and writing. We will consider such topics as: the colonial history and politics of explorers and ethnographers; liminality and the place of extreme experience--such as cultural dislocation, violence, derangement, intoxication, sex, possession, and dreaming-in fieldwork and writing; field-notes as an ethnographic genre, and their relationship to "official" published ethnography; ethnographic surrealism and surrealist ethnography; the dimensions of sensory experience (visual, auditory, olfactory, etc.) in fieldwork and ethnography; collecting and the powers of "exotic" objects; inter-subjectivity and its implications; and experimentation with alternate ethnographic forms, such as autobiography, film, diary, and poetry.	U	16, 17, 5	focused
79383	History	Capitalism: A Global History	What is capitalism? How does it differ from the systems that preceded it, and how did it come to revolutionize the globe? This course examines the development of capitalism from the 16th century to the present. We will read Karl Marx and Adam Smith, who both attempted to theorize the new, emerging system. We will survey the transition from feudalism to capitalism, the role of slavery in capitalist development, and changes in women's power and household production. We will examine the development and demise of the factory system and deindustrialization in America's rust belt cities as well as "globalization," the latest dynamic phase of capitalism. Finally, we will discuss the impact of technology, casual labor, low wages, and unemployment on democracy, the prison system, and the rise of a new technocratic elite.	U	5, 8, 1	focused
79384	History	Sex Before Kinsey: Theories of Sexuality in Europe and the US, 1890-1930	This mini-course surveys the history of European and American "sexology" from the late 19th through the early 20th century. Students will be introduced to world-famous theorists and researchers such as Sigmund Freud, Havelock Ellis, and Margaret Sanger [who opened the first birth control clinic in the U.S.). Readings and discussion will cover theories of heterosexuality, homosexuality, female sexuality, transsexuality, and erotic fetishism. Readings will include scholarly articles and a small group of primary sources drawn from theorists' publications/correspondence. The course grade will be based on attendance, participation/discussion of class readings, and three 3-4 page essays on the readings.	U	5, 4, 16	focused
79386	History	A Tale of Two Epidemics: Influenza 1918 and Covid 19	This course will compare the experiences of Americans during its two deadliest pandemics, the Influenza 1918 epidemic and the Covid-19 epidemic. Each week we will compare a facet of the two epidemics, such as government responses, medical knowledge, public health measures, African American experiences, global dimensions, and more. Students will do guided original research comparing a facet of the two epidemics, and the class will self-publish a collection of student essays as a book.	U	3, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79387	History	General Francisco Franco: Fascism and its Legacies in Spain	Francisco Franco was Europe's longest-ruling dictator. He ruled over Spain from 1939 to 1975. This course will examine the social and cultural context of the rise of Fascism in Spain. We will focus especially on the colonial legacy of Spanish fascism; The fall of the democratic II Spanish Republic and Franco's seizure of power during the bloody Spanish Civil War; the decades of his lengthy dictatorship; the social and cultural politics in transitioning Spain to democracy after his death; and the legacy of Spanish Fascism and Franco's dictatorship in contemporary Spain. In addition to class lectures, students will become familiar with these themes through the reading and discussion of historical texts, current political and cultural debates, music and film.	U	4, 16, 11	focused
79388	History	Race, Gender, and the Politics of Sports in America since 1900	The course will survey the history of sports in the United States, focusing primarily on the 20th century. Topics considered will include sports and race, gender, and politics; the commercialization of sport; and collegiate sports. We will pay particular attention to the way in which sports have served as an arena for dissent. Also covered will be Pittsburgh's relation to national sports trends. By the end of the semester students will gain an understanding of the changing role of sports in the United States.	U	5, 4, 10	focused
79390	History	History of Computing and Computer Science: Perspectives on the Digital Age	This course examines the history of computing with a focus on the history of computers and computing at Carnegie Mellon University. Students will read historical accounts of computing as well as research the history of computing at Carnegie Mellon using the materials and resources of the University Archives and libraries. Students in the course will collaboratively produce a public exhibition on the history of computing as their final project.	U	9, 8, 11	focused
79392	History	Europe and the Islamic World	Europe and the Islamic World explores the complex relationship between (Christian) Europe and Islamic civilization, from the conquest of the Byzantine Levant to modern-day Islamic immigration into Europe. The course will focus on a few landmark events in European/Islamic relations, such as the crusades, as well as various intellectual models describing European/Islamic relations over time. The course will also focus on developing research, writing, and documentary analysis skills relevant to the study of history.	U	10, 4, 17	focused
79395	History	The Arts in Pittsburgh & Beyond: Experiencing Music & Art in a Time of Pandemic	This course will examine the arts in Pittsburgh, both historically and in the present. We will focus especially on art exhibits and musical events scheduled by the city's museums and concert halls during the semester. The "curriculum" will derive from the artistic presentations themselves, which will provide a springboard for reading assignments, seminar discussions, and research papers in the history of music and art. We will also examine the historical development of cultural institutions in Pittsburgh. The History Department will pay for students' admission to all museums and studios. However, students will be charged a supplemental fee of approximately $275 to help subsidize the considerable expense of purchasing tickets for concerts and performances by the Pittsburgh Symphony, Pittsburgh Opera, Chamber Music Society, and Renaissance and Baroque Society. Attendance at all art exhibits and musical events is required. Prerequisite: Please check your overall course schedule: you must be available to attend art exhibits on several Fridays and Saturdays, and to attend musical events on several Thursday, Friday and Saturday evenings.	U	4, 17, 11	focused
79396	History	Music, Art, and Society in 19th and 20th Century Europe and the U.S.	This course will explore the interrelations between society and classical and popular music in the nineteenth and twentieth centuries in Europe and the United States. We will examine the importance of different musical forms in the life of society and how music contributed to the making of political consciousness, especially in the twentieth century. In addition to reading assignments, seminar discussions, and research papers in the history of music, students will be taken to performances of the Pittsburgh Symphony, Pittsburgh Opera, and Chamber Music Pittsburgh. A supplemental fee of approximately $275 will be charged to subsidize part of the considerable expense of purchasing tickets for concerts and performances. Prerequisite: Availability to attend musical events on several Friday and Saturday evenings.	U	11, 4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79397	History	Environmental and Public Health Crises in the City	Concern over Global Climate Change has increasingly focused on the environment of cities. our largest and most vulnerable population centers. Yet, since their origins, cities have consistently faced environmental challenges from both natural and human made factors. This course will explore some of these environmental challenges over time, examining issues including air and water pollution, floods, heat waves, earthquakes and hurricanes, disease and public health, and warfare. It will examine how these events have shaped and altered cities and urban life over time and consider issues relating to the desirability or undesirability of life in cities.	U	11, 12, 13	focused
79400	History	Global Studies Research Seminar	This research seminar is the capstone course for Global Studies majors. The course is designed to give you a chance to define and carry out a research project of personal interest. The first few weeks of the course will be devoted to developing a research topic and locating sources. We will then work on how to interpret and synthesize sources into a coherent and compelling thesis before you begin drafting your paper. Your research may be based on in-depth reading of a body of scholarly work, field notes from ethnographic observations, archival research, analysis of literary or visual media, or some combination of these sources. Incorporation of some non-English language sources is strongly encouraged where possible. Independent work, self-initiative, participation in discussion, and peer evaluations are required. There are several interim deadlines that will be strictly enforced in order to ensure successful completion of the course. Prerequisites: 79-275 and Theoretical and Topical Core must be complete or concurrently enrolled. Corequisite: 79-275.	U	17, 4, 8	focused
79420	History	Historical Research Seminar	The purpose of this research seminar is to help students conceptualize, design, organize, and execute a substantial research project that embodies and extends the knowledge and skill set they have been developing as History majors at Carnegie Mellon. The identification, collection and interpretation of relevant primary source data are integral parts of this intellectual task. Students will strive to hone written and oral presentation skills, deepen their command of research methodologies and strategies, and sharpen their abilities as a constructive critic of others' research. The seminar seeks to develop these intellectual skills through a combination of in-class, student-led discussions of everyone's research-in-progress, and regular individual consultations with the instructor.	U	4, 17, 11	focused
79449	History	EHPP Project Course	The Ethics, History and Public Policy Project Course is required for the Ethics, History and Public Policy major and is taken in the fall semester of the senior year. In this capstone course, Ethics, History and Public Policy majors carry out a collaborative research project that examines a compelling current policy issue that can be illuminated with historical research and philosophical and policy analysis for a chosen client. The students develop an original research report based on both archival and contemporary policy analysis and they present their results to their client and a review panel.	U	4, 17, 11	focused
79505	History	Social & Political History Internship	The Social & Political History program strongly encourages students to locate internship opportunities in Pittsburgh or elsewhere that complement their historical interests (as, for example, in a museum or historical society) or in areas of policy research that complement their historical interests (as, for example, in a government agency or non-profit organization). To earn academic credit for their internship, students will be required to maintain a weekly journal; write a short critical reflection on how the internship connects to their academic interests; and share their experience with other Social & Political History majors. The Academic Advisor will assist students with matching their interests to local organizations. SPH students can earn up to 9 units in each internship. Please note, however, that internship credits (students may complete up to three internships) do not count toward fulfillment of course requirements for the SPH major (though the units do count toward graduation).	U	4, 11, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
79506	History	Global Studies Internship	This course provides Global Studies majors with a chance to explore global connections in Pittsburgh. Majors, working in close consultation with the Global Studies director and advisor, will arrange an internship with a non-governmental organization (usually in Pittsburgh) whose mission has a global reach. This could include an organization that supports projects in other countries, works with immigrants in the Pittsburgh area, or participates in international policy making/governance. We strongly encourage students to seek out opportunities that require use of a second language. Students will be required to maintain a weekly journal; write a short critical reflection on how the internship connects to academic work; and share their experience with other Global Studies majors. Global Studies advisor and director will assist students with matching their interests to local organizations and identifying an on-site supervisor available to collaborate in the ongoing and final evaluation of the student's work. Prerequisite: Students must be Global Studies majors and obtain permission for the proposed internship from the Global Studies advisor.	U	4, 10, 8	focused
80100	Philosophy	Introduction to Philosophy	In this introductory course we will explore three major areas of Philosophy: Ethics, Metaphysics, and Epistemology. Accordingly the course is divided into three sections. In each section we will read primary sources and discuss some of the main philosophic problems associated with that area. These will include: moral problems (Ethics), problems rising from the debates about free-will, personal identity or intelligence (Metaphysics), and inquiries about the scope and limits of human knowledge (Epistemology). We will then introduce some theories designed to solve such problems, and try to understand the strengths and weaknesses of these theories. We will apply different techniques and theories to issues that we might encounter in the real world. We will use class discussions, homework and papers to learn skills for evaluating arguments. These skills include: how to present a philosophic argument, what are the assumptions that justify it, what are its weaknesses and its strengths, whether such weaknesses can be resolved and, if they cannot be resolved, why.	U	4, 17, 16	focused
80130	Philosophy	Introduction to Ethics	Philosophical ethics, or moral philosophy, covers a lot of ground. It asks and tries to answer questions like: What's good in life? What matters? What should I (and others) do? How should I (and others) act? What kinds of things out there must be treated ethically? Do we have moral duties to (at least some) non-human animals? Is morality subjective? Are there actually any objective moral truths? Morally speaking, what (if anything) is the difference between killing someone, and simply letting them die? In trying to answer these questions (and others), we'll engage in some wonderfully weird thought experiments, class discussions, smaller group discussions, debates, etc. We'll study and critique several moral theories which try to explain and help guide our moral judgments, and we'll try to apply these theories to real-life moral controversies. Past classes covered topics including drug prohibition, abortion, euthanasia, and physician-assisted suicide. This is an introductory philosophy class, so you'll be learning how to read, critique, do, and write philosophy generally, not just ethics. Considerable time and effort, both in lectures and in recitations, will be spent helping you learn to recognize and evaluate philosophical arguments, as well as empowering you to create, improve, and defend your own arguments in class assignments.	U	4, 16, 5	focused
80135	Philosophy	Introduction to Political Philosophy	At the heart of political philosophy lie fundamental questions such as: What constitutes a just society? How, and under what circumstances do individuals incur political obligations to a particular state? This course provides a systematic investigation of the way such questions are answered by dominant schools of liberal political theory, such as the social contract tradition, utilitarianism and libertarianism. Later we will introduce critiques from socialist, and feminist theorists. Readings are drawn from classic works by authors such as Plato, Hobbes and Locke, and from the works of more contemporary theorists like Rawls, and Nozick.	U	10, 5, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
80136	Philosophy	Social Structure, Public Policy & Ethics	The course will consider ethical questions surrounding social structure and public policy. It will analyze the role of political institutions and individual citizens in dealing with some of the greatest challenges facing our world: Global health crises, the spread of (and threats to) democracy worldwide, and world poverty. Some of the questions we will consider include: Are developed countries obligated to ameliorate poverty by providing foreign aid? What is democratic governance, and what do democratic representatives owe to their constituents? Should wealthy nations and corporations assist in the fight against life-threatening diseases worldwide? The course uses ethical and political theory, case studies, and empirical evidence to consider these questions.	U	1, 16, 3	focused
80150	Philosophy	Nature of Reason	This course offers an intellectual history of philosophical views regarding the nature of human reasoning in mathematics and the sciences, from ancient to modern times. The first part of the course traces the search for deductive methods for obtaining certain knowledge, starting with Aristotle and Euclid, and continuing through the Middle Ages and late Renaissance thought, to the work of Boole and Frege in the nineteenth century. The second part of the course considers the history of skepticism about empirical knowledge, covering Plato, Sextus Empiricus, Descartes, Pascal, and Hume, along with replies to skepticism in the works of Bayes and Kant. The third part of the course discusses theories of the nature of mind, culminating in the computational conception of mind that underlies contemporary cognitive science.	U	4, 11, 9	focused
80180	Philosophy	Nature of Language	Language is used to talk about the world or to describe it, but how do we go about describing language itself? Linguistics is the name given to the science of language, whose task it is to give such a description. The discipline of linguistics has developed novel tools for describing and analyzing language over the last two hundred years and in this course we learn what these tools are and practice applying them. Sub-areas of linguistics which we study include phonetics (the study of speech sounds), phonology (the study of sound systems), morphology (the study of parts of words), and syntax (the study of combinations of words). Beyond this, we look at changes in language over time, and we consider the puzzle of linguistic meaning. The methods of linguistics are useful in the study of particular languages and in the study of language generally, so this course is useful for students of foreign languages as well as those interested in going on to study language acquisition, psycholinguistics, sociolinguistics, philosophy of language, and computer modeling of language.	U	4, 17, 9	focused
80184	Philosophy	Disagreeable Language: talk in the age of polarization	What do you do when confronted with opinions that (to you) are obviously wrong - supported by facts that are not even based in (your) reality? This is a situation we more and more find ourselves facing, or would if we ever ventured out of our own ideological bubble (which is constantly replenished by Big Tech and only with information pre-matched to our biases). It is held in place by human language itself - our supposed primary means of communication. While it is true that pictures can lie -- one hundred years ago Arthur Conan Doyle got taken in by the Cottingley pixie photographs, and now there's CGI and Deepfake -- language has always been the premier instrument for the conveyance of untruths. And when the facts themselves are up for grabs, the traditional approach -- going outside of language for confirmation and fact-checking - doesn't work either. Can anything be done about this precarious situation? Disagreeable Language explores a possible solution -- through linguistics, the study of human language. A sub-field of linguistics is the study of language structure, an enterprise which is self-contained and relies on no information outside of language and speaker intuitions. But this independence from reality may make linguistics the right tool for the detection of reality. If patterns of untruth leave their mark in language itself, linguistic techniques would be the way to reveal them. That could provide an escape route out of the matrix. At the very least, students in this course will learn basic methods for interrogating the language we use to get through to one another, that is, basic methods for doing linguistics.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
80201	Philosophy	Knowledge and Justified Belief	Knowledge acquisition is central to the university's mission. The sciences seek knowledge of nature. Statistics concerns methods for finding and establishing scientific knowledge. Machine learning concerns the automated generation of knowledge. Database theory concerns the maintenance of knowledge. But then what are knowledge, justified belief, truth, and evidence, and how do all of those concepts fit together? The branch of philosophy that studies those questions is called epistemology, which just means "study of knowledge". This class confronts the central epistemological questions. Topics include the analysis of knowledge and justification (what are they?), skepticism (the justifiability of beliefs that goes beyond the data available), and the relationship between knowledge and deductive logic (are the consequences of knowledge knowable?). The proposed answers involve a subtle interplay of logic, probability, causation, and counterfactual reasoning. The course is self-contained, so there are no prerequisites.	U	4, 17, 9	focused
80208	Philosophy	Critical Thinking	This course is an introduction to practical reasoning. The course will contain an elementary introduction to concepts important for reasoning and decision making, such as validity, probability, and utilities. Students will extensively practice critically analyzing and evaluating a wide variety of arguments found in newspapers, magazines, and elementary accounts of scientific reasoning. In order to help students develop the skills to analyze and evaluate arguments, the course will introduce several software packages recently developed at CMU that help students diagram arguments and causal reasoning; these packages have been shown to improve students critical reasoning skills. In addition, students will learn about a wide variety of statistical, logical, psychological, and causal fallacies that are used to mislead people.	U	4, 6, 7	focused
80210	Philosophy	Logic and Proofs	Logic & Proofs is a web-based course and introduces students to central issues in modern logic. It is designed for individual learning with rich interactive environments and dynamic intelligent tutoring. The material is presented on-line, and most exercises are done on-line as well. Readings of historical and philosophical character complement the core content. This on-line course is supplemented, indeed given additional grounding, by weekly meetings in very small groups. There, we have collaborative reviews, substantive discussions and critical reflections. The central question of the course is this: How can we analyze the structure of rational discourse or, more specifically, the logical structure of argumentation? An answer to this question requires: (i) uncovering the logical form of statements; (ii) defining the correctness of logical steps; (iii) formulating inference rules for the logical forms; (iv) designing strategies for argumentation with the inference rules. The course takes these steps for both sentential and quantificational logic.	U	4, 9, 11	focused
80211	Philosophy	Logic and Mathematical Inquiry	Since ancient times, mathematical arguments have served as a paradigm for rational inquiry. This course studies the structure of such arguments and their applications. We will study foundational mathematical concepts and informal proofs, as they appear in everyday mathematics. At the same time, in parallel, we will study mathematical logic, which provides formal symbolic languages for mathematics. The course will make use of a computational "proof assistant" to develop fully rigorous, machine-checked proofs. This course prepares students to take the 310-311 series on the fundamental (in)completeness and (un)decidability theorems of modern logic.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
80212	Philosophy	Arguments and Logical Analysis	Are there rational methods that can further our knowledge? The notion of rational inquiry presupposes that there are appropriate methods for the pursuit of knowledge. In this course, we will investigate the means by which a successful argument justifies its conclusion, as well as various subtle ways in which other arguments fail. The course will explore the use of logic as an instrument in the study of arguments and reasoning, and it will serve as a gentle introduction to the elementary concepts of formal logic. We will take a historically informed approach to studying logic and argumentative fallacies, and we will discover that logical tools and methods are useful for constructing and analyzing arguments in all disciplines, from philosophy and history to psychology and physics. Our goals are to acquire a solid grasp of some fundamental tools of modern logic, and learn how to use them to make our thinking and writing clearer, more precise, and more critical. To this end, our coursework will consist in homework and exams on topics in logic, as well as writing assignments on a variety of topics. This course is intended for students from any discipline who would like to improve their writing and critical thinking skills, as well as students who are interested in learning logic without having had prior contact with the subject.	U	4, 17, 9	focused
80221	Philosophy	Philosophy of Social Science	This course will explore various philosophical issues germane to social science. The central question of the course asks whether we can use traditional scientific tools to understand social phenomena, e.g. wars and religions, in the same way that we use them to understand natural phenomena, e.g. gases, lasers and planetary orbits. Some of the more specific questions we address: Because humans possess free will and act with intentions while light rays and planets in motion do not, are we forced to use logically different species of explanations in the two cases? How can we explain social institutions that depend upon cooperation? Whereas natural scientists actively conduct experiments, social scientists can often only collect statistical data. Does this difference prevent social scientists from inferring causal relations? Is our understanding of social phenomena always value laden?	U	15, 13, 17	focused
80226	Philosophy	Revolutions in Science	Science is an ever-changing enterprise. Most scientific advances, though significant, occur within a stable framework of accepted theories and data. A few episodes of change in the history of science involve discarding and replacing fundamental theories of the world. These are often accompanied by significant changes in the vocabulary in which those theories are expressed, the tools used by scientists, the phenomena on which scientists focus, and the kinds of explanations they consider acceptable. A very small number of these episodes change the way humanity views its ability to know the natural world and its place in universe. The latter two kinds of change in science have often been called "scientific revolutions." We will focus on three such radical transformations: The "Copernican Revolution" (or "the Scientific Revolution") of the 16th and 17th centuries, the Darwinian revolution of the 19th century, and the quantum revolution of the late 19th and 20th centuries. This course has two intertwined components: history of science and philosophy of science. In the historical component, we will examine in some detail the three major scientific revolutions. The philosophical components will help us understanding the reasoning involved in scientific theory change. This course does not required detailed knowledge of any of the sciences used in examples of revolutionary change.	U	9, 11, 4	focused
80244	Philosophy	Environmental Ethics	In this class, we'll try to figure out what obligations we might have to the natural environment and the non-human living beings within it, as well as what justice requires of us in our use of natural resources given the needs of other human beings. Among other things, we'll spend considerable time on animal ethics: What moral obligations do we have to non-human animals? Is it morally OK to eat them? Does a dog count (morally speaking) as much as a human? Does a factory-farm chicken count as much as a wild endangered tiger? Then, given that many of the most pressing environmental problems¿like climate change¿are collective action problems, we'll consider why these problems are so sticky, what obligations we have as individuals in dealing with these problems, and what a just collective solution might look like. To that end, we'll examine the processes fueling climate change, we'll look at who is responsible for these processes, and we'll try to determine whether any current proposal to deal with climate change is an effective, just response to the problem.	U	13, 15, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
80245	Philosophy	Medical Ethics	This course provides an introduction to core ethical issues in health care, medical research, and public policy. Topics include: the moral responsibilities of health care providers to patients and various third parties such as the government or insurance companies, the status of health as a social good, and questions of individual liberty and social responsibility at the ends of life including issues such as abortion, physician assisted suicide, and the definition of death. We will also examine specific ethical issues in the conduct of medical research and look at the impact of technological innovation on our notions of health, disease, life, death, and the family. If time permits, we may also discuss issues related to genetics and cloning. While the course engages such substantive ethical issues it also attempts to sharpen students' skills in practical reasoning through argument analysis, analogical reasoning, and the application of theory and principles to particular cases.	U	9, 4, 3	focused
80246	Philosophy	Moral Psychology	Moral psychology is the study of how we think about morality, make moral judgments, and behave in moral situations. This has important implications for how we should think about morality, make moral judgments, and behave in moral situations. In this course we will examine empirical research on moral thinking and behavior by psychologists, neuroscientists, economists, and philosophers and discuss the implications this research has for issues in ethics. We will address questions such as: What motivates our moral behavior? Do we ever act altruistically or do we only do the right thing because it's somehow in our own interest? Is it even possible to tell what people's real motivations are? How do we make moral judgments and decisions? What roles do reason, intuition, and emotion play in our moral judgments? What role should they play? What role should a person's beliefs, desires, and intentions play in our judgments of how blameworthy the person is or of how much punishment he or she deserves? What role should the outcomes of the person's actions play in our judgments of him or her? Should we hold people responsible for things that are not entirely under their control?	U	4, 15, 17	focused
80249	Philosophy	AI, Society, and Humanity	AI and robotic technologies are rapidly developing and spreading, with corresponding social and human impacts & opportunities. Understanding these potential risks and benefits requires a multidisciplinary approach, drawing from ethics, philosophy, psychology, sociology, economics, and more. These diverse perspectives can help us to ensure that new technologies support and advance human and social values & interests. In this course, we will study relevant disciplinary methods & frameworks through a series of case studies of current or near-future AI and robotic technologies. We will learn to apply those techniques to analyze and understand the challenges & opportunities presented by novel technology.	U	9, 8, 1	focused
80250	Philosophy	Ancient Philosophy	This course will cover Ancient Greek philosophy from the pre-Socratics to the later Hellenistic writers. We will prepare the background for Socrates and Plato by studying major Presocratic philosophers such as the Milesians, Heraclitus, and Parmenides, and then dive in to a careful study of some of the central works of Plato and Aristotle. A key theme of the class will be the way in which Socrates, Plato, and Aristotle sought to define philosophy in opposition to sophistry, and how the lessons learned from their confrontation with sophistry informed their ethical and metaphysical thought. The final sections will discuss post-Aristotelian movements such as Epicureanism, Skepticism, and Stoicism.	U	17, 11, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
80251	Philosophy	Modern Philosophy	This class will focus on the history of Western philosophy in the modern period, with special emphasis on the "early modern" era of roughly 1600-1800. Massive upheavals and conflicts in science, politics, and religion fueled attempts to find new ways of making sense of the world, and we will try to situate our philosophers within this rapidly evolving intellectual context. In particular, we will examine the impact of these changes on two subfields of philosophy: metaphysics (the study of the nature of reality, distinguishing it from mere appearance), and epistemology (roughly, the study of knowledge itself). We will ask, and attempt answers for, questions like: What is knowledge, can we achieve it, and if so, to what extent? To what extent, if any, can our most basic scientific instruments, the human senses, lead us to the true nature of the world? These questions will unavoidably send us down paths into other subfields, like philosophies of mind, of free will, of ethics, and of religion. After reading early modern philosophers like René Descartes, Princess Elizabeth of Bohemia, John Locke, David Hume, and Immanuel Kant, we will turn to some more recent work in the modern and contemporary eras to see what lessons (if any) were learned, and what new approaches (if any) have been taken in the quest for knowledge and reality.	U	17, 5, 11	focused
80252	Philosophy	Kant	Immanuel Kant was a CMU sort of person. He was an enthusiastic follower of Isaac Newton, and his approach to fundamental philosophy was: "what would robotics be like from the viewpoint of the robot?" From that starting point, he investigated what would have to be the case for the robot to know anything about its environment. The resulting "critical philosophy" defined the relevant philosophical vocabulary for generations of prominent mathematicians and scientists into the 20th century, and is pivotal background both for both the "analytic" and the "continental" schools of philosophy. This course starts with essential background reading in pre-Kantian, early modern sources, including Descartes. Then it focuses on a detailed reading of Kant's Critique of Pure Reason and related texts. Course requirements include written answers to reading questions and two short paper projects. There are no prerequisites.	U	4, 9, 12	focused
80254	Philosophy	Analytic Philosophy	This course examines the revolutionary impact of philosophy at the turn of the 20th century on contemporary thought and progress. By the 1920s some scientists and philosophers became hopeful that the end of the long tradition of philosophical deadlock was finally within reach. Buoyed in particular by Einstein's theory of relativity and the invention of modern logic, they created a new kind of philosophy with the goal of applying logical and empirical methods to philosophical problems. This new approach led to new puzzles and paradoxes, along with a focus on the age old question of what can be known and what is meaningful. The modern fields of linguistics, cognitive science, and information and computer sciences all owe a debt to these sources, as does of course contemporary philosophy. Our quest will be to understand both what authors like Frege, Russell, and the Vienna Circle were up to in the first place, and how their work contributed to the world we live in today.	U	8, 9, 7	focused
80261	Philosophy	Experience, Reason, and Truth	A central issue in Western philosophy has been whether reason or experience (or some of both?) provides the foundations for human knowledge. This course explores that question by looking at various "empiricist" vs. "rationalist" debates from the 17th century to the present day. We will focus on the problems encountered in trying to give an adequate account of the our knowledge of the external world, the structure of our minds, and the nature and limitations of human knowledge. The scope of our investigation will extend to the nature of mathematical knowledge, to "thought experiments" in both science and philosophy, and to "nativism" vs. "empiricism" issues in contemporary cognitive science and moral theory. The course has two main goals: (1) to study key metaphysical and epistemological issues surrounding the nature of human knowledge and (2) to help improve our analytical and critical skills by extracting and evaluating various relevant philosophical arguments.	U	4, 17, 15	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
80282	Philosophy	Phonetics and Phonology I	This course aims to provide students with practical tools for the study of speech sounds. The acoustic properties of sounds are examined using spectrograms and other devices, with emphasis on vowels and sonorant consonants. Following this, basic phonological notions are covered, tracing their development in the twentieth century up through optimality theory. In optimality theory, contrast and allophonic variation are explained in terms of an input-output device which selects the most harmonic candidate still faithful to phonemes in the input. The course should be relevant not only to linguistics students, but to students of language generally, with applications to sociolinguistics, child language development, speech recognition technologies, and the study of foreign languages.	U	4, 9, 17	focused
80284	Philosophy	Invented Languages	Language is normally something that develops and and changes organically within human communities, without much in the way of organized design or invention. Over the centuries, however, many have succumbed to what J. R. R. Tolkien called the "secret vice" of language creation. The purposes of these invented languages have been diverse. Some, like Tolkien's Elvish languages, Okrand's Klingon, and Peterson's Dothaki and Trigedasleng have been designed for artistic or entertainment purposes: they have set out to be "natural" languages within fictional worlds. Others, like Zamenhof's Esperanto, Brown's Loglan, and Elgin's Láadan have tried to address perceived inadequacies of the natural languages that their creators saw in the world around them. The of study language invention is thus both the study of a distinctive art form, and an exploration of the history of how people have thought about language in different ages and societies. In this course, we will explore the linguistic considerations involved in language invention, and the linguistic lessons of the history of invented languages, with a particular emphasis on applying these insights to our own language invention projects. Over the course of the semester, students will be expected to develop invent their own languages, and to complete various shorter assignments to supplement relevant ideas and skills. This course does not assume any background in linguistics, and is intended to accommodate both newcomers and advanced students.	U	4, 9, 17	focused
80305	Philosophy	Decision Theory	This course is an introduction to formal models of choice and decision-making. We begin by examining choice under certainty, developing both qualitative and quantitative models of preference. We then expand our analysis to take into account uncertainty, focusing on the von Neumann-Morgenstern theory of expected utility and Savage's classic axioms. Empirical challenges to models are emphasized throughout, in response to which we will consider a variety of alternative representations of uncertainty (e.g., Dempster-Shafer belief functions, non-unique probability measures) and preference (e.g., framing effects, prospect theory).	U	6, 7	focused
80311	Philosophy	Undecidability and Incompleteness	U & I focuses on two fundamental results: the undecidability of logic (established by Alonzo Church and Alan Turing) and the incompleteness of mathematical theories (discovered by Kurt Gödel). The proofs of these results require a novel metamathematical perspective, but also striking logical concepts and fascinating mathematical techniques. In this course, the theorems are not just formulated but actually proved. We begin with the axiomatic development of elementary set theory that allows, at the same time, the formal representation of informal mathematics like number theory. With this basis, one can show that syntactic notions concerning set theory are representable in the very theory. It is then easy to prove that set theory is incomplete. To show that logic is undecidable, the crucial concept of computation is introduced via Turing machines. The two concepts - proof and computation - are fundamental for mathematics, computer science and, in particular, artificial intelligence. The undecidability and incompleteness results are among the most significant contributions of modern logic to the foundations of mathematics. They provide also the beginnings of a deeper understanding of mental processes in cognitive science and, thus, of the human mind. To understand the latter connections, we will read about and discuss historical as well as philosophical aspects of the subject.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
80312	Philosophy	Mathematical Revolutions	Mathematics is a central part of our intellectual experience. It is connected to sophisticated philosophical perspectives, say, in the work of Plato, Descartes, Leibniz, Kant, as well as in contemporary analytic philosophy; it is equally connected to fundamental views in the sciences, say, in the work of Ptolemy, Galileo, Newton, Einstein, as well as in contemporary cosmology. The common view that mathematics - if not directly "static", is evolving in a linear fashion - does not withstand historical scrutiny. Indeed, there are many dramatic conceptual changes concerning the very nature and object of mathematics. We examine three episodes in the relatively recent past that reflect radical transformations of the subject. They are closely associated with three mathematicians in whose work those revolutionary changes come to the fore most poignantly. The three episodes are framed by a discussion, at the beginning, of the axiomatic method and, at the end, of contemporary computational models of mathematical thinking. The episodes fall within the period from 1854 to 1954, but have deep roots in the past. The first episode deals with the shift from geometry to arithmetic as the foundational discipline for mathematics. The accompanying change in the methodological perspective is expressed in Hilbert's Foundations of Geometry, the center of the second episode. When joined with contemporaneous logical developments, that perspective underlies the formalization of mathematics. Gödel's incompleteness theorems imposed theoretical limits on that work. However, given Turing's analysis of computations, the question remains, how much of mathematical reasoning can be accomplished by computing machines. Completing a full circle, we incorporate central features of the axiomatic method into computational models of mathematical thinking.	U	4, 9, 11	focused
80316	Philosophy	Logic and AI	In this course, we will study logical systems that are relevant to, and motivated by, research in artificial intelligence. We will see how key ideas and advances in logic have found (and continue to find) natural applications in AI. More generally, we will see how logic and AI can benefit, and historically have benefited, from each other. A central aim of this course is to understand how logical languages of varying expressive power can be put to use in AI as a tool for representation and reasoning. Some of the topics that we will be focusing on are (1) non-monotonic and default logics, (2) modal logics for reasoning about knowledge/belief, temporal structures, and computation, (3) probabilistic logics (and the relation between logic and probability), (4) logics of graphical causal models and counterfactuals, as well as (5) elements of probabilistic programming and computable probability theory.	U	9, 17, 7	focused
80325	Philosophy	Foundations of Causation and Machine Learning	How can we define causality? Does smoking cause cancer? Can one find causality from observational data without temporal information? In our daily life and science, people often attempt to answer such causal questions for the purpose of understanding, proper manipulation of systems, and robust prediction under interventions. In the past decades, interesting advances were made in machine learning, philosophy, statistics, and economics for tackling long-standing causality problems, and a number of researchers have been recognized with the Turing Award (to Pearl in 2012) the Nobel Prize (to Granger in 2003 and to Sims in 2011). This course is primarily concerned with historical and technical developments of modern causality research, focusing particularly on how to discover causality from observational data and how to infer the causal effect of one variable on another. Thinking more broadly, causal analysis is a particular branch of unsupervised multivariate analysis. Accordingly, this course also provides a big picture of the foundations of causation and unsupervised machine learning. We start with unsupervised learning and multivariate statistical analysis problems including factor analysis, principal component analysis, and independent component analysis, and formulate their assumptions, develop their solutions, and study their connections with causal analysis. Finally, we investigate how the causal perspective helps in solving advanced machine learning or artificial intelligence problems, including transfer learning, image-to-image translation, reinforcement learning, and unsupervised deep learning.	U	3, 4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
80326	Philosophy	Epistemology of Machine Learning	Learning is hard! Programming a computer is also hard. Better that computers learn on their own from data how best to serve us. That is the goal of machine learning (ML), which is arguably the most successful branch of artificial intelligence. The very idea raises some natural, fundamental questions. What, exactly, is the goal of learning? Is it maintenance of consistency among our beliefs (Bayesian statistics), or is it a matter of estimating or predicting quantities in nature (frequentist statistics)? Is the goal prediction or truth; control or understanding; actual fact or necessary causal relations? Are predictions expected to be reliable beyond the narrow circumstances of training? Can learning be guaranteed to succeed by a specified time? Does success entail some detectable mark or sign of success that can be used to terminate the learning procedure? What roles do causality and simplicity play in learning, and how? Those questions arise spontaneously for the reflective ML researcher, but they also cross over into the foundations of statistics, the philosophy of science, and epistemology, the traditional philosophical study of the nature of knowledge and justified belief. This class provides an introduction to the relevant philosophical/foundational issues underlying ML research. It involves both philosophical reflection and exercises providing concrete experience with ML methods. A unifying theme is that strong definitions of successful learning imply correspondingly strong limits on what can be learned.	U	4, 17, 9	focused
80330	Philosophy	Ethical Theory	Every day, even in very subtle ways, we make judgments of value that shape our lives and our conduct. This course will examine four influential attempts at providing a systematic account of the source and nature of moral value, its relationship to other kinds of value, and the practical implications of different answers to these questions. This focus on the fundamental structure of moral value will frequently engage topics such as the nature of the good, subjectivist and objectivist accounts of value, forms of moral naturalism verses attempts at moral constructivism, and will draw on historical as well as more contemporary sources. Particular attention will be paid to articulating the specific sources of disagreement that distinguish competing moral theories in order to facilitate our ability to adjudicate between them on a reasoned basis.	U	11, 15	focused
80335	Philosophy	Social and Political Philosophy	Broadly speaking, political philosophers are interested in whether, and to what extent, government use of coercion can be justified, and how social and political institutions should be structured in order to be legitimate. This is an advanced course in social and political philosophy, aimed at providing students with a more in-depth familiarity with classic and contemporary questions both theoretical and applied. The course is topical, and course topics will vary from year to year. Typically 4-5 topics are covered in a term. Previous years' topics have included the nature and value of freedom, social contract theory, racial and epistemic injustice and the nature of white ignorance, the intersecting concepts of justice and equality, structural injustice, responsibility for injustice, and immigration. Students are expected to come away from the course with a strong understanding of some of the major debates in social and political theory as well as the tools to analyze ongoing debates within contemporary US and global politics regarding the appropriate way to organize our social and political reality. This course is primarily conducted as a seminar and is discussion-rather than lecture-based.	U	10, 16, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
80382	Philosophy	Phonetics and Phonology II	This course is a continuation of Phonetics and Phonology I (80-282), and is designed to expand upon the phonetic and phonological skills and knowledge developed in that course. Students will carry out a phonetic study (either acoustic or perceptual) designed by the instructor; the particular topic varies from semester to semester. As co-researchers, students will be involved in all aspects of data collection and analysis. Lessons in phonetics will be designed to train students on the necessary skills and concepts required, including understanding the articulatory, acoustic, and perceptual correlates of the phenomenon under investigation, as well as data analysis and interpretation of the results. A presentation session will be organized for the end of the semester. In tandem with the phonetic study, a related phonological phenomenon will be investigated throughout the semester. This phenomenon will be explored by using a set of case studies that can be investigated through various phonological and psycholinguistic perspectives. We will cover major developments in phonological theory, including SPE-style features, feature geometry/autosegmental phonology, and Optimality Theory. We will also consider these phenomena in light of more recent approaches to phonological representation, including Exemplar Theory and Articulatory Phonology. Assessment of phonetics will primarily come from the research project and in-class lab work, but will be supplemented with quizzes to ensure that core concepts are acquired. Assessment of phonology will primarily come from problem sets. Students will finish this course with a solid understanding of how to do phonetic research, and an appreciation of how various theoretical frameworks have attempted to account for phonological phenomena.	U	4, 17, 11	focused
80383	Philosophy	Language in Use	In ordinary conversation, what a speaker conveys by the utterance of a sentence may go beyond, or be quite different from, the meaning that could be assigned to the sentence or expression she uses without consideration of the context in which it occurs. For example, the sentence "I have homework" means one thing; but it conveys something more when uttered in answer to the question "Do you want to go see a movie tonight?" In this course, we explore how the systematic study of linguistic meaning can be expanded from the domain of the sentence to the domain of connected, multiparty discourse. This involves taking into account the contributions of context, and of speaker and hearer's beliefs, goals and intentions, to the construction of meaning. This course is one of the set of courses on language and meaning offered by the Program in Linguistics, including in addition to this: 80-283 It Matters How You Say It, 80-288 Intonation, and 80-381 Meaning in Language. Each of these courses can be taken independently; as a set, these courses provide a comprehensive introduction to contemporary approaches to natural language semantics and pragmatics.	U	4, 17, 9	focused
80385	Philosophy	Linguistics of Germanic Languages	The Germanic languages include English, Dutch, Frisian, German, Pennsylvanisch, Afrikaans, Yiddish, Icelandic and the Scandinavian languages, excluding Finnish. The course will serve as an extended case-study for the application of concepts and analytical strategies taught in basic linguistics courses to some of these languages. Specifically, we take a bottom-up approach to Dutch, Frisian, Icelandic, and Danish, starting with raw language material whenever possible, which we progressively analyze in terms of phonetics and phonology, morphology, and syntax. These case studies lead to comparisons between the languages and insight into their development and divergence over time. We follow this hands-on approach with historical and grammatical overviews, touching on some of the outstanding issues in Germanic linguistics. The approach should also help bring out the relevance of diachronic factors in the synchronic study of language, with historical forms of English being open to investigation, as these often reflect patterns found in contemporary Germanic languages.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
80405	Philosophy	Game Theory	Game theory is the study of interactive decision-making: making choices in the context of other agents who are also making choices. Famous examples include the "Prisoner's Dilemma" (pitting rational self-interest against the benefits of cooperation), and the "Cournot duopoly" (a basic model of market competition and supply-and-demand). Game theory has been applied to situations as diverse as traffic flow, auctions, the search and competition for scarce resources, and bargaining. This course will develop conceptual and technical facility with the mathematical tools used to model and analyze such situations. We will cover games in strategic and extensive form and games of perfect and imperfect information; we'll also study solution concepts such as Nash equilibrium and rationalizability. Finally, throughout the course we will take the opportunity to actually play several of the games we study to help build intuitions and foster insights into the formal mathematical models we develop.	U	11, 17, 9	focused
80413	Philosophy	Category Theory	Category theory is a formal framework devoted to studying the structural relationships between mathematical objects. Developed in the mid-20th century to attack geometrical problems, subsequent progress has revealed deep connections to algebra and logic, as well as to mathematical physics and computer science. The course emphasizes two perspectives. On one hand, we develop the basic theory of categories, regarded as mathematical structures in their own right. At the same time, we will consider the application of these results to concrete examples from logic and algebra. Some familiarity with abstract algebra or logic required.	U	4, 9	focused
80445	Philosophy	Shift Capstone Experience	The Societal and Human Impacts of Future Technologies capstone experience will be taken in either the fall or spring of the senior year. It is required for all SHIFT minors. The purpose of the capstone experience is for students to demonstrate learning over time within the minor. Key learning experiences include incorporating concepts, ideas, & frameworks from multiple disciplinary perspectives, using disciplinary perspectives in appropriate ways, given their complementary strengths & weaknesses, generating a multidisciplinary (2) of some current or near-future technology, collaborating with people of different disciplinary backgrounds, and communicating a single, integrated analysis of the impacts & opportunities of this novel technology (& recommended actions). SHIFT minors should work with the minor advisor during the Spring of their junior year to design an appropriate capstone experience.	U	4, 9, 17	focused
80449	Philosophy	EHPP Project Course	The Ethics, History and Public Policy Project Course is required for the Ethics, History and Public Policy major and is taken in the fall semester of the senior year. In this capstone course, Ethics, History and Public Policy majors carry out a collaborative research project that examines a compelling current policy issue that can be illuminated with historical research and philosophical and policy analysis for a chosen client. The students develop an original research report based on both archival and contemporary policy analysis and they present their results to their client and a review panel.	U	4, 17, 11	focused
80513	Philosophy	Seminar on Philosophy of Mathematics	This seminar will focus on two themes in philosophy of mathematics. First, we will consider contemporary readings in epistemology on the value of knowledge and the nature of understanding in light of recent work on mathematical understanding and explanation. Second, we will try to understand how mathematics enables its practitioners to come to consensus as to whether a mathematical claim has been established, and was able to do so even before there were formal axiomatic systems to serve as arbiters of truth. To that end, we will consider mathematical debates in the commentaries on Euclid, in early analysis, and in nineteenth century mathematics.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
80516	Philosophy	Causality and Machine Learning	In the past decades, interesting advances were made in machine learning, philosophy, and statistics for tackling long-standing causality problems, including how to discover causal knowledge from observational data, known as causal discovery, and how to infer the effect of interventions. A number of researchers have been recognized with the Turing Award (to Pearl in 2012) the Nobel Prize (to Granger in 2003 and to Sims in 2011). Furthermore, it has recently been shown that the causal view may facilitate understanding and solving various machine learning or artificial intelligence problems such as transfer learning, semi-supervised learning, disentanglement, and adversarial vulnerability. This course is concerned with understanding causality, learning causality from observational data, and using causality to tackle a class of learning problems. We will particularly focus on two key problems in causality. One is causal discovery. It is well known that "correlation does not imply causality," but we will make this statement more precise by asking what assumptions, what information in the data, and what procedures enable us to successfully recover causal information. Causal influences may take place between the underlying hidden variables, and what we measure may be their reflections; so we will also see how to find the underlying hidden "causal" variables as well as their causal relations by analyzing measured variables. Its implication in unsupervised deep learning will be discussed. The other is how to properly make use of causal information. This includes identification of causal effects, counterfactual reasoning, improving machine learning in light of causal knowledge, and forecasting in complex environments, and we will investigate how the causal perspective helps in domain adaptation, image-to-image translation, and deep reinforcement learning.	U	4, 9	focused
80517	Philosophy	Seminar on Topics in Logic: Algorithmic Randomness	What is randomness? One way to think about it is as a property of sequences of, say, events, experimental outcomes, observations, or symbols from some alphabet: a sequence is random if it is unruly, irregular, patternless. This conception of randomness plays a significant role in a variety of fields, including cryptography, information theory, the foundations of probability and statistics, computability theory, and certain computational models of learning. To build some intuition, consider the two binary strings 0010111110 and 0101010101. The first string seems more random-looking than the second. This is because the second string displays an obvious pattern that is very easy to describe and that makes it look highly predictable. But can these intuitions be made precise? Is it possible to provide a rigorous mathematical characterization of the notion of a random sequence? This seminar will provide an introduction to the theory of algorithmic randomnessan active branch of computability theoryaccording to which a sequence is random if it does not display any algorithmically detectable patterns. We will begin by discussing von Mises' theory of collectives, a precursor to the theory of algorithmic randomness; then, we will see how von Mises' work led to the modern computability-theoretic approach to randomness. We will focus on both the mathematical details of the theory of algorithmic randomness and its philosophical consequences. We will pay special attention to the connections between randomness, probability, and the philosophical interpretations of probability. Among the questions that we will address are: What is the relationship between probability and randomness? Is probability more primitive a concept than randomness, or is a precise analysis of randomness needed to understand what probabilities are? Is it possible to define "absolute" randomness? Does randomness have to satisfy any laws?	U	4, 17, 7	focused
80580	Philosophy	Seminar on the Philosophy of Language	This course will provide an advanced level introduction to core topics and issues in contemporary philosophy of language and linguistic semantics. Readings will include both classic papers that provide the foundation of contemporary discussions (e.g. Frege, Kripke, Montague) and papers drawn from the contemporary literature. Possible topics include: reference and problems of reference (hyperintensionality and de se); modality; semantics of tense; introduction to formal semantic theory; compositionality; convention and linguistic meaning. This is a graduate level course. Interested undergraduates require permission of the instructor to enroll.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82101	Modern Languages	Elementary French I	This course is for students with no prior experience in French. Using a proficiency-oriented approach, students will develop contextually appropriate interpersonal communication skills in both written and spoken French, develop reading and listening skills through the use of various media, understand fundamental grammar, acquire vocabulary, and gain a basic understanding of French and francophone cultures through class activities. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. A student with prior experience in French must take the placement exam.	U	4, 17, 9	focused
82102	Modern Languages	Elementary French II	This course is designed for students who have taken first-semester French at Carnegie Mellon or learned its equivalent as determined by placement. Using a proficiency-oriented approach, students will expand contextually appropriate interpersonal communication skills in both written and spoken French, continue to develop reading and listening skills through the use of various media, review previously learned and practice new grammar and vocabulary, and gain a further understanding of French and francophone cultures through class activities. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. A student with prior experience in French must take the placement exam.	U	4, 17, 9	focused
82103	Modern Languages	Elementary French I Online	This course is designed for students with no prior experience with French and who need a more flexible approach to language learning than that offered in a standard classroom course. Beginning language learners will develop communicative competence in the four basic skills of listening, speaking, reading and writing. Basic vocabulary and sentence structures for use in essential daily-life situations, as well as cultural information, are taught through the course materials and assignments. Materials are web-based, with extensive use of Internet technologies for listening, reading, and communication. During regular semesters, this course is offered in a hybrid mode requiring one 80-minute class per week in addition to weekly 20-minute individual meetings with the instructor or a peer speaking assistant. There is a materials fee for taking this course which is paid by credit card on first log-in to the course website. A student with prior experience in French must take the placement exam.	U	4, 9, 8	focused
82104	Modern Languages	Elementary French II Online	This course is designed for students who need a more flexible approach to language learning than that offered in a standard classroom course. Students will learn more useful and complex expressions and sentence structures necessary for use in everyday life. Students will continue building their skills in listening, speaking, reading, and writing for everyday communication. Additionally, course materials and assignments are designed to improve students' understanding of French and francophone cultures and societies. Materials are web-based with extensive use of Internet technologies for listening, reading, and communication. During regular semesters, this course is offered in a hybrid mode requiring one 80-minute class per week in addition to weekly 20-minute individual meetings with the instructor or a peer speaking assistant. There is a materials fee for taking this course which is paid by credit card on first log-in to the course website. A student with prior experience in French must take the placement exam.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82109	Modern Languages	Introduction to Arabic I	This course is the first part of a two-semester sequence (82-109, 82-110) for students with no background in Arabic. It covers the first half of 82-111 in one semester through introducing learners to Modern Standard Arabic (MSA) in its written and spoken forms to achieve communicative competence at the elementary level in all language skills (listening, speaking, reading, and writing). To this end the course follows a proficiency-oriented approach to language teaching. In addition to MSA, the course introduces students to one of the popular spoken dialects in the Arab world such as Egyptian, Levantine, or Moroccan (depending upon the instructor's background/expertise). Students will also study various cultural aspects of the Arab world through written, audio-visual and online-based materials. Regular homework, quizzes, tests, presentations, and class participation are required (three in-class hours per week plus six hours of required homework). Students who intend to do a minor in Arabic Studies should consult with the Arabic minor advisor before deciding on 82-109 or 82-111.	U	4, 17, 9	focused
82111	Modern Languages	Elementary Arabic I	This course introduces learners to Modern Standard Arabic (MSA) in its written and spoken forms to achieve communicative competence at the elementary level in all language skills (listening, speaking, reading, and writing). To this end the course follows a proficiency-oriented approach to language teaching. In addition to MSA, the course introduces students to one of the popular spoken dialects in the Arab world such as Egyptian, Levantine, or Moroccan (depending upon the instructor's background/expertise). Students will also study various cultural aspects of the Arab world through written, audio-visual and online-based materials. Students with prior knowledge of Arabic must take the placement exam.	U	4, 17, 9	focused
82112	Modern Languages	Elementary Arabic II	This course builds on Elementary Arabic I to continue introducing students to Modern Standard Arabic (MSA) to achieve communicative competence at the Novice-High/Intermediate-Low level in all language skills (listening, speaking, reading, and writing). To this end, the course follows a proficiency-oriented approach to language teaching. In addition to MSA, the course continues to introduce students to one of the popular spoken dialects in the Arab world such as Egyptian, Levantine, or Moroccan (depending upon the instructor's background/expertise). Students will continue to explore various cultural aspects of the Arab world through written, audio-visual and online materials.	U	4, 17, 9	focused
82114	Modern Languages	Arabic for Global Exchange Online	Arabic for Global Exchange is a course in Arabic language and culture that utilizes cognitive learning technologies and computer-assisted language instruction to enhance educational, governmental, and business exchanges that are increasingly vital to public policy and economic development in the global economy. This is a mini-course for individuals with no proficiency or extremely limited knowledge of Arabic language and culture who are about to begin study or work in an Arabic-speaking context. The course introduces learners to basic concepts and information to facilitate entry and engagement in an Arabic-speaking environment. The Arabic for Global Exchange project aims to meet a need for high quality, communication-oriented instructional materials to introduce basic cultural knowledge and survival language. Arabic for Global Exchange is a six-week, six-lesson, half-semester course (equivalent of six weeks of university-level instruction), or roughly sixty hours of student effort. Each of the six lessons in the course includes texts and activities to promote acquisition of cultural content in English as well as basic introductory exposure to the Arabic language.	U	4, 8, 17	focused
82115	Modern Languages	Beginning Arabic for Oral Communication	ARABIC FOR ORAL COMMUNICATION is designed for students who desire to learn how to orally communicate in Arabic or who have taken Arabic for Global Exchange. This course does not teach how to read or write Arabic. It offers students the opportunity to engage in speaking and listening activities and complete a variety of related oral practice assignments in and outside of class, using a spoken Arabic that would be widely understood anywhere in the Arab World. The conversation topics will be greetings, self-introduction, hobbies, proper terms of address in casual and professional settings, and describing feelings and places.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82119	Modern Languages	Arabic Calligraphy Culture & Skills	This course introduces its participants to historical and cultural contexts and various techniques used to produce Arabic calligraphy works. No previous knowledge of the Arabic script or language is necessary. At the end of the course, participants will demonstrate familiarity and comfort with key movements in the history and art of Arabic calligraphy, and read simple alphabet constructions or words in a variety of styles. Participants will apply proper techniques to producing calligraphy in two of the most commonly used styles, Naskh and Riq'ah, as well as experiment with some modern script styles. The class will use lecture discussions, audio-visual media, projects, guest speakers, and field trips as occasions arise.	U	4, 11, 9	focused
82121	Modern Languages	Elementary German I	This course is for students with no prior experience in German. Using a proficiency-oriented approach, students will develop contextually appropriate interpersonal communication skills in both written and spoken German, develop reading and listening skills through the use of various media, understand fundamental grammar, acquire vocabulary, and gain a basic understanding of German-speaking cultures through class activities. The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). A student with prior experience in German must take the placement exam.	U	4, 17, 9	focused
82122	Modern Languages	Elementary German II	This course is designed for students who have taken first-semester German at Carnegie Mellon or learned its equivalent as determined by placement. Using a proficiency-oriented approach, students will expand contextually appropriate interpersonal communication skills in both written and spoken German, continue to develop reading and listening skills through the use of various media, review previously learned and practice new grammar and vocabulary, and gain a further understanding of German cultures through class activities. The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). A student with prior experience in German must take the placement exam.	U	4, 17, 9	focused
82131	Modern Languages	Elementary Chinese I	This course is for students with no prior experience in Chinese. Using a proficiency-oriented approach, students will develop contextually appropriate interpersonal communication skills in both written and spoken Chinese, develop reading and listening skills through various media, understand fundamental grammar, acquire vocabulary, and gain a basic understanding of Chinese cultures through class and extracurricular activities. Regular homework, quizzes, tests, and participation in class are mandatory (four in-class hours per week). Students will learn the phonetic transcriptions of Chinese (Pinyin) for speaking and listening as well as Chinese characters for reading and writing. The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. A student with prior experience in Chinese must take the placement exam.	U	4, 17, 9	focused
82132	Modern Languages	Elementary Chinese II	This course is designed for students who have taken first-semester Chinese at Carnegie Mellon or its equivalent by placement. Students will continue developing contextually appropriate interpersonal communication skills in both written and spoken Chinese, developing reading and listening skills through various media, and working toward a deeper understanding of Chinese culture. Work for this course will include the introduction and use of more complicated sentence structures, grammar, and expressions. Students are also encouraged to communicate in longer sentences and write short paragraphs and essays in Chinese. Regular homework, quizzes, tests, and participation in class are mandatory (four in-class hours per week). Students will continue to learn the phonetic transcriptions of Chinese (Pinyin) for speaking and listening as well as Chinese characters for reading and writing. The elementary level is designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. A student with prior experience in Chinese must take the placement exam.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82133	Modern Languages	Elementary Chinese Online I	This course is designed for students who need a more flexible approach to language learning than that offered in a standard classroom course. It is a Chinese language course designed to help beginners develop communicative competence in the four basic skills of listening, speaking, reading and writing the Chinese language. Basic vocabulary and sentence structures for use in essential daily-life situations, as well as cultural information, are taught through the materials and assignments. Materials are web-based, with extensive use of Internet technologies for research, writing and communication. There is a required weekly class meeting for training and for group activities, and weekly individual meetings with a tutor or the instructor for conversation and practice.	U	4, 9, 17	focused
82134	Modern Languages	Elementary Chinese Online II	This course is the continuation of 82-133, Elementary Chinese I Online. Students will continue learning more useful and complex expressions and sentence structures necessary for use in everyday life. Students will continue building their skills in listening, speaking, reading, and writing for everyday communication, and their understanding of Chinese culture and society. There is a required weekly class meeting for training and for group activities, and weekly individual meetings with a tutor for conversation and practice.	U	4, 8, 9	focused
82135	Modern Languages	Cultural Roots: Chinese Language & Culture for Heritage Learners	Different from "Elementary Chinese I", this 9-unit Chinese language course is geared towards the needs of Chinese heritage students who have basic prior exposure to Chinese and with the intention to improve their Chinese literacy skills and Chinese culture awareness. This course helps students to better develop their daily reading and writing competence through a balanced and systematic training. By adopting the multimedia teaching materials, including language textbooks and culture-oriented audio and video English materials, this course will have an equal emphasis on both Chinese language and Chinese American historical events and culture. This course is intended to promote the students' cross-cultural knowledge and identity awareness. Students will be assessed in terms of their Chinese listening, speaking, reading and writing skills at the elementary level as well as their understanding of the Chinese American history and culture corresponding to their background. This course is taught in both Chinese and English.	U	4, 11, 17	focused
82137	Modern Languages	Chinese Calligraphy: Culture and Skills	Chinese calligraphy is a crucial part of Chinese culture and world art. It is also a clear manifestation of Chinese philosophy that has influenced Chinese people for several thousand years. This introductory course on Chinese calligraphy provides students with basic knowledge of Chinese calligraphy and how it mirrors Chinese history, culture, and philosophy. It will also introduce the fundamental characteristics of the Chinese writing system, its cultural content, and principles of formation as well as the skills used in Chinese calligraphy. At the end of the course, students will have a good understanding of Chinese characters and their cultural and philosophical background but also be able to appreciate the art and beauty in Chinese calligraphy. Classes include lectures, discussions, hands-on practice, and projects.	U	4, 11, 17	focused
82138	Modern Languages	Comparative China: "Crazy" Linguistically Rich Asian Languages	The languages spoken in China and Japan differ from those spoken in the west in a number of striking ways. In this 9-unit course, students will gain an understanding of the sound systems, morphosyntax, lexicon, writing systems, dialects, and varieties of Chinese and Japanese. Students will also learn how these neighboring languages and cultures have interacted and changed over time. The knowledge acquired in this course will be equally beneficial to those learning one of these languages and to those simply interested in better understanding East Asian languages and cultures.	U	4, 17, 9	focused
82141	Modern Languages	Elementary Spanish I	Elementary Spanish I is the first part of a two-semester course sequence for beginning students, emphasizing the development of communicative language and cultural competence. Students will work towards improving their writing, reading, listening and speaking abilities in Spanish, such that they become comfortable working with a variety of topics from Spanish-speaking cultural areas. Students will develop basic interactional and routine public communication patterns, frequently working in groups and pairs, and utilizing technologies that enhance learning opportunities and promote skill development. This course also provides extracurricular opportunities to interact with members of the Spanish-speaking community. Four hours of in-class instruction per week are required. A student with prior experience in Spanish must take the placement exam.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82142	Modern Languages	Elementary Spanish II	Elementary Spanish II is the second part of a two-semester course sequence for beginning students, emphasizing the development of communicative language and cultural competence. Students will work towards improving their writing, reading, listening and speaking abilities in Spanish, such that they become comfortable working with a variety of topics from Spanish-speaking cultural areas. Students will develop basic interactional and routine public communication patterns, frequently working in groups and pairs, and utilizing technologies that enhance learning opportunities and promote skill development. This course also provides extracurricular opportunities to interact with members of the Spanish-speaking community. Four hours of in-class instruction per week are required. A student with prior experience in Spanish must take the placement exam.	U	4, 17, 9	focused
82143	Modern Languages	Elementary Spanish I Online	Elementary Spanish Online I is for beginning students, emphasizing the development of communicative language and cultural competence. Students will work towards improving their writing, reading, listening and speaking abilities in Spanish, such that they become comfortable working with a variety of topics from Spanish-speaking cultural areas. Students will develop basic interactional and routine public communication patterns. This course is designed for students with no previous knowledge of Spanish and who need a more flexible approach to language learning than that offered in a standard classroom course. All materials are Web-based, with extensive use of Internet technologies for research, writing, and communication. During regular semesters, this course is offered in a hybrid mode requiring one 80-minute class per week in addition to weekly 20-minute individual meetings with the instructor or a peer speaking assistant. There is a materials fee for taking this course which is paid by credit card on first log-in to the course website. Students who have taken Spanish before are required to take the placement exam.	U	4, 17, 9	focused
82161	Modern Languages	Elementary Italian I	This course is for students with no prior experience in Italian. Using a proficiency-oriented approach, students will develop contextually appropriate interpersonal communication skills in both written and spoken Italian, develop reading and listening skills through the use of various media, understand fundamental grammar, acquire vocabulary, and gain a basic understanding of Italian culture through class activities. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. A student with prior experience in Italian must take the placement exam.	U	4, 17, 9	focused
82162	Modern Languages	Elementary Italian II	This course is designed for students who have taken first-semester Italian at Carnegie Mellon or learned its equivalent as determined by placement. Using a proficiency-oriented approach, students will expand contextually appropriate interpersonal communication skills in both written and spoken Italian, continue to develop reading and listening skills through the use of various media, review previously learned and practice new grammar and vocabulary, and gain a further understanding of Italian culture through class activities. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. A student with prior experience in Italian must contact the Department of Modern Languages for placement.	U	4, 17, 9	focused
82163	Modern Languages	Directed Language Study: Elementary Italian I or II	A self-paced version of first or second semester Elementary Italian, this course is for highly motivated students capable of working independently. The coursework includes weekly classes, aural practice using online materials, periodic assessments, and individual meetings with the instructor. Students are permitted to take only one semester of 82-163. A student with prior experience in Italian must take the placement exam.	U	4, 17, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82171	Modern Languages	Elementary Japanese I	This course is the first part of a two-semester course sequence (82-171, 82-172) for students with no prior experience in Japanese. It emphasizes the development of communicative language proficiency through oral practice, aural comprehension, reading, writing, and the study of cultural aspects of Japanese society. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. A student with prior experience in Japanese must take the placement exam.	U	4, 17, 9	focused
82172	Modern Languages	Elementary Japanese II	This course is a sequel to Elementary Japanese I (82-171) and continues to further the development of communicative language proficiency through oral practice, aural comprehension, reading, writing, and the study of cultural aspects of Japanese society. Regular homework, quizzes, tests, presentations, and class participation are mandatory (four in-class hours per week). The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. A student with prior experience in Japanese must take the placement exam.	U	4, 17, 9	focused
82173	Modern Languages	Introduction to Japanese I	This course is the first part of a two-semester sequence (82-173, 82-174) for students with no background in Japanese. Since it covers the first half of 82-171 in one semester, it is suitable for those students who need sufficient practice time both in and outside of class to begin their study of Japanese. It emphasizes the development of communicative language proficiency through oral practice, aural comprehension, reading, writing, and the study of cultural aspects of Japanese society. Regular homework, quizzes, tests, presentations, and class participation are mandatory (three in-class hours per week plus six hours of required homework). The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. Students who intend to minor or major Japanese should consult with their Japanese minor or major advisor before deciding on 82-171 or 82-173. Students with prior knowledge of Japanese must take the placement exam.	U	4, 17, 9	focused
82174	Modern Languages	Introduction to Japanese II	This course is a sequel to Introduction to Japanese I (82-173) for students with no background in Japanese. Since the course covers the second half of the 82-171 in one semester, it is suitable for those students who need lots of practice time both in and outside class. It continues to further the development of communicative language proficiency through oral practice, aural comprehension, reading, writing, and the study of cultural aspects of Japanese society. The elementary level is also designed to help students learn to reflect upon and draw upon strategies used by good language learners in their second language study. Regular homework, quizzes, tests, presentations, and class participation are mandatory (three in-class hours per week plus six hours of required homework The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. Upon completion of this course, students can take 82-172.	U	4, 17, 9	focused
82191	Modern Languages	Elementary Russian I	This course is for students who have never studied Russian. It begins the Russian language sequence and is offered in the fall semester only. The course takes a communicative approach to teaching basic skills in listening, speaking, reading and writing. Language is presented in communicative contexts illustrating cultural aspects of daily Russian life. The elementary level is also designed to help students learn to reflect and draw upon strategies used by good language learners in their second language study. Daily homework and participation in class are mandatory (four in-class hours per week), as is weekly consultation and conversation practice with a course assistant. A student with prior experience in Russian must take the placement exam. **If you would like to take this course, but the current time slot does not work with your schedule please contact the instructor as soon as possible and we may be able to accommodate you**	U	4, 17, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82192	Modern Languages	Elementary Russian II	Elementary Russian II is the second semester of a yearlong beginning Russian sequence. Students who complete this yearlong sequence will acquire the basics of Russian grammar and develop an active vocabulary of approximately 1,000 words. They will learn how to tell simple stories on familiar topics, ask questions, and express their opinions. They will be able to grasp the main ideas of short newspaper articles and understand the gist of straightforward Russian speech. Throughout the course, students will encounter oral, visual, and written content and engage in the interpretive, interpersonal, and presentational modes of communication. A student with prior experience in Russian must take the placement exam.	U	4, 9	focused
82194	Modern Languages	Intensive Russian (I & II)	This intensive course allows students to complete a yearlong elementary Russian program in one semester and proceed to Intermediate Russian. Students who complete this course will acquire the basics of Russian grammar and develop an active vocabulary of approximately 1,000 words. They will learn how to tell simple stories on familiar topics, ask questions, and express their opinions. They will be able to grasp the main ideas of short newspaper articles and understand the gist of straightforward Russian speech. Throughout the course, students will encounter oral, visual, and written content and engage in the interpretive, interpersonal, and presentational modes of communication. A student with prior experience in Russian must take the placement exam. **If you would like to take this course, but the current time slot does not work with your schedule please contact the instructor as soon as possible and we may be able to accommodate you**	U	4, 9	focused
82198	Modern Languages	Research Training: Modern Languages	These courses are designed to give eligible and interested students some hands-on research experience working on a faculty project or in a lab in ways that might stimulate and nurture the students' interest in doing more research. They are open to students who are Dietrich College, SHS, or BHA majors, double majors, and minors who will be second semester freshmen or sophomores during the semester they take the course. A sample course contract can be found here: http://www.cmu.edu/dietrich/docs/undergraduate/RTC-Contract.pdf F19 TOPICS Section A:Independent Civil Society and the Struggle for Democracy in Cuba As part of an ongoing project on contemporary, independent, civil society in Cuba, its struggle for democracy, and the tools it employs for this purpose, this study will involve guided research, analysis, and evaluation of the impact of their use of: (a) the methods of deliberative democracy and (b) digital platforms, and the impact of the Cuban government's use of (c) traditional repressive methods, and (d) similar digital technologies. Open to one or two students. Prerequisites: Students must have at least advanced-high level reading skills in Spanish and be fully proficient in English. Section C: Using Data to Improve Learning in French Online For this research we will analyze the data gathered from students using the French Elementary 1 Online course. This semester we will examine patterns of student use behaviors, for example, why do students skip certain items and why do some questions or question sequences result in all correct or all incorrect answers? Using the plotted data we will cross-reference student behaviors with actual course material to find solutions to improving the course. No knowledge of French or statistics is required, just a good eye for detail and a willingness to share ideas.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82200	Modern Languages	Careers, Cultures, & Languages	"But what are you going to do with it?" is a question you may have heard from family members and friends when you declared your intention to major or minor in Modern Languages. Many people assume there are no good jobs out there for people with a passion for learning languages outside of teaching it. Yet, nothing could be farther from the truth. The language services industry is a growing sector constantly in need of qualified employees. More than 3,000 different companies in the United States alone employ more than 55,000 people in the language services industry - and the numbers are increasing. In particular, students with double majors can find many lucrative job opportunities. This seminar will provide you with insight into a) the vast number of jobs the language services industry offers, b) what those jobs entail and c) how to apply for them. You will learn from professionals in the field what working in the language services industry is like and how to prepare for it while still in college. Every class session will feature a new guest speaker(s) who will describe their educational background, discuss their experience regarding language and culture and give practical advice on how to succeed in their particular field. At the end of the course, you will have grown your professional network, gathered the tools and knowledge you need to apply for jobs, and make the connections you need for a possible summer internship that can build your skills and help you discover how to make your passion for languages a career. The course will be taught in English.	U	4, 9, 8	focused
82201	Modern Languages	Intermediate French I	At the intermediate level, students will continue to improve listening, speaking, reading and writing skills with the goal of becoming more proficient in daily and extended communication needs. In addition to an ongoing review of basic grammar, a greater variety of grammar, expressions and complicated sentence structures will be taught so that students can carry on more sophisticated conversations on various topics. In-class activities and homework using authentic texts related to the broad spectrum of French and francophone cultures will be used to integrate language learning with content and culture. Regular homework, quizzes, tests, presentations, essays, and class participation are mandatory. A student with prior experience in French must take the placement exam.	U	4, 17, 9	focused
82202	Modern Languages	Intermediate French II	At the intermediate level, students will continue to improve listening, speaking, reading and writing skills with the goal of becoming more proficient in daily and extended communication needs. In addition to an ongoing review of basic grammar, a greater variety of grammar, expressions and complicated sentence structures will be taught so that students can carry on more sophisticated conversations on various topics. In-class activities and homework using authentic texts related to the broad spectrum of French and francophone cultures will be used to integrate language learning with content and culture. Regular homework, quizzes, tests, presentations, essays, and class participation are mandatory. A student with prior experience in French must take the placement exam. Prerequisite: 82-201 or placement	U	4, 17, 9	focused
82215	Modern Languages	Arab Culture Through Dialogues, Film, and Literature	This course introduces students to the Arab World through a lens that challenges stereotypes, fosters a better understanding of the social reality of Arab societies, and appreciates the diverse identities. The objective is to increase cross-cultural understanding and equip students with the skills needed to thrive in the 21st century and become global citizens. Students will build cultural literacy and relationships through virtual meetings with Arab students in Saudi Arabia, Egypt, Qatar, and Morocco, in addition to watching a variety of critically-acclaimed films and reading two novels. Topics covered are the diversity of the Arab World, homo/sexuality, gender roles, social values, the effect of modernization on changes, and revolution music and art that emerged since the Arab uprisings of 2011.	U	5, 4, 10	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82221	Modern Languages	Intermediate German I	The goal of Intermediate German I is to further develop students linguistic and cultural knowledge, allowing them to feel more comfortable as a user of German. By the end of the semester, students should be able to: use and understand German in everyday situations; communicate effectively in general areas and in individual areas of interest; understand general cultural perspectives in contemporary Germany; and read and understand authentic materials from German-speaking countries. Activities will help develop the four skills and of cultural knowledge. This course focuses on intercultural concepts and will help students see what things Germans view differently from other nations and what things might be similar. Topics will include issues such as travel, politics, immigration, and music. A student with prior experience in German must take the placement exam.	U	4, 10, 9	focused
82222	Modern Languages	Intermediate German II	In this class, students will expand and develop their speaking, listening, reading, and writing skills, as well as their cultural knowledge of German-speaking countries. This course focuses on intercultural concepts and will help students see what things Germans view differently from other nations and what things might be similar. Topics will include issues such as views on German history, prospects for Germany's future, art and artists, and the German film industry. By the end of the course, students should be able to make themselves understood in German and understand German-speakers with experience dealing with foreigners. A student with prior experience in German must take the placement exam. Instructions for the placement exam are available in Baker Hall 160. Prerequisite: 82-221 or placement	U	4, 9, 11	focused
82231	Modern Languages	Intermediate Chinese I	This course is the continuation of Elementary Chinese II (82-132). At the intermediate level, students will continue to improve the basic skills of listening, speaking, reading and writing with the goal of becoming more proficient in daily communication needs. In addition to an ongoing review of basic grammar, a greater variety of expressions and complicated sentence structures will be taught so that students can carry on more sophisticated daily conversations on various topics related to every day life. While equal emphasis will still be on both Pinyin and characters, students will be encouraged to use more and more Chinese characters with the help of Pinyin for communication. In-class and extracurricular activities related to the broad spectrum of Chinese culture will be organized to facilitate language learning using knowledge of the cultural background of the language. Regular homework, quizzes, tests, presentations, essays, and class participation are mandatory (four in-class hours per week). A student with prior experience in Chinese must take the placement exam.	U	4, 11, 17	focused
82232	Modern Languages	Intermediate Chinese II	This course is the second semester of Intermediate Chinese. More sophisticated grammar points and vocabulary are introduced to help students' listening, speaking, reading and writing skills reach the intermediate level. The course also helps students prepare for advanced Chinese by exposing them to formal and written expressions and increasing their "media literacy". This is accomplished by systematically and gradually selecting and blending idiomatic expressions, and authentic printed materials into the texts and exercises. Activities related to the broad spectrum of Chinese culture are organized to facilitate language learning with knowledge and analysis of the cultural background of the language.	U	4, 11, 9	focused
82235	Modern Languages	Fables, Legends and Stories from Ancient Chinese Civilization	This course is designed for intermediate level students who would like to focus on improving their reading and writing skills in Mandarin Chinese. One major course goal is to teach students to read in Chinese with fluency and proficiency within a format of rich cultural content by expanding their vocabulary and building up their knowledge of socio-cultural influences on Chinese language use. Readings will include traditional fables, mini-stories, and articles on the lifestyle and social changes in ancient and modern China. Discussion will be one major class activity, however students will also be expected to develop long-term retention and control of the knowledge acquired through reading and writing assignments.	U	4, 11, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82238	Modern Languages	Topics in Chinese Culture	Courses offered under this repeatable title will focus on aspects of modern and contemporary Chinese culture, including, for example, literature, the arts, theater and music, and gender studies. Through the critical analysis of original sources in translation, film, as well as outstanding works of scholarship, students will gain a deeper understanding of important developments in modern and contemporary China and will learn how to locate and evaluate sources of knowledge about China for future study. This course and all source materials will be in English. No knowledge of Chinese is required. Past titles have included Gender & Sexuality in China: Tradition and Transformation. F20 Gender & Sexuality in China: Tradition and Transformation Over the past 100 years, Chinese women and men have seen tremendous changes in their social and private lives as China underwent wars, revolutions, market reform and opening up. The study of gender and sexuality provides a unique opportunity to explore how Chinese social/ private life has been transformed through economic development and social revolution in China. The course begins with a background discussion of Chinese traditions in the field of gender and sexuality, and covers the period from the beginning of the 20th century to the present. It aims to help student explore the answers to questions on the cultural expectations behind the idea of "man", "woman" and "sex" and the role the government p has played in regulating intimacy/sex/gender in different historical periods of China. Discussions will also be conducted on the changes in Chinese people's gender/sexuality experiences in contemporary to help students develop a deeper understanding of the sexual revolution in China, and changing conceptions of gender/sexuality identity under Confucianism, Western Imperialism, socialism and globalization.	U	5, 8, 4	focused
82241	Modern Languages	Intermediate Spanish I	Intermediate Spanish I is the first part of a two-semester course sequence (82-241, 82-242) designed to familiarize students with the cultures and perspectives of the Spanish-speaking world. Students will develop self-expression across a range of culturally significant topics, improving their speaking, listening, reading, and writing skills while working with longer passages of language in context through reading, writing and listening/viewing (e.g. tv series, movies, short novels, plays) and frequently working in groups and pairs, and utilizing technologies that enhance learning opportunities and promote skill development. The course provides extracurricular opportunities to interact with members of the Spanish-speaking community.	U	4, 17, 9	focused
82242	Modern Languages	Intermediate Spanish II	Intermediate Spanish II is the second part of a two-semester course sequence (82-241, 82-242) designed to familiarize students with the cultures and perspectives of the Spanish-speaking world. Students will develop self-expression across a range of culturally significant topics, improving their speaking, listening, reading, and writing skills while working with longer passages of language in context through reading, writing and listening/viewing (e.g. tv series, movies, short novels, plays) and frequently working in groups and pairs, and utilizing technologies that enhance learning opportunities and promote skill development. The course provides extracurricular opportunities to interact with members of the Spanish-speaking community.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82245	Modern Languages	New Directions in Hispanic Studies	FALL 2020: Split Screen: US-Mexico Border in Film This course will explore filmic representations of the 'space in between', as produced in Mexico and in the United States. The border long has been a popular subject of films in both countries, laying bare the complexities of this culturally rich and politically contested space - a space of creativity and exchange as well as of violence and repression. From Espaldas Mojadas (1955) to A Touch of Evil (1958) to Por mis pistolas (1968), El Norte (1984), Lone Star (1996), Traffic (2000) to more contemporary representations such as Norteado (2009), Sicario (2015) and El Desierto (2015), films show this space in flux between a more porous, open land, a horizon of possibility, and a highly militarized zone. Representations of the border on film show its transformation from a place of crossing, exchange, and refuge to a site of exclusions, surveillance technologies, intense violence, and rampant human rights violations. As told from both sides of the border, films respond to the rapidly shifting terrain of immigration and economic policies to illustrate the ways in which humans, money, and goods -be they drugs, arms or legal products-move across borders, or alternately, are restricted (bordered). We will consider how films from both countries, responding to the same broader transnational context, produce unique visions of la frontera that serve to interrogate and contest each other, thus yielding a more nuanced, complicated narrative of this dynamic space.	U	16, 10, 8	focused
82261	Modern Languages	Intermediate Italian I	This course begins a two-semester course sequence (82-261, 82-262) for intermediate-level students. At the intermediate level, students will continue to improve listening, speaking, reading and writing skills with the goal of becoming more proficient in daily and extended communication needs. In addition to an ongoing review of basic grammar, a greater variety of grammar, expressions and complicated sentence structures will be taught so that students can carry on more sophisticated conversations on various topics. In-class activities and homework using authentic texts related to the broad spectrum of Italian culture will be used to integrate language learning with content and culture. Regular homework, quizzes, tests, presentations, essays, and class participation are mandatory. A student with prior experience in Italian must take the placement exam.	U	4, 17, 9	focused
82262	Modern Languages	Intermediate Italian II	At the intermediate level, students will continue to improve listening, speaking, reading and writing skills with the goal of becoming more proficient in daily and extended communication needs. In addition to an ongoing review of basic grammar, a greater variety of grammar, expressions and complicated sentence structures will be taught so that students can carry on more sophisticated conversations on various topics. In-class activities and homework using authentic texts related to the broad spectrum of Italian culture will be used to integrate language learning with content and culture. Regular homework, quizzes, tests, presentations, essays, and class participation are mandatory. A student with prior experience in Italian must take the placement exam. Instructions for the placement exam are available in Baker Hall 160.	U	4, 17, 9	focused
82267	Modern Languages	Topics in Italian Language & Culture	FALL 2019 Beyond the Mafia and Michelangelo: Italy Unmasked Eclipsed by the consumer obsessions of tourists and the most well-known figures of Italian history, the uniqueness of Italy, offering distinct cultures in the north, central, and south, is rarely understood by outsiders. In this course, students will discover an Italy rich with cultural variants, radically diverse histories, customs, cults, and superstitions, in addition to physical expressions of culture in cooking and clothing, art and architecture. Students will identify and critically analyze diversity within the peninsula and its islands, and expand their awareness and understanding of the role of culture in behavior. Film, documentaries, and readings from epistolary and literary sources will help reveal a more profound Italy, for example, the science of Dulbecco (the Human Genome), the architecture of Trulli conical houses, the religious importance of Pitigliano ('Little Jerusalem'), and the immigration problems of San Marino. Coursework will include class participation, readings, film viewings, and writing. Final projects will be based on interviews and oral histories with the Italo-American community in Bloomfield (Pittsburgh), leading to critical comparisons of that population with Italians in Italy. This course is offered in English.	U	10, 4, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82268	Modern Languages	Italian Film: Hidden Agendas from Cincitta	Mussolini declared: "Cinematography is the most powerful weapon." Accordingly, the films in this course explore the political and societal cultures of Italy, and their subsequent interrelationships and effects on Italian film. Students will follow a cinematic journey that begins with silent cinema, leads to the historical narrative of WWII and the resistance fighters of neorealism, then to the historical-political analysis of la questione meridionale (the problem with the south) and finally takes on a more comical vein with la commedia all'italiana(Italian comedy) finishing with a unique solution to the problem of unemployed graduates. Outcomes include analyses of the formal aspects of Italian cinema, the crumbling of post WWII political parties, the emergence of new political figures, and the "precari" generation of college graduates forced to work for meager wages and no rights while their peers leave the country to find work causing the so-called brain drain of Italy. Coursework will include active participation in class (30%), comprehension exercises (20%), personal impact summaries (10%), and a final paper or presentation (40%). Films will be viewed as homework in the Modern Languages Resource Center. The course is offered in English and there are no prerequisites.	U	4, 8, 16	focused
82271	Modern Languages	Intermediate Japanese I	This course is the first part of a two-semester course sequence (82-271, 82-272). At the intermediate level, students will continue to improve the basic skills of listening, speaking, reading and writing skills with the goal of becoming more proficient in daily communication needs, and takes an integrated approach to the study of Japanese language and culture, consisting of grammar review, reading, and intensive practice in written and spoken Japanese. Course materials include authentic audiovisual and written texts in addition to the assigned textbooks. Also integrated are cultural explorations through direct interactions with native speakers. Regular homework, quizzes, tests, presentations, essays, and class participation are mandatory (four in-class hours per week). A student with prior experience in Japanese must take the placement exam.	U	4, 17, 11	focused
82272	Modern Languages	Intermediate Japanese II	This course is a sequel to Intermediate Japanese I (82-27182-171). At the intermediate level, students will continue to improve the basic skills of listening, speaking, reading and writing skills with the goal of becoming more proficient in daily communication needs, and takes an integrated approach to the study of Japanese language and culture, consisting of grammar review, reading, and intensive practice in written and spoken Japanese. Course materials include authentic audiovisual and written texts in addition to the assigned textbooks. Also integrated are cultural explorations through direct interactions with native speakers. Regular homework, quizzes, tests, presentations, essays, and class participation are mandatory (four in-class hours per week). A student with prior experience in Japanese must take the placement exam. Prerequisite: 82-271 or placement	U	4, 17, 11	focused
82273	Modern Languages	Introduction to Japanese Language and Culture	This course is an introduction to modern Japanese. Given the close link between the Japanese language and culture, the examination of the distinctive characteristics of the Japanese language and its sociocultural context provides important insights into contemporary Japan. This course is taught in English and is intended both for individuals who want to gain a better understanding of modern Japanese society, as well as for students of the Japanese language.	U	4, 11, 1	focused
82278	Modern Languages	Japanese Film and Literature: The Art of Storytelling	This course explores how the art of storytelling is in tandem with the vicissitudes of the human condition as illustrated in Japan's variety of fictions, non-fictions, and films in the twentieth and twenty-first centuries. Analyses of each storytelling not only reveal the cultural dynamics behind Japanese modernity, but also invite students to find new insights into Japanese culture and their ways of perceiving our globalized world. What kind of cultural exchanges took place between modern Japan and the West? How are Japan's traditional values transformed in the face of modern technicalization and industrialization, compared to the modernization of other countries? And, in turn, what kind of impact has modern Japanese culture had on today's world? Tackling these questions among others, the course also extends to such issues as the legacy of traditional Japanese culture, the modern Emperor system, World War II experiences, emerging voices of minorities, and popular culture (e.g., anime and subculture). This course is taught in English.	U	4, 10, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82279	Modern Languages	Anime - Visual Interplay between Japan and the World	In contemporary Japanese culture, anime plays a vital role, unfolding a wide range of stories with its distinct modes of visual representation and complementing to other forms of culture (e.g., literature, film, and art). This course explores Japanese animes appeal to the international viewers today, centering around cultural analyses of anime such as the Studio Ghibli production and Cyberpunk. Equally important are to locate the origin of Japanese animation, which is also investigated through the prewar and postwar works of animation in conjunction with related forms such as manga, or comic strips (e.g., Osamu Tezukas works that was initially inspired by Disney) and to discuss the potential of anime as an art form.	U	11, 9	focused
82280	Modern Languages	Billingual & Bicultural Experiences in the US	What does it mean to be bilingual in the USA, when approximately 80% of Americans are monolingual English-speakers? In this course, we will discuss and reflect on key concepts and theories related to bilingualism, biculturalism, and their instantiations in the United States (present and past). Students will be given the opportunity to engage in personalized, hands-on projects to deepen their inquiry into course themes. Some possible topics to be covered include: the nature of bilingualism and biculturalism; the historical and social contexts of bilingualism in the United States; characteristics of languages in contact and bilinguals' language practices; policies around heritage language maintenance in education; and the connection between language, culture, and identity. This discussion-based course is taught in English and is open to all students, whether they identify as bilingual/bicultural, or are simply interested in the course topic. This course counts as an elective for Modern Languages students, a Gen Ed for Dietrich students, and may also be countable as an elective for other colleges (please check with your advisor)	U	4, 11, 1	focused
82283	Modern Languages	Language Diversity & Cultural Identity	Culture, language, and identity are intimately tied together. Individuals, families, communities, and nations identify themselves in relation to the language or languages they speak. Local, national, and international governmental organizations make choices about the language or languages they recognize and use for political and economic affairs. The United Nations even recognizes language as integral to maintaining the cultural heritage of communities and peoples around the world, and the freedom to choose ones language of expression as a universal human right. In this course, we will explore a variety of questions, advantages, and challenges related to language diversity and cultural identity across the globe. Our main focus will be on contexts of multilingualism that is, contexts in which two or more languages may be used. Adopting a comparative case study approach, we will explore the following themes: (i) The historical underpinnings of language diversity and its consequences for cultural identity today (e.g., migration, colonization, conquest); (ii) How language diversity and cultural identity shapes, and is shaped by, local, regional, national, and international politics; (iii) The relationship between language diversity and language use and visibility in public spaces (i.e., the linguistic landscape); (iv) Relations between linguistic communities (e.g., majority and minority language users) and the sense of belonging to a culture. The course is taught in English. Students who wish to take the course as a Modern Languages major or minor elective will need to complete their final project on a topic relevant to the language they study.	U	11, 10, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82285	Modern Languages	Podcasting: Language and Culture Through Storytelling	Do you love stories? Stories told on the radio have always had significant power. For example, the 1938 War of the Worlds broadcast by Orson Welles was so effective that it panicked the entire United States. Today, podcasts such as Serial, This American Life, and The Moth have the same power to tell stories and provide audiences with rich, intimate and immersive audio experiences while often supporting diversity and giving voice to minorities and those under-represented in mainstream media. Owing its rising popularity to the ease and accessibility of production and distribution, there has never been a better time to create and tell stories in audio. In this course students will take on the role of podcast producers, learning while creating a series of podcasts that explore linguistic and cultural landscapes with the goals of educating and entertaining. Possible audio resources include field interviews with native speakers in their own language, allowing student producers to document informants' personal histories and aspects of their life related to culture, multilingualism, or political, social or environmental issues. Students will blend studio recordings with interviews and/or suitable "found" recordings, music, and sound. Coursework will include skill development on audio recording and podcasting, production management, creative thinking, materials sourcing, and giving and receiving constructive feedback from classmates and varied audiences on team and individual projects. The course will be offered in English.	U	4, 12, 9	focused
82286	Modern Languages	Cultural Complexities	S21: SECTION A: A comparative approach to explore the legacy of slavery and anti-Black racism through the present-day situation of Black peoples in the French and Spanish-speaking worlds from a variety of perspectives. After an introduction to the dissemination of Black African peoples via the Diaspora, the remaining focus will be on their conversion into second-rate 'nationals' and the creation of Diasporic cultural in former African, European, and American slave trading or receiving countries, and in Africa. Students will conduct analyses of historical, literary, journalistic, film, and other "texts" through discovery-focused, inquiry-based methodologies. SECTION B: In today's society that explores Diversity, Equity, and Inclusion, one can ponder if Arab societies have made progress to achieve DEI towards minorities of religions (Muslims, Christians, Jews), sects (Sunni and Shi'a), ethnicities (Copts, Nubians, Kurds), Palestinians in Israel, homosexuals, and physical disabilities. This course aims to enrich students' understanding of the diversity of Arab countries and histories of intercommunal relations and conflict, explore the progress made in equating minorities to majorities, including them in various sectors, and granting them more rights. We will use readings, films, arts, and music, to engage with students in 4 Arab countries to further their learning. SECTION C: Students will examine Japanese multicultural experiences from the perspective of Diversity, Equity, and Inclusion. They will inquire into the extent to which marginalized groups are valued for their differences, enjoy equal possible outcomes, and feel a sense of belonging in societies where Japanese people are dominant or not. Also discussed is Japan's recent policy of Tabunka Kyosei Shakai (Multicultural Coexistence Society). Students will also compare Japan and their own country to reflect on the cultural diversity of their own society.	U	10, 4, 5	focused
82287	Modern Languages	Multicultural Immersion - Relating Your World in Virtual Reality	In this unique course, taught across two campuses in Pittsburgh and CMU-Q, Doha we will explore the ways cultures and identities often intersect, relate and contradict one another. Using Virtual Reality (VR), a technology that provides a type of immersion, we can see the world through other people's points of view. But can we really harness this technology to tell stories about languages and cultures, can we really empathize and understand another culture using VR? To discover the affordances of VR, we will use this immersive technology to tell stories and relate our understanding of the world for others to see, thus exploring cultural understandings. Learning through telecollaboration, in online, virtual and in-person workshops, this will be an opportunity to collaborate, blend ideas, gain valuable skills and build on new experiences. During the course, students will create 360 video outcomes that others will view and experience through headsets and immersive spaces. No technology knowledge is required.	U	4, 9, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82288	Modern Languages	Everyday Learning: Designing Learning Exp in Times of Unrest & Uncertainty	Could you make complex ideas accessible and engaging to learners everywhere? Could you use what you know to make society better, teach as an agent of social change? In these times of Covid-19 many people have used learning to stay connected with friends and communities, leading to a groundswell in teaching and learning online. In this course you will develop learning experiences using a variety of instructional methods in a range of contexts. Underpinning our work with ideas from philosophers and educators, we will explore the democratization of education in a post-Covid world and consider a shifting educational landscape inspired by the Black Lives Matter protests. We will look at the response from museums, libraries, cinemas, and civic spaces to better meet the diverse needs of learners in their communities. For our assessed projects, we will design and produce instructional videos, animation, audio content, paired with worksheets, talks, paper-based instructional materials. This is a 6-unit course (with an additional 3-unit written component for 9 units).	U	4, 9, 1	focused
82290	Modern Languages	Transformative Learning through Cross-Cultural Analysis	This course seeks to prepare students for informed, critical, and transformative engagement with communities other than their own, whether through Pittsburgh or other US-based research and learning, or through study or work abroad. The course encourages students to approach past and present societal and personal concepts, issues, themes, and problems globally and locally using a student-centered, discovery-focused, inquiry-based approach to analyze a number of ethnic or national perspectives. A primary course objective is for students to critically discover how and why societies dictate what people think about things, promote personal values and assumptions, and the resulting impact of social discourse and dominant norms on cross-cultural relations. The goal is that students discover how their own habits, behaviors, and actions can be influenced or transformed by this critical cultural analysis approach. The instructors role will be to provide content and structure, encourage students to contribute additional content, and supervise students guided inquiries and case-based projects (written, oral, digital). With the approval of the instructor, an additional three (3) units may be earned by completing a critical cross-cultural analysis final project.	U	4, 17, 1	focused
82291	Modern Languages	Intermediate Russian I	This course is designed for students who have taken two semesters of Russian at Carnegie Mellon or the equivalent. It is offered in the fall only. This course furthers communicative proficiency through intensive practice in written and spoken Russian. Complex grammatical structures and stylistic variations are mastered and extensive vocabulary is acquired. Through reading materials, fictional and non-fictional, acquaintance is made with the basic components of Russian cultural literacy as well as the distinctive cultural aspects of daily Russian life. Attention is directed toward the dynamic interaction of language and culture in order to foster cross-cultural awareness. Attendance is required at three-hourly class meetings per week, as is weekly consultation and conversation practice with a peer language assistant. **"If you would like to take this course, but the current time slot does not work with your schedule please contact the instructor as soon as possible and we may be able to accommodate you**	U	4, 9, 11	focused
82292	Modern Languages	Intermediate Russian II	In this second semester of the yearlong intermediate Russian course students will review the basics of Russian grammar, develop listening comprehension, and expand their vocabularies. They will learn to relate simple narratives on familiar topics, express their opinions, ask questions, and speak about hypothetical situations. Students will be able to grasp the main ideas and certain nuances of texts presented in print and visual media as well as conduct straightforward conversations with native speakers. Students will also begin to build their skills in interpreting Russian poetry, literary prose, and film. A student with prior experience in Russian must take the placement exam.	U	4, 8, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82293	Modern Languages	Russian Cinema: From the Bolshevik Revolution to Putin's Russia	"Last night I was in the kingdom of shadows," said the writer Maxim Gorky in 1896 after seeing a film for the first time. "How terrifying to be there!" Early film inspired fear and fascination in its Russian audiences, and before long became a medium of bold aesthetic and philosophical experimentation. This seminar-style course surveys the development of Russian and Soviet film, paying equal attention to the formal evolution of the medium and the circumstances¿historical, cultural, institutional¿that shaped it. We will examine Sergei Eisenstein's and Dziga Vertov's experiments with montage in light of the events of the Bolshevik Revolution and the directors' engagement with Marxism; Georgi Alexandrov's and the Vasiliev brothers' Socialist Realist production against the backdrop of Stalinist censorship; Andrei Tarkovsky's and Kira Muratova's Thaw-era films within the broader context of New Wave Cinema; and the works of contemporary directors, including Aleksei Balabanov, Alexander Sokurov, and Andrey Zvyagintsev, in connection with the shifting social and political landscape of post-Soviet Russia. Besides introducing students to the Russian and Soviet cinematic tradition, this course will hone their skills in close visual analysis. No prior knowledge of Russian language or culture is required. The course is conducted in English, but students will have the option to do work in Russian for three extra course units.	U	4, 17, 16	focused
82294	Modern Languages	19th Century Russian Masterpieces	In the 19th century, Russian writers produced some of the most beloved works of Western literature, among them Dostoevsky's Crime and Punishment, Gogol's Diary of a Madman, and Tolstoy's Anna Karenina, to name just a few. These novels continue to captivate audiences and inspire adaptations in theater, film, and television. This course will examine the fertile century that yielded these masterpieces. In addition to the works mentioned above, students will encounter texts by writers who may be less well known but are no less significant, including Pushkin, Lermontov, and Chekhov. We will consider the social and cultural circumstances in which these works were produced and reflect on the reasons these Russian masterpieces have appealed to audiences well beyond the Russian-speaking world. No prior knowledge of Russian language or culture is required. The course is conducted in English, but students will have the option to do work in Russian for three extra course units.	U	4, 16, 11	focused
82295	Modern Languages	20th Century Russian Masterpieces	The October Revolution of 1917 had profound effects not only for Russian society, but also for literature and culture. Even before the Revolution, Vladimir Lenin stressed the importance of literature on the hearts and minds of people. After the Revolution, the new Soviet state demanded writers to become, in Stalin's words, engineers of human souls, and proclaimed socialist realism as the only permissible method of creative work in literature. This course focuses on masterpieces of Russian prose and poetry of the 20th century. Readings will include the proletarian writings of Maxim Gorky, the symbolism of Alexander Blok, the futurism and modernism of Vladimir Mayakovsky, as well as works by many other authors. We will discuss such important issues for Russian cultural history as the role of the intelligentsia in the Russian Revolution; the content and method of Russian decadence; symbolism and modernism; and the experience of imprisonment, liberation, and exile that became so important for many writers and poets. No prior knowledge of Russian language or culture is required. The course is conducted in English, but students will have the option to do work in Russian for three extra course units.	U	4, 11, 9	focused
82303	Modern Languages	French & Francophone Cultures	Through deep cultural analyses of France and francophone spaces, students uncover the roots of the French mentality and how this mentality oftentimes clashes with 'francophone', which is to say 'French', citizens who remain the 'Other' even in the 21st century. Comparisons between past and current events in French and francophone histories explain in part the French mentality and why the French react to the world as they do, resulting in the ongoing challenges of integration and identity of citizens from former colonies. Students will address questions such as: "What is preventing full integration?" and "How can integration be successful?" The coursework will develop students' skills in writing, reading, speaking, and listening, and improve their control of grammar through class discussions, presentations, and essays. This course is repeatable with new topics.	U	4, 17, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82304	Modern Languages	French & Francophone Sociolinguistics	This course examines the French language in relation to the social and cultural lives of the people who use it across the French-speaking world. To do so, students will explore the links between the French language of all francophones, its use, and the expression of national, cultural, community, and individual identities through the study of diverse texts and data sources, including policy/legal documents, films, music, newscasts, digitized corpuses of spoken and written French, and computer/technology-mediated communication. Through readings, discussions, hands-on activities, and project work, students will 1) develop content knowledge with an emphasis on language ideologies, policy, and planning; language contact and multilingualism; and language variation and change; and 2) develop linguistic skills in French (reading, writing, listening, and speaking) with specific focus on advanced spoken and written expression. This course is repeatable with new topics.	U	4, 9, 17	focused
82311	Modern Languages	Advanced Arabic I	This course promotes multiple literacies in an integrated approach to Arabic language and culture studies and builds students' ability to function at the Intermediate High/Advanced Low level in a variety of topics. It also embraces the diglossic nature of Arabic by explicitly integrating the teaching of Arabic regional spoken varieties alongside Modern Standard Arabic. Moreover, the course incorporates Computer and other Technology Assisted Language Learning pedagogies to support student learning inside and outside the classroom. The course is aligned with ACTFL's updated Arabic guidelines that perceive the Arabic language as a continuum in which both the regional spoken varieties and Modern Standard Arabic constitute a whole in terms of usage.	U	4, 9, 11	focused
82312	Modern Languages	Advanced Arabic II	The course is the continuation of Advanced Arabic I. It continues promoting multiple literacies in an integrated approach to Arabic language and culture studies and builds students' ability to function at the advanced level in a variety of topics. It also embraces the diglossic nature of Arabic by explicitly integrating the teaching of Arabic regional spoken varieties alongside Modern Standard Arabic. Moreover, the course incorporates technology-assisted language learning pedagogies to enhance student learning inside and outside the classroom. The course also implements ACTFL's Arabic guidelines that recognize Arabic as a continuum in which both the regional spoken varieties and Modern Standard Arabic constitute a whole in terms of language use.	U	4, 9, 11	focused
82313	Modern Languages	Topics in Modern Arabic Language, Literature and Culture	This course explores definitions of culture and analyzes the dynamic role of language in culture, and culture in language, with an aim to foster cross-cultural awareness and self-realization while developing proficiency in Arabic. Using an integrated approach to the study of the Arabic language, literature, and culture through close readings of current media sources (press, news, magazines, as appropriate), and literary and cultural readings. Additionally, this course is designed to strengthen listening, speaking, reading and writing, within the context of an evolving Arabic culture.	U	17, 11, 4	focused
82314	Modern Languages	Literature of the Arabic-speaking World	This repeatable introductory course explores the Arab world through a thematic or conceptual focus. In spring 2018, the theme will be 'Diversity in The Arab Culture'. Coursework will include reading short stories and novels to understand the cultural context that gave rise to specific literary works. Students will also continue to develop their abilities to express their ideas both in speaking and in writing, as well as their listening skills in Modern Standard Arabic. There is no prerequisite for this course but it is expected that your language proficiency in the Arabic language is good. **This is a content course in the Arabic language and not an Arabic language course.**	U	4, 11, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82320	Modern Languages	Contemporary Society in Germany, Austria and Switzerland	This course offers an introduction to contemporary German culture since 1989. Switzerland and Austria will be frequently included in class discussions but the main focus will be on Germany. In the wake of reunification, constructions of German cultural identity have undergone radical changes. Through encounters with articles, literary texts, popular music, and film students will explore these transformations and examine German culture and (both individual and collective) "identities" after reunification. The class sessions will be organized around several thematic segments, including East/West relations during and after reunification, German media, multiculturalism and minorities, and, finally, a segment on how to navigate the business world in German-speaking countries. The course will be conducted entirely in German and is designed to deepen students' understanding and awareness of issues in contemporary German culture.	U	4, 10, 11	focused
82323	Modern Languages	Germany, Austria and Switzerland in the 20th Century	This course advances proficiency in communicative and grammatical skills in the German language and knowledge of German-speaking cultures through the study of important events, trends, and people of the twentieth century in Germany, Austria, and Switzerland. Examples will be drawn from literature, newspapers, television, film and other sources. Students will be expected to complete assignments that demonstrate the ability to express critical judgments in both written and oral form, documented through readings and personal research. The course includes a review of the most troublesome points of German grammar.	U	4, 17, 8	focused
82331	Modern Languages	Reading Into a New China I: Population, Youth, Marriage, & Housing	This course is designed for students who have reached the intermediate level of proficiency in the use of Chinese language to develop their language competency in all four skills to a more advanced level. Students will expand explicit knowledge of socio-cultural influences on Chinese language use, and be able to apply the knowledge to conduct culturally appropriate spoken and written communication across various social domains and genres. Topics to be covered in this class will be closely related to some current social issues in China, such as population, youth, love & marriage, and popular culture. Students will also develop a repertoire of strategies and resources to assist their learning so that they will be gradually become autonomous learners who are able to conduct independent learning of the Chinese language, culture, history, and society. Classroom discussions and essay writing will be the major forms of work throughout the semester. Research projects on Chinese culture and society are also a requirement so that students will be able to gain a deeper understanding of the cultural background of the language. With Pinyin for support, students will learn both the traditional and simplified forms of Chinese characters.	U	4, 11, 1	focused
82332	Modern Languages	Reading Into a New China II: Transportation, Education, Pop Culture, & Health	A continuation of Advanced Chinese I, this course is designed to train students' language proficiency in functioning with Chinese in situations beyond their everyday life. Students will continue to learn more complex language phenomena in order to do exposition, explanation, description and argumentation with Chinese. These language phenomena will be introduced to students together with their social and cultural backgrounds through texts and multimedia programs related to various social issues. Classroom discussions and research project presentations will be the major forms of oral practice, and writing practice will mainly focus on essays and research papers. All the discussions and research projects will focus on issues related to traffic, education, employment, pop cultures, healthy living, and other human relations as well as economic situations in China today.	U	4, 8, 11	focused
82333	Modern Languages	Introduction to Chinese Language and Culture	This course will introduce students to important developments in China's culture and language since the end of the nineteenth century. We will explore questions like: What is Chinese culture in the modern world? What is "modern" and what "traditional" Chinese culture? Who defines what Chinese culture is? How have education and language policies shaped Chinese cultural identities over the last century? In other words, we will talk about China's "Modernity Project." This course will allow students to look beneath the surface of cultural expressions and study the ideas and concepts that underlie China's culture today. In the first half of the course, we will explore the historical, social and political contexts in which Chinese culture became modern. In the second half, we will look at specific aspects of Chinese culture and language in the modern world. Following a brief historical overview, our focus will be on Mainland China. Students are encouraged to further explore their own special interests in a guided research project.	U	4, 8, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82334	Modern Languages	Structure of Chinese	This is an upper-level Chinese course for students who have completed the requirements for intermediate Chinese with the goal of enabling students to build up a more comprehensive and systematic understanding of the structure of Chinese so as to lay a solid foundation for the further development of their advanced level language proficiency. This course will cover major complicated structural phenomena in Modern Chinese through the study of specially selected sample texts. Special emphasis will be given to high frequent errors and weaknesses on particularly problematic elements and sentence structures that are common among non-native Chinese speakers. After this course, students can expect to have the ability to use Chinese more accurately and naturally in both speaking and writing on sophisticated topics in life.	U	4, 17, 9	focused
82340	Modern Languages	Business Language & Culture in China II	Designed for students who have had at least two years of Chinese language training, this 9-unit course aims to help students enhance their language proficiency in professional environment and develop in-depth understanding of the current business culture in China. Authentic materials from newspapers, magazines, TV shows and online sources will be introduced in class to help students deepen their understanding of the business culture in China. Students will be encouraged to foster creative and independent thinking skills, which are crucial for survival in today's business world, through a variety of classroom activities such as group discussion/debate, professional interviews, business project and presentation, and oral/written business reports. Professional language skills (both in speaking and writing), as well as social and business etiquette, will be also introduced and trained throughout the course.	U	4, 17, 8	focused
82342	Modern Languages	Spain: Language and Culture	This course is part of the post-intermediate, 300-level program that forms the introduction to the major or minor in Hispanic Studies. Students may begin with any one of the three courses at this level or they may be taken concurrently. Spain: Language and Culture focuses on the cultures of Spain, the autonomous regions and the creation of a national identity as a reaction to the multiple ethnicities that have inhabited the peninsula since ancient times. The course advances proficiency in grammatical accuracy, the ability to communicate one's ideas in Spanish, and cultural proficiency. The focus of in-class activities is on written and non-written sources such as history, literature, film, art, and elements of popular culture; the building of reading and writing skills will be complemented by continued oral practice in the form of small and large group discussions and class presentations. Treatment of reading selections is designed to increase students general familiarity with a variety of genres, devices, and discourse types and to build a foundation for the department's more advanced courses in literature, history and culture. The course will be taught in Spanish.	U	4, 11, 9	focused
82343	Modern Languages	Latin America Language and Culture	This course is part of the post-intermediate, 300-level program that forms the introduction to the major or minor in Hispanic Studies. Students may begin with any one of the three courses at this level or they may be taken concurrently. This course will explore Latin American culture and language, focusing on issues of cultural identity. Tracing the historical thread of the construction of Latin American cultural identity we will distinguish 6 periods organized around crisis when the topic of Who we are? becomes a central debate (Larrain 1996). These periods include: the conquest and colonization, the independence and constitution of nation-states, the inter war period and the depression, the 1970s and the military dictatorships and the present globalization stage. These phases in the development of a Latin American cultural identity represent the existence of certain dominant discourses and controversies that are important in understanding Latin American culture (Larrain 1996). The idea is to explore how Latin America imagines itself and constructs a narrative about its origins and development. There are three main questions we will be exploring throughout the course: Where does the discussion about Latin America emerge from?; How does Latin America think of itself?; What does Latin America want to be?. These questions will be explored historically through readings of philosophical and political texts that deal with Latin American identity as well as with literary texts, films and music that represent practices that enact this/ese identity/ies. The course will be taught in Spanish.	U	4, 16, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82344	Modern Languages	U.S. Latinos: Language and Culture	This course is part of the post-intermediate, 300-level program that forms the introduction to the major or minor in Hispanic Studies. Students may begin with any one of the three courses at this level or they may be taken concurrently. This course provides an introduction to and analysis of the cultures and histories of U.S. Latinos. The course will trace the historical trajectories of these groups, both those dating back centuries, such as Mexican-Americans and certain Caribbean populations, and those with more recent, quickly growing populations, such as Salvadoran and Honduran immigrants, in an effort to understand how their identities are forged and transformed over time, considering both internal and external perspectives. Our exploration of U.S. Latino history and cultures will compare and contrast the experiences of people from the above-described categories and analyze the dynamic tension amongst them, with other minority groups, and with the mainstream US society. We will examine a wide variety of materials, including texts, film, art, music etc. in order to gain a better understanding of Latino populations in the United States. Ultimately, we seek to question and to understand the complexities of Latinidad in the 21st century U.S. The course will be taught in Spanish.	U	4, 10, 11	focused
82345	Modern Languages	Introduction to Hispanic Literary & Cultural Studies	This advanced-level course is required for the Hispanic Studies major or minor, and should be taken prior to the 400-level courses. The course is transatlantic, incorporating the study of the cultures of Latinos in the US, Latin American and Spain. Topics vary from semester to semester, aiming to provide a thorough understanding of Latin American, Spanish and U.S. cultures in connection to issues such as race, gender, socio-economic class. Students will improve their language use (reading, speaking, writing, and listening). SPRING 2019: The Case of the Hispanic Detective: The development of a specific and idiosyncratic detective genre in Spain and Latin America is considered one of the most important cultural phenomena in the Hispanic World since the second half of the 20th century. This course is a thematic introduction to the cultural production of the transatlantic, Hispanic world (Spain and the Americas) through the lens of the Hispanic detective genre as presented in texts, film, music, and other arts. We will be using detective fiction as a tool to increase linguistic and cultural proficiency, while also addressing a selection of theoretical readings in order to gain knowledge about the development of the genre, often comparing it to the Anglo- and Francophone models. More importantly, we will use these texts as a means to inquire about the crucial roles played by language and discourse, politics, religion, and economic factors in the constant shaping and reshaping of the histories and cultures of the Hispanic world; likewise, these texts will be used to explore relevant and current issues such as socioeconomic, racial, and gender inequalities, immigration and exile, etc. Materials will include classic literary texts by Borges, Ocampo, Taibo II, Piglia, and Vázquez Montalbán, among others, alongside notable and more recent examples of the genre in various formats.	U	5, 4, 8	focused
82371	Modern Languages	Advanced Japanese I	This course emphasizes the acquisition of advanced level of communicative language proficiency by immersing students in authentic cultural explorations. The curriculum includes authentic reading texts, multimedia, interviews with native speakers, and viewing and summarizing Japanese films that depict current Japanese society and cultural trends. The course also provides an individualized learning environment throughout the term in improving students' language skills and cultural proficiency. Students may pick a topic of personal interest for their term project thesis. A student with prior experience in Japanese must take the placement exam.	U	4, 17, 8	focused
82372	Modern Languages	Advanced Japanese II	This course continues to further improve the acquisition of advanced level communicative language proficiency by immersing students in authentic cultural explorations. The curriculum includes authentic reading texts, multimedia, interviews with native speakers, and viewing and summarizing Japanese films that depict current Japanese society and cultural trends. The course also provides an individualized learning environment throughout the term in improving students' language skills and cultural proficiency. Students may pick a topic of personal interest for their term project thesis. A student with prior experience in Japanese must take the placement exam.	U	4, 17, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82373	Modern Languages	Structure of the Japanese Language	This course examines the basic Japanese grammar covered in elementary and intermediate Japanese courses by comparison with English and aids students in systematizing their knowledge of Japanese and in deepening their understanding of Japanese culture (i.e., cultural ways of thinking underlying Japanese verbal behaviors). After a brief discussion of the overall typological differences between the two languages and an initial training to analyze them cross-linguistically, it deals with specific areas of grammar that exhibit pervasive structural and semantic differences and serve as exercises for cross-linguistic analysis. On the basis of the discussions and exercises in class, students gather and analyze relevant Japanese data for their project, which facilitates their understanding of the grammar points and cultural ways of thinking in question, and develops their analytical skills. This course is taught in Japanese. A student with prior experience in Japanese must take the placement exam.	U	4, 3, 11	focused
82374	Modern Languages	Issues in Japanese Technology & Society	This course seeks to (1) introduce students to technical Japanese or Japanese language used in the field of science and technology, (2) acquaint them with current issues in Japan involving science and technology, and (3) deepen their understanding of the science and technology culture of Japan. It draws on various sources of information such as books, newspapers, video clips, and TV news to familiarize students with current issues in Japan related to science and technology. Through understanding those issues, the course enables them to acquire necessary knowledge of technical Japanese and Japanese cultural perspectives on science and technology. It also requires them to work on an individual project to form and express their own thoughts and opinions on a science and technology issue of personal interest. This course is taught in Japanese. A student with prior experience in Japanese must take the placement exam.	U	4, 9, 11	focused
82382	Modern Languages	Introduction to Translation	We will survey a number of different translation theories in order to understand the various approaches that are at our disposal when translating a text. All theory taught in class will be accompanied by hands-on translation projects that will give students the opportunity to try out their knowledge first-hand and evaluate the usefulness of different approaches on a personal basis. In addition, we will explore the profession of translation by researching conferences, forums, websites and associations. Last but not least, we will contact and interview a translator who does translation work we feel particularly passionate about. The course is meant as a general introduction to what it means to be a translator and is open to both undergraduate and graduate students with sufficient knowledge in a foreign language.	U	4, 12, 6	focused
82383	Modern Languages	Second Language Acquisition: Theories and Research	This course provides an introduction to research and theories in Second Language Acquisition (SLA). Processes that underlie the learning and use of second languages are examined from four perspectives: 1) as linguistic knowledge, 2) as a cognitive skill, 3) as a personality-meditated process, and 4) a socio-culturally mediated process. Factors examined include: age-related differences, the influence of the first language, the role played by innate (universal) principles, the role of memory processes, attitudes, motivation, personality and cognitive styles, and formal versus naturalistic learning contexts. Issues that arise from the course readings are investigated through practical experience in applying theoretical knowledge to small-scale empirical research projects. Students are also provided with opportunities to consider the relevance of these issues to their own language learning experiences.	U	4, 17, 10	focused
82391	Modern Languages	Advanced Russian I - BerlinÂ¿ParisÂ¿New YorkÂ¿Harbin	This course investigates the cultural history of the post-Revolutionary Russian emigration to capitals of Europe, North America, and Asia. We will examine the life of Russian émigré communities in each of these cities, through poetry, literary fiction, memoirs, and diaries. In addition to developing students' cultural awareness, this course aims to advance Russian language learning by expanding students' vocabulary, reinforcing grammatical knowledge, and developing their capacity to speak and write on abstract topics. The readings will be available in English, though students will be encouraged to read the works in Russian. In addition to discussing the texts in Russian, students will complete short weekly homework assignments. **If you would like to take this course, but the current time slot does not work with your schedule please contact the instructor as soon as possible and we may be able to accommodate you**	U	4, 11, 10	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82394	Modern Languages	Russian for Heritage Speakers: Babushkas, Russia & Beyond	This course is designed to address the linguistic and cultural learning needs of heritage speakers of Russian, those who grew up hearing and speaking Russian at home but who have had little or no formal study of Russian language, culture, or history. Although heritage speakers of Russian often achieve advanced or near-native listening comprehension skills, they require further training in reading, writing, and speaking. Heritage speakers may also be unfamiliar with important aspects of Russian culture key events in Russian and Soviet history, well-known cultural phenomena, literary works, films, and so on and have gaps in their knowledge of social norms. Russian for Heritage Speakers aims to fill these gaps through a combination of grammar instruction and student-led close analysis of texts and audiovisual material. The course is organized around five thematic units that allow students to learn about Russian culture while engaging in interpretive, interpersonal, and presentational modes of communication: "Foundations: Truth & Legends," "Revolutions: Political, Cultural, Social," "Student Life: ' ,'" "Russia in the World," and "Individual and Community."	U	4, 11, 10	focused
82411	Modern Languages	Topics in Arabic Media	Given the development and spread of new and multi-literacies around us today, the course focuses on reading and analyzing Arabic media sources to engage in discussions about current topics in our modern world. Topics of interest include (but are not limited to): Culture, politics, economy, environment, education, and linguistic diversity. While reading and writing will be mainly in Modern Standard Arabic, class discussions will be of a multidialectal and multilingual nature to encourage questioning, analyzing, and conceptualizing topics in various contexts.	U	4, 8, 17	focused
82412	Modern Languages	Topics in Arabic Studies	This course is designed for students who have completed Advanced Arabic. Students will study written, audio, and video material taken from well-known Arabic-language media outlets such as Al-Jazeera, BBC Arabic, al-Arabiyya, etc. Linguistically, this course focuses on Modern Standard Arabic (MSA) because the media is one of the main domains in which MSA is significantly utilized in our modern age. Students will utilize reading, writing, and speaking skills to engage actively in class activities such as group discussions, debates, interviews, short presentations, etc. Students will prepare and present a final project in Arabic to share with the class. **The course can be repeated but after consent of instructor.**	U	4, 17, 9	focused
82415	Modern Languages	Topics in French and Francophone Studies	This repeatable course explores target cultures through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills. FALL 2019: La France au Moyen Orient	U	4, 16, 11	focused
82416	Modern Languages	Topics in French and Francophone Studies	Spring 2020: Culture of Games and Gaming Culture: Learning French Culture through Games and Game Design In the French cultural landscape, there is a privileged role for play as a form of entertainment but also as a way of learning and a vehicle for constructing the social bond. Indeed, games are currently the second most sold - and used - cultural product after books in France, a testimony to the cultural importance of games. And even though France is the second largest producer of video games (behind the US), other forms of games are still thriving. Play is central to (human) societies and cultures. Learning a culture by studying its games provides unique insights into what brings people together and how that culture is transmitted. In addition to providing rich cultural representations, games are effective learning tools because they provide players with opportunities for problem solving and honing a variety of skills. In this course co-taught by Prof. Dubreil and Sabrina Haskell, an expert game designer previously at Schell Games, students will explore French culture through playful practice and critical analysis. We will play a variety of French games, which we will then analyze for their linguistic and cultural content as well as their mechanics. Over the course of the semester, students will then design their own "French games" with the instructors' guidance. This 9-unit course will be delivered with an atypical distribution of hours since we will meet for 6 hours in class (or in the maker space) but you will have less personal work outside of class. At the end of the course, we will submit students' projects to gaming conventions where students may be able to travel to present them.	U	1, 6, 10	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82425	Modern Languages	Topics in German Literature and Culture	This repeatable course explores the culture of the German-speaking nations through a thematic or conceptual focus. Students critically analyze authentic documents, for example, historical, biographical, and literary texts, as well as film and works of the visual arts while improving and expanding their language skills. FALL 2019: 82-425 Thirty Years Later: The Collapse of East Germany and the Fall of the Berlin Wall This course, conducted entirely in German, observes the thirtieth anniversary of the collapse of the German Democratic Republic (GDR) in the autumn of 1989 and the fall of the Berlin Wall on November 9, 1989. These events in 1989 were followed by German reunification in October of 1990. The revolution in East Germany, the collapse of the GDR, the fall of the Berlin Wall, and German reunification fundamentally transformed Germany, Europe, and the world. The course will take a close look at the events of 1989 and 1990. Course materials will include documentary and fiction films, plays, essays, novels, and articles. A central part of the course will be interviews conducted by the class as a whole and by individual students with eyewitnesses to the events of 1989-1990. These interviews will be recorded and archived, and students will be required to complete a final project that summarizes what they have learned about these momentous events and their significance. Required work includes active participation in class, preparation of all readings, watching all assigned films, taking two tests, completing an eyewitness interview, completing a final project, and leading one class session, together with a partner, in the final weeks of the semester.	U	4, 11, 8	focused
82426	Modern Languages	Topics in German Literature and Culture	This repeatable course explores the culture of the German-speaking nations through a thematic or conceptual focus. Students critically analyze authentic documents, for example, historical, biographical, and literary texts, as well as film and works of the visual arts while improving and expanding their language skills. SPRING 2020: The German Zero Hour--Seventy-Five Years Later This course, conducted entirely in German, commemorates the seventy-fifth anniversary of the end of World War Two in Europe. That war was the bloodiest and most destructive in human history, and its end brought radical changes to Europe and Germany. The Zero Hour created the Europe and Germany of the postwar period. It was a period of deep misery and humiliation for many Germans, but also a time of new beginnings. In this course we will study the cultural artifacts of the Zero Hour period: stories, poems, novels, essays, films, paintings, music. ***Additionally, for another three units (for a total of 12), partial funding is available for up to ten students in the course to travel to Berlin during Spring Break of 2020 (March 9-13) to study the Zero Hour at the site of the convulsive final Battle of Berlin, which brought about the end of World War Two in Europe. Students who choose to take part in the Berlin trip will help create digital media content that will assist future Carnegie Mellon students who wish to study the meaning and significance of the German Zero Hour. Students who elect not to travel to Berlin will receive nine units for the course. All students in the course will be required to complete readings, write a number of brief essays, take two tests, and create a final project.	U	4, 8, 12	focused
82432	Modern Languages	Chinese Popular Culture: A Game of Learning	F20: There are two reasons why the course is called "A Game of Learning" (and not "A Game of Thrones"): 1. We will be using a video game (i.e. Chinese Parents) as the primary learning resource to explore, discuss, and analyze different aspects of Chinese society and popular culture, such as naming, education, school life and youth culture; 2. We will be using a "gameful learning theory" to design and structure the course, so that all your efforts and accomplishments will earn your precious points (Yes, just like in a game) that help you get your desirable grade at the end of the semester. In other words, with the exception of a few core assignments, you will have the option to complete or not complete all other assignments based on your learning interest and habit. With this power in hand, you can create a unique learning process and a "game ending" that is solely your own.	U	4, 9, 7	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82440	Modern Languages	Studies in Chinese Literature & Culture	This repeatable course explores target cultures through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills. SPRING 2021 INTO THE WORLD OF THE ANOMALIES: CHINESE GHOST LITERATURE AND CULTURE Through close reading of a 17-century Chinese literary masterpiece, Strange Tales from a Chinese Studio (Liaozhai zhiyi, ¿¿¿¿/¿¿¿¿), this course invites students to explore the richly "bizarre" world of ghosts and anomalies that constitutes an important aspect of Chinese culture. Selections of Chinese ghost stories and strange tales will be introduced throughout the semester. Their contents range from sketchy notes about outlandish figures and creatures to lengthy stories about bewitching dreams, haunting ghost and fox romances. In addition, students will also be asked to read academic writings in English about ghost literature and culture in traditional China. These writings will help students look into the special nature of the Chinese concept of ghost, as well as the cultural mindset that motivated the composition, collection and circulation of the strange tales in traditional China.	U	4, 11, 15	focused
82450	Modern Languages	Advanced Research in Hispanic Language & Culture	This course permits in-depth, 400-level study in the following courses: 82-342 Spain: Language and Culture, 82-343 Latin America: Language and Culture, and 82-344 U.S. Latinos: Language and Culture. Students will meet with the regularly scheduled 300-level class, read additional texts, and produce research assignments as agreed upon by the instructor and student. The focus is on a deeper understanding and individualized research of the course topics. Prerequisite: Permission of instructor	U	4, 17, 2	focused
82451	Modern Languages	Studies in Latin American Literature and Culture	This repeatable course explores the cultures of Latin America through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills. SPRING 2020: Chronicling Popular Music and Counterculture in Latin America In this course we will explore Latin American popular music, from son and bomba to rock en español, reggaeton and beyond, as represented in a variety of literary and non-literary cultural texts (e.g. ads, songs, music videos, short stories, films, etc.). We will use multimedia formats to chronicle our observations on the role that playing, listening and dancing to these rhythms has in the constitution of counter/cultural groups and identities at the local and global levels. The course will focus on Latin American cultural production from the second half of the 20th century, but will also consider alternate and/or more recent examples in order to enrich our historical understanding of the topic. Assigned texts for this course include, among others, readings by Julio Cortázar, Rosario Ferré, José Agustín, Luis Rafael Sánchez, Andrés Caicedo, Ana Lydia Vega, and Rita Indiana; films such as La noche de los lápices, and documentaries like Buena Vista Social Club, among others. We will also listen to numerous musical examples belonging to different regions and periods.	U	10, 4, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82455	Modern Languages	Topics in Hispanic Studies	This repeatable course explores Spanish-speaking cultures through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills. FALL 2020: Is Seeing Believing? Science in the Hispanic World How have the humanities and the arts dialogued with and shaped scientific inquiry? How does scientific development and discourse impact cultural production? How did the "scientific revolution" play out in early modern Spain? How did the encounter with American cultures challenge scientific inquiry? What alternatives did it offer? What is the current relationship between science and the humanities in the Hispanic world? This course attempts to answer these questions by focusing on literature and works of art in the Spanish-speaking world throughout time. Improve your Spanish while you discover the complex relationship between science and the humanities. Given the importance of vision and visibility in science, this course is guided by the study of optics, and will also explore other sciences such as astronomy, cartography, medicine, and chemistry. In this course we will analyze literary texts, works of art, historical documents, case studies, and systems of thought that emerge in the transatlantic Hispanic world. Students will identify key points and developments in the relationship between science and the arts. Assessments of the course include a variety of written assignments (Canvas posts, short essays), an oral presentation, and class discussions. If available, a trip to a cultural event or exhibit in a museum will be part of the course. The class will be conducted entirely in Spanish. Advanced level students, native and heritage speakers, and enthusiasts of the sciences and humanities are welcomed in this class.	U	4, 11, 9	focused
82473	Modern Languages	Topics in Japanese Studies	This repeatable course explores target cultures through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, cultural, social, historical, biographical, filmic, artistic, literary, musical, linguistic, and theoretical perspectives, while improving and expanding their language skills. FALL 2018: Youth Culture Japanese society is currently confronted with a massive array of social and cultural anomalies among its youth. In the culture, which values and emphasizes conformity, the phenomenon is utterly unprecedented. Accordingly, in this course, we will first explore the defining features of these anomalies by examining how Japanese youth are portrayed in modern day fictions and films. We will then scrutinize the extent to which these portrayals actually reflect real lives of young Japanese by analyzing newspaper articles and essays commenting on the social issues surrounding them. Finally, we will take a close look at the dramatic social changes, over the past three decades, to trace their long-term impacts as a significant factor contributing to the emergence of the new culture, particularly with respect to the changing youth behaviors. F17:The Evolution of Japan's Urban Culture This course analyzes various aspects of Japan's urban culture, the evolution of which has centered around Tokyo, focusing on such topics as the Taisho modernism during 1912-1926, the post-WWII Americanization of Japanese culture and society, the culture surrounding the Bubble Economy during 1980-1995, and the popular culture that has continued to thrive on a global scale, through fictions, non-fictions, films, and multimedia. Taught in Japanese.	U	4, 11, 1	focused
82474	Modern Languages	Topics in Japanese Studies	This repeatable course explores target cultures through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, cultural, social, historical, biographical, filmic, artistic, literary, musical, linguistic, and theoretical perspectives, while improving and expanding their language skills. SPRING 2020: The Evolution of Japan's Urban Culture This course analyzes various aspects of Japan's urban culture, the evolution of which has centered around Tokyo, focusing on a main question: how Japanese culture has reinvented itself, particularly between the first Tokyo Olympics (1964) and the second (2020). With this question in mind, the course also extends to such topics as the post-WWII Americanization of Japanese culture and society, the culture surrounding the Bubble Economy during 1980-1995, and the popular culture that has continued to thrive on a global scale, through fictions, non-fictions, films, and multimedia.	U	4, 11, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
82511	Modern Languages	Special Topics in Arabic Studies	This repeatable course explores the Arabic language and culture through a thematic or conceptual focus. Students critically analyze authentic documents through, for example, historical, biographical, filmic, artistic, literary, musical, and theoretical perspectives, while improving and expanding their language skills.	U	4, 11, 8	focused
82512	Modern Languages	Arabic Language and Identity: A Social Perspective	This course explores language use and social identity. To this end, the course will be focusing on identifying and analyzing linguistic and cultural practices and the implicit and explicit ideologies that are reflected through these practices. Although the course is conducted mainly in Arabic, multilingual and multidialectal practice are welcome as the course encourages the fluidity of language use to (1) reflect the sociolinguistic reality of our modern world, (2) maximize participation and discussions of language and identity, and (3) enhance knowledge construction. Possible themes for this semester include (but not limited to) language of the media and social media outlets, language in the workplace, language and education, language and gender, etc.	U	4, 5, 1	focused
82533	Modern Languages	Cultural Topics in Chinese Studies	SPRING 2021: Chinese Wisdom: A Global Perspective What is Chinese wisdom and can it be attained or developed? What is wise if reality isn't what it used to be? Do you claim to be a wise person? If so why and if not why not? This course will inspect various responses to these questions from Chinese philosophy tradition and its current applications from global perspectives. Philosophy is defined as the love or pursuit of wisdom and Chinese philosophy is the intellectual tradition of the Chinese culture from the early-recorded history to the present day. The course will explore some major Chinese philosophy traditions such as Daoism/Taoism, Confucianism, Buddhism, Legalism, and Mohism, and look at specific aspects of Chinese wisdom in modern and contemporary China today, including Chinese wisdom on food, medicine, Fengshui, architecture, painting, calligraphy, Taichi, etc. Students are encouraged to further explore their own special interests in a guided research project. Regardless of whether one agrees with these "wisdoms" or not, they should be studied and taken seriously by anyone who is trying to understand China. This course is conducted in Chinese and/or English, with the help of videos/films and classroom discussions. Students are expected to have excellent Chinese language skills. To promote intercultural communications, the course welcomes and invites participations of native Chinese speakers and cross-cultural peer learning.	U	4, 17, 11	focused
82705	Modern Languages	Translation Workshop II	This course is relevant to the mission of the Department of Modern Languages because it explores theoretical & applied approaches to translation as a form of intercultural communication in English & second languages. This process involves the analysis & repurposing of texts for functional use for different audiences & cultures. Students will further develop & refine their practical translation skills; gain familiarity with textual conventions that govern source & target texts within these domains & deepen their understanding of both L1 & L2 as languages for special purposes; explore & utilize translation resources available to them as well as create their own, domain-specific resource kits.	G	9, 16, 11	focused
84104	Institute for Politics and Strategy	Decision Processes in American Political Institutions	This is an interdisciplinary introduction to the study of politics and government in the United States. It familiarizes the student with the basic structures and processes of American government, but moves beyond the purely descriptive into the realm of the analytical. The main theoretical tools are spatial models of political decision-making, and models of collective action problems. The position taken in this course is that understanding American philosophical ideas about authority, power, and freedom is as central to demystifying the U.S. form of democracy as is understanding how decision-making institutions function. Thus, on one side, this course looks at how American political thought is infused into political institutions and society. On the other side, it investigates institutional arrangements using rationalistic theories. In addition, scientific writings at the intersection of psychology and economics are used to probe the possibility of gaining explanatory leverage on U.S. politics from the perspective of behavioral decision-making theories.	U	16, 4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
84110	Institute for Politics and Strategy	Foundations of Political Economy	Political Economics studies the interplay between economics and politics. Politicians, for example, may deviate from welfare-maximizing policies due to political pressures. Conversely, the economic and political consequences of policy decisions can shape the choices of future governments. The course will provide a broad, accessible introduction to the key issues in micro and macroeconomics, international economics, and financial markets, emphasizing those most valuable to understanding the interaction of politics and economics. The course will examine core economic concepts to illuminate how economies work, what constraints governments face, and what the welfare implications are of policy choices. From there, the course will expand to illustrate the political and ideological influences on monetary policy and central banking, the political factors shaping economic crises, the international factors influencing the implementation of domestic polices, and political influences on economic integration.	U	8, 1, 10	focused
84198	Institute for Politics and Strategy	Research Training: Institute for Politics and Strategy	This course is part of a set of 100-level courses offered by Dietrich College departments as independent studies for second-semester freshmen, and first- or second-semester sophomores, in the College. In general, these courses are designed to give students some real research experience through work on a faculty project or lab in ways that might stimulate and nurture subsequent interest in research participation. Faculty and students devise a personal and regularized meeting and task schedule. Each Research Training course is worth 9 units, which generally means a minimum for students of about 9 work-hours per week. These courses are offered only as electives; i.e., they cannot be applied toward a college or major requirement, although the units do count toward graduation as elective units. Additional details (including a roster and descriptions of Research Training Courses available in any given semester) are available in the Academic Advisory Center. Prerequisites/ restrictions: for Dietrich College students only; only for second-semester freshmen, or first- or second-semester sophomores; minimum cumulative QPA of 3.0 (at the time of registration) required for approved entry; additional prerequisites (e.g., language proficiency) may arise out of the particular demands of the research project in question.	U	4, 17, 9	focused
84200	Institute for Politics and Strategy	Acceleration: A Global Security War Game in the Age of Pandemic	This micro-course will expose students to the multi-faceted nature of key twenty-first century security challenges through the lens of a war game. The value of war games is increasingly recognized by scholars and practitioners due to their ability to make us think creatively and rigorously. This course will feature a weekend-long (Thursday-Sunday) digital war game run by terrorism scholar and author Dr. Daveed Gartenstein-Ross, along with a team of other experts, role players, and referees from his firm Valens Global. The war game will focus on security challenges, both old and new, that are impacted by the pandemic. "Acceleration" will examine three major intersecting trends: -The white supremacist extremist movement becoming increasingly powerful and taking on territorial aspects. -The weakening of states throughout the globe, including the risk of state collapse and resulting refugee flows. -A polluted information environment that allows various actors to engage in large scale manipulation and deception. Students will negotiate with key actors, make vital decisions, and otherwise attempt to shape the course of events. They will leave the course with a greater appreciation not only for the complex security and cooperation dilemmas facing the world, but also an understanding of how war games can help us think critically about those issues. The course will meet on Thursday, March 25, 2021 (7-9PM), Friday, March 26, 2021 (1-4PM), Saturday, March 27, 2021 (12-5PM), Sunday, March 28, 2021 (12-2PM). Students will also be expected to attend a CIRP Policy Forum Zoom Lecture with Becca Wasser from the Center for a New American Security on Thursday, April 8, 5:45-6:45PM.	U	4, 16, 10	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
84202	Institute for Politics and Strategy	Simulating Nuclear Non-Proliferation	Sitting at the crossroads of political science, national security, and technology, nuclear non-proliferation often involves using physical science to solve some of the globe's most crucial and complex issues, including WMD proliferation and the peaceful uses of nuclear energy. In this micro-course and simulation, the students will learn about the cutting-edge fields of non-proliferation and international safeguards from Brookhaven National Laboratory experts, and get to experience the technical and political challenges of enforcing non-proliferation rules. The virtual, five-week, once-a-week course will include modules on the nuclear fuel cycle; causes of nuclear proliferation; the nuclear non-proliferation regime; technical, legal, and political aspects of nuclear safeguards; and a simulation in which students will play the role of IAEA inspectors. Class sessions will occur on April 2, 9, 23, 30, and May 7.	U	7, 4, 13	focused
84250	Institute for Politics and Strategy	Writing for Political Science and Policy	The aim of this course is to equip students with the essential skills necessary to successfully write academic research papers and theses in political science, and professional documents such as policy memos, op-eds, political speeches, briefs, and PowerPoint slides. Students thus learn fundamentals of writing for political science and public policy. Key topics include principles of rhetoric, evidence-based argumentation, citation, concision, and framing. Students also learn how to cite properly using citation management software EndNote and construct powerful tables and figures using quantitative datasets. This is a writing-intensive course in which students practice writing, edit peers' writing, read about how to write, and analyze examples of stellar writing. A final project entails writing a draft senior thesis proposal.	U	4, 17, 16	focused
84265	Institute for Politics and Strategy	Political Science Research Methods	This course provides an overview of research methods in political science. Students will learn to think like social scientists and develop skills required by the discipline. The course emphasizes the nature of causality and how causal claims can be made in the social sciences. The goal for the class is for students think critically about the strengths and weaknesses of various methodological approaches and identify the methodological tools that are most appropriate for answering different research questions. Furthermore, students will increase their ability to consume political science research from a variety of subfields while also learning to design and present their own research.	U	4, 9, 16	focused
84275	Institute for Politics and Strategy	Comparative Politics	This course is an introduction to the subfield of Political Science called Comparative Politics. Scholars in this subfield use comparative methods to study and compare domestic politics across countries. In this course, we aim to learn about how political systems differ, discuss why they differ and explore the consequences of such variation. The course is divided into four sections. In the first part, we will examine the main theories and methods used to conduct research in the subfield, and discuss the development and consolidation of the modern state. In the second section, we will examine political regimes, including variation among democracies and nondemocracies. In the third unit, we will study some of the countries' central political institutions. We will compare presidentialism to parliamentarism, and examine legislatures, electoral systems, and political parties. In the final segment, we will scrutinize political mobilization and conflict. We will discuss interest groups, nationalism, social movements, protests, populism, clientelism, revolutions, civil wars, terrorism, and globalization. Throughout the course, the discussion will focus mainly on the Americas and Europe, but not exclusively. Students will be required to apply the comparative methods discussed in the course to make in-class presentations about different countries.	U	4, 16, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
84291	Institute for Politics and Strategy	Geopolitical Challenges of a Changing Middle East I: Politics, Security, & Law	This is one of three micro courses under the umbrella title of "Geopolitical Challenges of a Changing Middle East: Politics, Security, and Law," jointly taught by Dr. Ignacio Arana, Dr. Colin Clarke, and Dr. Geoffrey McGovern. This course examines the domestic politics in the contemporary Middle East. It reviews the types of political systems present in the region and the developments that have taken place in the last decades, especially since the Arab Spring. The course is divided into two sections. The first part provides an introduction to the subfield of Political Science called Comparative Politics. Scholars in this subfield use comparative methods to study and compare domestic politics across countries. Here we will discuss how political regimes differ, discuss why they differ and explore the consequences of such variation. In the second section, we will examine the political systems that exist in the Middle East, and do a general review of the recent political trajectories of the countries of the region.	U	4, 16, 17	focused
84292	Institute for Politics and Strategy	Geopolitical Challenges of a Changing Middle East II: Politics, Security, & Law	This is one of three course proposals under the umbrella of "Geopolitical Challenges of a Changing Middle East," jointly proposed by Dr. Colin Clarke, Dr. Ignacio Arana, and Dr. Geoffrey McGovern. This course examines the security dimensions of the contemporary Middle East. The region has undergone a significant transformation over the past decade alone, with new configurations of power and a realignment of geopolitical interests, alliances, and rivalries taking shape. The course is broken down into three primary sections. The first part examines the shifting geopolitics in the region in order to provide a broad overview of the primary areas affecting various Middle Eastern countries' foreign and security policies. This section looks at two of the defining issues of the region, including terrorism and counterterrorism, as well as the impact of natural resources and energy security. The second part of the course analyzes major events in the Middle East, including the Syrian civil war, the Arab Spring, and the rivalry between Saudi Arabia and Iran, and the security implications of each of these themes. Finally, the third section concludes with an examination of the illegal blockade against Qatar, the Israeli-Palestinian conflict, and a review of sectarianism throughout the region, assessing the significance of each of these topics and measured against other topics explored earlier in the semester. The Middle East is a region in constant flux. Only by questioning our assumptions and pursuing new lines of inquiry can students truly begin to grasp the intricacies and nuances of geopolitics in the Middle East and Persian Gulf.	U	7, 16, 4	focused
84293	Institute for Politics and Strategy	Geopolitical Challenges of a Changing Middle East III: Politics, Security, & Law	This is one of three micro courses under the umbrella of "Geopolitical Challenges of a Changing Middle East: Politics, Security, and Law," jointly taught by Dr. Geoffrey McGovern, Dr. Colin Clarke, and Dr. Ignacio Arana. This course examines the historical roots and development of International Law: what is it, where does it come from, how does it operate in theory and in practice? As the world draws ever-closer in the movement of people, products, and ideas, the fundamental structures of self-governance, self-determination, and the design of decision-making institutions requires global citizens to reflect on the ways we identify, address, and hopefully resolve collectively-shared problems amid an ecosystem of sovereign states. The course is divided into two sections. The first looks to the historical-legal development of the law of nations. It will draw upon legal curricula (treaties, international agreements, domestic law, norms, etc.) as the source material for how International Law has developed and in turn shaped the development of the current international arrangement. The second will ask how the current arrangement of decision-making authority can meet the emerging needs of the globe: how collective action problems can be resolved through the alignment or misalignment of sovereign powers and interests. Some game-theoretic work will be introduced to supplement the historical-legal perspective from the first section.	U	9, 4, 15	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
84306	Institute for Politics and Strategy	Latin American Politics	The world's most unequal region is an area of contrasts. Ethnically diverse, stable and tumultuous, young and old, urban and rural, learned and illiterate, prosperous and poor, independent yet dependent. The social and material disparities that have characterized the region since colonial times has been a permanent source of instability and the cause of numerous political and economic experiments. Social scientists have found much material in the region to study democratic innovations, revolutions, coups, civil wars, military dictatorships, impeachments, populism, clientelism, corruption, import substitution industrialization, neoliberalism, socialism, regime changes, social movements, welfare policies, regional integration, and diversified leadership. The overarching question to be explored in this course is what forces affect the emergence, development, collapse, reemergence, and consolidation of democracy. To understand the region's present, it is necessary to study path dependence. Thus, the course centers in three historical periods. First, we will briefly examine Latin American history from its conquest to the end of World War II (1492-1945). The aim is to uncover the demographic and geographical setting with its economic, social, and political evolution. The second part centers on the Cold War (1947-1991) and its combination of political and economic experiments. The third part covers the last forty years, including the wave of transitions to democracy to the current challenges to democratic consolidation. We will also address how Latin America has integrated to globalization and how the relationship with the US and China has experienced fundamental changes since the 1990s.	U	16, 10, 1	focused
84310	Institute for Politics and Strategy	International Political Economy	This course explores how political institutions, process, and actors influence economic interactions both domestically and internationally. During the semester, we will address two key questions: 1) how do governments collaborate to regulate, and stabilize, the trans-boundary flow of capital, goods, and services?; 2) what are the distributional effects of the current world economic order? In exploring these question from diverse theoretical lenses, we will discuss topics ranging from monetary and exchange rate policies, intentional trade, and global integration of production to the role of multinational corporations, social movements and civil society organizations, as well as institutions for corporate social responsibility, in the global economy. By the end of the course, students will be prepared to compare and contrast the theoretical propositions, and policy recommendations, of rival schools of thought.	U	4, 8, 1	focused
84313	Institute for Politics and Strategy	International Organizations and Law	This course provides students with a comprehensive overview of the role and function of international organizations and international law in global affairs. In this course, we will consider the historical development of the international legal system and theories and sources of international law. We will examine the dynamics of key international organizations within the United Nations system, the emergence of regional organizations and their role in global governance, and the relationship between international law and domestic law. Throughout the course, students will be asked to analyze current events through the lens of international law. Students will learn to read and analyze primary legal sources and gain familiarity with current research in the field. By the end of the course, students should be able to assess the record of international institutions in promoting international security, facilitating and regulating the use of emerging technologies, influencing the conduct of war, protecting human rights, and addressing global environmental concerns.	U	16, 4, 12	focused
84323	Institute for Politics and Strategy	War and Peace in the Contemporary Middle East	This course examines the drivers of war and peace in the contemporary Middle East and North Africa (MENA) region. The course is structured around five major types of armed conflict that plague the region today - civil wars, insurgent and terrorist campaigns, enduring rivalries, regional disputes, and external interventions. We will delve into the theories of what fuels - and what resolves - each of these types of conflict, while exploring cases around the region such as the disputes in Libya, Syria, Yemen, Iraq, and Turkey, as well as broader clashes like the Arab Israeli conflict, Shi'a-Sunni conflict, and recent great power interventions in the region. The course will rely on a mixture of research articles and books as well as more diverse materials such as war reporting, films, and memoirs in order to give students a holistic understanding of these issues.	U	4, 16, 7	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
84325	Institute for Politics and Strategy	Contemporary American Foreign Policy	This course provides a survey of American foreign policy since World War I. We will cover topics such as America's entry into the Great War, the League of Nations and America's role in global self-determination movements, the perennial battles between isolationism and internationalism, the creation of a US-led world order after 1945, Cold War nuclear strategy and nuclear nonproliferation, the modern domestic politics of foreign policy, the international dimensions of the civil rights movement, US covert action, the challenges of managing unipolarity, and contemporary issues of climate change, humanitarian intervention, terrorism, and international economic policy. This is an interdisciplinary course that marries American, Diplomatic, and Global History with International Relations and Political Science. We will make some use of primary sources and data analysis. A good grasp of 20th century American and world history, and some familiarity with IR theory are not requirements but will prove helpful. By the end of the semester, students should have acquired a broad understanding of the most important foreign policy events of the last century and have the tools to analyze foreign policy decision-making.	U	13, 8, 16	focused
84326	Institute for Politics and Strategy	Theories of International Relations	This course focuses on teaching the main approaches for the study of international relations. Although you will learn about some current international issues and about the evolution of international relations, and see how various theories would explain important past international events, the focus of this course is analytic rather than substantive. In other words, it will focus on general arguments and their underlying logic rather than on specific events and details or, for that matter, definitive answers as to 'which side is right'. As such, this course will help you to better understand the world we live in and provide you with tools for analyzing various international events. It will also acquaint you with many of the frameworks frequently used by statesmen, either implicitly or explicitly, in order to understand the world and to make policy on various issue areas. The course will begin by analyzing approaches from the three main levels of analysis: the individual, domestic (liberal and non-liberal theories) and systemic (neorealism, etc.). It will move on to discuss approaches which focus on, for example, the effects of strategic interactions between states, of international institutions and of norms and of the overall 'social environment' that states live in. The course will then conclude by discussing the future of international relations.	U	4, 8, 16	focused
84331	Institute for Politics and Strategy	Money, Media, and the Power of Data in Decisionmaking	This course focuses on the impact of three critical influences on policy and decisionmaking in Washington D.C.: money, in the form of political campaign dollars in particular; media, from national to local; and data that can define the policy problem and solution. The course will dive into each topic through a series of case studies of policies whose successful adoption and implementation hinged upon money, media or data. Students will come away from the course with the background and context to critically consider tough questions about the right role of these powerful influences on national policy. (Is the media "broken?" ; What is the prospect for moderating the impact of money on policy? ; Is the influence of data and facts on the wane in a hyper partisan political context?) THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.	U	4, 16, 7	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
84335	Institute for Politics and Strategy	Intelligence and Policy	This course examines the critical role of intelligence in policy formulation, executive branch decision-making, and execution of policy in shaping national policy. The course provides a brief introduction to the Intelligence Community (IC) while exploring the role of intelligence organizations, processes, collection, analysis, production and dissemination in developing geo-political assessments informing policy formulation. We will also examine why it is important for policymakers to have a good understanding of stated and unstated assumptions influencing analytical judgements, risks and opportunities, and potential individual and bureaucratic biases. The course will focus on a few decisions from President George H.W. Bush to President Obama, with primary focus on lessons learned through quick reviews of the two wars with Iraq, the low-level Middle East conflict between the wars, and the campaign against Al Qaeda and ISIS. Students will be introduced to contemporary news articles from the period under investigation, original documents, declassified memos, decision papers, briefings, and interviews with key military and civilian planners and decision makers. With the passage of time and the consequences of decisions known, judging the role of intelligence in historical events requires an exploration of the decisions and also the what ifs. Along with being introduced to basic intelligence analytical issues related to policy support, students will learn how factors of leadership, personalities, organizational dynamics, institutional cultures, interagency dynamics, and parochialisms within agencies influence how intelligence is used. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.	U	4, 16, 9	focused
84336	Institute for Politics and Strategy	Implementing Public Policy: From Good Idea To Reality	Good public policy doesn't just "happen." Rather, successful policy is the result of thorough research, careful drafting, and successful navigation within the government or non-government organization whose leadership may ultimately promulgate it. The course begins with a brief review of government and organizational behavior in a bureaucracy, and the identification of a federal agency's current policy system as a framework to which we will turn throughout the term. Study then turns to an overview of legal research skills. Though usually the province of law students and attorneys, such skills will enable students to know when policy may be crafted "from scratch" -- or where, when, and how policy must conform to larger governing legal or regulatory structures. Students will then consider a particular sub-specie of public policy, administrative law, which addresses the special circumstance of regulatory agencies and the statutory regimes that create and govern them. The course culminates with students developing and "staffing" a notional policy, modeled on the federal agency policy system studied throughout the term. This course may benefit a range of audiences: students considering government and related policy careers; future business leaders who must set standards for business practices, employee behavior, or operations within the confines of governmental regulations; prospective paralegals and attorneys; or anyone interested in exploring "what the rules are" and why. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.	U	4, 8, 17	focused
84338	Institute for Politics and Strategy	Political News Coverage in the Era of Trump, Twitter, and "Fake News"	This class will cover political reporting on the 2020 campaign, how the candidates portray themselves, and how party tenets have evolved in recent years. We will also examine media buying, grassroots vs astroturf support, the role big money, unions and small donors play. Guest speakers will include prominent political reporters, pundits (who seem to play an increasingly important role influencing public opinion), and campaign veterans. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.	U	4, 16, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
84340	Institute for Politics and Strategy	Making Change: How Organized Interests Work in Washington	American politics has many elements and founding principles. Among them is the right of individuals- alone or in groups- to assemble and petition the government in pursuit of their interests and beliefs. This class will highlight the intersection between pressure groups, politics, and policy in Washington, DC. More specifically - based in the political science and other academic literature- the class will examine how organized interests engage and try to influence elected and public officials as they make decisions and take actions related to the nation's political and policy agenda. The class will also interact with Washington-based advocacy and lobbying organizations to see how those ideas are applied in real life scenarios. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.	U	4, 16, 9	focused
84348	Institute for Politics and Strategy	Advocacy, Policy and Practice	This course examines the role that advocacy and advocacy organizations play at all stages of the policymaking and implementation process, from grassroots to professional advocacy organizations, public facing communications initiatives to internal policy-focused actions. Part of the course will focus on the history of advocacy in policy making, and case studies will be used to explore the players, outcomes, and influences of advocates when designing and implementing policy. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.	U	4, 9, 16	focused
84352	Institute for Politics and Strategy	Representation and Redistricting	What does it mean to be represented? Who is represented, who isn't? What is the nature of that representation? In practice, does the norms of representation result in policy congruence? In this course, we will explore the concept of representation, what it means in theory, and how it works in practice. We will explore the theoretical underpinnings of representation from a democratic norms perspective, the legal and constitutional nature of U.S. institutions, and evaluate empirically how well represented the public is. In the United States, legislative elections are held in single-member districts, which require the drawing of district boundaries every decade. Several weeks of the course will be devoted to understanding this process. The course will culminate with a final project in which we will draw electoral maps that are legally compliant and will be proposed for the 2021 round of redistricting.	U	16, 17, 15	focused
84360	Institute for Politics and Strategy	CMU/WSP Internship Seminar	The internship is the experiential "core" of the Washington Semester Program. Students intern three days per week, for approximately 24-25 hours, in offices from Capitol Hill to the White House and including opportunities in cabinet agencies, nonprofit institutions, museums, advocacy groups, policy think tanks, cultural institutions, and news organizations. Through the internship, students gain professional experience and make long-lasting professional and personal contacts. In addition, students meet once a week with the CMU internship faculty for a 2-hour seminar to report and reflect on their internship experiences, and address pressing current issues from the perspective of their internship organization. In addition, the weekly seminar typically includes 1-2 CMU alumni from the Washington, DC, area. Their personal and professional experiences become part of the seminar conversation, and they make themselves available to students as ongoing sources of information and advice. THIS COURSE IS RESTRICTED TO STUDENTS PARTICIPATING IN THE CARNEGIE MELLON UNIVERSITY WASHINGTON SEMESTER PROGRAM (CMU/WSP) ONLY.	U	4, 17, 11	focused
84361	Institute for Politics and Strategy	Leaders and International Security	This mini course will investigate different approaches to studying the role of leaders in international security. We will cover approaches that draw on political psychology, biographical analysis, and decision-making theories, among others, to examine how individual leaders shape the foreign policy of major countries.	U	16, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
84370	Institute for Politics and Strategy	Global Nuclear Politics	The taming of the atom is one of the defining features of the modern era. The awesome creative and destructive potential of nuclear energy has had enormous impact on great power politics, the environment, economic development, and international institutions. Limiting the risk of nuclear Armageddon is one of the dominant challenges in US foreign policy and global governance alike. In this course, we will study 1) why and how countries pursue nuclear weapons and what happens when they acquire them; 2) the national policies and international regimes that have been devised to curb their spread and use, while allowing for the diffusion of energy technology, 3) the national and transnational civil society movements that have fought to roll back the nuclear age or limit its harmful effects, and 4) the role of private actors such as scientists and corporations.	U	8, 7, 9	focused
84372	Institute for Politics and Strategy	Space and National Security	Space systems contribute a great deal to America's security, prosperity, and quality of life. This course examines how space-based services provide critical support to military and intelligence operations and contribute to national security more broadly. The course is designed to investigate several interrelated themes, weaving together relevant aspects of technology, strategy, and policy. The material is approached from both functional and historical perspectives, beginning with the basics of military and intelligence space operations and ending with an examination of the space- and cyber-related technical, strategic, and political challenges facing the nation today and in the foreseeable future.	U	9, 16, 1	focused
84373	Institute for Politics and Strategy	Emerging Technologies and the Law	This course provides a forum for students to consider the relationship between key emerging technologies and the law. In the first half of the course, each session will be dedicated to discussing the legal implications of a particular emerging technology, including autonomous vehicles, artificial intelligence, cryptocurrency and blockchain technology, stem cell therapy, quantum computing, and 3D printing. In the second half of the course, we will turn to overarching themes at the intersection of law and technology, including emerging technologies and the law of armed conflict, policing and surveillance, intellectual property, and privacy. Throughout the course, students will be asked to consider whether existing legal frameworks are sufficient to address issues related to emerging technologies.	U	4, 9, 16	focused
84380	Institute for Politics and Strategy	Grand Strategy in the United States	This course introduces students to the concept of grand strategy in the United States, broadly defined as the combination of diplomatic, economic, military, and political factors used by American presidents and their administrations to advance U.S. interests throughout the world. In the context of highly interdependent domestic and international politics, leaders must develop strategies that address a diverse range of internal, state, and non-state challenges while also dealing with the myriad challenges resulting from globalization, or the intersection of international politics, culture, markets, and technology. This course will review American diplomatic history over the ages, with a focus on both Cold War and post- Cold War American presidencies and their respective approaches to defending American national security whilst also playing a role as one of the world's leading powers. The course will conclude with an assessment of American grand strategy over the course of the past decade and how the United States manages relations with rising powers like China, revanchist states like Russia, and host of near-peer and other adversaries, including Iran and North Korea.	U	8, 4, 9	focused
84382	Institute for Politics and Strategy	Conflicts in the Middle East: Iran, Iraq, and Proxy Warfare	This class will focus on Iran in the post-1979 era, the rise of Lebanese Hezbollah, and various militia groups in Iraq as the face of new modes of warfare. Military institutions were traditionally built on the Clausewitzian theory of state-on-state conflict; the post-Westphalian world produced new forms of conflict that could not have been predicted. This class will discuss the transformation of warfare in the Middle East with an emphasis on Iran and Iraq. Since the Iranian Revolution in 1979, Iran has changed the nature of conventional warfare and ushered in an era of proxy warfare. The lessons learned from the Iran-Iraq war and decades of living under sanctions has cultivated a regime rooted in survivability at all costs. The last four decades demonstrated Iranian endurance while challenging US interests in the Middle East.	U	15, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
84386	Institute for Politics and Strategy	The Privatization of Force	This course considers different forms of privatized force and security over time and across various strategic contexts, from historical mercenarism up to modern-day private military and security contractors. While going through the historical and modern material chronologically, the course considers the various issues that arise with each form of privatized force, including questions that arise regarding the state's monopoly on violence, legal and humanitarian issues, and civil-military relations. These range from theoretical concerns regarding modern definitions of the state, to practical operational-level concerns pertaining to field coordination issues between the military and private contractors in modern conflicts.	U	16, 9, 11	focused
84387	Institute for Politics and Strategy	Technology and Policy of Cyber War	This course examines underlying and emerging technologies and policies associated with cyber war and cyber threats. The technological concepts reviewed in this course include but are not limited to the internet, networks and sensors, and trends associated with "hyperconnectivity" (e.g., The Internet of Things). The course will review history, international policy, military doctrine, and lessons learned from the use of cyber operations and cyberspace in conflicts. The principle objective of this course is to introduce students to the technological and policy variables that affect the ability to manage cyber conflicts.	U	9, 4, 8	focused
84388	Institute for Politics and Strategy	Concepts of War and Cyber War	This course examines traditional theories, concepts, and practices in international relations and warfare- conventional, unconventional, and modern- and relates them to the emerging dynamics of cyber war. The principle concepts examined in this course reflect, have shaped, and continue to shape state and non-state actor behaviors and their calculations of how to prepare for and prosecute warfare. These include, among others, conventional and nuclear deterrence, offense-defense dynamics, first strike capabilities, and irregular warfare. The course will focus on theory but will leverage history, military doctrine, and cases to highlight the challenges of integrating cyber war into defense planning and practice. Students will be challenged to consider how the 2009 introduction of cyberspace as a warfighting domain- in addition to land, maritime, air, and space- affects the ways that scholars and practitioners- operating with force structures and strategic, operational, and tactical concepts that are decades, if not centuries old- conceive of and practice warfare in the 21st Century. The principle objective of this course is to introduce students to cyber war within the context of traditional, and emerging, concepts of armed and unarmed warfare. This course will focus on two core areas: 1) a discussion of traditional concepts of warfare in the physical domains; and, 2) a discussion of cyber war and its intersection with these traditional concepts.	U	4, 14, 9	focused
84389	Institute for Politics and Strategy	Terrorism and Insurgency	There are many forms of political violence but not all are created equal. Some, like terrorism, are a tactic while others, like insurgency, are a strategy. How important is it to define terrorism and insurgency? What are the differences and similarities between them? This course will go into depth to analyze both terrorism and insurgency and their various manifestations. The course will provide a historical overview of how terrorism and insurgency have evolved over time, while also focusing on groups, methods, ideologies and organizational structures. Is the terrorism conducted by Salafist groups like Al-Qaida and the Islamic State significantly different than that perpetrated by ethno-nationalist groups like the Provisional Irish Republican Army and Tamil Tigers? What are the best methods to counter-terrorism and how successful have states been- both historically and more recently- at combating the threat posed by terrorism and insurgency?	U	16, 10, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
84390	Institute for Politics and Strategy	Social Media, Technology, and Conflict	This course will examine the role that social media and technology have had on conflict and governance over the past decade. Interconnectedness has expanded dramatically and continues to expand, not only within coastal cities but also between them and their hinterlands, from city to city, and between home populations and global networks, including diaspora populations. The Arab Spring uprisings were significantly influenced by the use of cell phones, social media, and text-messaging as organizing tools. But it is not only protesters that are harnessing the power of social media and emerging technologies- insurgent groups like the Islamic State have been able to use Twitter, YouTube, Telegram and other social media platforms to their advantage. Apps have been used to both recruit and fund raise for terrorist groups, while individuals living on the other side of the world are radicalized by virulent ideologies spread through the Internet. The proliferation of so-called "fake news" and the ubiquity of social media has introduced an entirely new variable into the study of conflict and relations between individuals, small groups, non-state actors, and nation-states.	U	14, 9, 11	focused
84402	Institute for Politics and Strategy	Judicial Politics and Behavior	This course is a survey of research and insight into one of the most unique American government institutions: the judiciary. Rather than exclusively reading case law (as one would do in a Constitutional Law class), this course examines court structure, rules of law and, most importantly, judges as actors within an institutional setting. We will focus on how rules, norms, and expectations guide the decisions, actions, and range of options available to judges. Here we will study the nature of judicial decision-making and its antecedents, the organization of the judicial branch and its implications for behavior, and the strategic interactions both within courts and between the courts and the more "political" branches of government. The course will look at state and federal courts within the United States, supplemented with examples from international jurisdictions. Material from law, history, economics, political science, sociology, and psychology will be introduced throughout the semester. Although some of the literature uses empirical and/or game theoretical models, students are not expected to have mastered these tools prior to taking the course.	U	4, 16, 17	focused
84405	Institute for Politics and Strategy	The Future of Warfare	Warfare is constantly evolving. Long gone are the days of set-piece battles involving conventional military forces. In the contemporary conflict environment, hybrid actors and proxy groups wage war in an asymmetric and irregular manner, relying on ambiguity, strategic surprise and deception to accomplish their objectives. This course will examine new trends in warfare, from the onset of cyber war to the development of violent non-state actors with conventional military capabilities. Moreover, this course will explore the concept of the "gray zone," an area of neither declared nor undeclared hostilities where U.S. adversaries like Russia, China, Iran and others are gradually allocating resources. Case studies examined in this course will include Russian hybrid warfare in Crimea and Ukraine, Chinese cyberwarfare and information operations, Iranian sponsorship of proxy militias in Syria and Lebanon and a range of other emerging trends in areas such as technology, demographics, urbanization and social media, all of which are combining to radically alter the way wars are fought today.	U	16, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
84450	Institute for Politics and Strategy	Policy Forum	The Policy Forum course takes a critical look at decision making in domestic politics and US foreign policy. It does so through weekly roundtable discussions with a diverse set of thought leaders. Based on intellectually significant essays that students are expected to read in advance of each class, these discussions give students an opportunity to ask probing questions about the three branches of the US government, media, embassies, advocacy groups, international organizations, and nongovernmental organizations. This course seeks to help students understand the responsibilities and activities that leaders and decision makers carry out on behalf of their organizations. Students are instructed in how to confidently and respectfully ask critical questions of those shaping policy. The term "roundtabling" is used to describe submitting an issue for critical discussion among relevant stakeholders. Knowing how to direct a roundtable is a significant element in the professional development of anyone interested in taking part in the policy arena, and this course helps students hone this important skill. In requiring students to read important essays related to each class session and then step back from discussions with leaders to write analytical essays, this course teaches students how to develop strong arguments based on solid logic and credible evidence, an essential component in making democracy work.	U	4, 16, 9	focused
84498	Institute for Politics and Strategy	Undergraduate Research	Students conduct research under the supervision of an Institute for Politics and Strategy faculty member. Students who wish to engage in research should seek out a faculty member whose interests are appropriate to the research. Prerequisite: Students must also complete an "Independent Study/Research for Credit" form, available from the IPS Deputy Director or on the IPS website. Permission of a faculty sponsor.	U	4, 17, 8	focused
85102	Psychology	Introduction to Psychology	The world is a crazy, confusing place. Much of what we encounter is ambiguous, dynamic, and misleading. Somehow, we have to make sense of it. And because we can't leave well enough alone, we also try to make sense of ourselves and the people with whom we interact. This class is about how we do that. The course provides an overview of the major areas of scientific psychology, exploring the models of our mind, brain, and behavior that explain wide areas of human (and non-human) functioning. Topics range from neuroscience and the biological basis of behavior, to memory and thought, to social interaction and psychological development over the lifespan, to abnormal psychology, psychopathology, and treatment. Tuesday and Thursday lectures will provide a broad survey of topics and findings in psychology and how to use scientific reasoning to answer questions about the mind. Recitation sections will focus on learning the methods, issues, and applications germane to empirical psychology. At the end of this course, students will not only be more knowledgeable about psychology, but be able to apply their knowledge about psychology to be better thinkers, learners, and consumers of information in general.	U	4, 9, 8	focused
85104	Psychology	Psychopathology	This course provides an introduction to the science and practice of psychopathology. Students will examine definitions of psychopathology in a historical and contemporary context, explore issues relevant to diagnosis and patient care, and be introduced to various diagnostic categories for psychological disorders. Students will also learn about potential determinants of and treatments for psychological disorders in the context of major theories and empirical findings in the field. Emphasis will be placed on three major paradigms in psychopathology: genetics, neuroscience, and cognitive behavioral. An assigned memoir, case studies, and short video clips will be used to illustrate the human side of mental illness.	U	4, 3, 11	focused
85106	Psychology	Animal Minds	With intricate cultures, impressive technology, and layered social lives, humans seem to stand apart from their animal kin. However, humans and non-human animals share many aspects of their mental lives, and, upon closer inspection, some animals even reveal cognitive abilities far beyond the capacities of humans. Through comparing and contrasting human and non-human cognition, we can learn about human psychological uniqueness and its evolutionary origins, and fundamental properties of cognitive processes in general	U	15, 9, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
85107	Psychology	The Psychology of Video Games	This course will explore how the features of video game design and use relate to characteristics of human psychology. We will discuss design and use issues such as microtransactions, online gaming communities, and reward/scoring, and try to understand how these features are (or are not!) well suited to the human mind, with a particular focus on learning, memory, attention, and perception. Student presence will sometimes be required but many course sessions will be asynchronous.	U	4, 9	focused
85150	Psychology	Cognitive Science at CMU and beyond	This course provides an introduction to the broad field of Cognitive Science, with a particular emphasis on psychological methods and the role of memory in cognition. In addition to giving students a sense of some of the applied areas that use Cognitive Science research, this course gives a sampling of research questions and phenomena to help decide whether this might be a good choice for a major or minor while studying at Carnegie Mellon. Topics that will be discussed include attention, perception, cognitive illusions, memory, language acquisition and skill acquisition. There is an emphasis of the applications of cognitive science to real life situations, for example, best practices for learning in an academic setting. The course will also provide the opportunity to learn about the scientific method and collect data by running an experiment (online, on a computer). The class meets twice per week for 1.5 hours for each class. The plan is to focus more on lecture and discussion of readings on Tuesday and focus more on teaching new skills such as experimental design, data analysis and running experiments on Thursday.	U	4, 9, 17	focused
85211	Psychology	Cognitive Psychology	How do people perceive, learn, remember, and think? This course will consider perception, language, attention, learning, memory, reasoning, and decision making. Experimental findings and formal models will be discussed in each part of the course.	U	4, 8, 9	focused
85213	Psychology	Human Information Processing and Artifical Intelligence	This class will review various results in cognitive psychology (attention, perception, memory, problem solving, language) and use of artificial intelligence techniques to simulate cognitive processes.	U	9, 4	focused
85219	Psychology	Biological Foundations of Behavior	This course will provide students with a general introduction to the underlying biological principles and mechanisms which give rise to complex human cognitive, perceptual and emotional behavior. Topics to be covered include: the anatomical structure of nerve cells and how they communicate, properties of brain organization and function, processing in sensory and motor systems, biological characteristics of human cognition, and neural and hormonal influences on health and emotion. This course will focus on how emerging methods and approaches are beginning to make it possible for psychologists, computer scientists, and biologists to gain an integrated understanding of complex behavior.	U	4, 9, 1	focused
85221	Psychology	Principles of Child Development	This course is about normal development from conception through adolescence. Topics include physical, perceptual, cognitive, emotional and social development. Students will learn facts about children at various points in development, theories about how development works, and research methods for studying development in infants and children. Students will be encouraged to relate the facts, theories and methods of developmental psychology to everyday problems, social issues and real world concerns.	U	4, 17, 1	focused
85232	Psychology	Thinking in Person vs. Thinking Online	Being online changes how we think. Different media lead us to ask different questions, remember (or forget) different information, attend to different details, and interact with other people in different ways. These types of thinking aren't inherently better or worse, but they may be better or worse for facilitating specific goals. Too often, we use a particular medium/technology without considering how it will influence our thinking. This can lead us to be less efficient or less effective at a task than we otherwise might be, or can qualitatively change the nature of our outcomes. In this class, we will explore how the media we use affects the character of our thinking, so as to enable students to make mindful and deliberate choices about how to interact with media in ways that support the type of thinking desired and appropriate for their goals. Moreover, we will examine how to optimize media for specific goals in important applied domains, such as education, medicine, policy, child-rearing, and dating.	U	4, 9, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
85241	Psychology	Social Psychology	The focus of this course will be on how peoples behavior, feelings and thoughts are influenced or determined by their social environment. The course will begin with lectures and readings on how social psychologists go about studying social behavior. Next, various topics on which social psychologists have done research will be covered. These topics will include: person perception, prejudice and discrimination, the nature of attitudes and how attitudes are formed and changed, interpersonal attraction, conformity, compliance, altruism, aggression, group behavior, and applications of psychology to problems in health care, law, politics, and the environment. Through readings and lectures on these topics, students will also be exposed to social psychological theories.	U	10, 4, 5	focused
85251	Psychology	Personality	The primary purpose of personality psychology is to understand human uniqueness--how and why it is that one person differs from others, in terms of the ways he or she thinks, feels, and acts. Students in the course will be exposed to several broad theoretical perspectives, each of which attempts to capture and understand the origins and consequences of individual distinctiveness from a slightly different vantage point. Included among these approaches are the dispositional or trait, psychoanalytic, learning, humanistic, and cognitive self regulation perspectives. This is a survey course and is intended to provide students with a broad background of theory and research in the area. Class meetings consist primarily of lecture, but there is some discussion too. Students will be given the opportunity to assess their own personalities during the course. A consistent theme throughout the course is the relationships between aspects of one's personality and physical health. https://www.cmu.edu/dietrich/psychology/pdf/syllabi-2018-spring/85-251%20Scheier%20revised.docx	U	4, 17, 1	focused
85294	Psychology	Teaching Assistantship	This course is designed to provide students with an apprenticeship in the practice of teaching through one-on-one interaction with a faculty member in the design, administration, and teaching of a course. The student should have previous coursework in the topic domain of the course to ensure that they have the basic skills and background necessary to contribute to the course. The Teaching Assistantship will be supervised by a faculty member, and should result in a concrete, measurable contribution to a course (such as the design of assignments or exams) and/or a reflection on the practical and pedagogical considerations of course design (such as a paper). It is the student's responsibility to make independent arrangement for independent course study courses with individual faculty members. This should be done the semester before a student wishes to register for one of these courses. The course may be taken for any number of units up to 9, depending on the amount of work done.	U	4, 17, 9	focused
85309	Psychology	Statistical Concepts and Methods for Behavioral and Social Science	Research in the Social Sciences is a project of understanding the ways in which people are similar while grappling with the ways in which they are different. Statistical methods are a powerful tool for managing the tension between the two. This course introduces the statistical methods most commonly used in in the social sciences, as well as their implementation in the R programming language. Topics involve exploratory data analysis, sampling and randomization, hypothesis testing, and power analysis.	U	17, 1, 4	focused
85310	Psychology	Research Methods in Cognitive Psychology	This is a course in which students develop the research skills associated with cognitive psychology and cognitive science. Students learn how to design and conduct experiments, and analyze and interpret the data they collect. The course covers a variety of experimental designs, e.g., factorial, Latin Squares. Analyses of response times, qualitative data, and signal detection are also covered. Cognitive modeling will also be discussed. Topics include mental imagery, memory, and perception. The class format consists of lectures, discussions and student presentations.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
85314	Psychology	Cognitive Neuroscience Research Methods	This is a hands-on laboratory course designed to foster basic skills in the empirical approaches used in cognitive neuroscience research. Students will learn how to evaluate which cognitive neuroscience method is best suited to a research question, basic experimental design and analysis, and how to formally present empirical results. The course will focus on functional MRI, but will also cover structural MRI (diffusion imaging) and EEG, and survey various other methods. Students will work with actual datasets using the current software used by cognitive neuroscience researchers. You must have taken 36-309 previously, as well as one of the following: 85-310, 85-320, 85-330, 85-340, 09-207, or 03-124. A background in basic neurobiology, such as 85-219, and comfort with using research software such as SPSS as well as basic programming are encouraged but not required.	U	4, 9, 17	focused
85320	Psychology	Research Methods in Developmental Psychology	This is a laboratory course, in which the student will have direct experience working with children, as well as writing research reports and designing and critiquing research in child development. The purpose of the course is to develop research expertise that will assist the student both in carrying out research and in evaluating the research of others. Special emphasis will be given to the unique methodological problems associated with the study of development. Students must be sure they are also available to attend the Children's School during specific blocks in addition to the class meeting times. Either MW 8:30-10:30am, TR 8:30-10:30am, MW 12:30-2:15pm or MW 12:30-2:15pm.	U	4, 17, 7	focused
85340	Psychology	Research Methods in Social Psychology	This course is designed to provide students with the necessary knowledge to evaluate research, make transitions between theory and the operations that test the theory, and to design and carry out original research. Topics will include the nature of proof and causal inference, manipulation of indepen-dent variables, measurement of dependent variables, questionnaire design, experimental ,and quasi-experimental, design and ethical issues involved in doing research. Survey, observational and experimental techniques as applied in both field and laboratory settings will be covered. Students will be expected to criticize completed research. They are also expected to design measures and complete their own original studies. During the course of the semester students will also be expected to design and carry out an original research project as well.	U	4, 17, 9	focused
85350	Psychology	Psychology of Prejudice	This course is devoted to the study of both traditional and more modern forms of prejudice and discrimination and the psychological processes that can arise from categorizations and stereotyping. The class provides an overview of the cognitive and emotional underpinnings of prejudice and discrimination as it pertains to many forms of inequality. The psychological theories underlying these behaviors will be examined as well as their impact on the lives of stigmatized individuals. Its goal is to examine a number of social differences and understand how prejudice can impact many areas of society. In addition to the traditional forms of prejudice based on such things as race, gender and age; other inequalities that result from less traditional groupings such as social class, appearance, and disability and will be explored. Research on issues of social identity, intergroup relations and the reduction of prejudice will be examined through readings and class activities.	U	10, 5, 1	focused
85354	Psychology	Infant Language Development	While adults struggle to learn languages, almost all infants acquire language with seemingly little effort. This course examines infants' learning abilities and language milestones with a focus on several different theoretical accounts of language development, and the way empirical data can be used to assess those theories. The course is reading intensive, and evaluation will be based on both written assignments and oral participation.	U	4, 17, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
85360	Psychology	Origins of Intelligence	The nature and origins of human intelligence is a much-debated topic. Questions about the evolution and development of intelligence in humans, how intelligence compares among animals, the basis of intelligence in the brain, how to create intelligence in machines, the role of genes and experience, and individual variability in intelligence are all areas of vigorous scientific inquiry. Popular "folk" views of intelligence (that may be misguided or incorrect) have shaped all levels of society from parenting to politics. There is no universally accepted definition of human intelligence but one conceptualization is 'the ability to remember, reason, plan, and solve novel problems". This course will explore scientific and popular views of the origins of intelligence. The approach will be to read popular science articles and books that deal with intelligence in humans, animals, and machines and locate the primary scientific work on which those claims are made in order to evaluate the rigor and validity of intelligence theories. The course assignments will primarily consist of oral and written critiques of theories and data on the science of intelligence.	U	15, 17, 8	focused
85363	Psychology	Attention, Its Development and Disorders	TThis seminar will discuss a broad range of topics pertaining to the study of human attention, including: theoretical frameworks and biological foundations of human attention; interrelationship between attention and other aspects of cognition (such as perception, memory, and executive functions); development of attention in infancy and childhood; biological and psychological foundations of attention disorders. Students will be expected to read original research articles, lead and participate in class discussions, and complete a term paper.	U	4, 17, 8	focused
85370	Psychology	Perception	Perception, broadly defined, is the construction of a representation of the external world for purposes of thinking and acting. Although we often think of perception as the processing of inputs to the sense organs, the world conveyed by the senses is ambiguous, and cognitive and sensory systems interact to interpret it. In this course, we will examine the sensory-level mechanisms involved in perception by various sensory modalities, including vision, audition, and touch. We will learn how sensory coding interacts with top-down processing based on context and prior knowledge and how perception changes with learning and development. We will look at methods of psychophysics, neuroscience, and cognitive psychology. The goals include not only imparting basic knowledge about perception but also providing new insights into everyday experiences.	U	4, 9, 17	focused
85377	Psychology	Attitudes and Persuasion	This advanced undergraduate course will focus on the topic of attitude change and how various persuasive techniques are used to shape human response. The dynamics of propaganda and what makes the techniques effective on social and consumer decisions will be addressed. The primary goals of the course are to 1) understand the dynamics of attitude change; 2) explore the mechanism by which attitude change techniques operate and 3) examine relevant theories and research in persuasion. Examples of topics covered include the origins of attitudes, how attitudes influence judgments, social power and attitude change, and how individual decisions are influenced by the mass media. Classic and contemporary research in the area of persuasion will be examined in the form of course readings and assignments.	U	4, 17, 1	focused
85385	Psychology	Auditory Perception: Sense of Sound	This course explores how our sense of hearing allows us to interact with the world. Students will learn about basic principles of sound, spatial sound, sound quality, hearing impairment, auditory perception, interactions with other modalities, and auditory cognition. Topics may also include musical acoustics, basic auditory physiology, sound-semantic associations, acoustic analysis, and sound-making gestures. We will consider not only simple laboratory-generated signals, but also more complex sounds such as those in our everyday environment, as well music and speech. Students will gain some in-class experience with generating sounds and analytic listening. After students reach a sophisticated level of understanding of the auditory fundamentals, they will apply their knowledge to the study of several current issues in auditory research.	U	4, 17, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
85395	Psychology	Applications of Cognitive Science	The famous psychologist George Miller once said that Psychology should "give itself away." The goal of this course is to look at cases where we have done so -- or at least tried. The course focuses on applications that are sufficiently advanced as to have made an impact outside of the research field per se. That impact can take the form of a product, a change in practice, or a legal statute. The application should have a theoretical base, as contrasted, say, with pure measurement research as in ergonomics. Examples of applications are virtual reality (in vision, hearing, and touch), cognitive tutors based on models of cognitive processing, phonologically based reading programs, latent semantic analysis applications to writing assessment, and measurses of consumers' implicit attitudes. The course will use a case-study approach that considers a set of applications in detail, while building a general understanding of what it means to move research into the applied setting. The questions to be considered include: What makes a body of theoretically based research applicable? What is the pathway from laboratory to practice? What are the barriers - economic, legal, entrenched belief or practice? The format will emphasize analysis and discussion by students.	U	4, 8, 17	focused
85406	Psychology	Autism: Psychological and Neuroscience Perspectives	Autism is a disorder that affects many cognitive and social processes, sparing some facets of thought while strongly impacting others. This seminar will examine the scientific research that has illuminated the nature of autism, focusing on its cognitive and biological aspects. For example, language, perception, and theory of mind are affected in autism. The readings will include a few short books and many primary journal articles. The readings will deal primarily with autism in people whose IQ's are in the normal range (high functioning autism). Seminar members will be expected to regularly enter to class discussions and make presentations based on the readings. The seminar will examine various domains of thinking and various biological underpinnings of brain function, to converge on the most recent scientific consensus on the biological and psychological characterization of autism. There will be a special focus on brain imaging studies of autism, including both structural (MRI) imaging of brain morphology and functional (fMRI and PET) imaging of brain activation during the performance of various tasks.	U	17, 1, 3	focused
85407	Psychology	Neuroscience of Concepts	Conceptual knowledge underpins all aspects of everyday experience, from language, to thinking, to recognizing familiar objects, people and places. This seminar will survey major theories and findings about how the brain represents 'meaning.' The course will emphasize research using neuropsychological methods in brain-damaged patients and functional neuroimaging in healthy participants. Students will read primary empirical and theoretical review articles to develop an understanding of both classic findings and recent discoveries about how the human brain represents meaning.	U	4, 17, 9	focused
85414	Psychology	Cognitive Neuropsychology	This course will review what has been learned of the neural bases of cognition through studies of brain-damaged patients as well as newer techniques such as brain stimulation mapping, regional metabolic and blood flow imaging, and attempt to relate these clinical and physiological data to theories of the mind cast in information-processing terms. The course will be organized into units corresponding to the traditionally-defined subfields of cognitive psychology such as perception, memory and language. In each area, we will ask: To what extent do the neurological phenomena make contact with the available cognitive theories? When they do, what are their implications for these theories (i.e., Can we confirm or disconfirm particular cognitive theories using neurological data?)? When they do not, what does this tell us about the parses of the mind imposed by the theories and methodologies of cognitive psychology and neuropsychology?	U	9, 4	focused
85419	Psychology	Introduction to Parallel Distributed Processing	This course provides an overview of Parallel-Distributed-Processing/neural-network models of perception, memory, language, knowledge representation, and learning. The course consists of lectures describing the theory behind the models as well as their implementation, and their application to specific empirical domains. Students get hands-on experience developing and running simulation models.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
85421	Psychology	Language and Thought	This course allows the student to explore ways in which the mind shapes language and language shapes the mind. Why are humans the only species with a full linguistic system? Some of the questions to be explored are: What kinds of mental abilities allow the child to learn language? What are the cognitive abilities needed to support the production and comprehension of sentences in real time? How do these abilities differ between people? Are there universal limits on the ways in which languages differ? Where do these limitations come from cognition in general or the specific language facility? Why is it so hard to learn a second language? Are there important links between language change and cultural change that point to links between language and culture?	U	15, 4, 11	focused
85422	Psychology	Clinical Psychology: Science and Practice	In this course, students will be exposed to the science and practice of clinical psychology, with a particular emphasis on the synergistic relationship between clinical psychological research and clinical practice. We will focus on the four major activities that clinical psychologists engage in (research, assessment, diagnosis, and psychotherapy). Students will learn about the clinical characteristics of major psychological disorders and the empirically-validated treatments available for these conditions. We will make frequent use of research findings and the scientific method to evaluate and understand concepts in clinical psychology. Critical thinking will be emphasized as we explore the scientific strengths and limitations of various treatments for psychological disorders. This course is designed to be a smaller seminar course for juniors and seniors considering graduate school in clinical psychology.	U	4, 17, 3	focused
85426	Psychology	Learning in Humans and Machines	This course explores how probabilistic methods can help to explain cognition and to develop intelligent machines. The applications discussed include perception, language, memory, categorization, reasoning, decision-making, and motor control.	U	4, 15, 9	focused
85429	Psychology	Cognitive Brain Imaging	This seminar will examine how the brain executes higher level cognitive processes, such as problem-solving, language comprehension, and visual thinking. The topic will be addressed by examining what recent brain imaging studies can tell us about these various kinds of thinking. This new scientific approach has the potential of providing important information about how the brain thinks, indicating not only what parts perform what function, but also how the activity of different parts of the brain are organized to perform some thinking task, and how various neurological diseases (e.g. aphasia, Alzheimer's) affect brain activity. A variety of different types of thinking will be examined, including short-term working memory storage and computation, problem solving, language comprehension, visual thinking. Several different technologies for measuring brain activity (e.g. PET and functional MRI and also some PET imaging) will be considered, attempting to relate brain physiology to cognitive functioning. The course will examine brain imaging in normal subjects and in people with various kinds of brain damage.	U	3, 9, 17	focused
85432	Psychology	Data Science for Psychology and Neuroscience	This course will cover advanced topics in statistics and experimental design necessary for applied research in modern psychology, including information design, exploratory data analysis, data visualization, nonparametric statistics, data and inference errors (multicollinearity, overfitting, Simpson's and Robinson's paradox), sanitization (data anonymization, de-identification), and linear models (including conditional process models). Students will get hands on experience with simulating, analyzing, and visualizing data in the R statistical environment.	U	4, 9, 17	focused
85435	Psychology	Biologically Intelligent Exploration	Humans and other mammals exhibit a high degree of control when selecting actions in noisy contexts, quickly adapting to unexpected outcomes in order to better exploit opportunities arising in the future. This course will explore both the cognitive and neurobiological systems of adaptive decision-making, through a mixture of readings, lectures, and hands-on modeling projects (in Python and Matlab).	U	15, 9, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
85442	Psychology	Health Psychology	This course is concerned with how behavior and psychological states influence the development of and recovery from disease. The class provides an overview of existing psychological and epidemiological data on the relationship between behavior and disease and addresses the issue of how behavior, emotion and cognition can influence the disease processes. Topics include: measures and concepts, stress and disease, stress and coping, personal control, helplessness and disease, social support and health, reactivity to stress, behavior and hypertension, coronary heart disease, infectious diseases and immune function, and the effectiveness of behavioral interventions in health. Only Juniors and Seniors will be admitted into the course and instructor permission is required.	U	3, 1, 17	focused
85443	Psychology	Social Factors and Well-Being	This course will focus on the role that our social environment plays in our feelings of well-being and in the maintenance of our mental and physical health. Topics to be discussed include marriage, widowhood, loneliness, social support, social participation, social aspects of personality (e.g., social anxiety, extraversion, agreeableness, and hostility), social stressors (betrayal and conflict), discrimination, and socioeconomic status. We will consider how each social factor develops, the extent to which we can alter it or its effects on our lives, and how it influences our overall well-being.	U	10, 5, 1	focused
85446	Psychology	Psychology of Gender	This course is devoted to the investigation of psychological gender rather than biological sex. That is, sex differences will be explored from a social psychological (e.g., socialization) perspective. Implications of both male gender role and female gender role in the areas of relationships and health will be the course focus.	U	5, 10, 1	focused
85480	Psychology	Internship in Clinical Psychology	This course allows students to gain applied clinical experience in a mental health setting. Students will work alongside psychology professionals at designated field placements. This course is designed to help students apply and expand their knowledge of clinical psychology and to develop appropriate professional work standards. Students will spend the majority of their time (8 hours per week) in an applied clinical setting, with a one hour per week supervision meeting with Dr. Kasey Creswell. Students must be currently enrolled in 85-422 (Clinical Psychology: Science and Practice) or have already taken this course. Instructor permission is required. Please contact Dr. Kasey Creswell if you are interested in enrolling at kasey@andrew.cmu.edu.	U	4, 17, 1	focused
85482	Psychology	Internship in Psychology	The Internship in Psychology is designed to enable students to gain experience in professional settings related to their studies in Psychology and earn credit for the intellectual work involved. It is the students responsibility to locate an internship site and on-site supervisor, as well as to identify a CMU faculty sponsor. The student registers for the internship by submitting a completed internship form to Emilie O'Leary in Baker Hall 339.	U	4, 8, 17	focused
85505	Psychology	Readings In Psychology	As the name implies, the emphasis in the Reading course is on reading articles and books in some specified area. The students work in the course must lead to the production of a written paper which will be read by the instructor directing the readings. Often the reading is related to a research project which the student may wish to conduct. Readings courses have also been used to give students an opportunity to receive instruction in areas which are not included elsewhere in our course listing. The course may be taken for any number of units up to 9, depending upon the amount of work to be done.	U	4, 17, 9	focused
85506	Psychology	Readings in Psychology	As the name implies, the emphasis in the reading course is on reading articles and books in some specified area. The students work in the course must lead to the production of a written paper which will be read by a psychology faculty instructor directing the readings. Often the reading is related to a research project which the student may wish to conduct. Reading courses have also been used to give students an opportunity to receive instruction in areas which are not included elsewhere in our course listing. The course may be taken for any number of units up to 9, depending upon the amount of work to be done. This course is special permission and can only be added in consultation with a psychology faculty member and registered by the Undergraduate administrator, Emilie O'Leary emilier@andrew.cmu.edu.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
85507	Psychology	Research in Psychology	This course may include field study, applied work, or laboratory research. The student should have previous training in the basic research skills that will be used in his/her project, especially statistical methods and experimental design. Independent Research Projects will be supervised by a faculty member and must result in a written paper. It is the students responsibility to make arrangements for independent study courses with individual faculty members. This should be done the semester before a student wishes to register for one of these courses. The course may be taken for any number of units up to 12, depending upon the amount of work to be done. Please contact the CMU psychology faculty member you wish to work with to get approval to enroll then email Emilie Rendulic at emilier@andrew.cmu.edu in order to be registered for the course.	U	4, 17, 9	focused
85508	Psychology	Research in Psychology	This course may include field study, applied work, or laboratory research. The student should have previous training in the basic research skills that will be used in his/her project, especially statistical methods and experimental design. Independent Research Projects will be supervised by a faculty member and must result in a written paper. It is the students responsibility to make arrangements for independent study courses with individual faculty members. This should be done the semester before a student wishes to register for one of these courses. The course may be taken for any number of units up to 12, depending upon the amount of work to be done.	U	4, 17, 9	focused
85509	Psychology	Research in Psychology Practicum	All students registered for research units via 85-198 or 85-507/508 * to register, in addition, for this 1 unit course. This course will meet every other week (online, at a time to be determined by survey). This course will provide students with an opportunity to frame their research experience in a broader professional and scholastic perspective, as well as an opportunity to get feedback on ongoing research experiences. Topics to be covered include professional development, protections for researchers and participants (including Title IX), problem solving, and communication. Students will complete short homework assignments in relation to each topic as a way of maintaining engagement with the course materials, as well as brief written assignments reflecting on their research experience. Students will be connected with resources like the Global Communications Center and the Career and Professional Development Center to help students contextualize their research experience in ways that contribute to their ongoing professional aspirations.	U	4, 17, 9	focused
85765	Psychology	Cognitive Neuroscience	This course will cover fundamental findings and approaches in cognitive neuroscience, with the goal of providing an overview of the field at an advanced level. Topics will include high-level vison, spatial cognition, working memory, long-term memory, learning, language, executive control, and emotion. Each topic will be approached from a variety of methodological directions, for example, computational modeling, cognitive assessment in brain-damaged humans, non-invasive brain monitoring in humans, and single-neuron recording in animals. Lectures will alternate with sessions in seminar format. Prerequisites: Graduate standing or two upper-level psychology courses from the areas of developmental psychology, cognitive psychology, computational modeling of intelligence, neuropsychology or neuroscience.	G	4, 15, 17	focused
86375	Center for the Neural Basis of Cognition	Computational Perception	In this course, we will first cover the biological and psychological foundational knowledge of biological perceptual systems, and then apply computational thinking to investigate the principles and mechanisms underlying natural perception. The course will focus on vision this year, but will also touch upon other sensory modalities. You will learn how to reason scientifically and computationally about problems and issues in perception, how to extract the essential computational properties of those abstract ideas, and finally how to convert these into explicit mathematical models and computational algorithms. Topics include perceptual representation and inference, perceptual organization, perceptual constancy, object recognition, learning and scene analysis. Prerequisites: First year college calculus, some basic knowledge of linear algebra and probability and some programming experience are desirable.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
86631	Center for the Neural Basis of Cognition	Neural Data Analysis	The vast majority of behaviorally relevant information is transmitted through the brain by neurons as trains of actions potentials. How can we understand the information being transmitted? This class will cover the basic engineering and statistical tools in common use for analyzing neural spike train data, with an emphasis on hands-on application. Topics may include neural spike train statistics (Poisson processes, interspike intervals, Fano factor analysis), estimation (MLE, MAP), signal detection theory (d-prime, ROC analysis, psychometric curve fitting), information theory, discrete classification, continuous decoding (PVA, OLE), and white-noise analysis. Each topic covered will be linked back to the central ideas from undergraduate probability, and each assignment will involve actual analysis of neural data, either real or simulated, using Matlab. This class is meant for upper-level undergrads or beginning graduate students, and is geared to the engineer who wants to learn the neurophysiologist's toolbox and the neurophysiologist who wants to learn new tools. Those looking for broader neuroscience application (eg, fMRI) or more focus on regression analysis are encouraged to take 36-746. Those looking for more advanced techniques are encouraged to take 18-699. Prerequisites: undergraduate probability (36-225/227, or its equivalent), some familiarity with linear algebra and Matlab programming	G	4, 9, 11	focused
88120	Social & Decision Sciences	Reason, Passion and Cognition	This course will introduce students to major concepts and theories in the social and decision sciences, focusing in particular on how cognition and emotion shape judgment and choice. We will address such questions as: In what ways do emotions influence judgments and choices? What are some common mistakes in judgment and decision making? Can information shape our choices even if we do not consciously recognize the information? Throughout the course, the emphasis will be on understanding: (1) basic theories and research findings of decision science and psychology, and (2) the relevance of research findings to everyday life.	U	4, 17, 1	focused
88150	Social & Decision Sciences	Managing Decisions	This course will introduce the major concepts behind "good" decision making. Future employers will pay handsomely for decisions that are well thought out, defendable, and understandable. Being able to organize decision processes in a way that will achieve these goals is not trivial. Biases brought on by emotions and heuristic shortcuts often jeopardize the quality of a decision. Multiple levels of "good" decision making will be investigated ranging from life choices to national climate policies. Techniques that account for uncertainty and time preferences will be introduced.	U	13, 8, 10	focused
88198	Social & Decision Sciences	Research Training: Social and Decision Sciences	This course is part of a set of 100-level courses offered by H&SS departments as independent studies for second-semester freshmen, and first- or second-semester sophomores, in the College. In general, these courses are designed to give students some real research experience through work on a faculty project or lab in ways that might stimulate and nurture subsequent interest in research participation. Faculty and students devise a personal and regular-ized meeting and task schedule. Each Research Training course is worth 9 units, which generally means a minimum for students of about 9 work-hours per week. These courses are offered only as electives; i.e., they cannot be applied toward a college or major requirement, although the units do count toward graduation as elective units. Additional details (including a roster and descriptions of Research Training Courses available in any given semester) are available in the H&SS Academic Advisory Center. Prerequisites/ restrictions: for H&SS students only; only for second-semester freshmen, or first- or second-semester sophomores; minimum cumulative QPA of 3.0 (at the time of registration) required for approved entry; additional prerequisites (e.g., language proficiency) may arise out of the particular demands of the research project in question.	U	4, 17, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
88221	Social & Decision Sciences	Analytical Foundations of Public Policy	In this course, students will achieve an analytical understanding of some of the most pressing policy challenges of our day. The focus of the course lies in the interaction between markets and government. The course will first introduce analytical foundations of how markets, voting and governments work, and important shortcomings of each. The course will briefly touch on a comparative cross-national perspective on the balance between markets and government pursued in different countries. The second part of the course focuses on a substantive understanding of current policy issues, including health care, inequality, economic conditions of the politically pivotal middle class, resource constraints, globalization, technological change, and the role of all of these topics in political debates, and voter demands. A pre-requisite for this course is 73-102 Principles of Microeconomics.	U	8, 1, 4	focused
88223	Social & Decision Sciences	Decision Analysis	This course offers practical guidance about how to make better decisions and teaches students how to use modeling to do decision analysis. We analyze decisions involving uncertainty, risk, and time delay. In addition to methods of decision analysis, the course will also emphasize sensitivity analysis and communication of recommendations.	U	4, 9	focused
88231	Social & Decision Sciences	Thinking in Person vs. Thinking Online	Being online changes how we think. Different media lead us to ask different questions, remember (or forget) different information, attend to different details, and interact with other people in different ways. These types of thinking aren't inherently better or worse, but they may be better or worse for facilitating specific goals. Too often, we use a particular medium/technology without considering how it will influence our thinking. This can lead us to be less efficient or less effective at a task than we otherwise might be, or can qualitatively change the nature of our outcomes. In this class, we will explore how the media we use affects the character of our thinking, so as to enable students to make mindful and deliberate choices about how to interact with media in ways that support the type of thinking desired and appropriate for their goals. Moreover, we will examine how to optimize media for specific goals in important applied domains, such as education, medicine, policy, child-rearing, and dating.	U	4, 9, 1	focused
88251	Social & Decision Sciences	Empirical Research Methods	This course teaches students how to evaluate and conduct original research regarding human behavior, whether it be in economic, social, or political settings. The course gives students practical experience in many of the most commonly used research techniques, including surveys, experiments, and quasi-experimental analysis. Although the course focuses primarily on the relationship between formulating research questions and implementing the appropriate methods to answer them, students can expect regularly to apply the statistical techniques learned in the course prerequisites, including regression.	U	8, 4, 1	focused
88252	Social & Decision Sciences	Causal Inference in the Field	Causal questions are pervasive in the social and behavioral sciences, and empirical researchers often use regression analysis as a tool for tackling such questions. This course focuses on the scientific problem of analyzing causal hypotheses in real-world settings, not on the mathematical details of regression. After clearly distinguishing prediction from causation, we discuss how to represent causal hypotheses and how to use regressions to analyze both predictive and causal hypotheses. Using in-class data exercises throughout, we will examine how to move from an interesting but somewhat vague question about the world (e.g., do police discriminate based on race and gender, do NFL athletes choke under high pressure, does parenthood improve happiness) to a clear statistical model that, when estimated, meaningfully addresses the question asked. The course emphasizes causal analysis as the main research goal and multivariate linear regression as the main statistical tool. After mastering basic techniques, we will introduce students to more advanced econometric approaches such as panel regressions and instrumental variables to deal with trickier settings in which causal inference is more challenging (e.g., do more guns lead to more violence?). In keeping with the hands-on philosophy of the course, a central focus of the semester will be a group research paper/presentation where students will have the opportunity to formulate and empirically test a research question of their choosing. Students will learn how to find, clean, and analyze a new dataset, and then concisely communicate their findings in the form of a scientific paper (and accompanying presentation). The research project makes this course excellent preparation for any student who hopes to ultimately write an undergraduate thesis.	U	5, 4, 16	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
88281	Social & Decision Sciences	Topics in Law: 1st Amendment	In their firm desire to perfect the new Constitution, which defined and limited the powers and roles of their new government, the founding fathers insisted on explicit statements that would protect the rights of the new nation's citizens. Indeed, the protection of these essential rights in many ways drove and defined their successful rebellion from Britain. This impulse resulted in ten amendments to the Constitution, which we have come to know as the Bill of Rights. The very first (and arguably considered at the time as the most essential) of these was the First Amendment, which we sometimes call the "free speech" amendment to the Constitution. This amendment guarantees every U.S. citizen five freedoms: freedom of religion, speech, press, peaceable assembly, and the freedom to petition the government for redress of grievances. This course examines the historical and philosophical roots of this key constitutional amendment, how it has been fleshed out and defined over time through case law, and the bases of some more recent critics of this amendments and current interpretations.	U	16, 5, 11	focused
88284	Social & Decision Sciences	Topics of Law: The Bill of Rights	This course examines the history and place of the Bill of Rights in our nation's constitutional framework. It focuses on the historical origins of the U.S. Constitution, of each of the first ten amendments to the Constitution (that we refer to as the "Bill of Rights"), how the meanings and interpretations of these have evolved over time, and what they mean to us today. Each article of the Bill of Rights will be examined in terms of its original intentions, and then through cases that have challenged and been interpreted through the Bill's articles.	U	16, 11	focused
88300	Social & Decision Sciences	Programming and Data Analysis for Social Scientists	This course provides a first introduction to the statistical programming language R, and is designed primarily with social science majors in mind. Students will develop skills in all facets of the data analysis pipeline, from installing and loading packages and reading in files to data cleaning, munging, visualization and modeling. We welcome students who will be coding for the first time!	U	4, 1, 12	focused
88302	Social & Decision Sciences	Behavioral Decision Making	Behavioral decision making is the study of how people make decisions, in terms that can eventually help them to make better decisions. It draws together research from psychology, economics, political science, and management, among other fields. It has applications that range from managing potentially hazardous technologies, to involving patients more fully in the choice of medical procedures, to the design of computer-interactive systems. The course covers behavioral theories of probabilistic inference, intuitive prediction, preference, and decision making. Topics include heuristics and biases in inference and prediction, risk perceptions and attitudes, strategies for combining information from different sources and dealing with conflicting objectives, and the roles of group and emotional processes in decision making. The course emphasizes the mutually reinforcing relationship between theory and application.	U	9, 17, 12	focused
88341	Social & Decision Sciences	Team Dynamics and Leadership	Much of the work in groups and organizations consists of communication. You communicate to get information that will be the basis of decisions, to provide a vision for the people who work for and with you, to coordinate activity, and to sell yourself and your work. The goal of this course is to identify sources of communication problems within an organization and ways to overcome them. To do this requires that we know how communication normally works, what parts are difficult, and how to fix it when it goes wrong. The focus of this course is on providing you with a broad understanding of the way communication operates within dyads, work groups, and organizations. This course is not a practicum in public speaking or writing, although you will get some experience writing, speaking and managing impressions. Rather the intent is to give you theoretical and empirical underpinnings for the communication you will undoubtedly do when you return to work. Readings come from both the research and the managerial literatures. Among the topics considered are managerial communication, persuasion and conformity, self presentation and person perception, social networks. Cases and group projects give you an opportunity to apply what you've learned.	U	17, 9, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
88344	Social & Decision Sciences	Environmental Policy and Planning	Environmental Policy and Planning provides an introduction to how environmental policies have been and can be designed/created, implemented, and evaluated amidst complex information-based, social, political, and cultural processes. The course emphasizes a systems-based methodological approach for addressing the complexities involved in framing, analyzing, and designing an implementation plan for policy construction. The course also explores through landmark and contemporary case studies several dimensions of environmental policy-making: - Contextual, historical, and structural aspects of environmental policy-making at the local, state, federal, and international levels - Use of quantitative and qualitative analytical tools (from core program + new tools) - The process of how policies derive their meanings.	U	12, 13, 8	focused
88360	Social & Decision Sciences	Behavioral Economics	This course introduces students to behavioral economics, an emerging subfield of economics that incorporates insights from psychology and other social sciences into economics. We will examine evidence on how human behavior systematically departs from the standard assumptions of economics, and then investigate attempts by behavioral economists to improve economic analyses.	U	8, 4, 1	focused
88365	Social & Decision Sciences	Behavioral Economics and Public Policy	Economics has up to now been the social science that has been most broadly and deeply involved in public policy. With its rational choice perspective, the economic perspective has tended to favor certain types of policies namely those that enhance the efficiency of market mechanisms and lower the cost of information. In this course we will spend the first several classes reviewing the assumptions, implications for public policy and limitations of the rational choice perspective. The remainder of the course will then be devoted to examining different public policy issues, including saving, health care, crime and drug abuse, through the competing lenses of traditional and behavioral economics.	U	16, 8, 1	focused
88366	Social & Decision Sciences	Behavioral Economics of Poverty and Development	This course will introduce students to the study of economic development and poverty alleviation, with a special focus on recent insights from the intersection of psychology and economics. We will primarily focus on the health, microfinance, agriculture, and education sectors in developing countries. The course will have a methodological component largely centered on using experiments to evaluate interventions and policies that apply to households, small firms, and farms. While we will cover standard economic approaches, we will give extra attention to how a behavioral lens can help in both understanding development issues (e.g. barriers to household risk management) and in designing effective interventions (e.g. the timing of fertilizer sales).	U	2, 1, 4	focused
88367	Social & Decision Sciences	Behavioral Economics in the Wild	Behavioral Economics is a sub-field of economics that, relying on insights from psychology and decision-making, aspires to describe actual behavior with greater empirical accuracy and psychological realism than that implied by the standard neoclassical model. In this course, we will investigate the success of this approach in explaining ostensible anomalies in the "wild" such as under-savings for retirement, over-consumption of unhealthy food, extreme aversion to losses among investors, workers, and home-owners, the over-confidence of corporate CEOs and NFL general managers, and the influence of emotions on domestic violence, stock market activity, and risk-taking. We will first document and review the underlying theory for three conceptual departures from the standard model -non-standard preferences (e.g., present-bias, reference dependence), non-standard beliefs (e.g., overconfidence, gambler''s fallacy), and non-standard decision-making (e.g., heuristics, emotions, framing effects)-and then quickly move to assess the evidence for these claims in field settings. We will additionally explore how markets respond to behavioral biases, and discuss recent research in behavioral policy with an emphasis on policies aimed at increasing savings, improving food choice, and heightening program take-up and compliance. The course will be paper-centric and we will review a variety of popular empirical methods from field experiments to quasi-experimental approaches (e.g., estimation through regression-based panel analyses, difference-in-differences, and instrumental variables). Student evaluation will be based on performance on problem sets, an exam, as well as a short class presentation of an empirical paper of choice.	U	16, 5, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
88380	Social & Decision Sciences	Dynamic Decisions	Decisions we make every day may range from simple and routine to novel and highly complex. For example, decisions while driving (judging the distance to the front car, the speed, the directions, and making choices accordingly) seem effortless and routine after some experience, while triaging patients in an emergency room under scarce resources may be quite overwhelming for everyone. Both types of decisions however, have something in common: they are made in the presence of change and in the absence of explicit information of probabilities, possible alternatives, and outcomes. Our decisions in such situations are the result from the interaction between the dynamic environmental demands and our cognitive processes. In this course you will learn how decisions are made in different dynamic situations and how our cognitive processes (e.g., attention, experience, risk tendencies, and other factors) influence the way those decisions are made. Students will be introduced to different aspects of decision processes by analyzing the sources of error in complex problems, such as cases of accidents and disasters (natural or man-made), in multiple disciplines (e.g., aviation, management, military strategy, and others). The course will also use simulation-based representations of dynamic decision making situations (e.g., microworlds) to illustrate relevant cognitive processes needed for learning, adaptation and choice. Finally, students will learn how to construct mathematical/computational models of dynamic systems, be able to interpret simulation results and to explore scenarios regarding effects of variables in the models and the predictions that the models can make.	U	4, 11, 1	focused
88388	Social & Decision Sciences	Psychological Models of Decision Making	This course provides an introduction to the techniques and theories for modeling decision making. The topics covered include: signal detection theory, normative and descriptive decision modeling, multidimensional scaling, and diffusion models. The course will include an introduction to the theory behind the models as well as "hands on" computational applications of the models with data. The topics covered in this course can be used in a variety of applied settings-ranging from medical and public policy to marketing and psychological research-to produce simplified representations of seemingly complex phenomena.	U	17, 2, 9	focused
88399	Social & Decision Sciences	Undergraduate Research	Students conduct research under the supervision of a Social & Decision Sciences faculty member. Students who wish to engage in research should seek out a faculty member whose interests are appropriate to the research. Prerequisite: Students must also complete an "Independent Study/Research for Credit" form, available from the SDS Coordinator of Student Programs in Porter 208A and 208G. Permission of a faculty sponsor.	U	4, 17, 8	focused
88411	Social & Decision Sciences	Rise of the Asian Economies	For most of the past quarter century, no region of the world has been more economically dynamic than Asia. This course is designed to provide students with the essential knowledge necessary to evaluate opportunities and risks in Asia. The course will use analytical tools drawn from economics and finance, business cases, and guest lectures to focus on the key strengths that sustained economic growth in East Asia for decades, the weaknesses that undermined that growth in the late 1990s, and what lies ahead. The course will also examine Indian economic growth since the early 1980s, and compare India's experience with that of the East Asian economies. A special focus will be placed on recent developments in India and China and the prospects for continued growth in those countries over the next decade.	U	8, 4, 9	focused
88415	Social & Decision Sciences	Science and Innovation Leadership for the 21st Century: Firms, Nations, and Tech	Science and Innovation Leadership for the 21st Century introduces students to the fundamental principles surrounding global competitiveness and technological change in the 21st century. The course is broken into three sections. The first section introduces students to competing economic, sociological, and political science theories on the structures supporting technological change. The second section presents the contemporary literature on technological change. The concluding section leverages lessons from the preceding two sections to evaluate national innovation systems, and the factors that lead to national comparative advantage. Students should leave the class able to reflect competently on what the existing literature tells us about the factors influencing global technology competitiveness, and on how modern changes in the structures supporting innovation as well as technology itself may be changing the rules of the game for firms and for nations. The course is open to undergraduate juniors and seniors.	U	9, 8, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
88418	Social & Decision Sciences	Domestic Negotiation	Negotiation is the art and science of securing an agreement between two or more interdependent parties. Decision-makers use negotiation to reach agreements with co-workers, bosses, clients, subordinates, firms, family and friends. Hence, the ability to negotiate effectively is a critical skill. In this course, students will develop a systematic and insightful approach to negotiation. Students will learn to analyze the features of the negotiation environment, develop an understanding of effective negotiation strategies and tactics, and identify the barriers and the psychological factors that may prevent decision-makers from reaching wise agreements. Considerable emphasis will be placed on negotiation exercises and role-playing. In-class discussions and lectures will supplement the exercises. This course will focus on negotiations in a wide variety of context: public policy negotiations, business negotiations, salary negotiations, and inter-personal negotiations.	U	4, 8, 9	focused
88451	Social & Decision Sciences	Policy Analysis Senior Project	Students in this course apply the research and analytical methods learned in their other courses to a real-world problem. Students decide how to structure the problem, divide into teams responsible for its different parts, identify and analyze relevant literature, collect data, synthesize their results, and present their conclusions in oral and written form to a review panel of individuals concerned with the problem. Faculty members help them along the way. Performance is based on students' contribution to the process and substance of the class, as observed by the faculty and by their fellow students. One or two such projects is offered every term. A complete list of previous topics is available from the department. Course is open only to seniors in SDS.	U	4, 17, 1	focused
88452	Social & Decision Sciences	Policy Analysis Senior Project	Students in this course apply the research and analytical methods learned in their other courses to a real-world problem. Students decide how to structure the problem, divide into teams responsible for its different parts, identify and analyze relevant literature, collect data, synthesize their results, and present their conclusions in oral and written form to a review panel of individuals concerned with the problem. Faculty members help them along the way. Performance is based on students' contribution to the process and substance of the class, as observed by the faculty and by their fellow students. One or two such projects is offered every term. A complete list of previous topics is available from the department. Course is open only to seniors in SDS.	U	4, 17, 1	focused
88453	Social & Decision Sciences	Behavioral Economics, Policy, and Organizations Capstone	The Capstone in Behavioral Economics, Policy, and Organizations will work to apply the theories, concepts, and statistical techniques mastered in prior courses to an applied project. Students will work closely both in teams and individually with the instructor on a project that will address a problem posed by an organization or government that behavioral economics can help to solve. Students will work to structure the problem, design an intervention or study, collect and analyze the data, and make recommendations for implementation. Students will manage the project and drive interactions with the client organization.	U	4, 17, 9	focused
88499	Social & Decision Sciences	Advanced Undergraduate Research	Students conduct research at an advanced level under the supervision of a Social & Decision Sciences faculty member. Students who wish to engage in advanced research should seek out a faculty member whose interests are appropriate to the research. Students must also complete an "Independent Study/Research for Credit" form, available from the SDS Coordinator of Student Programs in Porter 208A as well as 208G. Prerequisite: Permission of a faculty sponsor.	U	4, 17, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
90401	Public Policy & Mgt:Sch of Pub Pol & Mgt	Media & Communication Design I	The Media and Communication Design course focuses on using desktop publishing software to effectively communicate messages in printed form. The goal of this course is to use the combination of type, color, shapes, illustrations and images to produce professional printed materials. The skills learned in this course can easily be translated to other media. This course will teach a combination of graphic design skills and software skills. Most classes will consist of two thirds lecture and one third hands-on work with the software. The software being taught is Adobe InDesign Creative Cloud (CC), Adobe Illustrator CC and Adobe Photoshop CC. Students will gain experience in preparing documents that are professional in form and content. Student will learn how to design and publish products such as newsletters, posters, logos, packaging, signs, books, flyers, magazines, annual reports, invitations and advertisements. Students will also learn the terminology, procedures and production requirement to effectively communicate with ad agencies, design firms and commercial printers.	U	4, 9, 8	focused
90403	Public Policy & Mgt:Sch of Pub Pol & Mgt	Gender, Politics and Policies in the US and Across the World	1.-Women political participation in the U.S. and in selected countries across the world including the expansion of political and voting rights, the role of women as political leaders and the overall participation of women in the political and policymaking process. Within the U.S., we will pay attention to the situation of racial and sexual minorities including African-American and Latina women, as well as issues affecting Lesbian and Transgender Women. 2.-The evolution of women's economic rights in the U.S. and selected countries. Central issues here are the wage gap, the glass ceiling, and the overall female participation in the private sector. 3.-Women in conflict and sex trafficking: Lastly, the course will examine the role of women in conflict as both participants and victims as well as the role of both men and women in preventing sex trafficking. Goals of this course: The readings and class discussions are going to focus not only what has happened, but also on the policies that are been implemented and should be implemented to reduce the negative effect of past actions. The course should be of interest to both men and women because we are all part of the same society.	U	5, 16, 10	focused
90404	Public Policy & Mgt:Sch of Pub Pol & Mgt	Poverty, Inequality and Social Policies: An International Comparison	In her book Social Forces and States Judith Teichman argues that "significant and long term improvement in distributional outcomes is a daunting political task [that requires] a strong societal consensus on the importance of the reduction in inequality, one that compels political leaders to make difficult policy changes." Teichman's words indicate that poverty and inequality are not just socioeconomic problems, but critical political and policy problems both in the U.S. and in the rest of the world and that, these problems do not have easy solutions. This class attempts to tackle some of those complex problems by looking at poverty, inequality and the social and economic policies designed to ameliorate these problems in the U.S. and selected African, Asian, European and Latin American countries.	U	1, 8, 10	focused
90427	Public Policy & Mgt:Sch of Pub Pol & Mgt	Healthcare Management	This course introduces students to the knowledge and skills required to strategically manage the rapidly changing internal and external environment of health care organizations. Through readings, lectures, class discussions and case reviews, the course is designed to provide students with a foundation in contemporary health care organizational structures and management practices. Students will explore problems and decisions facing health care executives in areas such as clinical quality, organizational effectiveness, efficiency, growth, stakeholder conflicts, provider incentives, margin versus mission tradeoffs, human resources, strategic planning and the like, all in a highly complex political environment. A primary theme of this course is the application of ethical management practices as codified in the American College of Healthcare Executives' Code of Ethics. By providing a general overview of the responsibilities of health care leaders and managers, students will have a contextual reference for the application of future coursework. This is a hybrid course where discussion will take place both in the classroom and online via Canvas. Several lectures have been taped and should be watched before coming to class in order to ensure preparation and participation. In lieu of assignments, students will be required to respond to prompts / exercises in class and on the Canvas discussion board and interact with their fellow students. Excellent attendance and active participation are required in order to succeed in the class.	U	4, 8, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
90433	Public Policy & Mgt:Sch of Pub Pol & Mgt	Population Health	It is a societal imperative that we improve the quality of health for all Americans while reducing the cost. In so doing, we must move from a reactionary, disease driven, hospital-dominated model to one that creates the appropriate level of incentives and health delivery infrastructure so that patients embrace strategies to prevent disease and promote healthy living and behavior. What is Population Health and what role do individuals, executive branch agencies, and non-profits play in the protection and promotion of positive health outcomes? How are health outcomes assessed? In this introductory course, we will examine the way health care delivery systems, public health agencies, community-based organizations, and many other entities work together to develop interventions to improve the health outcomes in the local, national, and global communities they serve. We will first learn to examine health issues from a population health perspective.	U	9, 3, 8	focused
90434	Public Policy & Mgt:Sch of Pub Pol & Mgt	Health Care Geographical Information Systems	A geographic information system (GIS) provides an effective way to visualize, organize and manage a wide variety of information including administrative and medical record data, social services, and other location data. Public health departments, hospitals, and medical research agencies are using GIS to map health-related events, identify disease clusters, investigate environmental health problems, and understand the spread of disease. This course uses a unique approach for teaching GIS in health care. It imbeds learning how to use GIS software in the context of carrying out projects for visualizing and analyzing health-related data. Each week includes lectures and computer labs that focus on a health, technical, or policy issue which use Esri's ArcGIS Pro and Platform technologies to analyze data or solve a problem. Students learn to create Story Maps to convey their maps and associated text to the public and decision makers. Through assignments and projects students will not only learn how to use the software but will also learn the many distinctive advantages of using GIS for health care policy making and planning. By the end of the course, students will have sufficient background so that they can become expert users of GIS in health care organizations - building, managing, and using GIS maps and health data. Prerequisites: 90-728 Introduction to Database Management, 91-802 Information Systems for Managers or permission of instructor.	U	4, 3, 9	focused
90435	Public Policy & Mgt:Sch of Pub Pol & Mgt	Public Finance	Public Finance (90-736/90-435) provides an introduction to the theory and practice of how national, regional and local governments should and actually finance their budgets for operating and capital project purposes. To accomplish this, the course reviews: i] rationales for government intervention in the market place, ii] analyzes methods of resolving conflicts over the size of the public sector budget, iii] extensively analyzes the rationales and issues of various types of tax revenue, and iv] reviews the effects of public sector spending and taxes on the aggregate economy. Throughout, Public Finance emphasizes the interplay between how current revenue policy is fashioned, and how the models and their key assumptions along with political processes interact which result in changes in current law at the federal, state, and local levels. Public Finance focuses mainly on the revenue side of the public budget. Two courses typically offered by Professor Strauss in the Spring build on Public Finance. Public Expenditure Analysis (90-774/90-474) deals with techniques for evaluating private and public expenditure and capital spending decisions. Education Finance and Policy (90-817) deals in-depth with issues surrounding multi-level government finance from US and international perspectives. Public Finance is taught in lecture/discussion format with an emphasis on developing each student's reasoning skills. Original course lecture outlines in .doc format are maintained in Canvas, along with working Excel examples used in class, and assigned and optional readings. Evaluation is based on evaluation of short-essay midterms and final exams, problem sets and class participation. Students may drop the lowest midterm and problem set grade. For more information about Professor Strauss and this course, see respectively: www.andrew.cmu.edu/user/rs9f and www.andrew.cmu.edu/user/rs9f/public_finance_4_18_2019.pdf	U	4, 8, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
90436	Public Policy & Mgt:Sch of Pub Pol & Mgt	Health Systems	Health Policy and Delivery Systems is a foundation course intended to introduce students to many of the broad subjects that will be detailed in more advanced course work. This introduction provides a framework to aid students in navigating from public policy through to healthcare delivery. Public policy is the study of the written and unwritten principles on which law is based. Laws and regulations translate policy into action. Public policy and laws form the basis of health policy. Health policy is supported by: - Public health initiatives focused on preventing disease, prolonging life and promoting health for the entire population. (i.e. diabetes awareness) - Population health is interested in the outcomes of individual groups and the distribution of outcomes among the groups. (i.e. income equality and infant mortality) - Healthcare delivery is focused on access, quality, and cost. At this time in our history, Healthcare Reform best embodies the intent of this aspect of health policy. Through the use of group assignments, students will create a model which links the external environment into healthcare delivery profitability. Modeling is a form of combining individual technical components with the greater knowledge and conceptualization of the entire process. Its promise is to promote better decision making by envisioning how micro decisions interconnect to mission, goals, and outcomes.	U	3, 4, 10	focused
90442	Public Policy & Mgt:Sch of Pub Pol & Mgt	Critical AI Studies for Public Policy	With the rapid development of algorithmic and computing power as well as tech industry's capacity to collect massive data, Artificial Intelligence (AI) techniques have increasingly become a ubiquitous part of our everyday lives, ranging from fields such as communication, healthcare, finance, policing and workplace management. Instead of studying AI as a purely technical subject, in this course, we will critically examine the most recent developments and deployments of AI from a social, cultural and policy perspective. Drawing upon real-world cases, this course will introduce students to the basic concepts and main topics to think AI socially, help them understand the potential benefits and pitfalls of various contemporary AI applications, and think toward future AI systems that can deliver greater social good. The course will include a mix of lectures, group discussions, guest lectures and small group in-class activities. Students will be asked to come to class having carefully read the required readings, submit response and discussion questions on Canvas respond to each other. Building on concepts and cases discussed in this class, students will also be asked to write two policy memos (one mini, one final) on the topic of their choice.	U	9, 4, 8	focused
90443	Public Policy & Mgt:Sch of Pub Pol & Mgt	Urban and Regional Economic Development	The course will introduce students to the theory and practice of economic development in the United States. An introduction to basic analytic techniques used by both researchers and economic development practitioners will be coupled with a broad overview of the research literature in the fields of urban and regional economics. Emphasis will be placed on the public sector's role in promoting economic development and public policy at the federal, state and local levels that are focused on improving economic conditions for people, places and regions. Optional readings will focus on Pittsburgh's economic development and regional economic change since WWII.	U	8, 4, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
90445	Public Policy & Mgt:Sch of Pub Pol & Mgt	Social Entreprenuership	With a world threatened by rising inequalities (especially in the post-pandemic time) and the effects of climate change, we are in the middle of an era where we are seeing the growth of social entrepreneurship - both in the upsurge of new ventures and within corporations as they seek to respond to demand from their consumers and the public toward a focus not solely on profit, but on a "triple bottom line" - an equivalent focus on PURPOSE -- people and the planet. This course is for students that want to learn how to take ideas that respond to societal needs and frame it within a sustainable business structure. Ideas may be for new social ventures or innovations within existing institutions and corporations. The students will work on an idea they have and take it through a model "accelerator" program curriculum. Accelerators are "fixed-term cohort-based programs that include seed investment, mentorship," a curriculum that aims to fast forward business planning and strategy and culminate in what is typically called "demo day" - an opportunity for participating teams to present to potential investors. The course is open to students from different disciplines. This course will utilize online resources as well as readings culled from leading resources on lean business planning. It is an applied learning course and will require working practical knowledge of basic financial statements. At the end of the course, students will be able to take an idea through a model accelerator curriculum - from establishing a mission, vision, theories of change and impact pathways to market and competitive analysis, identifying target markets, customer acquisition, basic financial modeling to crafting the pitch deck. Students will be able to understand a basic structure to business modeling that they can use to form the basic guiding foundations to future new ventures - as startups or as innovations within corporations.	U	13, 4, 8	focused
90472	Public Policy & Mgt:Sch of Pub Pol & Mgt	Health Policy	This course introduces students to the concepts, theories, and tools of health policy. The aims of this course are to provide students with (1) the ability to identify key problems facing the United States health system, (2) increase the appreciation for and understanding of health policy as an important and useful tool for enhancing population health, and (3) mechanisms to address a current health policy issue from legal, economic, behavioral, and political perspectives. In addition, students will be introduced to a cross-national comparison of health systems.	U	8, 4, 1	focused
90474	Public Policy & Mgt:Sch of Pub Pol & Mgt	Public Expenditure Analysis	Public Expenditure Analysis is a 12 unit course designed to deal with the expenditure side of the public sector budget in a series of modules. It has been conceptualized as a blending of private finance and public expenditure principles. The former provides a systematic framework, capital budgeting, for the evaluation of private-sector capital projects, while the latter builds on the former, and introduces issues of externality, the social rate of discount, and incomplete markets through the mechanism of shadow pricing. Public Expenditure Analysis prepares those Heinz and other CMU students seeking careers in the public sector, or those parts of the private sector that routinely deal with the public sector's capital budgeting decisions. It answers the question "when should a community build a bridge?" Public Expenditure Analysis is divided into 4 modules. In Module 1, the course develops the essential techniques of private sector evaluation principles for short-term and long-term capital projects. In Module 2, special problems which arise in the evaluation of public sector capital projects are discussed; a variety of evaluation techniques and applications especially suited to public sector projects are then examined. In Module 3, actual cost-benefit studies in the policy areas of education, environment, health, criminal justice, transportation and recreation are examined. In Module 4, evaluation at a high level of aggregation is dealt with through the use of generational accounting models. These models are examples of aggregate long and short-term public evaluation problem areas typically dealt with by national governments. Also in Module 4 groups of students perform and report a critical review of a cost-benefit study they have chosen. Throughout the course, similarities and differences between the public sector and private sector are emphasized, and examples from the real world are discussed in class.	U	4, 8, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
90489	Public Policy & Mgt:Sch of Pub Pol & Mgt	Resilient & Sustainable Communities	90-489: This course is a parallel listing for the graduate level listing of 90-789 under the same title. The course examines past and current community development topics and trends associated with creating and/or maintaining sustainable communities. Such topics include sustainable development, creative capitalism, regional planning and visioning, governance, regional equitable development, sustainable business practices, green/clean tech, smart growth and smart transportation, carbon management, resource conservation, local living economies, energy systems and strategies, dynamics of neighborhoods, among other topics. Emphasis will fall on how these various dimensions need to strategically align to promote sustainable communities amidst their complexities. The class will also delve into a variety of green and sustainable development practices to provide frameworks for integrating traditional community development practices with sustainable development practices. The class takes lessons from the past (both what has worked and what did not work) as well as appropriate, current practices and explores how to apply them to a variety of community situations and conditions. The focus is on urban communities in the U.S and worldwide, both large and small. The course includes experiential, hands-on learning (projects, case studies, analyses, presentations, field trips, and guest lectures) as well as reflective components (readings, discussion, and papers).	U	15, 13, 7	focused
90717	Public Policy & Mgt:Sch of Pub Pol & Mgt	Writing for Public Policy	Professional writing, or writing for business-focused, industry-specific contexts, differs from academic writing in objective, audience, structure, style, and format. It focuses more on problem solving than on exposition of ideas and is generally targeted to diverse audiences with varying levels of expertise. Therefore, effective writing in the workplace often requires adapting writing skills and habits to meet reader's needs. Additionally, when hiring recent graduates for a mid-level position, employers identify writing skills as one of the top five factors signaling leadership potential. Whether you're looking to maximize the impact of your communications at work, seeking project funding, or looking to increase your visibility on-line, this seven-week mini course will prepare you to assume a leadership role in your industry through effective written communication. This course will not only help you refine the essentials of workplace writing, but will also provide strategies, guidelines, and best practices for writing the kinds of industry-specific documents that policy, information security/systems, and creative industry professionals need. This course is designed for experienced writers who want to take their skills to the next level. This course assumes basic proficiency in English grammar.	G	4, 9, 8	focused
90718	Public Policy & Mgt:Sch of Pub Pol & Mgt	Strategic Presentation Skills	Strategic Presentation Skills provides practical instruction for preparing and delivering professional presentations. Activities and assignments include: analyzing audience members, writing outlines, creating cohesive visuals, and speaking extemporaneously. Students target and engage specific audiences using a communication style suitable for workplace environments. Overall, the course helps students develop confidence and apply effective techniques when speaking in a public setting.	G	4, 8, 17	focused
90721	Public Policy & Mgt:Sch of Pub Pol & Mgt	Healthcare Management	This course introduces students to the knowledge and skills required to strategically manage the rapidly changing internal and external environment of health care organizations. Through readings, lectures, class discussions and case reviews, the course is designed to provide students with a foundation in contemporary health care organizational structures and management practices. Students will explore problems and decisions facing health care executives in areas such as clinical quality, organizational effectiveness, efficiency, growth, stakeholder conflicts, provider incentives, margin versus mission tradeoffs, human resources, strategic planning and the like, all in a highly complex political environment. A primary theme of this course is the application of ethical management practices as codified in the American College of Healthcare Executives Code of Ethics. By providing a general overview of the responsibilities of health care leaders and managers, students will have a contextual reference for the application of future coursework.	G	4, 8, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
90723	Public Policy & Mgt:Sch of Pub Pol & Mgt	Financial Statements and Analysis of Companies	This course provides an overview of how managers, investors, creditors, and other parties use financial information to assess the financial and operating performance of companies. The first part of the course looks at how a company's transactions are measured, recorded and presented to stakeholders. In the second part of the course you will use the Annual Report and Form 10-K that is prepared by publicly held companies to evaluate and analyze the financial status of a company for which you have no information except the annual published financial report or financial statements.	G	8, 9, 10	focused
90765	Public Policy & Mgt:Sch of Pub Pol & Mgt	Cities, Technology and the Environment	This mini will explore the interaction of cities, technology and the natural environment over time. More specifically, it will consider several major issues confronting cities today: (1) water supply, wastewater and storm water disposal and flooding; (2) Energy and Environment; (3) Transportation, suburbanization and land use; and (4) Brownfield creation and development. In a number of instances, the Pittsburgh region will be used to provide examples of these issues. These themes will be approached through a combination of class discussions, lectures, and visiting speakers. Class participation is expected, and will comprise a portion of the grade. Students will be expected to prepare a problem-oriented paper on one of the areas focused on in the course.	G	6, 12, 11	focused
90789	Public Policy & Mgt:Sch of Pub Pol & Mgt	Resilient & Sustainable Communities	This course examines past and current community development topics and trends associated with creating and/or maintaining sustainable communities. Such topics include sustainable development, creative capitalism, regional planning and visioning, governance, regional equitable development, sustainable business practices, green/clean tech, smart growth and smart transportation, carbon management, resource conservation, local living economies, energy systems and strategies, dynamics of neighborhoods, among other topics. Emphasis will fall on how these various dimensions need to strategically align to promote sustainable communities amidst their complexities. The class will also delve into a variety of green and sustainable development practices to provide frameworks for integrating traditional community development practices with sustainable development practices. The class takes lessons from the past (both what has worked and what did not work) as well as appropriate, current practices and explores how to apply them to a variety of community situations and conditions. The focus is on urban communities in the U.S and worldwide, both large and small. The course includes experiential, hands-on learning (projects, case studies, analyses, presentations, field trips, and guest lectures) as well as reflective components (readings, discussion, and papers).	G	15, 13, 7	focused
90798	Public Policy & Mgt:Sch of Pub Pol & Mgt	Systems Analysis: Environmental Policy	Systems Analysis: Environmental Policy provides an introduction to how environmental policies have been and can be designed/created implemented and evaluated amidst complex information-based social political and cultural processes. The course emphasizes a systems-based methodological approach for addressing the complexities involved in framing, analyzing, and designing an implementation plan for policy construction. The course also explores through landmark and contemporary case studies several dimensions of environmental policymaking: * Contextual historical and structural aspects of environmental policymaking at the local state federal and international levels * Use of quantitative and qualitative analytical tools (from the core program as well as new tools) * The process of how policies derive their meaning. * Contemporary challenges and opportunities in environmental policymaking. Strategies for successful policymaking in the contemporary landscape.	G	12, 13, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
90808	Public Policy & Mgt:Sch of Pub Pol & Mgt	Energy Policy	This seminar will provide an introduction to modern U.S. energy policy. Our goal will be to understand, from a practical perspective, how economics, technology, politics, public opinion and national security all influence the development and implementation of policy. Questions that we will address include: Why has energy taken on such a critical role in the public policy agenda? How has U.S. energy policy changed over the years and what lessons have we learned from past initiatives? How much influence does government really have? How have new technologies changed the energy landscape and our interactions with other countries? The class will begin with an overview of the energy sector and the related government structure. After covering some historical context, we will discuss Presidential initiatives and legislative activity. We will then consider some case studies, such as the Keystone Pipeline, the development of the Marcellus Shale, and carbon taxes that demonstrate conflicting viewpoints about appropriate energy policy. The class will also explore international energy security issues like liquefied natural gas and crude oil exports. This course is a seminar class; I will provide a framework and then guide a discussion among the students. Your preparation and participation are essential. Each session will begin with a short review and discussion of current events in the energy sector, including how energy and environmental issues are being addressed by 2020 presidential candidates. We will also hear from guest speakers, including a number of current and former senior government officials.	G	7, 13, 9	focused
90818	Public Policy & Mgt:Sch of Pub Pol & Mgt	Lean Performance Improvement Lab: H C	This course provides an overview of the current state of the quality movement in Health Care. A public health perspective as well as an individual perspective will be considered from both a U.S. and international view. Relevant history, current gurus, landmark publications, theories, tools, and environmental factors will be discussed. We will explore the cost/quality connection and analyze the complex forces that shape or hinder the transformation of health care from the current state to a person centered quality focused Health Care System. We will learn to use industrial models to improve processes in the health care industry. The concepts and skills needed to create a work environment where these tools can be utilized will also be explored.	G	9, 12, 4	focused
90832	Public Policy & Mgt:Sch of Pub Pol & Mgt	Health Law	This course introduces students to the laws that impact the provision of health care services. With the increasing intersection between health care and the law, executives and others involved in the administration and delivery of health care services are likely to encounter a wide range of legal and regulatory issues, particularly as the fate of the Affordable Care Act is debated. This course is designed to provide students with the practical knowledge needed to identify legal issues inherent in health care and to understand the legal ramifications of administrative and management decisions. Specific course topics include: sources of law, the US court system and legal procedures, professional and institutional liability, governmental regulatory methods, antitrust law, fraud laws, corporate compliance programs, issues concerning informed consent, credentialing of medical professionals, termination of care, and health care reform. Upon completion of this course the student should be able to: 1. Explain the US legal system and sources of law in the United States. 2. Recognize and apply laws, regulations, and policies that govern the administration and delivery of health care services. 3. Identify potential legal ramifications of health care management and administrative decisions. 4. Identify issues that warrant seeking the assistance of legal counsel.	G	4, 16, 1	focused
90833	Public Policy & Mgt:Sch of Pub Pol & Mgt	Population Health	It is a societal imperative that we improve the quality of health for all Americans while reducing the cost. In so doing, we must move from a reactionary, disease driven, hospital-dominated model to one that creates the appropriate level of incentives and health delivery infrastructure so that patients embrace strategies to prevent disease and promote healthy living and behavior. What is Population Health and what role do individuals, executive branch agencies, and non-profits play in the protection and promotion of positive health outcomes? How are health outcomes assessed? In this introductory course, we will examine the way health care delivery systems, public health agencies, community-based organizations, and many other entities work together to develop interventions to improve the health outcomes in the local, national, and global communities they serve. We will first learn to examine health issues from a population health perspective.	G	9, 3, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
90834	Public Policy & Mgt:Sch of Pub Pol & Mgt	Health Care Geographical Information Systems	A geographic information system (GIS) provides an effective way to visualize, organize and manage a wide variety of information including administrative and medical record data, social services, and other location data. Public health departments, hospitals, and medical research agencies are using GIS to map health-related events, identify disease clusters, investigate environmental health problems, and understand the spread of disease. This course uses a unique approach for teaching GIS in health care. It imbeds learning how to use GIS software in the context of carrying out projects for visualizing and analyzing health-related data. Each week includes lectures and computer labs that focus on a health, technical, or policy issue which use Esri's ArcGIS Pro and Platform technologies to analyze data or solve a problem. Students learn to create Story Maps to convey their maps and associated text to the public and decision makers. Through assignments and projects students will not only learn how to use the software but will also learn the many distinctive advantages of using GIS for health care policy making and planning. By the end of the course, students will have sufficient background so that they can become expert users of GIS in health care organizations - building, managing, and using GIS maps and health data. Prerequisites: 90-728 Introduction to Database Management, 91-802 Information Systems for Managers or permission of instructor.	G	4, 3, 9	focused
90836	Public Policy & Mgt:Sch of Pub Pol & Mgt	Health Systems	Health Systems is a foundation course intended to introduce students to many of the broad subjects that will be detailed in more advanced course work. This introduction provides a framework to aid students in navigating from public policy through to healthcare delivery. Public policy is the study of the written and unwritten principles on which law is based. Laws and regulations translate policy into action. Public policy and laws form the basis of health policy. Health policy is supported by: - Public health initiatives focused on preventing disease, prolonging life and promoting health for the entire population. (i.e. diabetes awareness) - Population health is interested in the outcomes of individual groups and the distribution of outcomes among the groups. (i.e. income equality and infant mortality) - Healthcare delivery is focused on access, quality, and cost. At this time in our history, Healthcare Reform best embodies the intent of this aspect of health policy. Through the use of group assignments, students will create a model which links the external environment into healthcare delivery profitability. Modeling is a form of combining individual technical components with the greater knowledge and conceptualization of the entire process. Its promise is to promote better decision making by envisioning how micro decisions interconnect to mission, goals, and outcomes.	G	3, 4, 10	focused
90861	Public Policy & Mgt:Sch of Pub Pol & Mgt	Health Policy	This course introduces students to the concepts, theories, and tools of health policy. The aims of this course are to provide students with (1) the ability to identify key problems facing the United States health system, (2) increase the appreciation for and understanding of health policy as an important and useful tool for enhancing population health, and (3) mechanisms to address a current health policy issue from legal, economic, behavioral, and political perspectives. In addition, students will be introduced to a cross-national comparison of health systems.	G	8, 4, 1	focused
90882	Public Policy & Mgt:Sch of Pub Pol & Mgt	Behavioral Economics in Public Policy	"Economics has up to now been the social science that has been most broadly and deeply involved in public policy. With its rational choice perspective, the economic perspective has tended to favor certain types of policies, namely those that enhance the efficiency of market mechanisms and lower the cost of information. In this course we will spend the first several classes reviewing the assumptions, implications for public policy, and limitations of the rational choice perspective. The remainder of the course will then be devoted to examining different public policy issues, including saving, health care, crime and drug abuse, through the competing lenses of traditional and behavioral economics."	G	16, 8, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
93430	Creative Enterprise:Sch of Pub Pol & Mgt	Disruptive Technologies in Arts Enterprises	The world is undergoing monumental change. Much of this is fueled by the aftermath of the introduction of the World Wide Web in the mid-1990s and the entry of the personal computer to the mass marketplace. These actions opened up opportunities for computing and creativity using modern technology akin to the industrial revolution. Richard Florida identified and coined the term creative economy. Some have also coined this time as the second renaissance noting that this era is changing our core frameworks for civilization. As in the age of the renaissance, creativity and the arts are often at the cutting edge for creating and incorporating technologies in the world even though some nonprofit institutions seem slow to adapt. This seminar course provides students with multiple perspectives on how emerging technologies are disrupting arts enterprises, including arts-making, audience engagement, and arts management. From the Internet of Things to Virtual Reality, students will investigate what is happening in the field and what's on the fringe and about to break into the marketplace. Through readings, hands-on activities, and individualized research the course provides a breadth of understanding of multiple technologies for students overall while each individual student pursues deeper expertise in one or two technologies of their choice. The material submitted for assignments may be recommended to be included in the content created for AMT Lab (www.amt-lab.org) Readers for the platform are arts management professionals working in the field. Approximately 3000 individuals from around the world read the content monthly. The process for publication is provided on Canvas.	U	9, 4, 17	focused
93703	Creative Enterprise:Sch of Pub Pol & Mgt	Arts Enterprises: Management & Structures	Arts Enterprises: Structures and Management examines the fundamental structures, governance, and management systems involved in running a successful 21st century arts enterprise. The course goes beyond a 'principles of arts management' position to introduce students to the local, national, and international forces that make running an arts-based business unique. Students discover how arts enterprises are governed internally (formal leadership) and externally (public policy, market forces, and financial realities). Furthermore, students learn how enterprises engage multiple stakeholders, from artists or politicians to staff or audiences. Almost daily, arts managers are faced with choices that affect internal operation dynamics and external stakeholder relations. During the course, students will discern the day-to-day systems and operations of well-run arts organizations and investigate moments of failure in order to find the lessons learned. The course provides a lens into the nexus of institution-artist-audience within a framework of mission-impact and ROI. This course provides students with both the fundamentals and the emerging practices within arts enterprises creating a foundation for subsequent, advanced coursework. Students will encounter the theoretical frameworks necessary to understand the enterprise, and then ground the theory in real-life experience, case studies, and course-exercises. The course is organized in 4 modules: Public Policy and the Arts, Law and Structuring a Business, Running the Enterprise, and Issues in the Field. For the purpose of this course, arts enterprises will be defined as those that create relationships between artists and audiences. Arts enterprises include, but are not limited to: orchestras, opera companies, music ensembles, museums, arts centers, theatre companies, presenting organizations, multi-media centers, artist agencies, galleries, media and dance companies.	G	4, 9, 8	focused
94403	Heinz College Wide Courses	Consulting Lab	Communication is the glue that holds consulting engagements, teams, and relationships together. Arguably, the better a consultant you are, the better a communicator you are, and the best communicators tend to make very good consultants (nice symmetry there). Poor communication and other 'soft skills' can derail a consulting engagement and with it, a promising consulting career. As an example, a Gartner Group study found that 80% of all IT projects were late, over budget, or failed completely because of poor communication at the outset. This course will help students interested in a consulting career acquire new skills in everything from personal branding to asking high-value, incisive questions to building strong, long-term client relationships	U	4, 17, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
94408	Heinz College Wide Courses	Management Consulting	This is an applications course exploring the profession of management consulting and the art and science of providing management counsel to organizations in the public and private sectors. The course is designed to provide a framework for collaborating with organizations to solve problems and to execute projects efficiently and effectively. Students will explore and utilize practical tools that will enable them to solve problems and execute projects as external or internal consultants or as individual contributors or leaders within organizations. The course introduces frameworks as well as quantitative and qualitative methods that are typically used in management consulting.	U	4, 9	focused
94411	Heinz College Wide Courses	Strategy Development	This course introduces students to frameworks for understanding strategy development and implementation. Through a combination of theory and practice, students will be exposed to processes for formulating a sound, rational business strategy as well as the discipline required to successfully implement that strategy. Course activities and concepts include: 1) situational and environmental analysis, 2) internal capabilities assessment, and 3) appropriate linkage to an organizations vision, mission, objectives, and historical performance. In addition, although these processes are most often attributed to private sector operations, this course is designed to consider the similarities and differences of strategy development in government entities and nonprofits as well. There are no prerequisite courses.	U	4, 8, 12	focused
94413	Heinz College Wide Courses	Project Management	As organizations continue to look for ways to reduce costs, managers are often expected to oversee special projects in addition to their traditional responsibilities. When a project is too complex for one person to handle, the project manager is expected to lead a team of diverse employees to complete the assignment. This course will assist the project manager to break down a complex project into manageable segments, lead a diverse project team, and use effective tools to ensure that the project meets its deliverables and is completed within budget and on schedule. Over the course of the mini, students will complete a plan for an actual project, giving them valuable experience with the relevant tools and skills, including Microsoft Project software.	U	4, 8, 17	focused
94483	Heinz College Wide Courses	Applied Ethical Analysis	This course provides a framework to increase accountability through ethical decision-making. The goal of this course is to allow you to understand the complexity and consequences of decisions, the utility of ethics in personal and professional life, and the motivations of others (be they ethical or not). You will gain the ability to recognize and address underlying principles in a variety of contextual dilemmas. Students will learn to practically apply established theory and methodology to create and sustain trustworthiness. Case studies, small group discussions, scholarly readings, and videos will demonstrate the relevance and importance of applied ethics.	U	4, 6, 16	focused
94486	Heinz College Wide Courses	Advances in Robotic Process Automation	Today's new generation of sophisticated workforce robots act across business functions, integrate cloud and legacy applications, and are self-managing, scalable and fully dynamic. This course is an introduction into the fundamentals of Robotic Process Automation (RPA) and how it is transforming the world by combining software robotics with the power of artificial intelligence (AI) and machine learning (ML). During the class we will dig into the technology, understand how advanced RPA delivers business value, identify processes ripe for this automation, and build an RPA business case. We will also discuss the talent implications of bringing "bots to work" and the impact on the organization and its workforce. Throughout the course we will be joined by business leaders who will share their experiences and leverage exercises designed to provide hands-on automation opportunities including use of a test environment. For the final project, students will have the opportunity to be an "automation strategy consultant" that assesses and develops a business case for a real-world automation candidate.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
94700	Heinz College Wide Courses	Organizational Design & Implementation	This course draws on insights and knowledge about organizational behavior with an eye toward using such information for managing in complex organizations. It is intended to provide managers with skills and perspectives that will enable them to work successfully in organizations. Specific topics will include work motivation leadership job design biases in managerial decision making understanding group processes building bases of power in organizations managing conflict and the relationship between the organization and its environment.	G	4, 8, 9	focused
94701	Heinz College Wide Courses	Business Writing	This course focuses on effective writing techniques for professionals. Assignments include a business proposal, an employment letter, a memo, a performance evaluation, and interoffice correspondence. Since writing is a cumulative skill, an emphasis is placed on the revision process through in-class workshops. Students learn to communicate professionally and succinctly using a variety of business formats.	G	4, 8, 1	focused
94702	Heinz College Wide Courses	Professional Writing	Communication in written form is an essential element of management. Employers value talent with an aptitude for the effective exchange of information and ideas. Accordingly, this course focuses on teaching transferable writing skills pertaining to content, organization, format, clarity, and tone. The course challenges students to convey critical thinking as they anticipate the perspectives of stakeholders in professional situations, consider feasibility, evaluate options, and provide recommendations. Class meetings entail readings, discussions, and editing sessions on the following topics: business correspondence, press releases, Web content, consulting reports, executive summaries and proposals. Coursework emphasizes precise, concise, persuasive writing based on authoritative sources. Overall, students are expected to demonstrate an interest in professional development beyond simply completing the assignments. Writing resources and sample documents are provided.	G	4, 8, 9	focused
94705	Heinz College Wide Courses	Health Economics	This course will teach the student to use economic analysis to understand critical issues in health care and health policy. We will address issues such as the following: 1. What factors best explain the level and rate of growth of U.S. health expenditures? 2. Does the recent high rate of growth of U.S. health care expenditures make U.S. firms less competitive in international markets? 3. What are some of the likely consequences (intended and unintended) of the proposed reforms to Medicare? 4. Can physicians induce demand for their services? 5. What are the impacts of managed care on the health care system? 6. Do strong affiliations between physicians and health plans hurt competition? The student who successfully completes this course will be able to: 1. Identify the flow of resources in the U.S. health care system how purchasers pay for their services and how providers obtain their revenues. 2. Understand the value of health and health care. 3. Evaluate how health care resources should be allocated. 4. Describe the structure of the health insurance industry explain the incentives facing insurers understand the strategies they use to compete and their impacts on social welfare. 5. Understand the demand for medical care and what role providers play in shaping this demand. 6. Explain the economics of managed care and describe how competition works in health care. Class will consist of lectures and group presentations. Evaluation will include homework problems group projects and exams. This course will interest any individual planning a career in health or related industries. It will also be of interest to students who wish to understand how economics is applied to some of our most prominent and contentious policy issues. Skill.	G	1, 9, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
94706	Heinz College Wide Courses	Healthcare Information Systems	In a value-based care delivery environment with its emphasis on improving costs and service efficiency without risking quality of care, information technology has emerged as a powerful driving force in helping to achieve multiple goals within healthcare organizations. The explosive advances in information technology combined with the current challenges facing healthcare delivery have created the need for skilled individuals who can develop, understand, manage, and integrate healthcare information systems in organizations. This course will explore the concepts and application of major information systems methodologies and approaches in the delivery of modern healthcare systems, including traditional face-to-face, online, and mobile and social media enabled care delivery. A semester-long group project that synthesizes the different topics via the design and implementation of a working, integrated, healthcare decision support application will be a required component of the course.	G	9, 1, 12	focused
94806	Heinz College Wide Courses	Privacy in the Digital Age	Privacy is a complex and multi-faceted concept. This course combines technical, economic, legal, psychological, ethical, and policy perspectives to present a holistic view of its role and function in the digital age. The reduction of the cost of storing and manipulating information has led organizations to capture increasing amounts of information about individual behavior. New trade-offs have emerged for parties involved with privacy-enhancing or intrusive technologies: individuals want to avoid the misuse of the information they pass along to others, but they also want to share enough information to achieve satisfactory interactions; organizations want to know more about the parties with whom they interact, but they do not want to alienate them with policies deemed as intrusive. Is there a "sweet" spot that satisfies the interests of all parties? Is there a combination of technological solutions, economic incentives, and legal safeguards that is acceptable for the individual and beneficial to society? This course tries to address the above questions.	G	8, 9, 1	focused
95410	Information Systems:Sch of IS & Mgt	Blockchain Fundamentals	This class will be a deep-dive into blockchain technology. We will discuss the fundamental cryptographic under-pinnings of the technology as well as different consensus mechanisms currently available. We'll discuss both single-purpose blockchains such as Bitcoin as well as general-purpose implementations. We'll discuss govern-ance of blockchain technology and related challenges, as well as legal challenges and concerns. This course will also provide an overview of blockchain programming, highlighting both existing challenges and specific nu-ances in blockchain programming. Students should leave the class with a better understanding of what block-chain technology is, what types of problems are best suited for blockchain-based solutions, as well as a more thorough understanding of the impact that blockchain technology is having across the board.	U	4, 9	focused
95411	Information Systems:Sch of IS & Mgt	Blockchain Technologies	This is a hands-on course covering blockchain technologies. We will discuss cryptography, BitCoin, Ethereum, decentralized peer to peer systems, Merkle Trees, distributed hash tables, smart contracts, distributed consensus, Solidity, ERC-20 Tokens, distributed ledger use cases and CMU Coin, and self-sovereign identity. The course includes hands on lab exercises building smart contracts.	U	9, 15	focused
95433	Information Systems:Sch of IS & Mgt	Internet of Things	Prerequisites: The ability to program is a prerequisite. Course Description: Traditional products are becoming smart products and smart products are becoming connected. From smart homes to smart cities, this trend is likely to have a profound impact on our future. This course takes the view that the internet of things is best viewed as an extension of the World Wide Web. So, we will spend some time studying how the Web was designed and how its principles can be used to design the internet of things. This course combines weekly readings from journal articles with hands-on exercises and programming. The student will work with modern IOT technologies, standards, and platforms. We will connect sensors and actuators to the cloud but will do so in a way that is based on sound architectural principles.	U	4, 9, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
95444	Information Systems:Sch of IS & Mgt	Cybersecurity Policy and Governance I	The ability to secure information within a modern enterprise is a growing challenge. Threats to information security are global, persistent, and increasingly sophisticated. Long gone are the days when managers could hope to secure the enterprise through ad hoc means. Effective information security at the enterprise level requires participation, planning, and practice. Fortunately, the information security community has developed a variety of resources, methods, and best practices to help modern enterprises address the challenge. However, employing these tools demands a high degree of commitment, understanding, and skillattributes that must be sustained through constant awareness and training. An essential part of the information security plan is cyber security policy this includes the written plans for how the enterprise IT assets will be protected. This course provides students with information on the origin of cyber security policy, governance structures for policy creation, selection and implementation of policy, and audit and control functions to ensure compliance and efficacy. Students will be exposed to the national and international policy and legal considerations related to cybersecurity and cyberspace such as privacy, intellectual property, cybercrime, homeland security (i.e., critical infrastructure protection) and cyberwarfare, and the organizations involved in the formulation of such policies. Broader technology issues also are discussed to demonstrate the interdisciplinary influences and concerns that must be addressed in developing or implementing effective national cybersecurity laws and policies.	U	9, 4, 16	focused
95451	Information Systems:Sch of IS & Mgt	Making Products Count: Data Science for Product Managers	Product managers engage in a variety of complex activities critical to product success including - Gathering product requirements - Prioritizing features - Forecasting customer demand - Customer segmentation - Pricing - Allocating marketing spend - Identifying buying patterns - Analyzing and responding to customer feedback Historically decisions in these areas have often relied on intuition and guesswork, leading to misjudgment of the market and other key factors, and ultimately, product failures. Developments in data science, combining the increasing availability of data from internal and external sources with new algorithms that exploit that data at scale, offer new possibilities for putting product management decisions on a more quantitative and rigorous footing. Students in this course will be introduced to a variety of data science techniques applicable to activities to which product managers typically contribute. These techniques include preference modeling, time series forecasting, regression, clustering, classification, A/B testing, and analytics for unstructured data, including clickstreams, text, speech, and images. This course is for students who are looking for an introduction to applying data science to product management. Backgrounds in basic statistics, and some programming experience are required. Hands-on exercises in Python will illustrate the concepts, but please note this is not a Python class; students who are unfamiliar with Python will be given access to online tutorials to build up their Python skills. In-class exercises and weekly assignments will mainly focus on data science techniques and their application to decision making at various stages of the product life cycle. In the final project, students will select from a variety of data sets to address a product management issue in more depth, from framing the problem through modeling to communicating results.	U	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
95452	Information Systems:Sch of IS & Mgt	Introduction to Information Security Management	This course is intended to give students an introduction to a variety of information and cyber security topics. As a survey course, it will cover foundational technical concepts as well as managerial and policy topics. Coverage includes foundations of information security; introductory cryptography; program, data, and operating system security; security of user-web interaction; safeguarding the Internet of Things; cyberwarfare; securing virtual, cloud, and mobile environments; network concepts and network security; incident management and IT auditing processes; security risk management; legal and ethical issues of security and privacy. Students are exposed to common sources of vulnerability information and how to incorporate this information into information security management processes. The purpose of the course lectures, assignments, readings, and examinations are to ensure students have sufficient technical awareness and managerial competence that will enable them to pursue advanced study in information security policy and management. There is no prerequisite for this course, however successful students will have fundamental knowledge of information and computer systems, and a general awareness of security issues in these systems.	U	4, 9, 17	focused
95455	Information Systems:Sch of IS & Mgt	Information Security Risk Management I	This is an undergraduate course. Graduate students looking to take this course should register for 95-755. This course examines information security as a risk management problem where the organization identifies information security risks, evaluates those risks, and makes risk mitigation and acceptance decisions given its resource constraints. Students will learn foundational concepts in risk management and economic valuation and will be introduced to standard risk management approaches for identifying, analyzing, responding, and monitoring risks. Both qualitative and quantitative approaches will be examined.	U	4, 8, 1	focused
95481	Information Systems:Sch of IS & Mgt	Web Application Development	With to the ability to capture everything the users do, web applications are at the front lines of data analytics. Web applications should leverage analytics-based insights to adapt to their users. As such, this course is not simply an introduction to HTML/JavaScript programming. Approaches that we will cover includes the instrumentation of a web page to capture user behavior. We will analyze data indicators as an approach to characterize users. This will allow our development to be driven by the ability to personalize the web application experience. At the same time, the course will detail how the web application is used as input to search and advertising engines which use analytics to drive users, and what to do to optimize results. This course assumes no significant programming exposure, and is more highly structured to support the students that may or may not have a significant programming background. Note that all students will be initially added to the wait list, so you should come to the first class even if you are on the waiting list.	U	4, 17, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
95482	Information Systems:Sch of IS & Mgt	Enterprise Web Development	Please note that all students will be initially added to the wait list. Students are moved from wait list to the course based on various factors. Please come to the first class even if you are on the waiting list. This course assumes some previous programming exposure (variables, arrays, loops, and decision structure). Students without much programming experience should take 95-881, Web Application Development, which does not assume as much programming experience, and is much more structured to support students with less programming exposure. The course content will be different, meaning that 95-881 is not a subset of 95-882. Enterprise web applications are a complex relationship between the client, server, and any additional back-end services. Web systems are becoming more supportive of users such that the system must adapt based on the needs and behaviors of the users. This course will support the understanding of the data that drives the enterprise web development, which includes the analysis of web traffic and usage, ads, and the personalization of the web experience. This course focuses on the development of an enterprise web application with specific emphasis on the server-side enterprise web application programming and an n-tier system approach. The students in teams will design and develop a full enterprise web application including an n-tier implementation over the lifetime of the course. The development aspect will include server programming languages and systems (such as PHP, Django, Node) and database support (such as mySQL) as well as appropriate front-end development. Course evaluation will include weekly quizzes based on assigned readings, a cumulative final exam and a course project which is the enterprise web application that the students will build.	U	4, 17, 9	focused
95483	Information Systems:Sch of IS & Mgt	Ethical Penetration Testing	This course will introduce students to professional penetration testing by teaching offensive tactics along with the appropriate methodologies and responsibilities it takes to ethically attack systems. The majority of time will be spent in hands-on labs performing reconnaissance, discovering vulnerabilities, developing exploits, and carefully penetrating targets.	U	4, 9	focused
95702	Information Systems:Sch of IS & Mgt	Distributed Systems for Information Systems Management	With the emergence of the Internet as a computing platform, distributed applications are being widely deployed by organizations. Understanding the principles/theory and the technologies underlying distributed computing and systems design is increasingly important. Examples of technologies supporting such deployment include JEE architecture and Web services. This course has three major objectives. First, it is designed to introduce students to the principles underlying distributed computing and the design of distributed systems. Second, it aims to provide students with the opportunity to exercise these principles in the context of real applications by having the students use technologies such as XML, SOAP, Web services, and JEE-based application servers. Finally, it seeks to endow students with the capacity to analyze, design, evaluate and recommend distributed computing solutions skills in response to business problems. Distributed Computing Principles - Distributed computing architectures: P2P, client server - Inter-process communication - Distributed objects and remote invocation - Naming and Name services - Time and Global State Management - Transactions and Concurrency control - Distributed Transactions Material on principles of distributed systemsare taught from books such as Tannenbaum and Steen or the Coulouris et al. book on Distributed Systems. Internet-enabled Distributed Computing Technologies - Application Server architectures: JEE - Extensions of the Java Distributed Object model and the DCOM component-based architectures - Web Services: WSDL, UDDI, SOAP, XML - http-based RPC combined with standards for interface definition and naming. - Discussion and application of select API's from the API layer of the JEE architecture to illustrate distributed transactions, middleware access protocols (MQ Series API), and Messaging services (JMS).	G	4, 9, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
95717	Information Systems:Sch of IS & Mgt	Writing for Information Systems Management	Communication in written form is an essential element of management. Writing for business-focused, industry-specific contexts differs from academic writing. Accordingly, this course focuses on teaching transferable, career-enhancing writing skills: developing essential and persuasive content, applying logic, organizing information, targeting diverse audiences with varying levels of expertise and roles, addressing feasibility, ensuring clarity, controlling tone, maintaining format norms and designing documents for readability. The course challenges students to meet readers' needs by conveying critical thinking via anticipating the perspectives of stakeholders in professional situations. Coursework emphasizes precise, concise phrasing in actionable communications. Digital tips and strategies for collaborative writing will be discussed. Writing resources and sample documents will be provided. Note: This course assumes proficiency in English grammar. Numerous resources for improving written English skills are provided via Canvas.	G	4, 9, 17	focused
95718	Information Systems:Sch of IS & Mgt	Professional Speaking	Enrollment: limited to 10 students per section Students must attend the first meeting if they intend to enroll in the class. Whether we like it or not, all the skill, talent, and creativity in the world isn't enough in the workplace. The ability to actively communicate ideas quickly, credibly, and memorably is a key "soft skill" that is a requirement for senior workers, and a prerequisite for advancement in almost every industry. This course gives students who aren't natural-born presenters (which is about 99% of the population) some key skills, techniques, tricks, and insights into the essence of verbal communication in the enterprise, and will help you give your ideas the noticeability and power they need in todays marketplace. Whether you're looking for a job, a raise, a way to have your voice heard more convincingly and effectively in meetings, or funding for a big idea, your ability to effectively present yourself and your ideas is a critical and often overlooked skill.	G	4, 9, 8	focused
95752	Information Systems:Sch of IS & Mgt	Introduction to Information Security Management	This course is intended to give students an introduction to a variety of information and cyber security topics. As a survey course, it will cover foundational technical concepts as well as managerial and policy topics. Coverage includes foundations of information security; introductory cryptography; program, data, and operating system security; security of user-web interaction; safeguarding the Internet of Things; cyberwarfare; securing virtual, cloud, and mobile environments; network concepts and network security; incident management and IT auditing processes; security risk management; legal and ethical issues of security and privacy. Students are exposed to common sources of vulnerability information and how to incorporate this information into information security management processes. The purpose of the course lectures, assignments, readings, and examinations are to ensure students have sufficient technical awareness and managerial competence that will enable them to pursue advanced study in information security policy and management. There is no prerequisite for this course, however successful students will have fundamental knowledge of information and computer systems, and a general awareness of security issues in these systems.	G	4, 9, 17	focused
95818	Information Systems:Sch of IS & Mgt	Privacy, Policy, Law And Technology	This course focuses on policy issues related to privacy from the perspectives of governments, organizations, and individuals. We will begin with a historical and philosophical study of privacy and then explore recent public policy issues. We will examine the privacy protections provided by laws and regulations, as well as the way technology can be used to protect privacy. We will emphasize technology-related privacy concerns and mitigation, for example: social networks, smartphones, behavioral advertising (and tools to prevent targeted advertising and tracking), anonymous communication systems, big data, and drones. This course is part of a three-course series of privacy courses offered as part of the MSIT-Privacy Engineering masters program. These courses may be taken in any order or simultaneously. Foundations of Privacy (offered in the Fall semester) offers more indepth coverage of technologies and algorithms used to reason about and protect privacy. Engineering Privacy in Software (offered in the Spring semester) focuses on the methods and tools needed to design systems for privacy.	G	9, 4, 1	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
98012	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Fun with Robots	Fun with Robots is a hands on introduction to robotics. Absolutely no prior experience in programming, electronics, or robotics is needed. Students will learn to program their robot to complete fun challenges like finding a light or following a line. Through these labs we will introduce important robotics concepts used in robotics labs and in real-world robotics. We will cover basic sensors, circuits, programming, motors and motor control, and more! Students can keep their robots, a servo, and other electronics parts used in the labs after successfully finishing the course and paying $25 lab fee.	U	4, 9	focused
98038	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Anime From Astro Boy to Your Name	Anime is a limited animation style which originates from post World War II Japan, developed alongside Japanese Consumer Media into an artistic movement, and can be considered one of modern Japan's major cultural exports. Through this course, we will be exploring the history of the development of Anime and Contemporary Japan, as well as examining how these came to affect Anime and Anime Culture in the present day. This course is open to anyone with interest in Japanese Media History and Culture and does not require prior knowledge on the subject.	U	4, 11, 9	focused
98127	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Game Creation for Ppl Who Want to Create Games	In this course students will learn the basics of game creation. The course is intended for both beginners and experienced game designers. Students will learn fundamental tools like Unity, Audacity, and Photoshop.	U	4, 17, 9	focused
98163	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Introduction to Tetris	Students taking this course will learn about finesse and efficient piece placement, how to create T-spin and combo setups for quick line clearing, and dominate both speed and versus versions of the classic game of Tetris.	U	4, 12	focused
98174	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Great Ideas in Tech Interviews & Coding Screens	This course will teach students how to tackle questions commonly asked during technical interviews for internships and full-time job opportunities. Each lecture will focus on a different topic such as data structures, dynamic programming, and system design questions. Students will learn how to apply and modify classic algorithms and data structures from classes like 15-122 and 15-210 to solve problems that frequently show up in the coding challenges during the job interviews. We hope students come out of this course better prepared for the interview season, both technically and in terms of presenting themselves.	U	4, 9, 8	focused
98205	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Introduction to Minecraft	Minecraft is a widely popular computer game. It places you in a randomly generated world of blocks and sets you free to survive and be creative. This course will provide an in-depth introduction of how to play Minecraft, including basic survival skills, as well as exploring new areas the game has expanded into. Along with playing survival Minecraft together on a class server with custom plugins and fun features to explore, (such as dungeons and treasure hunts built by us,) we will play Minecraft minigames in class and explore possibilities such as playing on public servers and setting up modded Minecraft. This class is designed for both players completely new to the game as well as those with plenty of experience looking to play Minecraft with some new friends. The course will be mainly taught on a private class server, so students should purchase a copy of Minecraft before the first class. The game costs $27 and is required for the course.	U	4, 9, 8	focused
98212	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Competitive Computer Security	A fast-paced introduction to CTF (Capture the Flag) events. CTFs are offensive security competitions where players hack into competition-provided services in order to access and read the flag, scoring points for their team. These competitions generally focus on exploit development, reverse engineering, vulnerability research, cryptosystem analysis, and web platform exploitation. CTFs have grown into a massive international field, with Google, Facebook, Amazon, and Tencent among others sponsoring and hosting global CTFs. This course will guide students from a background understanding of computer internals through understanding where and how those can go wrong, culminating in being able to solve challenges found on major easy/medium-difficulty competitions.	U	4, 17, 9	focused
98230	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Avatar: The Last Airbender & The Legend of Korra	Explore the influences behind the shows Avatar: The Last Airbender and The Legend of Korra, such as Asian history, concepts of balance, and multiple forms of martial arts. Each week we will watch an episode pertaining to a topic and then discuss different elements of the episode as well as our opinions.	U	4, 9, 11	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
98242	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Intro to Esoteric Programming Languages	How do you fix the following compilation error: "PROGRAMMER IS INSUFFICIENTLY POLITE"? How do you bake a cake while printing "Hello world!" Welcome to the wonderful world of esoteric programming languages, where everything is possible but nothing of interest is easy. Learn how to write a program that you can't see, compute factorials using Magic: the Gathering, and compile a painting. Along the way, we'll answer questions like "What is a programming language?" and "Why does my compiler have indigestion?" Step into the realm of ">>[-]<<[->>+<<]" and come explore the outer boundaries of relatively sane computation.	U	4, 9	focused
98244	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Sign Language Through Pop Music	In this class, you will learn sign language to the rhythm of well-known music! Each class will cover a different topic, starting at fingerspelling and basic conversation and moving to signs for school and family topics. The history of sign language and deaf culture will be explored as well. Each week the assignment will be to learn the signs for the chorus of a song that uses words learned in class. The final project is to create a sign language music video or present a live choreography.	U	4, 11, 17	focused
98258	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Introduction to Competitive Pokemon	Do you want to be the very best, like no one ever was? Pounding the Elite Four into dust with your level 100 team is one thing, but defeating a human trainer on equal footing is another. Competitive Pokemon involves strategy, teambuilding, predictions, and a thorough understanding of battle mechanics, all under a rainbow of different battle formats, each with their own set of rules and playstyles. This course will introduce basic mechanics and teambuilding principles, as well as the most popular competitive formats such as VGC, Smogon singles, and Battle Spot singles. No competitive experience required, but experienced players may also learn something new! All teambuilding and battling will be done through the free online simulator Pokemon Showdown.	U	4, 10, 9	focused
98262	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Intro to Boardgames	This course will introduce students to the hobby of boardgames, nonstandard cardgames and miniature wargames. We will be playing a wide variety of game genres and investigating their mechanics, with the ultimate goal of expanding your knowledge of the wide varieties of games and understanding their mechanics enough to extend similar principles of play to games that use similar mechanics. What Kinds of Games will we be playing: Eurogames: Settlers of Catan, Carcassonne, Ticket to Ride, Stone Age, Puerto Rico, etc. Nonstandard Card Games: Fluxx, Pit, Race for the Galaxy, The Resistance, etc. Miniature Wargames (The games we will play are similar to): Warhammer (Fantasy/40K), Flames of War, Bolt-Action, Dystopian Wars, etc. Board wargames: Diplomacy, Axis and Allies, Battle Cry, etc. What Kinds of Games we will NOT be playing (Including but not limited to the following examples): Common household boardgames: Risk, Monopoly, Dominoes, Sorry, Apples to Apples, Scrabble, Clue, Life, Trivial Pursuit, etc. Standard 52 Card Deck Card Games: Blackjack, Poker, Rummy, etc. Traditional Games: Chess, Checkers, Go, Nine Man's Morris, etc.	U	4, 2, 1	focused
98269	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Intro to Sabermetrics & Exploring Baseball Data	Born in the 1970s and popularized by "Moneyball" as a radical challenge to traditional baseball statistics, sabermetrics has developed into a new way of understanding America's pastime. Its practitioners have created new statistical tools and revised our old ways of thinking about the game, transforming the way fans and front offices view and assess players. This introduction to the basics of sabermetrics will explain concepts including normalization, peak versus career performance, linear weights and runs created, as well as popular calculations like OPS (On-Base plus Slugging), WHIP (Walks and Hits per Inning Pitched), PF (Park Factor) and others increasingly used by members of the sabermetrics community.	U	4, 9, 8	focused
98272	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Financial Literacy for Beginners	This course is an introductory class designed to provide an overview of basic financial literacy. Based on the national Moneythink curriculum taught to high schoolers, this course will break down ways for each student to think about their own spending habits and come up with ways to make better financial decisions. We will start off with basic knowledge about budgeting, banking, credit/debit cards, and go into some of the basic economics you should know when handling any money. This course will also integrate simple monetary biases that people have, and how to tackle and handle those situations. Students should be able to balance their finances and have a financial goal for the future by the end of this course.	U	4, 8, 10	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
98288	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Star Wars: The Course Awakens	Do you hate sand? Do you constantly worry about the droid attack on the Wookies? If so, then this might be the class for you! You don't have to travel to a galaxy far, far away to take part in our discussion-based class about all things Star Wars. We'll follow our heroes Luke, Leia, Han, and Jar Jar Binks as we delve into the uniqueness of the most successful movie franchise ever made. But don't expect blind praise for all of Lucasfilm's work. We will critique each movie in-depth with analysis of the plot, character development, special effects, and, most importantly, memes. There will be a comprehensive exam at the end of the semester that counts for exactly 0% of your final grade, and we only require your attendance and participation. Are you ready for Star Wars StuCo?	U	4, 11	focused
98295	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Lock Picking and Physical Security	The purpose of this class is to both study the wide array of techniques used in modern-day security and to gain real skills in lock picking and bypass techniques. We will study the design of pin tumbler padlocks and deadbolts, which comprise the majority of locks one will encounter. Students will learn how to use single-pin-picking techniques to pick such locks. We will also look at bypass techniques such as unshielded padlock entry, bump keys, and padlock shimming. With this knowledge, students will be able to assess the security of their belongings and, of course, will never get locked out of their homes again. There is a fee of $30 per student to cover the cost of basic tools and a practice lock.	U	4, 9, 17	focused
98303	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Introduction to Freestyle Rap	Are you a fan of hip-hop who wants to learn how to create your own rhymes? Are you a quick-minded individual who enjoys a mental challenge? Have you ever heard a track and thought "damn, I just wanna drop some hot sh*t all over that beat"? Then this is the class for you. Freestyle rap is a difficult but rewarding mental exercise that, when mastered, is guaranteed to sound dope as hell. This class will start from the basics and work up to more and more complicated techniques. We promise that anyone who completes this class will be able to spit Sway-in-the-Morning-level bars, anytime, anywhere. All skill levels are welcome!	U	4, 8, 10	focused
98309	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Build Your Own Startup	This course follows a practical approach to learning about entrepreneurship. It focuses on startups centered around tech, in particular. Students are divided into teams within the class, who soon become their co-founders. Lectures cover interesting content related to entrepreneurship and tech such as product market fit, marketing strategies, financing a business, and wireframing. Every week is centered around one of these topics and students are expected to practically apply their understanding of those topics in their actual startup. Final grading is heavily focused on the student's pitch on his/her startup.	U	4, 9, 8	focused
98317	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Hype for Types	Type theory is a foundation of mathematics that can serve as an alternative to set theory. It is integral to programming languages, which rely on type systems to ensure code correctness. This course aims to go over fun and weird results in type theory that you might otherwise have to read complicated academic papers to understand, as well as to provide a foundation to help understand these fun results. We'll provide plain English explanations of concepts such as algebraic datatypes, derivatives of types, negative types, type isomorphisms, and the Curry-Howard correspondence. Some math and programming background (around the level of 15-150) is required, though a type theory background is not necessary.	U	4, 9	focused
98331	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Animation and Video Editing	Ever watch a cartoon and wonder how its animated? Ever see a music video and think how they edited it? Wish you could do the same? In today's age, time-based mediums such as videos are becoming one of the most viewed mediums. In this course, we will cover studio standards for making videos and animations by merging classing animation techniques with professional video-editing techniques and software. Students will be exposed to Hand-Drawn Animation, Vector-Based Animation, Video Editing, Kinetic Typography & Motion Graphics. This course covers the entire creative process from storyboarding & animatics to editing & post-production with tools such as After Effects, Flash Professional, Illustrator & Photoshop. No animation or art experience required.	U	4, 9	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
98336	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Introduction to Greek Mythology	Mythology came about as early as the twelfth century BCE in Ancient Greece, and was a vital part of Ancient GrecoRoman society. Even today, in the 21st century, the stories and lessons of Greek mythology influence and shape modern society. In this class, we will explore every aspect of Greek Mythology, from its stories of creation, to the major gods and goddesses and what they represent, and how it has influenced its successors, such as other religions of the world and the arts and theatre. We will dive into the world of Mount Olympus and try to answer why the power of storytelling in Ancient Greece had such a lasting impact on future generations, and how we can see manifestations of these stories and the lessons they teach in modern media. There is no prerequisite knowledge required for this class.	U	4, 11, 7	focused
98338	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Memes for StuCo-Taking Teens	Have you ever made a meme, posted it to an internet forum, and had it fail miserably? Perhaps you have found a hilarious meme on Reddit and wanted to know more about its origins. Join the creator of the CM Memes for Spicy Teens Facebook group and its mod team as we dive deep into the origins of memes, the subcultures created around "good content", and the future of Internet inside jokes.	U	4, 5, 9	focused
98352	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Introduction to Star Trek	Nerds: the final frontier. These are the voyages of the Star Trek StuCo. Its one semester mission: to explore strange new shows, to seek out new films and new episodes, to boldly go where no StuCo has gone before! This course is for everyone who wants to learn more about Star Trek. Whether you've watched no Star Trek, or all of Star Trek, this StuCo is an forum for fans to simply watch Star Trek and talk about it. We will spend each class discussing a different topic in the Star Trek universe, discussing plot elements, behind-the-scenes fun facts, and the impact Star Trek had on pop culture. Fee Structure: You are expected to watch Star Trek episodes as homework every week. This means you must have access to Star Trek episodes - Netflix, Prime Video, Hulu and CBS All Access have all the episodes we will watch in class. If a student does not have access to any of these services, they are expected to buy a subscription for the semester. This will cost at least $5.99 a month, depending on which service you choose to pay for.	U	4, 11	focused
98359	StuCo (Student Led Courses)	Student Taught Courses(StuCo): Survey of Horror in Media	This course aims to provide a brief introduction to the horror genre across multiple mediums. We will engage with works of horror from diverse sources(television, feature films, short stories, video games, fine art, and music) created over a period of nearly 200 years with the goal of pinpointing the characteristics of effective horror media. The course will be discussion based with attendance assessed through an in-class entry ticket and a post-discussion reflection. Each week, students will be expected to preview the materials for the discussion. The final assessment will be the student's choice between an argumentative essay on a work of horror of his/her choice or an original work. Final projects, regardless of choice, will be presented to the class during the final week. The course will feature material that is violent and often disturbing by nature.	U	4, 16, 9	focused
98368	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Introduction to the Kardashians	Have you had an intense desire to learn about Americas real first family, the Kardashians, your whole life and no way to fulfill it? Look no further than this course as we will go deep into the Kardashian-Jenner family history as well as their amazing reality TV show: Keeping Up With the Kardashians. By the end of this course, you can expect to be familiar with the entire family tree, be a full expert on all things Kardashian and know how to fight for and defend your favorite Kardashian regardless of the scandal that may be facing them. This is the course you may have never knew you wanted, but definitely needed.	U	4, 11	focused
98369	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Brooklyn Nine-Nine	Brooklyn Nine-Nine is a cop comedy that first aired in 2013 and is continuing to this day. This Emmy, Golden Globe, Critics Choice, and GLAAD Media award-winning show centers around Jake Peralta and the rest of the 99th precinct of the NYPD. Part of Brooklyn Nine-Nines success is due to their skill at balancing a comedic atmosphere while also addressing and discussing current social issues. In this class, you will learn about a social issue each week and then watch an episode that addresses said social issue. Some topics to be addressed include mental health, sexual harassment, racism, and LGBTQ+ representation. Anyone is free to join the noicest and toitest StuCo at CMU - no prior knowledge is required!	U	16, 5, 4	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
98371	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Introduction to Old Irish	In this course, we will learn the basics of the Old Irish language and relevant concepts in linguistics. Topics in Old Irish include orthography, sounds, noun declension, verb morphology and syntax. Topics in linguistics include historical linguistics, phonology, and the special status of Celtic languages in the Indo-European language family. We will read a variety of texts. Upon completion of the course, in addition to gaining an understanding of the topics above, students will be able to read and translate Old Irish text given a dictionary.	U	4, 11, 9	focused
98372	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Introduction to Battlestar Galactica	In 1982, Edward James Olmos played Detective Gaff in Blade Runner. Four years later, when offered the lead role on Star Trek: The Next Generation, he turned it down. Why? He didn't want to do any more sci-fi. Why, then, did Olmos agree to lead the reboot of Battlestar Galactica, a cheesy science fiction show from the 70s that earned most of its fans by coasting on Star Wars hype? Through the course of a semester, we attempt to answer this question, and in the process, explore Battlestar Galactica's impact on American society. This course is for everyone who wants to learn more about Battlestar Galactica. Whether you've watched no Battlestar Galactica, or all of Battlestar Galactica, this StuCo is a forum for fans to simply watch the show and talk about it. We will spend each class discussing a different topic in the Battlestar Galactica universe, discussing plot elements, behind-the-scenes fun facts, and the impact Battlestar Galactica had on pop culture.	U	4, 11, 16	focused
98373	StuCo (Student Led Courses)	Student Taught Courses (StuCo): The Legend of Zelda: The Tri Course	Nintendos The Legend of Zelda series has captivated video game fans for over thirty years as it has continuously evolved through new hardware and designs. In this course we will discuss various topics in the Legend of Zelda, both gameplay-wise and artistic, in an attempt to figure out what makes the series so appealing, and where it may go next. Experience or access to the games is not required. Its dangerous to go alone -- take this StuCo!	U	4, 9	focused
98374	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Steep by Steep: Investeagation into Tea Culture	Not only is tea one of the most widely consumed beverages in the world, but many cultures have developed unique traditions surrounding it. In this course, students will be introduced to the rich history surrounding tea in various countries including but not limited to the US, China, Japan, Russia, and Morocco. Students will also become familiar with a wide variety of brewing methods and types of tea as well as get the opportunity to sample some of these teas. There will be very short quizzes before every lecture on prior material covered. COURSE FEE: $2.	U	4, 11	focused
98375	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Introduction to Meta-Learning	This course is designed to better students studying and learning skills. Students, especially at elite colleges, have acquired extensive knowledge, yet many have never put adequate effort into considering the methods they use. This, of course, is counterintuitive because knowledge about how to learn is perhaps the most essential and widely applicable skill students can obtain. Successful learning is the foundation of excellence and discovery; therefore, students should be just as concerned with the process of improving as with the product of success. The first portion of the course will focus on scientifically-backed learning principles that are essential to problem solving such as the often-misinterpreted role of memory, recall, and attention. We will then transition into more specific learning strategies that apply these principles. Finally, the class will conclude with the role of lifestyle in learning and the habits of successful learners. By the end of the course students should be able to apply this knowledge at the university level, for personal projects, and beyond.	U	4, 9, 8	focused
98376	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Interpreting Film Through Painting	This course is meant to introduce students to painting in a fun and less traditional way. Throughout the course, students will paint their interpretations of the themes in different movies. The course is meant to help students, even those who do not consider themselves as artistic, to learn the basic techniques of painting and to apply them to fun subject material. Through their art, students will also learn to interpret thematic motif elements in films and add their own perspective to it in their art. COURSE FEE: $20. There is a $20 course fee to provide for materials (painting paper, paints, and canvas for the projects).	U	4, 9, 12	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
98377	StuCo (Student Led Courses)	Student Taught Courses (StuCo): The Way We Live Now	Have you ever thought about what the world would be like if Mark Zuckerberg was a woman? What music would you listen to if you didnt know what was popular? Isnt it weird that you could live next door to someone your entire life and experience life completely differently? If you have taken any tech classes here, have you ever discussed how and what ideologies are embedded into the systems we create? This course creates a space where students can grow together in their awareness of themselves in the context of the physical-digital space we live in today. Essentially, we want to explore the question What does it mean to be human in our times? in a casual, open setting.	U	4, 9, 5	focused
98378	StuCo (Student Led Courses)	Student Taught Courses (StuCo): First Clip to Video Editing	First Clip to Video Editing is a video editing course for beginners. Start with the basics of Adobe Premiere, you will learn various video editing skills from transitions to color grading and create your own cool projects. There will be plenty of chances to analyze existing works as well as hands on experiences. A professional camera is preferred but NOT compulsory. Through completing an individual midterm project and a group final project, students will gradually form their own workflow and editing style, communicating and expressing themselves in a new way.	U	4, 17, 9	focused
98379	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Neuroscience for Non-Majors	Anybody can learn neuroscience. Whether you are an artist, scientist, writer, philosopher, musician, or anyone else, as long as you are interested in how the mind works, this course is for you. Understanding the processes that determine your consciousness, emotions, reality, perceptions, and the only way you have ever experienced life is immensely powerful and meaningful. This introduction to neuroscience is tailored to accommodate for ANY background. The course will teach fundamental neuroscience concepts. It will also provide an overview of areas in current neuroscience research (learning and memory, neurodegenerative and psychiatric diseases, etc.), experimental techniques used in neuroscience research, and neuroscience applications in a variety of different fields ranging from science fiction writing to philosophy to artificial intelligence. Instead of a midterm or final exam, there will be two projects that encourage you to use your individual creativity and the unique backgrounds and sets of skills you bring to the course.	U	4, 3, 17	focused
98380	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Practical Economics	While Economics is an applied science, it is oftentimes described in abstract terms and graphs. This class aims to show how Economics can be used in the real world to solve the biggest problems facing society. Students will learn about and discuss topics such as Game Theory, Behavioral Economics, Inequality, and Automation. Students will better understand how to improve the world by making better decisions. No previous knowledge of Economics is needed.	U	4, 10, 1	focused
98384	StuCo (Student Led Courses)	Student Taught Courses (StuCo): Harmonious Scenic Watercolor	Watercolor is an expressive medium that captures the mood of the painter through clever use of color. This course will introduce you to various watercolor techniques, scenic painting practices and relevant color theory. Together, we will explore the beauty of nature using harmonious color palettes. No prior knowledge of watercolor or color theory is required.	U	4, 15	focused
99101	Carnegie Mellon University-Wide Studies	Computing @ Carnegie Mellon	Computing@Carnegie Mellon (C@CM) is a 3-unit, pass/fail mini course that will help you develop foundational computing and information literacy skills, focusing on the tools and technologies that are specific to Carnegie Mellon so you can be successful in your other academic courses. All undergraduate students are required to take the course. C@CM is offered in a hybrid format through the Open Learning Initiative's (OLI) online course environment; meaning that you'll complete your coursework online and attend a face-to-face recitation session for review and supplemental instruction.	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
99129	Carnegie Mellon University-Wide Studies	DC Grand Challenge First-Year Seminar: Unreality: Immersive and Spatial Media	Virtual news stories and game worlds are accessible by putting on cardboard goggles, theme parks are engineered to provide convincing multisensory experiences, and workforces are reliant on augmented views of factory floors. Immersive and spatial media constitute a suite of emerging technologies that offer the opportunity to expand arts, entertainment, science, design, commercial enterprises and countless other domains in ways that were previously limited to science fiction. The potential for augmented reality to disrupt our current technological ecosystem is tremendous. Many of these technologies are now 50 years old and just starting to enter the commercial realm. As immersive experiences and augmented realities become more integrated into our work and leisure, do we need to worry about the ways that unreality affect our experiences of reality, or our interactions with each other? How do we know that we can trust our senses to tell us what is real? How do we begin to grapple with the ethical, cultural, social, technological, and regulatory implications of this shift?	U	9, 15, 17	focused
99153	Carnegie Mellon University-Wide Studies	Mindful Living	The goal of this course is to increase students¿ internal resources for meeting stress through mindfulness-based meditation training. Each week, students will be trained in ¿formal¿ mindfulness meditation practices and asked to meditate at home with the help of brief guided meditation recordings. Students will also be given weekly ¿informal¿ mindfulness practice suggestions to help them translate the skills of formal meditation practice into daily life. Class meetings will give students the weekly opportunity for reflection, discussion, and questions based on their experience of formal and informal practice assignments.	U	4, 8	focused
99352	Carnegie Mellon University-Wide Studies	IDeATe: Soft Fabrication Skills	PLEASE NOTE: The specific meeting dates for the A1 section of this micro course are Sep 14, Sep 21, Sep 28. Textiles are a ubiquitous part of our everyday tactile experience. This workshop series aims to introduce textile techniques to participants with diverse backgrounds across the CMU campus. The fabrication skills and concepts that will be covered in this course will be taught from an interdisciplinary approach to merge practices in arts and technology. Students will learn methods of working with fabric such as hand and machine sewing, felting and knitting, along with merging aspects of digital fabrication and physical computing using flexible materials. Through discussions and demos, participants will have the opportunity to explore new methods of fabrication to integrate into their own practice.	U	4, 9, 12	focused
99353	Carnegie Mellon University-Wide Studies	IDeATe: CAD and Laser Cutting	PLEASE NOTE: The specific meeting dates for the A1 section of this micro course are Sep 28, Oct 5, Oct 12. The specific meeting dates for the A2 section of this micro course are Oct 27, Nov 3, Nov 10. This micro course is an introduction to Computer Aided Design (CAD) and the use of laser cutters for fabrication. Students will learn the basics of SolidWorks, a popular CAD package. They will also receive hands-on training in the use of laser cutters to turn their designs into physical objects. Students who complete this course PLUS the separate fire safety training will be able to use the IDeATe facility (Hunt Library) laser cutters on their own for future course work or personal projects.	U	4, 9	focused
99355	Carnegie Mellon University-Wide Studies	IDeATe: Introduction to Arduino	7PLEASE NOTE: The specific meeting dates for the A1 section of this micro course are Sep 27, Oct 4, Oct 11. The specific meeting dates for the A2 section of this micro course are Nov 1, Nov 8, Nov 15. This workshop aims to demystify the Arduino microcontroller through hands-on work in the lab creating simple machines with embodied behaviors. The Arduino is a versatile resource for physical projects for students in all disciplines. This course brings students over the beginner's threshold to a basic understanding of the use, terminology, and potential of the Arduino. The skills and concepts taught in this course are presented from an interdisciplinary approach which merges practices in arts and technology. The first portion will teach the essential skills for creating a simple sensor-driven physical computing system, and the second portion will reinforce those skills by making a simple interactive project. The course has no technical prerequisites, although uses a little bit of algebra-level math. Undergraduate students, graduate students, faculty and staff interested in learning new skills in an interdisciplinary environment are welcome!	U	4, 9, 8	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
99357	Carnegie Mellon University-Wide Studies	IDeATe: Pragmatic Photography	PLEASE NOTE: The specific meeting dates for the A3 section of this micro course are January 19, January 26, February 2. The specific meeting dates for the B3 section of this micro course are February 15, February 22, February 29. Pragmatic Photography is a digital imaging course for the non-photographer. A tech-first approach provides a strong grounding in the core concepts and techniques of image-based media. This course will enable students to create photographs for project documentation. This class will not require special cameras or software; students will use commonly-available photo-editing software to create images using DSLRs, point and click cameras, or their cell phones. The course focuses on general principles that apply across different equipment and software.	U	4, 9, 17	focused
99358	Carnegie Mellon University-Wide Studies	IDeATe: Introduction to the Unity Game Engine	PLEASE NOTE: The specific meeting dates for the A3 section of this micro course are January 19, January 26, February 2. The specific meeting dates for the B3 section of this micro course are February 15, February 22, February 29. This course is designed for students with little to no experience working with game engines as entry point into the field of game development. Students will learn the basics of the Unity3D engine, and to creatively and effectively build their own simple games. This course will cover topics such as navigating and using the engine, basic game programming in C#, user interface development and introductory game design principles. Students will be assessed based on the functionality of their games and will receive further feedback on their implementation, execution and creativity.	U	4, 9, 17	focused
99361	Carnegie Mellon University-Wide Studies	IDeATe Portal	Full descriptions of each section topic are available at https://courses.ideate.cmu.edu/99-361. IDeATe Portal courses introduce students to key aspects of critical, creative, and technical practice and prepare them to engage in productive interdisciplinary Collaborative Studio coursework in IDeATe minor areas. In section A: Inflatables, students will focus on the design, fabrication, and creative applications of sculptural and inflatable forms created from soft materials. Section B: Intelligent Environments highlights the motivation and requirements for intelligent environments and components that could be used to add functionality to existing environments. Section D: Learning About Learning is a hands-on experiential class where students will gain knowledge, expertise, and empathy towards how humans learn, how we learn from objects, how we learn from our spaces, and how our objects and spaces learn from us.	U	4, 9, 17	focused
99362	Carnegie Mellon University-Wide Studies	IDeATe: Intelligent Learning Spaces	Intelligent Learning Spaces explores the interactions between human learning and the spaces in which learning occurs. In this project-based course, students discuss, analyze, define, and apply theory from education, architecture and the arts to their project work. Students investigate precedents and existing experiences to create their own learning manifestos and designs. Imagination, in-class participation, speculation, empathy and 360-degree awareness are key components of this class. Students work on scaffolded projects that build on their knowledge to showcase their intentions and creativity, reacting to a variety of contexts relevant to learning. Students have opportunities to develop creative inquiry skills and apply critical perspectives through project-based work that requires experimentations, hands-on learning, reflection, and documentation.	U	4, 9, 17	focused
99363	Carnegie Mellon University-Wide Studies	IDeATe: Spatial Storytelling	Spatial Storytelling promotes the use of digital storytelling methods and methodologies across disciplinary topics. In this Spring mini, students are guided through the process from identifying a research problem, collecting data from diverse sources, learning specific geospatial mapping tools, and finally crafting narrative. They will work with spatial information (geospatial data) to build complex multimodal narratives around social issues. By the end of this course, students will know: what are spatial data, how to find and identify different types of spatial data, how to create a story based on data, and how to analyze data in geospatial software. Students will be able to develop constructive critique and data literacy skills to critically review peer work across disciplinary topics. Using competencies gained over the semester, students will create an online interactive narrative and to present it to the broader community.	U	4, 1, 17	focused

Course #	Department	Course Title	Course Description	Grad (G) Undergrad (U)	SDGs	sustainability-
99406	Carnegie Mellon University-Wide Studies	Directed Study in Education	This course supports the development and improvement of the dozens of educational outreach endeavors implemented by university academic departments, student organizations and others. It is important that we continually review, evaluate and improve the educational outreach offerings of the university to ensure that accurate information is being disseminated to the appropriate audience in a way that improves some aspect of life in the community. Students must prepare a final work product such as a report that demonstrates independent learning was achieved. For example, if the work is to determine the effectiveness of a university educational outreach program on the targeted population, the report should include information about the program, a review of literature related to the program goals, methods used to determine effectiveness (including any IRB approvals that are necessary), a summary of results, and recommendation of program improvement. Other projects may be designing, implementing or evaluating a new outreach offering, creating a more effective method for university students to learn about and participate in educational outreach programs, or in-depth research about a topic related to education of children, such as the funding system for public schools or a review of the preparation of teachers for classroom experiences across several countries. Note that other projects are acceptable. Students must submit a proposal for their semester-long project to the instructor before registration will be approved.	U	4, 17, 16	focused
99735	Carnegie Mellon University-Wide Studies	Proseminar in Entrepreneurial Leadership	The course is a required, one-unit weekly seminar for James R. Swartz Entrepreneurial Fellows and, if appropriate, other students such as undergraduate Innovation Scholars who are interested in entrepreneurship. Location: Swartz Center in Tepper Quad - Innovation Room, Floor 3.	G	4, 9, 17	focused