UNIVERSITY OF DELHI

CNC-II/093/1/EC-1273/25/
Dated: 13.05.2025
20

NOTIFICATION

Sub: Amendment to Ordinance V

(ECR 38-22 dated 17.01.2025)

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

The following syllabi of Department of Electronic Science under the Faculty of Inter-disciplinary and Applied Sciences based on Undergraduate Curriculum Framework 2022, are notified herewith for the information of all concerned:

(i) BSc. (Hons.) Electronics – Semester-VII and VIII ***(Annexure-1)***
(ii) BSc. (Hons.) Instrumentation – Semester-VII and VIII ***(Annexure-2)***

REGISTRAR

Annexure-1

ELECTRONIC SCIENCE

CORE AND DSE COURSES OFFERED BY DEPARTMENT OF ELECTRONIC SCIENCE

VII Semester

Category I

Electronics Course for Undergraduate Programme of study with Electronics as a Single Core Discipline

(B.Sc. Honours in Electronics)

DISCIPLINE SPECIFIC CORE COURSE –19: Control Systems

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Control Systems	4	3	-	1	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices	-

Learning Objectives

This course provides the fundamental understanding of Mathematical modeling and analysis of open loop and closed loop control systems in terms of electrical equivalent circuits. Student should be in position to explain the nature of stability of systems using different criteria and plots. They should be able to identify the Controllability and Observability of a system to explore its applications.

Learning outcomes

After successful completion of this course, student will be able to

- Analyze the concepts of open and closed loop control systems
- Develop the mathematical model of a physical system
- Analyze the stability of control systems with the help of different criteria and plots.
- Identify the needs of different type of controllers.
- Analyze controllability and Observability by state space models.

SYLLABUS OF ELDSC-19 Total Hours- Theory: 45 Hours, Practicals: 30 Hours

UNIT – I (11 Hours)

Introduction to classification of systems: Linear and Nonlinear systems, Time invariant and Time varying system, Continuous time and Discrete time system, Dynamic and Static system, SISO and MIMO, Open loop and Closed loop control systems, Transfer functions, Mathematical modelling of Physical systems (Electrical, Mechanical and Thermal), D.C. motors and A.C. servomotors, block diagram representation & signal flow graph, Mason's Gain Formula, Effect of feedback on parameter variations

UNIT – II (12 Hours)

Test input signals for transient Analysis, transient response of first , second and higher order system for different test input signals , Time domain performance parameters of second order System , Steady state errors and Static error constants

Concept of Stability: Effect of location of poles on stability, Asymptotic stability and Conditional stability, Routh – Hurwitz criterion, Root Locus techniques and their applications. concept and applications of PI, PD and PID controllers .

UNIT – III (11 Hours)

Advantages of frequency domain analysis, Frequency domain specifications, Correlation between time and frequency response, Polar plot, Logarithmic plots (Bode Plots), Gain and Phase margins, Nyquist stability criterion.

UNIT – IV (11 Hours)

Definition of State, State variables and State models, State Space Representation of dynamic systems (Electrical networks and nth order differential equation), State Transition Matrix, Decomposition of Transfer Function, Controllability and Observability.

Compensation Techniques: Concept of compensation techniques Lag, Lead and Lag-Lead networks

Practical component (if any) – Control Systems Lab

(Hardware and Scilab/MATLAB/Other Mathematical Simulation software)

Learning outcomes

The Learning Outcomes of this course are as follows:

- Perform experiments involving concepts of control systems
- Design experiments for controlling devices like AC/DC motor etc.
- Study behavior of systems

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. To study response of systems for various standard test input signals.
2. To study position and speed control of DC motor.
3. To find torque speed characteristics of AC servomotor.
4. To study time and frequency domain specifications of a control system.
5. To plot Bode, Root locus and Nyquist plots and determine stability.
6. To study the effect of PI, PD and PID controller on closed loop systems.
7. State space analysis for a given Transfer function

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than six.

Essential/recommended readings

1. J. Nagrath& M. Gopal, Control System Engineering, New Age International, 5th Edition, 2007
2. K. Ogata, Modern Control Engineering, Pearson, 5th Edition, 2010
3. B. C. Kuo and Farid Golnaraghi, Automatic control system, 9th Edition, Wiley, 2009

Suggestive readings

1. Joseph J Distefano, Allen R Stubberud, Ivan J Williams, - Control Systems, Schaum's Out lines, Tata McGraw Hill, third Edition, 2010

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE) COURSES OFFERED BY THE DEPARTMENT

DISCIPLINE SPECIFIC ELECTIVES (DSE-1)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Machine Learning ELDSE7A	4	3	-	1	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices	-

Learning Objectives

Machine Learning (ML) has emerged as one of the most dominant fields under AI, which has produced a significant impact in almost all the other sectors of science and technology including consumer electronics, robotics, Internet of Things and preventive health care to name a few. The primary focus of this course is to provide a comprehensive understanding of various advanced machine learning algorithms which can be used to design efficient automated systems and learning agents which are able to self-adapt and reprogram themselves according to their changing surroundings. These intelligent agents designed using ML algorithms have the ability to self-learn from the consequences of their past actions such that they can make improved decisions in the future.

Learning outcomes

After successful completion of this course, student will be able to

CO1 Develop a good understanding of machine learning concepts

CO2 Formulate a machine learning problem

CO3 Develop a model using supervised and unsupervised machine learning algorithms for classification, regression and clustering

CO4 Evaluate performance of various machine learning algorithms on various data sets of a chosen domain.

SYLLABUS OF ELDSE-7A Total Hours- Theory: 45 Hours, Practicals: 30 Hours

Unit I: (12 Hours)

A Brief overview of Machine Learning: Supervised Learning, Unsupervised Learning and Reinforcement Learning. Supervised Learning Vs. Unsupervised Learning. Classification Vs. Regression Analysis. Criteria for selecting training data and test data, concept of over-fitting and under fitting.

Supervised Learning : Regression Analysis in Supervised Learning- Linear Regression: Simple Linear Regression, Multiple Linear Regression, Polynomial Regression, Feature selection algorithms.

Classification algorithms in Supervised Learning - Linear models for classification, Logistic Regression, K-NN Algorithm, Decision Tree Classification Algorithm, Random Forest Algorithm, Support Vector Machine Classifier

Unit II : (11 Hours)

Unsupervised Learning: Clustering, K-Means Clustering Algorithm, Agglomerative Clustering, DBSCAN (density-based spatial clustering of applications with noise), Comparing and Evaluating Clustering Algorithms, Generating Association Rule, Principal Component Analysis (PCA), Non-Negative Matrix Factorization (NMF), Manifold Learning with t-SNE Clustering.

Unit III: (12 Hours)

Probabilistic Reasoning Models and Bayesian Learning:

Bayesian Networks- representation, construction and inference, Temporal model: concept of Transition probability. Naïve Bayes algorithm.

Markov Decision Process (MDP) Model: Simple Markov Model and Hidden Markov model, MDP formulation, utility theory, utility functions, value iteration, policy iteration and Q- Learning. Elements of MDP Model, Concept of Sequential Decision Processing, Example of MDP Problem: Agent in a grid world.

Reinforcement Learning: Passive Reinforcement learning and Active Reinforcement Learning.

Unit IV: (10 Hours)
Computational Learning Theory:
Probably Approximately Correct (PAC) learning model, Sample Complexity for finite hypothesis spaces, Sample Complexity for infinite hypothesis spaces, Mistake bound model of learning.
Instance Based Learning: Distance Weighted Nearest Neighbor algorithm.

Practical component (if any) – Advanced Machine Learning Lab
(Algorithms to be implemented in Python or any other suitable programming language)

Learning outcomes

At the end of this course, Students will be able to

CO1 Effectively use various machine learning tools
CO2 Understand and implement the procedures for machine learning algorithms
CO3 Design Python programs for various machine learning algorithms
CO4 Apply appropriate datasets to machine learning algorithms
CO5 Analyze the graphical outcomes of learning algorithms with specific datasets

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. Perform Simple Linear Regression and Multiple Linear Regression.
2. Write a program to implement Logistic Regression.
3. Write a program to implement the following algorithms
    a. K-NN Classifier
    b. Decision Tree Classification Algorithm
    c. Support Vector Machine Classifier
4. Write a program to implement K-Means Clustering Algorithm
5. Write a program to demonstrate Agglomerative Hierarchical Clustering
6. Write a program for construction and inference of a Bayesian network
7. Write a program to implement Naïve Bayes classifier.
8. Write a program to implement Simple Markov and Hidden Markov Model
9. Write a program to demonstrate sequential decision processing in Markov Decision Process model by considering the problem of an agent in a grid world

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than eight.

Essential/recommended readings

1. Introduction to Machine Learning with Python, by Andreas C. Müller, Sarah Guido, O'Reilly Media, Inc., 2016.
2. Machine Learning by Tom. M. Mitchell, Tata McGraw Hill, 1st ed (reprint) 2017.
3. Introduction to Machine Learning by Nils. J. Nilsson, 1998.
4. Introduction to Machine Learning by E. Alpaydin, PHI, 2005.

Suggestive readings

1. Machine Learning: A Probabilistic Perspective by Kevin P. Murphy, MIT Press, 2012.
2. Pattern recognition and Machine Learning by Christopher M. Bishop, Springer, 2006.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-2)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Neural Networks and Deep Learning ELDSE7B	**4**	**3**	**-**	**1**	**Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices**	**-**

Learning Objectives

This course aims to develop a fundamental understanding of the basic principles behind deep learning and focuses on learning complex, hierarchical feature representation from raw data. The course applies and evaluates deep learning on standard data set and suggests examples of how deep learning can be used in different domains. This course must enable student to read and critically assess papers on deep learning and their applications, such as Image classification, Natural Language Processing.

Learning outcomes

On successful completion of this course, students will be able to

CO1 Describe the major differences between deep learning and other types of machine learning algorithms.

CO2 Differentiate between the major types of neural network architectures (multi-layered perceptrons, convolutional neural networks, recurrent neural networks, etc.) and what types of problems each is appropriate for.

CO3 Design neural network architectures for new data problems based on their requirements and problem characteristics and analyze their performance.

CO4 Describe some of the latest research being conducted in the field and open problems that are yet to be solved.

SYLLABUS OF ELDSE-7B **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

Unit I: (11 Hours)
Introduction to Deep Learning:
Definition of Deep Learning (as a subset to Machine Learning, Artificial Intelligence), Intuition and the need of Deep Neural Networks, structure of Artificial Neural Networks (ANNs) (input layer, hidden layer, output layer), need of Activation Functions, types of Activation Functions (Threshold function, Sigmoid function, ReLU function, Hyperbolic Tangent function). Softmax

Unit II : (12 Hours)
Neural Networks:
Idea of Perceptron, Multi-Layer Perceptron, Feed Forward Networks (FFNs), Backpropagation, Loss of functions, Gradient Descent.
Introduction to the types of Deep Neural Networks: Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), Radial Based Networks, Deep Neural Networks, Long Short-Term Memory Networks (LSTMs), Learning/Training and optimisation algorithms for each type, Restrictive Boltzmann Machines (RBMs), Stacking RBMs, Belief Nets.

Unit III: (11 Hours)
Principal Component Analysis and Regularization:
Eigen values and Eigen vectors, Principal Component Analysis (PCA) and its interpretation, Singular Value Decomposition, Autoencoders and relation to PCA, Regularization in Autoencoders, Bias Variance Trade-off, L1 and L2 regularization, Dropout regularization, Early Stopping to prevent overfitting, Ensemble method.

Unit IV: (11 Hours)
Introduction to CNNs and Deep Learning Application:
Convolution, Filter (Kernels), Pooling, Deep CNNs, state of the art Deep CNN architectures – LeNet, AlexNet, VGG, ResNet, ShuffleNet. Weights initialization, Batch normalization, Hyperparameter optimization, Understanding and visualizing CNNs. Use of optimization methods for neural networks (AdaGrad, RMSProp, Adam), Second order methods for training.
Applications: Virtual Assistants, Chatbots, Image captioning, Self-Driving Cars, Natural Language Processing, Visual Recognition, Large Language Models (LLMs).

Practical component (if any) – Neural Network and Deep Learning Lab
(Python- using the Deep Learning Libraries)

Learning outcomes

At the end of this course, Students will be able to

CO1 Implement fundamental building blocks.
CO2 Apply their learning to real world scenarios.
CO3 Design NN architectures for new Data problems.

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. Write a program to predict Handwritten Digits using a Neural Network.
2. Write a program to predict whether the income of a person exceeds a certain amount per year based on specific criteria, using TensorFlow and any data set from a Machine Learning Repository
3. Write a program to analyze various aspects of an individual and predict what class of income he/she belongs to (example: >50k or <=50k) by using census data.
4. Write a program to classify images of cats and dogs using a neural network.
5. Write a program to predict the prices of stocks using the "Google stock price" data using LSTM.
6. For the dataset (California Housing Price/Pima Indians Diabetes), apply regularization techniques.
7. Apply PCA to reduce MNIST dimensions (visualizing eigenvalues/vectors), then train a neural network with L2/dropout regularization to explore bias-variance tradeoffs and prevent overfitting.
8. Fine-tune a pre-trained VGG19 model on Kaggle's Chest X-Ray dataset (5,863 images) to classify pneumonia vs normal cases, experimenting with batch normalization and learning rate decay while analyzing performance metrics.

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than seven.

Essential/recommended readings

1. Deep Learning, An MIT Press book, Ian Goodfellow and Yoshua Bengio and Aaron Courville http://www.deeplearningbook.org

2. S. Haykin, Neural Networks and Learning Machines, Prentice Hall of India, 2010
3. B. Yegnanarayana, Artificial Neural Networks, Prentice- Hall of India, 1999

Suggestive readings

1. Satish Kumar, Neural Networks - A Classroom Approach, Second Edition, Tata McGraw-Hill, 2013
2. C.M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-3)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Digital Communication System ELDSE7C	4	3	-	1	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices	-

Learning Objectives

The course introduces students to the fundamentals and key modules of digital communication systems with emphasis on digital modulation techniques and error and code detection. The basics of information theory, source coding techniques and entropy of source will also be covered.

Learning outcomes

On successful completion of this course, students will be able to:

- Understand the concept of digital communication system.
- Compare various digital modulation and demodulation techniques.
- Understand the effect of noise on system performances.
- Generate coding sequences for different error correcting codes.

SYLLABUS OF ELDSE-7C **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

UNIT – I (12 Hours)

An overview of sampling theorem and multiplexing.
Random processes, stationary processes, mean, correlation, and covariance functions: autocorrelation function, cross-correlation function, Power spectral density.
Information Theory: Entropy, Information rate and channel capacity: Hartley's law, Shannon Hartley's theorem, Source coding: Huffman coding.

UNIT – II (12 Hours)

Digital base band transmission and Reception: line coding (Unipolar Return to Zero (RZ), Unipolar Non-Return to Zero (NRZ), Bipolar NRZ, split phase Manchester, differential coding) comparison in performance and Power spectra density. Probability of error, ISI, Matched filter, probability of error using matched filter.

UNIT – III (10 Hours)

Digital Modulation Schemes: ASK(Amplitude Shift Keying), FSK(Frequency Shift Keying), PSK(Phase Shift Keying), DPSK(Differential Phase Shift Keying), QPSK(Quadrature Phase Shift Keying), QAM(Quadrature Amplitude Modulation) and M-ary coding. Constellation diagram, transmitter and receiver block diagram.

UNIT – IV (11 Hours)

Channel/line coding: ASCII and EBCDIC binary codes, Error, Error detection and correction using parity, checksum, Vertical redundancy Check (VRC), Longitudinal Redundancy Check (LRC), Cyclic Redundancy Check (CRC), Linear block code, Hamming code.

Practical component (if any) – Digital Communication System Lab
(Hardware and/or software using MATLAB/SCILAB)

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand sampling.
- Understand basic theories and generation and detection of Digital communication techniques.
- Simulate and use software for applications in communication electronics.

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. Study Sampling theorem using software.
2. Study of generation of Unipolar and bipolar RZ & NRZ Line coding.
3. Study of Amplitude Shift Keying (ASK).
4. Study of Frequency Shift Keying (FSK).

5. Simulate Phase Shift Keying (PSK)- Binary Phase Shift Keying (BPSK)- and Quadrature Phase Shift Keying (QPSK) using software.
6. Study of Quadrature amplitude Modulation (QAM).
7. Study the Hamming Code-7bit generation.

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than six.

Essential/recommended readings

1. W. Tomasi, Electronic Communication Systems: Fundamentals through Advanced, Pearson Education (2024), 5th Edition
2. S. Haykin, Digital Communication, John Wiley India (Circa 2021), 3rd Edition
3. B. Sklar, Digital Communication, 2nd Edition, Pearson Education (2024)
4. J.G. Proakis, Fundamentals of Communication Systems, Pearson Education (2024), 2nd Edition

Suggestive readings

1. L. W. Couch II, Digital and Analog Communication Systems, Pearson Education (2005)
2. H. P. Hsu, Analog and Digital Communications, Tata McGraw Hill (2006)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-4)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Optical Communication System ELDSE7D	4	3	-	1	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices	-

Learning Objectives

This course introduces the student to the fundamentals of optical communications, including the optical sources at the transmission station, the transmission medium, and the optical detectors at the reception station. The course aims to develop an understanding of the LASERS, optical amplifiers, and design considerations of a fiber optic communication systems, bit error rate and rise time budgeting and power budgeting.

Learning outcomes

On successful completion of this course, students will be able to:

- Describe the difference between LED and Laser diode (LD) and choose a proper light source for optical communication.
- Understand the design of an optical communication system, to calculate the power requirements for a given fiber optic communication link, and hence compute loss and dispersion.
- Understand various low loss optical communication windows, importance of 1330nm and 1550nm wavelengths in optical communications.
- Understand optical fiber amplifier including erbium doped fiber amplifier.

SYLLABUS OF ELDSE-7D **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

UNIT – I (12 Hours)
Sources for optical fiber communication: Optical Communication requirements, LASER fundamentals: Absorption and emission of radiation, condition for amplification of radiation, LASER oscillations. Basics of semiconductor lasers, laser diode characteristics, LED characteristics.

UNIT – II (10 Hours)
Detectors for optical fiber communication: Principle of optical detection, PIN photodetector, responsivity and quantum efficiency, speed of response, avalanche photodetector

UNIT – III (12 Hours)
Design considerations of fiber optic communication system: Characterization of an optical fiber: measurement of its radius, numerical aperture, cut-off wavelength (Marcuse's formula) Analog and digital modulation (direct), noise in detection process: shot noise, thermal noise, SNR, Bit error rate (BER), system design: power budgeting, rise time budgeting

UNIT – IV (11 Hours)
Optical Fiber amplifiers: Wavelength dependence of loss and dispersion of a single mode fiber and various loss windows: significance of 1300nm and 1550nm wavelength in optical communications. Introduction to semiconductor optical amplifiers, Block diagram of an optical amplifier at 1550nm communication wavelength, Optical amplification, absorption and emission cross-sections for a typical erbium doped fiber amplifier, Energy levels of erbium ions in silica matrix

Practical component (if any) – Optical Communication System Lab
(Hardware and/or software)

Learning outcomes

The Learning Outcomes of this course are as follows:

- Perform experiments based on LEDs and laser diodes.
- Characterize an optical fiber in terms of measuring its radius, numerical aperture, and cut-off wavelength.
- Design an optical link and calculate the power budgeting.
- Understand an optical fiber amplifier.

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. To study the characteristics of LED.
2. To study the characteristics of semiconductor laser diode.
3. To study the characteristics of Silicon and Germanium photo-detectors.
4. To couple optical light into SMF and MMF and study the fundamental mode pattern and the speckle pattern.
5. To measure the parameters of a single mode optical fiber: radius, numerical aperture, cut-off wavelength.
6. To design an optical communication link and study power budgeting (simulation).
7. To design an optical circuit showing direct analog and digital modulation schemes.
8. To study the bending losses in an optical fiber link.
9. To study an EDFA (simulation).
10. Study of an OTDR instrument.

ONLINE virtual lab:

1. Amrita Vishwa Vidyapeetham Virtual Lab
2. Virtual Labs ofcvlab.vesit.ves.ac.in

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than nine.

Essential/recommended readings

1. Ajoy Ghatak and K Thyagarajan, Introduction to Fiber Optics, Cambridge University Press, New Delhi (2024)
2. D.K. Mynbaev and Lowell L. Scheiner, Fiber-Optic Communication Technology, Pearson Education (2024).

Suggestive readings

1. J. M. Senior, Optical fiber communication systems: principles and practice, Pearson Education in south Asia, (2009).
2. J. Gower, Optical communication systems, Pearson Education
3. G. Keiser, Optical communications, McGraw Hills education (2003)
4. M. R. Shenoy, S. K. Khijwania, et al., Fiber optics through Experiments, Viva books (2011)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-5)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
CMOS Digital VLSI Design ELDSE7E	4	3	-	1	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices	Digital Electronics, Analog Electronics-I & II, Basic VLSI Design

Learning Objectives

This course introduces the student to develop the ability to design and analyze combinational and sequential digital circuits using VHDL/Verilog; design methodologies of memory circuits such as SRAM and DRAM; acquire hands-on skills in layout design and to simulate and analyze VLSI circuits, including post-layout simulations

Learning outcomes

On successful completion of this course, students will be able to:

- Design and analyze CMOS-based combinational and sequential circuits, focusing on performance metrics like power, delay, and reliability.
- Design and evaluate memory circuits, including SRAM and DRAM, considering trade-offs in stability, speed, and power.
- Demonstrate proficiency in creating and verifying layouts of digital circuits, ensuring adherence to design rules and industry standards.
- Utilize EDA tools for circuit design, simulation, and layout verification.

SYLLABUS OF ELDSE-7E   Total Hours- Theory: 45 Hours, Practicals: 30 Hours

UNIT – I (12 Hours)

HDL: History of HDL; Structure of VHDL; VHDL Modules : entity, architectures, concurrent signal assignment; Data Flow Modelling, Structural Modelling, Behavioural Modelling.

UNIT – II (14 Hours)

Verilog: Verilog/VHDL Comparisons; Module, Data Types, Operators and Expressions, Instantiation and Hierarchical Design, Blocking and Non-Blocking Assignments, Gate Level, Dataflow and Behavioural Modelling, RTL, Verilog Tasks and Functions, Design Flow and Verilog Test Bench

UNIT – III (10 Hours)

SRAM and DRAM : 6T SRAM cell design and read & write-operation, stability analysis and noise margins, stick diagram of a traditional 6T SRAM cell, DRAM architecture and refresh mechanism, DRAM Architecture - One-transistor, Three-transistor and Four-Transistor DRAM cell, DRAM subarray -Open and Folded Bitlines.

UNIT – IV (09 Hours)

Layout Design Rules and DRC : basic layout design rules, metal layers, contacts, and vias in CMOS layouts, design rule checks, layout versus schematic, Inverter Cell Layout. Introduction to - post-layout simulation; parasitic extraction; full-custom layout design; concept of standard cell & parameterized cells; importance of VLSI CAD tools; ASIC design flow vs. FPGA flow.

Practical component (if any) – Digital VLSI Design Lab

(Practicals to be performed using VHDL/Verilog, Ngspcie/LTspice/QUCS, kiCAD/MagicVLSI, XCircuit, OpenRAM, CADENCE/MENTOR GRAPHICS)

Learning outcomes

The Learning Outcomes of this course are as follows:

- Apply VHDL/Verilog to design the Digital Circuits
- Get familiarized with the VLSI design Simulation Tools
- Create Layout of a CMOS inverter and perform design rule checks (DRC).

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. Design Full Adder/Subtractor using VHDL.
2. Design a Counter using VHDL.
3. Design MUX/Multiplier Circuit using Verilog
4. Design ALU using Verilog
5. Design a 6T SRAM cell, simulate its read/write operation.

6. Draw the stick diagram for a CMOS inverter and basic gates like NAND and NOR.
7. Create the layout of a CMOS inverter, ensuring compliance with basic design rules. Perform design rule checks (DRC).
8. Perform post-layout simulation for a CMOS inverter, including parasitic extraction. Analyze the impact of parasitics on circuit performance.

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than seven.

Essential/recommended readings

1. J. Bhasker, A Verilog® HDL Primer, BSP, 3rd Edition, 2024, ISBN: 9788178001425
2. Samir Palnitkar: Verilog HDL-A guide to digital design and synthesis-, Pearson, 2003, ISBN- 0-13-044911-3 / 978-0130449116
3. Wayne Wolf: Modern VLSI Design: IP-Based Design, PHI, 4th Edition, 2015, ISBN-9780137145003
4. Weste and Harris: CMOS VLSI Design: Circuits and Systems Perspective, Pearson/Addison-Wesley,4th Edition, 2010, ISBN- 9780321547743
5. Kang and Lebelbigi: CMOS Digital IC Circuit Analysis and Design, McGraw-Hill Education, 4th Edition, 2014, ISBN- 9780073380629

Suggestive readings

1. Jan M. Rabaey, Anantha Chandrakasan, and Borivoje Nikolic: Digital Integrated Circuits: A Design Perspective, Prentice Hall Electronics, 2003, ISBN-10 0130909963; ISBN-13 978-0130909961
2. Randall L. Geiger, Phillip E. Allen, and Noel R. Strader: VLSI Design Techniques for Analog and Digital Circuits, McGraw Hill, 1989, ISBN-10 0070232539; ISBN-13 978-0070232532

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-6)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introduction to Nanoscience ELDSE7F	4	4	-	-	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices	-

Learning Objectives

This course introduces the student about nanoscience, which includes the fundamental understanding of effect of size and the related physics involved behind it. They will study fundamentals of quantum physics and its applications in nanoengineering and properties of nanostructures as well as nanomaterials.

Learning outcomes

On successful completion of this course, students will be able to:

- Develop the fundamental base of nanoscience.
- Acquire knowledge of effect of size and the related physics involved behind it.
- Understand the behavior and properties of nanomaterials.

SYLLABUS OF ELDSE-7F **Total Hours- Theory: 60 Hours**

UNIT – I (13 Hours)

Introduction to Nanoscience: Definition and Importance of Nano, Opportunities at nano scale, Scientific revolution- emergence and challenges of nanomaterial and nanotechnology with examples (daily life, health care and energy)

Implications of Nanoscience and Nanotechnology on Society, Harnessing Nanotechnology for Economic and Social Development

Influence of nano over micro/macro, surface to volume ratio-dangling bonds, chemical activity of nanoparticulates, sensing applications with example of graphene. Size effects-idea about electronic wave function, Population of the conduction and valence bands, Quasi Fermi levels, examples of metal nanoparticles.

UNIT – II (17 Hours)

Fundamentals of Quantum Theory: Origins of Quantum Physics, Particle properties of waves: Black body radiation, Photoelectric effect, Compton Effect; Wave properties of particles: De Broglie waves, Wave description, Particle diffraction, The Wave Particle Duality, The Uncertainty Principle, The Wave Packet and the Wave Function, The Schrödinger Equation, The Expectation Value, The Free Particle Solution, The Linear Harmonic Oscillator Problem, The Kronig-Penney Model for Electron in a 1-Dimensional Lattice

UNIT – III (13 Hours)

Quantum Nanoengineering:

Particle in a Box, Quantum Limit: From 3D to 0D, Quantum Confinement in Semiconductors: Potential Step, Potential Barrier, Quantum Well. Atomic structure: Electron orbits, The Bohr atom; Quantum Structure: 2D (Quantum well), 1D (Quantum Wires), 0D (Quantum Dots);

3D Density of States, 2D Model- Energy Eigen values and Density of States, 1D Model-Energy Eigen values and Density of States, Q0D Model- Energy Eigen values

UNIT – IV (17 Hours)

Quantum Effect on Properties of Nanostructures and Nanomaterials: Melting Point-Variation in bulk vs nanoparticles, nanowires, nanosheets, superheating, liquid drop model (Quantitative); Electronic structure and Optical Properties-band gap dependence on the size of the nanoparticles(quantitative), concept of excitons; Mechanical Properties- ductility, strain hardening, yield stress, dynamic response, creep(qualitative); Dielectric Properties- particle size dependence of refractive constant, extinction coefficient (quantitative), Magnetic Properties-idea about diamagnetism, paramagnetism, ferromagnetism, Curie temperature, remanent magnetization, coercive field; saturated magnetization and its dependence on size and temperature(quantitative)

Size dependent electronic Properties (Classification of materials based on band structures - Brillouin zone – Effect of temperature, Quantized conduction, Ballistic transport, Coulomb blockade).

Practical component (if any) – None

Essential/recommended readings

1. Introductory Nano science by Masuro Kuno, Garland science (2011)
2. Concepts of Modern Physics by Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, MedTech Science Press, 8th Edition, 2024
3. Nanophysics and Nanotechnology by Edward L. Wolf Wiley-VCH-2006
4. Nanotechnology: Principles & Practices, S.K. Kulkarni, Springer, 2015.

Suggestive readings

1. Introduction to Nanomaterials and Devices: Omar Manasreh (Wiley), 2011
2. Introduction to Nano, Basics to Nanoscience and Nanotechnology, Amretashis Sengupta, Chandan Kumar Sarkar Editors, 2015, Springer, ISBN 978-3-662-47313-9
3. Textbook of Nanoscience and Nanotechnology, B S Murty and others, 2013, Springer, e-ISBN 978-3-642-28030-6

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-7)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Embedded System Design with ARM ELDSE7G	4	3	-	1	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices	

Learning Objectives

The course aims to introduce students to ARM microcontroller architectures. Students will gain an understanding of the core features, instruction sets, and peripheral interfacing capabilities of ARM Cortex-M3 microcontrollers. The course further intends to equip students with practical skills in assembly and embedded C programming, along with foundational knowledge of real-time operating systems (RTOS), enabling them to design, develop, and troubleshoot embedded systems effectively.

Learning outcomes

On successful completion of the course, student will be able to:

- Describe the architectural features and instructions of ARM Cortex-M3 microcontroller.
- Apply the knowledge gained for programming ARM Cortex-M3 to interface peripherals for different applications.
- Apply RTOS concepts such as task scheduling, synchronization, interrupts, and timers in embedded systems.
- Analyze and debug embedded system applications using ARM Cortex-M3 microcontrollers.

SYLLABUS OF ELDSE-7G **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

Unit – I (11 lectures)
ARM Microcontroller Architecture:
Introduction to ARM microcontroller families, features, and applications. Thumb-2 technology, Architecture of ARM Cortex-M3, various units in the architecture, General Purpose Registers, Special Registers, Exceptions, Interrupts, Stack Operation, Reset Sequence, Debugging Support.

Unit – II (11 lectures)
ARM Cortex-M3 Instruction Set:
Assembly basics, Addressing Modes, Instruction lists and description, Thumb and ARM instructions, Special instructions, Useful instructions, CMSIS, simple assembly language programs.

Unit - III (11 lectures)
ARM Cortex-M3 Peripherals:
ARM Cortex M3 Peripherals: GPIO control, Timer configurations, and basic Interrupt handling, Introduction to Embedded C programming for ARM. Peripheral programming in Assembly and Embedded C language.

Unit - IV (12 lectures)
RTOS Based Embedded System Design:
Operating System Basics, Types of Operating Systems, Architecture of an RTOS, Important features of RTOS, Embedded Systems Programming, Locks and Semaphores, Operating System Timers and Interrupts, Exceptions, Tasks. Task states and scheduling, Synchronization, Real-time clock and system clock.

Practical component (if any) – Advanced Embedded System Design with ARM Lab
(Practicals to be performed using Hardware/Simulator)

Learning outcomes

The Learning Outcomes of this course are as follows:

- Write Assembly language/C Language program for ARM Processor.
- Able to interface and program peripherals like LED, actuators, LCD display etc. on ARM Ports.
- Prepare the technical report on the experiments carried.

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. Write a program to perform arithmetic operations on two 32-bit numbers.
2. Write a program to generate an A.P. / G.P. / Fibonacci series.

3. Write a program to sort a given list of 32-bit numbers in ascending/descending/reverse order.
4. Write a program to configure and blink / toggle GPIO pins at a specific rate.
5. Write a program to design a counter (decade, hexadecimal, etc.) on an LCD / 7-segment display.
6. Write a program to read a 4×4 keyboard and display the key code on an LCD / 7-segment display.
7. Write a program to generate PWM signals to control the brightness of an LED.
8. Write a program to control the speed of a DC motor
9. Design RTOS Based Parameter Monitoring and Controlling System for collecting the data from sensor interfaced with microcontroller.
10. Implement a real-time clock using RTOS timers

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than nine.

Essential/recommended readings

1. Joseph Yiu, "The Definitive Guide to ARM CORTEX - M3 and CORTEX M4 Processors" 3rd Edition, Newnes, (Elsevier), 2014. ISBN: 978-0124080829.
2. K.V.K.K Prasad, "Embedded Real Time Systems", Dreamtech Publications, 2003. ISBN: 978-8177224610
3. Raj Kamal, "Embedded Systems", 3rd Edition, McGraw Hill Publications, 2017. ISBN: 978-9332901490
4. Colin Walls, "Embedded RTOS Design: Insights and Implementation", 1st Edition, Newnes, (Elsevier), 2020. ISBN: 978-0128228517

Suggestive readings

1. Yifeng Zhu, "Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C", 3rd Edition, E-Man Press LLC, 2017, ISBN: 978-0982692660
2. Jonathan W. Valvano, "Embedded Systems: Real-Time Operating Systems for ARM Cortex-M Microcontrollers", 2nd Edition, Createspace Independent Pub, 2012. ISBN: 978-1466468863

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

ELECTRONIC SCIENCE

CORE AND DSE COURSES OFFERED BY DEPARTMENT OF ELECTRONIC SCIENCE

VIII Semester

Category I

Electronics Course for Undergraduate Programme of study with Electronics as a Single Core Discipline
(B.Sc. Honours in Electronics)

DISCIPLINE SPECIFIC CORE COURSE –20: Power Electronics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Power Electronics	4	3	-	1	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices	-

Learning Objectives

This course introduces the student to the fundamental understanding of power control in domestic and industrial applications through semiconductor devices. It also familiarise students with role and advantage of power semiconductor devices in automating the control of heavy machinery or power control circuits. This course forms the basis for bridging the knowledge of circuits, devices, embedded systems, machines and controls systems together, useful for the present era of e-control in every domain.

Learning outcomes

On successful completion of this course, student will be able to:

- Understand the salient features and applicability of various types semiconductor devices through comparative study for power control
- Understand the construction, working and control of thyristors for power applications
- Develop understanding of various methods of conversion between DC and AC power
- Apply the learning for power control in real-life domestic applications

SYLLABUS OF ELDSC-20 **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

UNIT – I (12 Hours)

Power Semiconductor Devices:

Definition and Applications of Power Electronics, Need and History of Power Semiconductor Devices, Introduction of various Power Semiconductor Devices (Power diodes, different types of Transistors and Thyristors), Vertical structure, Enhancement of voltage blocking and current carrying capability.

Power Transistors: Comparative study (structural, operational, functional, specifications) of Power BJT, Power MOSFET and IGBT as power switch: Vertical structure, Enhancement of voltage and current rating, IV characteristics, Safe Operating Area, switching characteristics/performance, equivalent structure

Second breakdown, saturation and quasi-saturation state in BJT, inversion in Insulated Gate Bipolar Transistor(IGBT), Latch-up in IGBT

Thyristors: Comparative Study of Silicon Controlled Rectifier(SCR), Diode for Alternating Current(DIAC), Triode for Alternating Current(TRIAC) and Gate Turn-Off Thyristor(GTO) as power switch: Structure, IV characteristics, utility

Comparative of specifications of Power BJT, Power Metal-Oxide-Semiconductor Field-Effect Transistor(MOSFET), IGBT, SCR and GTO

UNIT – II (10 Hours)

Semiconductor Controlled Rectifier (SCR):

Dynamic Turn-on and Turn-off characteristics, Turn-on methods, Gate triggering circuits (R, RC and Unijunction Transistor(UJT) triggering), Gate characteristics, Forced Commutation circuits, Voltage commutation, Current commutation, Load commutation, Two Transistor model, Internal regeneration, Factors affecting the characteristics/ratings of SCR, Protection of SCR, gate protection, di/dt and dv/dt protection using snubber circuit, series and parallel combination of SCRs

UNIT – III (13 Hours)

DC Power Control:

Single phase AC-DC converters: Phase-controlled rectifiers, half wave-controlled rectifier with resistive and inductive load, full wave-controlled rectifier using centre-tapped transformer and bridge configuration for resistive and inductive load, use of free-wheeling diode

DC-DC converters: Basic chopper circuit and classification, control strategies, step-up/down chopper (using both SCR and MOSFET), Class A-E choppers, Jones Chopper (load sensitive voltage commutation), Morgan's chopper

Applications of Phase-controlled rectifiers and choppers like DC motor speed control (in both directions), Light intensity of LED array, Variable DC power supply

UNIT – IV (11 Hours)

AC-AC converters: variable-voltage single phase AC power control, SCR and DIAC triggered TRIAC for half wave, full wave AC power control with inductive & non-inductive loads variable-frequency AC-AC Converters, introduction to single phase cycloconverters with resistive and inductive loads

DC-AC converters: Classification of inverters, Improved series inverter, limitations of series inverter, Parallel inverter with reactive feedback, single phase bridge inverter, introduction to McMurray Inverter, voltage control using PWM

Thyristor based control of domestic appliances like fan/others and Speed control of induction motors (block diagrams only)
Idea of Applicable IS/IEC Standards for Invertors and UPS.

Practical component (if any) – Power Electronics Lab
(Hardware and Software Simulation using Multisim/MATLAB/Other Electronics Simulation Software)

Learning outcomes

The Learning Outcomes of this course are as follows:

- Functioning and control of different types of transistors and thyristors
- Working of DC Power control circuits
- Working of AC Power control circuits
- To design and develop a small power control system

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. Study of IV characteristics of SCR/TRIAC, MOSFET/IGBT (Familiarity with use of commercially available Data-Sheet)
2. SCR based phase-controlled rectifier with (a) R and RC triggering (b) R and RL loads (c) with and without free-wheeling diode
3. SCR/MOSFET based chopper (DC-DC converter)
4. AC-AC voltage controller using SCR/TRIAC (a) R and RC triggering (b) R and RL loads (c) with and without free-wheeling diode
5. Study of series, parallel and bridge inverter
6. Study of single phase cycloconverter
7. Micro-projects based on power electronics (at least one)
    a. DC motor control using SCR/IGBT based rectifier (AC-DC converter)
    b. Battery eliminator with 0-12V, 1A rating
    c. AC motor (Fan) speed control using DIAC triggered TRIAC
    d. AC voltage controller using TRIAC with UJT triggering

e. SCR based temperature controller using thermistor
f. Light intensity controller in an LED array
g. Any other similar circuit

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than five and one micro-project.

Essential/recommended readings

1. Principles of Electric Machines and Power Electronics, P.C. Sen, John Wiley & Sons, 3rd Edition, 2013
2. Power Electronics Circuits, Devices and Applications, M.H. Rashid, Pearson Education, 4th Edition, 2024
3. Power Electronics, P.S. Bimbhra, Khanna Publishers, 7th Edition, 2024
4. Power Electronics, M.D. Singh & K.B. Khanchandani, McGraw Hill Education, 2nd Edition, 2014

Suggestive readings

1. Power Electronics: Devices, Circuits and Industrial Applications, V.R. Moorthi, Oxford University Press
2. Power Electronics, K. Hari Babu, Scitech Publishing
3. An Introduction to Thyristors and their applications, M. Ramamoorty, Palgrave Macmillan/East West Press

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE) COURSES OFFERED BY THE DEPARTMENT

DISCIPLINE SPECIFIC ELECTIVES (DSE-1)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Natural Language Processing ELDSE8A	4	3	-	1	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices	-

Learning Objectives

This course introduces the student to the fundamental understanding of Natural Language Processing (NLP) which is a rapidly developing field with broad applicability throughout the hard sciences, social sciences, and the humanities. This course is intended as a theoretical and methodological introduction to the most widely used and effective current techniques, strategies and toolkits for natural language processing, with a primary focus on those available in the Python programming language.

Learning outcomes

On successful completion of this course, student will be able to:

CO1 Analyze the natural language text.

CO2 Define the importance of natural language.
CO3 Understand the concepts of Text mining.
CO4 Illustrate information retrieval techniques.
CO5 Analyze the natural language text.

SYLLABUS OF ELDSE-8A **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

Unit I: (11 Hours)
Overview and Language Modeling:
Origins and challenges of NLP-Language, Phases and components of NLP, Applications-Information Retrieval, Unigram Language Model, Bigram, Trigram, N-gram, Advanced smoothing for language modelling, Empirical comparison of smoothing techniques, Applications of Language Modelling.

Unit II: (12 Hours)
Part of Speech and Word Form:
Natural Language Generation, Parts of Speech Tagging, Morphology, Named Entity Recognition, Rule-base and Stochastic POS tagger, Markov Model, Maximum Entropy model, Bag-of-Words, skip-gram, Continuous Bag-of-Words, Embedding representations for words Lexical Semantics, Word Sense Disambiguation, Knowledge-Based and Supervised Word Sense Disambiguation.

Unit III: (11 Hours)
Text Analysis, Summarization and Extraction:
Text Summarization – Extraction and Abstraction, Information Extraction - Tokenization, Named Entity Recognition, Relation Extraction, Information Retrieval, Stop-Word, Stemming, Term weighting, Term Frequency, Document Frequency, Document Frequency Weighting (TFIDF), Text Classification (TF-IDF/Term Frequency Technique), Sentiment Mining.

Unit IV: (11 Hours)
Machine Translation:
Need of MT, Problems of Machine Translation, MT Approaches, Direct Machine Translations, Rule-Based Machine Translation, Knowledge Based MT System, Statistical Machine Translation (SMT), Parameter learning in SMT (IBM models) using EM), Encoder-decoder architecture, Neural Machine Translation.

Practical component (if any) – Natural Language Processing Lab *(Python/MATLAB)*

Learning outcomes

At the end of this course, Students will be able to

CO1 To experiment with the concepts introduced in the course Natural Language Processing.

CO2 Ability to program various techniques of NLP.

CO3 Design and develop applications for text or information extraction/summarization/classification

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. Perform sentence tokenization to break a text paragraph into individual sentences.
2. Perform word tokenization to break a text paragraph into individual words.
3. For the text selected in Practical 1, remove stop words and punctuation marks.
4. Apply the stemming technique to the text document selected in Practical 1 to obtain root words.
5. Perform different forms of lemmatization on the text document selected in Practical 1 to obtain base forms of words.
6. Extract the top 10 most common words in the selected text, excluding stop words.
7. Extract nouns and pronouns from the text and calculate similarities between any two words using a suitable method.
8. Case Study – Sentiment Analysis: Students will preprocess a text dataset (e.g., movie reviews or tweets) using tokenization, stemming, and feature extraction (TF-IDF or word embeddings). They will build and evaluate a sentiment classification model (e.g., Logistic Regression or Naive Bayes) and analyze its performance using metrics - Accuracy and F1-score.
9. Case Study - Language identification: Students will work with a multilingual dataset to preprocess text and extract features using character or word-level n-grams. They will train a language classification model (e.g., Naive Bayes or Random Forest) to identify the language of text samples and evaluate it with a confusion matrix and accuracy metrics.

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than eight.

Essential/recommended readings

1. Daniel Jurafsky and James H Martin, "Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition", 2nd Edition, Prentice Hall, 2013.
2. James Allen, "Natural Language Understanding", 2nd edition, Benjamin/Cummings publishing company, 1995.
3. Eisenstein, J. (2019). Introduction to Natural Language Processing, MIT Press.

Suggestive readings

1. Natural Language Processing with Python – Analyzing Text with the Natural Language Toolkit, Steven Bird, Ewan Klein, and Edward Loper.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-2)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Mobile and Satellite Communication ELDSE8B	**4**	**3**	**-**	**1**	**Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices**	**-**

Learning Objectives

The course will introduce the fundamental concepts of communication systems in the field of wireless communication. It will discuss the fundamental operation and design problems of wireless communication systems and thus help gain an understanding over the applications of communication in day-to-day real world.

Learning outcomes

On successful completion of this course, student will be able to:

- Understand fundamentals of Wireless Communication System
- Comprehend the Protocols and Technologies in the Wireless Environment
- Understand the working of a Cellular Communication System.
- Understand the working of Satellite Communication.

SYLLABUS OF ELDSE-8B Total Hours- Theory: 45 Hours, Practicals: 30 Hours

UNIT – I (12 Hours)

Introduction to Wireless Communication: Principle of Wireless Communication: advantages, disadvantages and applications. Cellular Revolution, Spread Spectrum: The Concept of Spread Spectrum, Frequency Hopping Spread Spectrum, Direct Sequence Spread Spectrum, Code Division Multiple Access, Generation of Spreading Sequences, Coding and Error Control: Block Error Correction Codes (Hamming Code and Cyclic Codes), Automatic Repeat request (Flow and Error Control)

UNIT – II (11 Hours)

Wireless LAN Technologies and Protocols: Network Topologies, LAN, MAN, WAN and PAN. Wireless LAN: Applications, Requirements and Technology, Infrared LANs, Spread Spectrum LANs and Narrow Band LANs
Wireless LANs: IEEE 802.11 Protocol Stack,
Broadband Wireless: IEEE 802.16 Protocol Stack,
Bluetooth: Architecture, Applications and Protocol Stack

UNIT – III (11 Hours)

Satellite Communication: Satellite Orbits, Kepler Laws, Satellite Communication Systems, Repeaters and Transponders, Communication Subsystems, Power Subsystem, Telemetry, Command and Control Subsystems, Ground Stations.
Applications: Communication Satellites, Digital Satellite, Surveillance Satellites, Navigation Satellite, GPS.

UNIT – IV (11 Hours)

Cell Phone Technologies: Evolution of Mobile Radio Communication, Paging System, Cordless Telephones Systems, Internet Telephony.
Cellular Telephone Systems: Cellular Concepts, Frequency Allocation, Multiple Access, AMPS, Digital Cell Phone Systems, Advanced Cell Phones, Personal Satellite Communication System.

Practical component (if any) – Mobile and Satellite Communication Lab
(Hardware/Software) The practical needs to be performed on MATLAB/Packet Tracer/VLabs or any other equivalent software/supporting hardware

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand the basic elements of a wireless communication system.
- Build and understand the various network topologies.
- Understand the concept of various important parameters related to wireless communication systems.
- Prepare the technical report on the experiments carried.

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

S.No.	Category	Title of Experiment
1	Wireless Communication	Simulate TDMA, FDMA and CDMA for wireless communication using MATLAB or equivalent.
2	Simulation of network topologies	Implement MESH/STAR/RING/BUS topology in Packet Tracer.
3	Tracing across Networks	Connect two different networks using a router in Packet Tracer and show movement of packets from one network to the other.
4	Bluetooth Simulation	Connect two Bluetooth devices-Portable Music Player & Bluetooth speaker and Configure to play music using Packet Tracer.
5	Frequency Reuse	Find the co-channel cells for a particular cell. http://vlabs.iitkgp.ac.in/fcmc/exp6A/index.html
6	Frequency Reuse	Find the cell clusters within certain geographic area. http://vlabs.iitkgp.ac.in/fcmc/exp6B/index.html
7	Sectoring	The aim of the experiment is to understand the impact of many different parameters which influence the downlink C/I ratio. http://vlabs.iitkgp.ac.in/fcmc/exp7/index.html#
8	Handoff	To study the effect of handover threshold and margin on SINR and call drop probability and handoff probability. http://vlabs.iitkgp.ac.in/fcmc/exp8/index.html
9	Calculation of Boundary Coverage Probability	To calculate the probability that the received signal level crosses a certain sensitivity level. http://vlabs.iitkgp.ac.in/fcmc/exp4/index.html
10	Calculation of SINR including Beam Tilt	To understand the concept of co-channel interference and hence Signal to Interference and Noise Ratio. http://vlabs.iitkgp.ac.in/fcmc/exp5/index.html
11	Satellite Network	Simulation of a Satellite Network http://vlabs.iitkgp.ac.in/ant/4/theory/

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than ten.

Essential/recommended readings

1. Wireless Communications and Networks by William Stallings, Pearson Education, 2nd Edition, 2004
2. Principles of Electronic Communication Systems, Louis E. Frenzel, McGraw-Hill Education, 5th Edition, 2022

Suggestive readings

1. Electronic Communication Systems, Fifth Edition by Wayne Tomasi (Pearson Education)
2. Data Communication and Networking, Fourth Edition by Behrouz Forouzan (Tata McGraw Hill)
3. Wireless Communications Principles and Practice, Third Edition by Theodore Rappaport (Pearson Education)
4. Satellite Communications, Third Edition by Dennis Roddy (Tata McGraw Hill)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-3)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
CMOS Analog VLSI Design ELDSE8C	4	3	-	1	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices	Digital Electronics, Analog Electronics-I & II, Basic VLSI Design

Learning Objectives

This course introduces the student to the fundamental understanding of Analog Circuits, Switched Capacitor Circuits, Phase locked loops, Converters and Filters.

Learning outcomes

On successful completion of this course, student will be able to:

- Extend the mixed signal design to different applications
- Comprehend the concept of Switched Capacitor Circuits
- Understand different types of Phase Locked Loops
- Build Mixed Signal Circuits and understand different Continuous Time Filters
- Analyze the Data Converter architecture and choose the most appropriate Data Converter for the specified applications

SYLLABUS OF ELDSE-8C **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

UNIT – I (09 Hours)

CMOS Analog Circuits: Current Sources and Sinks, Current Mirror, Differential Amplifiers, Operational Amplifiers-Basic CMOS Op-Amp design, Operational Transconductance Amplifiers, CMOS Instrumentation Amplifier.

UNIT – II (12 Hours)

Switched Capacitor Circuits: Overview of Switched Capacitor circuits, Basic building blocks, Operation and Analysis, Non-ideal effects in Switched Capacitor Circuits, Switched Capacitor Integrators, First Order Filters

UNIT – III (09 Hours)

Continuous Time Filters: Overview of gm-C (Transconductor-C) filter, CMOS Transconductance Amplifier using Triode and active transistors, MOSFET-C filters

UNIT – IV (15 Hours)

Phased Locked Loop (PLL): Simple PLL, Basic PLL topology, Dynamics of Simple PLL, Overview of Charge Pump PLLs, Applications: Frequency Multiplication and Synthesis and Skew reduction.

Data Converter Fundamentals: Sample and Hold Circuit, Ideal D/A and A/D converter, Quantization Noise, Performance limitations. Types of A/D and D/A converters (overview of any one or two)

Practical component (if any) – CMOS Analog VLSI Design Lab

(Practicals to be performed using Ngspcie/LTspice/QUCS, CADENCE/MENTOR GRAPHICS)

Learning outcomes

The Learning Outcomes of this course are as follows:

- Apply VLSI design methodologies to analyze and design the Analog Circuits
- Comprehend the design and working of Mixed Signal Circuits
- Get familiarized with the VLSI design Simulation Tools

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. Implement a Current Mirror Circuit
2. Implement an Operational-Transconductor Amplifier
3. Implement a Sample and Hold Circuit for a given sampling rate.
4. Implement a First order Switch Capacitor Filter
5. Implement a Simple Phase Locked Loop Circuit
6. Implement a Single-ended First Order Gm-C Filter
7. Implement an A/D converter or D/A converter

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than six.

Essential/recommended readings

1. R. Jacob Baker, CMOS Mixed-Signal Circuit Design, Wiley Interscience, 2nd Edition, 2008, ISBN-10 0470290269, ISBN-13 9780470290262
2. Tony Chan Carusone, David Johns, Kenneth Martin, Analog Integrated Circuit Design, Wiley Student Edition, 2013, ISBN-10 9788126543939, ISBN-13 978-8126543939
3. Behzad Razavi, Design of Analog CMOS Integrated Circuits, TMH Edition, 2nd Edition, 2017, ISBN-10 938706784X, ISBN-13 978-9325983274

Suggestive readings

1. Philip E. Allen and Douglas R. Holberg, CMOS Analog Circuit Design, Oxford University Press, International Second Edition/Indian Edition, 2016, ISBN-10 0199765073, ISBN-13 978-0199765072

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-4)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Nanomaterials and their Applications ELDSE8D	4	4	-	-	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices	-

Learning Objectives

This course builds the basic background of nanomaterials, nanostructures and their properties. Classification of nanomaterials and its chemistry is explained and in addition to this, they are made aware of the various applications of nanomaterials.

Learning outcomes

On successful completion of this course, student will be able to:

- To understand classification of nanomaterials.
- To have a broad idea of applications of nanoscience in various fields.
- To understand carbon technology in nanoscience and nanotechnology.
- To have an idea of nano devices and sensors

SYLLABUS OF ELDSE-8D **Total Hours- Theory: 60 Hours**

UNIT – I (14 Hours)
Nanomaterials:
Classification of nanomaterials: Nanosized metals and alloys, semiconductor, Ceramics- a comparison with respective bulk materials, Organic compounds and polymers, carbon age-new form of carbon (CNT to Graphene), Nanocomposites.

Nano ceramics: Dielectrics, ferroelectrics and magneto ceramics, Nanopolymers: Preparation and characterization of diblock Copolymer based nanocomposites, Nanoparticles polymer ensembles; Applications of Nanopolymers in Catalysis.

Classification of conducting polymers: Intrinsic and extrinsic conducting polymers - Chemical and electrochemical methods of the synthesis of conducting polymers.

UNIT – II (16 Hours)
Applications of Nanomaterials for Sustainable Environment:
Nanomaterials in Energy Technology- Introduction: Nanotechnology for sustainable energy- Energy conversion process, indirect and direct energy conversion, use of nanoscale catalysts to save energy and increase the productivity in industry.

Electrochemical Energy Storage Systems: Batteries: Primary, Secondary, Lithium, solid-state and molten solvent batteries; Lead acid batteries; Nickel Cadmium batteries; Advanced batteries.

Nanomaterials in Energy Storage: Nano-electrochemical systems, nanomaterials for rechargeable batteries, nanomaterials for fuel cells.

Environmental applications of nanomaterials: Mechanism for remediation of aqueous contaminants, photocatalyst; membranes incorporating nanomaterials, transport processes in membrane technology; nanomaterial-based adsorbents for water and wastewater treatment – adsorption at metal oxide surfaces, hybrid adsorbents.

UNIT – III (14 Hours)
Carbon Nanotechnology:
Introduction to carbon nanotubes and their applications in various industries, supercapacitors, hydrogen storage; Nanomaterials for solar power: Solar energy materials, Solar energy devices, silicon solar technology for clean energy, Light Emitting Diodes, LED displays.

UNIT – IV (16 Hours)

Nano Devices and Sensors:

Introduction to Gas sensors; Characteristics of Gas sensors; Types of Gas sensors; Solid State Gas sensors: Chemiresistive Gas sensors (Semiconducting Metal Oxide based sensors, Carbon Nano Tube based nano sensors).

Miscellaneous applications: Microfluidics and Microsystems, Micro-electromechanical systems, ChemFET (NEMs and MEMS based sensors), Optic Gas sensors, Spectroscopic Gas sensors, Chemical Sensors: Electrochemical Gas Sensors.

Nano magnetism

Magnetism and Magnetic Materials, Basics of Magnetism, Magnetic Domains and Anisotropy, Magnetic Nanostructures, Magnetism of Nanosized Materials, Spintronics technology and the challenges, Electron and nuclear spin devices

Practical component (if any) – None

Essential/recommended readings

1. Introduction to Nanomaterials and Devices , Omar Manasreh, Wiley, 1st Edition, 2011
2. Textbook of Nanoscience and Nanotechnology, B.S. Murty, P. Shankar, Baldev Raj, B.B. Rath, James Murday, 2013, Springer, e-ISBN 978-3-642-28030-6
3. Nano: The Essentials - Understanding Nanoscience and Nanotechnology, T. Pradeep, Tata McGraw-Hill (TMH) Education, 1st Edition, 2007
4. Linden's Handbook of Batteries (and Fuel Cells), Thomas B. Reddy (original: David Linden, Thomas Reddy), McGraw-Hill Education, 5th Edition, 2019
5. Mark R. Wiesner, Jean-Yves Bottero, Environmental Nanotechnology: Applications and Impacts of Nanomaterials, McGraw-Hill, 2nd Edition, 2016

Suggestive readings

1. Diallo, M., Duncan, J., Savage, N., Street, A., and Sustich, R. (Eds). "Nanotechnology Applications for Clean Water" William Andrew. 2008
2. Martin A Green, Solar cells: Operating principles, technology and system applications, Prentice Hall Inc, Englewood Cliffs, NJ, USA, (1981).
3. Nanosensors: Physical, Chemical, and Biological by Vinod Kumar Khanna, Publisher: CRC Press.
4. Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-5)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Nanomaterials Characterization ELDSE8E	4	3	-	1	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices	-

Learning Objectives

The course will teach various existing techniques used in nanotechnology; their Physical principles/concepts involved in fabrication of the materials at nano scale. The students will study various advanced characterization equipment used to characterize different types of materials including advanced optical and magnetic characterization techniques.

Learning outcomes

On successful completion of this course, student will be able to:

- Understand the concept of Top-down and Bottom-UP approaches for synthesis and processing of nanomaterials
- Understand structural and optical characterization of nanoparticles
- Understand electrical and magnetic characterization of nanoparticles

SYLLABUS OF ELDSE-8E **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

UNIT – I (11 Hours)
Introduction to Synthesis Approaches:
Concept of bulk versus nanomaterials and dependence of properties on size. Introduction to 'Top down' vs. 'Bottom up' approaches for synthesis of nanostructures (with suitable examples.), Physical, chemical and biological synthesis mechanism. Advantages and disadvantages of top down. Advantages and disadvantages of bottom up

UNIT – II (12 Hours)
Characterization and Data Analysis: Scattering & Imaging techniques:
Structural: X-Ray Diffraction, Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy, Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM).

UNIT – III (11 Hours)
Characterization and Data Analysis using Spectroscopic techniques:
Optical: Ultraviolet-Visible-Infrared Absorption, Fourier Transform Infrared Spectroscopy, Raman Spectroscopy, Photoluminescence

UNIT – IV (11 Hours)
Characterization and Data Analysis: Electrical and Magnetic
Electrical: Electrochemical techniques (Cyclic Voltammetry), resistivity, Four Probe Method
Magnetic: Magneto-Resistance, Vibrating Sample Magnetometer, , Magneto Optical Kerr Effect, Magnetic Force Microscopy.

Practical component (if any) – Nanomaterials Characterization Lab
(Use any relevant software(s))

Learning outcomes

The Learning Outcomes of this course are as follows:

- Calculate the material parameters of nanomaterials using suitable characterization techniques using secondary data.
- Visit to Research laboratories/ Instrumentation Centre and use advanced tools/techniques for synthesis and characterization of nanomaterials.
- Prepare technical reports of the experiments carried out.

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. XRD analysis of the given XRD spectra using secondary data and thus determine the particle size and other parameters of nanomaterial.

2. To analyze chemical properties of a nanomaterial using UV-Visible spectroscopy secondary data
3. Find out the optical band gap of a nanomaterial using UV-Visible spectroscopy secondary data.
4. Software like ImageJ based structural analysis from secondary data (SEM/TEM).
5. To identify the presence of functional groups in nanomaterials using FTIR secondary data.
6. Report writing and presentation of the Lab Visit

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than five.

Essential/recommended readings

1. Introduction to Nanotechnology, Charles P. Poole Jr and Frank J. Owens, Wiley Interscience, 1st Edition, 2003.
2. Nanotechnology: Principles & Practices, S.K. Kulkarni, Capital Publishing Company (India), 2024, ISBN 9789381891810
3. Nanotechnology Synthesis to Applications, Sunipa Roy, Chandan Kumar Ghosh, Chandan Kumar Sarkar, CRC Press (Routledge), 1st Edition, 2020

Suggestive readings

1. Nanostructures and Nanomaterials Synthesis, Properties, and Applications, Guozhong Gao, Imperial College Press, 2004

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-6)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Digital Control System ELDSE8F	4	3	-	1	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices	-

Learning Objectives

This course introduces the students to fundamental concepts, principles and application of digital control system analysis and design. The topics cover classical control design as well as the modern control design methods

Learning outcomes

On successful completion of this course, student will be able to:

- Familiarize basic concepts for analysis of discrete-time domain systems.
- Use of pulse transfer function in discrete time systems.
- Stability analysis of digital control systems
- Design of compensators and controllers for desired time/frequency response.
- Design of estimators and observers

SYLLABUS OF ELDSE-8F **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

UNIT – I (11 Hours)
Digital Control System:
Overview of control systems (open-loop vs closed-loop), Introduction to digital control systems, Continuous-time vs discrete-time control systems, Sampling theory: Sampling theorem and Nyquist rate, Aliasing and anti-aliasing filters, Reconstruction using zero-order hold (ZOH), Quantization effects, Discrete-time signals and systems, Z-transform and pulse transfer functions

UNIT – II (11 Hours)
Stability Analysis:
Stability analysis of discrete-time systems: Jury's stability criterion, Stability analysis using bi-linear transformation, Time response of discrete-time systems-Transient and steady-state responses, Design of sampled data control system-Discrete Root locus analysis, Frequency domain analysis: Bode and Nyquist plots (for sampled systems), Concept of Lyapunov stability

UNIT – III (11 Hours)
Discrete State-space Analysis:
State variable model, State-space representations for discrete-time systems, canonical forms, the solution to discrete-time state-space equation, state transition matrix (STM), controllability, observability and stability of discrete state space models

UNIT – IV (12 Hours)
Design and Analysis of Discrete-time Control System*:
Design of digital control based on the frequency response method Bilinear Transformation and Design procedure in the w-plane, Lead, Lag and Lead-Lag compensators, and digital PID controllers, Deadbeat control design. Design of state feedback controller through pole placement – Necessary and sufficient conditions

*Note: Controllers like digital PID, state-feedback controllers are to be designed in the discrete-time domain to work with sampled data. Software tools like MATLAB/Simulink to simulate and optimize digital controllers.

Practical component (if any) – Digital Control System Lab
(Software Platform: MATLAB/Simulink or similar software)

Learning outcomes

The Learning Outcomes of this course are as follows:

- Perform experiments involving concepts of Digital Control for Automation
- Simulate different types of Digital Filters
- Perform the stability analysis of a system

- Design and simulate controllers using different techniques studied in theory paper
- Prepare the technical report on the experiments carried

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. Simulate the step response of a sampled-data (digital) control system
2. Stability analysis of a system using bode plot, root locus, and pole-zero gain representation
3. To obtain closed loop step and impulse response of a first order unity feedback system
4. Simulate a PD, PI and PID control design with a discrete-time controller. Compare the steady state response.
5. Simulate a frequency-domain controller to transform a continuous-time control design to a discrete-time control design
6. Design and simulate a Frequency-response controller or a State-feedback controller
7. Design of lead-lag compensator

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than six.

Essential/recommended readings

1. Katsuhiko Ogata, "Discrete-Time Control Systems", 2nd Edition, Pearson, 1995, ISBN 9780130342812 (International), 9789332549661 (India).
2. M. Gopal, "Digital Control and State Variable Methods", 4th Edition, McGraw Hill Education, 2022, ISBN 9780071333276.
3. Benjamin C. Kuo, "Digital Control Systems", 2nd, Oxford University Press /Saunders College Publishing, 1995, ISBN 9780195104377/ 9780132111720.

Suggestive readings

1. C. Phillips, H. Nagle, A. Chakrabortty, "Digital Control System Analysis & Design", Pearson
2. G. F. Franklin, J. D. Powell and M. L. Workman, "Digital Control of Dynamic Systems", Addison Wesley, Pearson

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

ANNEXURE-2

Structure of B.Sc. (Hons) Instrumentation

6.1 Credit and Paper Distribution for B.Sc. (Hons) Instrumentation

Papers	Semester	Credits (L-T-P)	Name of the Paper	Papers	Semester	Credits (L-T-P)	Name of the Paper
FIRST YEAR							
DSC-1	I	3-0-1	Analog Electronics (INDSC1A)	DSC-4	II	3-0-1	Fundamentals of Digital circuits (INDSC2A)
DSC-2	I	3-0-1	Basic circuit theory (INDSC1B)	DSC-5	II	2-0-2	Sensors and Actuators (INDSC2B)
DSC-3	I	2-0-2	Testing and Measurement (INDSC1C)	DSC-6	II	3-0-1	Electronic Instrumentation (INDSC2C)
GE-1	I	4 credits	Choose one from pool of GE courses	GE-2	II	4 credits	Choose one from pool of GE courses
AEC-1	I	2 credits	Choose one from pool of AEC courses	AEC-2	II	2 credits	Choose one from pool of AEC courses
VAC-1	I	2 credits	Choose one from pool of VAC courses	VAC-2	II	2 credits	Choose one from pool of VAC courses
SEC-1 **One paper is to be selected out of the given two options**				SEC-2 **One paper is to be selected out of the given two options**			
SEC-1	I	0-0-2	Programming using Python (INSEC1A)	SEC-2	II	0-0-2	Applied Cryptography (INSEC2A)
SEC-1	I	0-0-2	Quantum computation (INSEC1B)	SEC-2	II	0-0-2	Big data Analytics (INSEC2B)
Semester I – Total Credits- 22				**Semester II – Total Credits- 22**			
Students on exit shall be awarded Undergraduate Certificate in Instrumentation after securing the requisite 44 credits in Semesters I and II							
SECOND YEAR							
DSC-7	III	2-0-2	Analytical Instrumentation-I (INDSC3A)	DSC - 10	IV	3-0-1	Biomedical Instrumentation (INDSC4A)
DSC-8	III	3-0-1	Operational Amplifiers and Applications (INDSC3B)	DSC - 11	IV	2-0-2	Machine Learning (INDSC4B)
DSC-9	III	3-0-1	Mathematical techniques for Instrumentation (INDSC3C)	DSC - 12	IV	3-0-1	Optical Instrumentation (INDSC4C)
AEC-3	III	2 credits	Choose one from pool of AEC courses	AEC-4	IV	2 credits	Choose one from pool of AEC courses
VAC-3	III	2 credits	Choose one from pool of VAC courses	VAC-4	IV	2 credits	Choose one from pool of VAC courses
DSE-1 One paper is to be selected out of the given three options OR GE-3				**DSE-2 One paper is to be selected out of the given three options OR GE-4**			
DSE-1	III	3-0-1	Signals and Systems (INDSE3A)	DSE-2	IV	3-0-1	Linear Integrated Circuits (INDSE4A)
DSE-1	III	2-0-2	VHDL Programming (INDSE3B)	DSE-2	IV	3-0-1	Statistical Tools and Techniques (INDSE4B)
DSE-1	III	2-0-2	Programming Using MATLAB (INDSE3C)	DSE-2	IV	2-0-2	Virtual Instrumentation (INDSE4C)
SEC-3 **One paper is to be selected out of the given two options**				SEC-4 **One paper is to be selected out of the given two options**			
SEC-3	III	0-0-2	Simulation tools & techniques(INSEC3A)	SEC-4	IV	0-0-2	PCB designing(INSEC4A)
SEC-3	III	0-0-2	Testing & Calibration(INSEC3B)	SEC-4	IV	0-0-2	PLC & SCADA(INSEC4B)

Semester III – Total Credits- 22				**Semester IV – Total Credits- 22**			
Students on exit shall be awarded Undergraduate Diploma in Instrumentation after securing the requisite 88 credits on completion of Sem IV							
THIRD YEAR							
DSC - 13	V	2-0-2	Advanced Biomedical Instrumentation (INDSC5A)	DSC - 16	VI	3-0-1	Analytical Instrumentation-II (INDSC6A)
DSC - 14	V	3-0-1	Microprocessor (INDSC5B)	DSC - 17	VI	3-0-1	Analog devices and circuits (INDSC6B)
DSC - 15	V	3-0-1	Power devices and Electrical machines (INDSC5C)	DSC - 18	VI	3-0-1	Control System (INDSC6C)
GE-5	V	4 credits	Choose one from pool of GE courses	GE-6	VI	4 credits	Choose one from pool of GE courses
SEC-5 **One paper is to be selected out of the given two options**				SEC-6 **One paper is to be selected out of the given two options**			
SEC-5	V	0-0-2	Instrumentation and digital forensic techniques (INSEC5A)	SEC-6	VI	0-0-2	VLSI design & verification(INSEC6A)
SEC-5	V	0-0-2	Virtual & Augmented Reality (INSEC5B)	SEC-6	VI	0-0-2	Deep learning(INSEC6B)
DSE-3 One paper is to be selected out of the given three options				**DSE-4 One paper is to be selected out of the given three options**			
DSE-3	V	3-0-1	Reliability and Quality Control (INDSE5A)	DSE-4	VI	3-0-1	Artificial Intelligence (INDSE6A)
DSE-3	V	3-0-1	Communication Systems (INDSE5B)	DSE-4	VI	3-0-1	Process Control Dynamics (INDSE6B)
DSE-3	V	2-0-2	Computer Aided Design (INDSE5C)	DSE-4	VI	3-0-1	Research Methodology**(INDSE6C)
				** If a student wishes to pursue a four years Honours Degree with research, it is compulsory to opt for Research Methodology paper.			
Semester V – Total Credits- 22				**Semester VI – Total Credits- 22**			
Students on exit shall be awarded Bachelors of Honours (3 years) Instrumentation after securing the requisite 132 credits on completion of Sem VI							
FOURTH YEAR							
DSC - 19	VII	2-0-2	Embedded systems and Robotics (INDSC7A)	DSC-20	VIII	2-0-2	Industrial Automation using PLC and SCADA (INDSC8A)
Three DSE courses OR Two DSE and one GE OR One DSE and two GE (Out of seven DSE options)				**Three DSE courses OR Two DSE and one GE OR One DSE and two GE (Out of seven DSE options)**			
Dissertation on Major (6 credit) OR Dissertation on Minor (6 credit) OR Academic Project/ Entrepreneurship (6 credit)				Dissertation on Major (6 credit) OR Dissertation on Minor (6 credit) OR Academic Project/ Entrepreneurship (6 credit)			
Semester VII – Total Credits- 22				**Semester VIII – Total Credits- 22**			
Students on exit shall be awarded Bachelor of Instrumentation (Honours with Research/Academic Projects/Entrepreneurship) or (Honours with Research in Discipline1 (Major) with Discipline-2 (Minor) after securing the requisite 176 credits on completion of Semester VIII.							

IAPC- Internship/Apprenticeship/Project/Community Outreach

IAPRC- Internship/Apprenticeship/Project/Research/Community Outreach

*DSE in VII and VIII Semester (DSE 5-10) will be aligned stream wise as under so that student can specialize in a particular domain of Instrumentation. Accordingly, student can do his Major dissertation in that domain.

List of DSC, DSE and GE papers with credit distribution (L-T-P)

DSC papers:

1. Embedded Systems and Robotics (VII sem) 2-0-2
2. Industrial Automation using PLC and SCADA (VIII sem) 2-0-2

DSE papers (VII Sem):

1. Modern Instrumental Methods of Analysis 3-0-1
2. CMOS Digital Integrated Circuit Design 3-0-1
3. Advanced Electronic Instrumentation 3-0-1
4. VLSI Fabrication Technology 3-0-1
5. Measurement Technology 3-0-1
6. Materials Science for Instrumentation and Sensor Development 3-0-1
7. MEMS Technology and Applications 3-0-1

DSE papers (VIII Sem):

1. Biosensors and Nanotechnology 3-0-1
2. Medical Image Processing and Healthcare Management 3-0-1
3. Semiconductor Device Modeling and Simulation 2-0-2
4. Optoelectronic Devices and Applications 3-0-1
5. Advanced Process Control 3-0-1
6. Pneumatic and Hydraulic Systems 3-0-1
7. Sustainable Energy Technologies 3-0-1

GE papers (VII Sem)

1. Instrumentation and Control 3-0-1
2. Photovoltaic Technology and Applications 3-0-1
3. Machine Intelligence 2-0-2

GE papers (VIII Sem)

1. Robotics 2-0-2
2. Augmented and Virtual Reality 2-0-2
3. 3D Printing and Design 2-0-2

DISCIPLINE SPECIFIC CORE COURSE- 19: Embedded Systems and Robotics (INDSC7A)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Embedded Systems and Robotics (INDSC7A)	04	02	-	02	Course admission eligibility	Basic Electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- Understand Embedded Systems: Learn the architecture, features, and applications of embedded systems, including RISC vs. CISC and Von-Neumann vs. Harvard architectures.
- Explore Microcontrollers: Get familiar with Arduino and AVR microcontroller (ATMega32) architecture and programming.
- Arduino Programming: Set up Arduino IDE and program digital inputs/outputs, analog inputs, and serial communication.
- Sensor and Actuator Integration: Interface sensors (e.g., temperature, light) and actuators (e.g., motors, servos) with Arduino.
- Robotics Basics: Understand robotics, motor control, and sensor integration to build basic robots and robotic arms using Arduino.

Learning Outcomes

After successful completion of the course, students will be able to:

- Embedded System Knowledge: Ability to describe the features, architecture, and applications of embedded systems, including key microcontroller architectures.
- Microcontroller Proficiency: Gain proficiency in programming and interfacing with Arduino and AVR microcontrollers (e.g., ATMega32).
- Arduino Programming Skills: Demonstrate the ability to program Arduino for handling digital/analog inputs, outputs, and serial communication.
- Sensor and Actuator Control: Successfully interface and control sensors and actuators (e.g., motors, temperature sensors) using Arduino.
- Robotics Application: Design and program basic robotic systems, including motor and sensor integration, using Arduino.

SYLLABUS OF DSC- 19

UNIT-I **(8 hours)**

Basic Concepts of Embedded Systems: Introduction to computer, microprocessor and microcontrollers. Characteristics, Requirements and Applications of Embedded Systems. Overview of Von- Neumann and Harvard architecture, RISC and CISC microcontrollers .

UNIT-II **(6 hours)**

Introduction to Arduino : Functional Block Diagram of Arduino, Functions of each Pin. Overview of the Integrated development environment (IDE), I/O Functions, Looping Techniques, Decision Making Techniques. ATMega32 microcontroller internal architecture, instruction set and addressing modes

UNIT-III **(8 hours)**

Programming with Arduino: Basic Programming with Sensors and Actuators. Serial Communication: Sending and receiving data with a peripheral (USART) . Interfacing : DC motors, servo motors, and stepper motors with Arduino and other Hardwares Seven Segment Display, LCD, Buzzer ,and Relays.

UNIT-IV **(8 hours)**

Introduction to Robotics: Origin of automation, types of Robot, robot joints, Forward and reverse kinematics , Basics of Electronics for Robotics , robotics skills with sensor integration, Basic interfacing programming concept

Practical component: **(60 hours)**

1. To analyze the block diagram of an embedded system and identify its components.
2. Setting up Arduino Environment, Install the Arduino IDE, understand its interface, and upload a "Blink LED" program.
3. Write a program and design a circuit to turn an LED on and off using a push button.
4. Write a program for reading analog Inputs and monitoring outputs.
5. Write a program to interface Temperature Sensors with Arduino.
6. Write a program to interface motors and control speed.
7. Write a program to interface Pressure Sensor Arduino
8. Write a program to interface Current Sensor with Arduino.
9. Write a program to Interface pH Sensor with Arduino for Water Quality Monitoring
10. Write a program to do serial communication to send and receive data between Arduino and a computer.
11. Write a program Controlling DC Motors with H-Bridge, speed using L293D motor driver IC.

12. Write a program to interface ultrasonic sensors to detect obstacles and control a motorized robot.
13. Any one of the following mini projects or on similar concepts incorporating data acquisition from sensors/ input device, data analysis & control and display of result on any output device: Digital Thermometer, Light-Activated Lamp, Distance Measurement System, Traffic Light Simulation, Line-Following Robot. Automatic Plant Watering System, Solar Power Monitoring System, Energy Consumption Tracker, Water Quality Monitoring System, Automatic Irrigation System, Smart Street Lighting System, Air Quality Monitoring, CO2 Emission Tracker, Temperature and Humidity Logger, Smart Fish Tank Monitoring System, Biodiversity Protection System, Waste Segregation System, Smart Composting Bin, Smart Factory Prototype, Smart Health Monitoring System, Indoor Air Quality Monitor

Essential/recommended readings

1. Muhammad Ali Mazidi, Janice Gillispie Mazidi, The 8051 Microcontroller and Embedded Systems, Pearson education Asia, New Delhi (2007), 2nd Edition.
2. Michal Mc Roberts "Beginning Arduino" Second Edition, Technology in Action
3. Massimo Banzi, "Getting started with Arduino" 2nd Edition, Orelly 2011
4. Richard Blum, "Arduino Programming in 24 Hours", Pearson Education, 1st
5. edition, 2015.
6. James M. Fiore, Embedded Controllers using C and Arduino, 2019
7. https://docs.arduino.cc/learn/

Suggestive readings

1. Raj Kamal: Microcontrollers, Architecture, Programming, System Design, 2nd Edition, Pearson.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 20: Industrial Automation using PLC and SCADA (INDSC8A)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		

Industrial Automation using PLC and SCADA (INDSC8A)	**04**	**02**	**-**	**02**	**Course admission eligibility**	**Basic knowledge of programming**

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the importance of automation techniques in manufacturing and process industries.
- To impart the role of PLC in industry automation.
- To understand the significance and usage of SCADA in process automation industry.
- To expose to various control techniques employed in process automation.

Learning Outcomes

After successful completion of the course, students will be able to:

- Understand the need for automation in process industries and learn about PLC
- Learn the programming languages of PLC
- Design distributed Control Systems (DCS) and its applications
- Learn about SCADA, its usage in process automation industry and associated communication networks
- To apply PLC programming and implement it on PLC kits.

SYLLABUS OF DSC- 20

UNIT-I **(07 Hours)**

Single loop control, Centralized control, Distributed control systems, Open systems, SCADA systems, Types of data available, Data communication components and protocols.

UNIT-II **(08 Hours)**

Programmable Logic Controllers (PLC), Block diagram of PLC, input/output systems, CPU, memory Unit, Programmer Units, Peripheral devices, Controller programming tools, Programming of PLCs, Basic instruction sets, Design of alarm and interlocks, Networking of PLC, Overview of safety of PLC with case studies.

UNIT-III **(07 Hours)**

Automation in Process Industries

Introduction to computer based industrial automation- Direct Digital Control (DDC), Distributed Control System (DCS), PLC vs. DCS systems, Local control Units, dedicated card controllers, Unit Operations controllers, DCS multiplexers, DCS system integration

UNIT-IV **(08 Hours)**

Supervisory Control and Data Acquisition (SCADA) Systems, Types of supervisory systems, Components of SCADA Systems, field data interface devices, communication network and other details, System Architecture: monolithic, distributed, networked, application of SCADA in the industry; security and weakness of SCADA Systems

Practical component: (Software/ Hardware) **(60 hours)**

1. Identify various components, modules, and front panel status indicators of a given PLC
2. Design the PLC ladder diagram to test the START-STOP logic using two inputs and one output
3. Design the PLC ladder diagrams for all fundamental logic gates
4. Design the PLC ladder program to Verify DeMorgan‟s Theorems
5. Design the PLC ladder diagrams for various arithmetic operations
6. Design the PLC ladder diagrams for various logical operations
7. Design a PLC ladder program for the blinking of LEDs
8. Design the PLC ladder diagram for implementing a digital timer
9. Design the PLC ladder diagram for implementing a digital counter
10. Design the PLC ladder diagram for sequential control of the DC motor.
11. Design the PLC ladder diagram for a temperature control system
12. Design the PLC ladder diagram for a flow control system
13. Design the PLC ladder diagram for a level control system
14. Interface personal computers in a network using different topologies
15. Identify the various level of distributed control system
16. Develop a SCADA mimic diagram and tag database for On-Off control of lamp
17. Develop a SCADA mimic diagram and tag database for Traffic light control system
18. Develop a SCADA mimic diagram and tag database for level control system
19. Develop a SCADA mimic diagram and tag database for water distribution system
20. Develop a SCADA mimic diagram and tag database for an elevator system
21. At least one industrial visit to study applications related to the subject and submission of the relevant report.

Essential/recommended readings

1. Frank D. Petruzella, "Programmable Logic Controllers", 5th Edition, McGraw-Hill, New York, 2016.
2. John W. Webb and Ronald A. Reis, "Programmable Logic Controllers: Principles and Applications", 5th Edition, Prentice Hall Inc., New Jersey, 2003.
3. Bhatkar, Marshal, "Distributed Computer Control & Industrial Automation", 1st Ed., Dekker Publication, 1990.
4. Jai Prakash Gupta, Sanjay Gupta, "PC interface For Data Acquiring & Process Control", 2nd Ed., Instrument Society of America, 1994.

Suggestive readings

1. Krishna Kant, "Computer - Based Industrial Control", 2nd Edition, Prentice Hall, New Delhi, 2011.
2. Yoram Koren, "Robotics", McGraw Hill, 1992.
3. Lukas M.P, "Distributed Control Systems", Van Nostrand Reinhold Co., New York, 1986.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

DISCIPLINE SPECIFIC ELECTIVE –: Modern Instrumental Methods of Analysis (INDSE7A)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Modern Instrumental Methods of Analysis (INDSE7A)	04	03	-	01	Course admission eligibility	Analytical Instruments

Learning Objectives

The Learning Objectives of this course are as follows:

- To familiarize with advanced spectroscopic techniques such as Mass spectrometry, NMR spectroscopy and X-Ray spectroscopy
- To understand the perspective of different advanced analytical methods.

- To describe the principle, instrumentation and working of X-Ray spectroscopy and its applications
- To study principles and applications of modern and hyphenated chromatographic methods.
- To disseminate the principle and instrumentation of thermo-analytical instruments along with their applications for analyzing products of different origin.

Learning Outcomes

After successful completion of the course, students will be able to:

- Get the understanding of advanced spectroscopic techniques such as Mass spectrometry and NMR spectroscopy.
- Understand the principle, instrumentation, and application of electro analytical instruments.
- Describe the principle, instrumentation and working of X-Ray spectroscopy and its applications.
- Understand the principle and applications of modern and hyphenated chromatographic methods.
- Understand the principle and instrumentation of thermo-analytical instruments along with their applications for analyzing products of different origin.
- Assess and evaluate the potential of different modern analytical methods for resolving various scientific challenges.

SYLLABUS OF DSE

UNIT-I **(13 hours)**

Nuclear Magnetic Resonance (NMR) Spectroscopy: Theory, chemical shift and spin-spin splitting, coupling constant, environmental effects- shielding and deshielding effects due to electronegativity on NMR spectra, instrumentation of NMR, FT-NMR and its advantages, applications.

UNIT-II **(10 hours)**

Mass Spectroscopy: Theory, gaseous ion source, sample inlet system, magnetic sector mass analyzer, electron multiplier detector, Isotopic abundances, metastable ions and applications.

UNIT-III **(10 hours)**

X-ray Spectroscopy: Principle, absorption, emission and diffraction of X-rays, Bragg‟s Law, Instrumentation: sources, X –ray tube, crystal monochromators, X-ray detectors (Ionization, proportional and GM counter, γ camera), applications.

UNIT-IV **(12 hours)**

Thermo-analytical Methods: Thermal detectors. Thermo-gravimetry, Differential Thermal analysis, Differential scanning calorimetry, Principle, Instrumentation, thermobalance, Applications of thermo-analytical techniques.

Hyphenated techniques: Introduction to GC-MS and LC-MS techniques and their applications.

Practical Component **(30 Hours)**

1. Quantitative Analysis of organic compounds using Gas chromatography/ GC/MS chromatography.
2. Quantitative Analysis of organic compounds using HPLC/ LC-MS chromatography.
3. Study of NMR (Simulation based/Demo).
4. Study of Mass spectrometer (Simulation based/Demo).
5. Study of X ray spectrometer (Simulation based/Demo).
6. Study of thermo-analytical instruments (Simulation based/Demo).
7. Industrial visits / Group Projects based on analytical techniques.

Essential/recommended readings

1. Skoog & Lerry, Instrumental Methods of Analysis, Saunders College Publications, New York, 4th Edition 1992.
2. H.H.Willard, Instrumental Methods of Analysis, CBS Publishers 7th Edition 1988.
3. D.C. Harris, Quantitative Chemical Analysis, W.H. Freeman, 7th Edition 2010.
4. Gary D. Christian, Analytical Chemistry, John & Sons, Singapore, 6th Edition 2004.
5. Skoog, West and Holler, Analytical Chemistry, Saunders College Publications, New York, 5th Edition 1990.
6. Vogel‟s Textbook of Qualitative Chemical Analysis, ELBS, 4th Edition 1978.
7. J.A. Dean, Analytical Chemistry Notebook, McGraw Hill, 14th Edition 1992.
8. John H. Kennedy, Analytical Chemistry: Principles, Saunders College Publication, 2nd Edition 1990.

Suggestive readings

1. Galen W. Ewing, Instrumental Methods of Chemical Analysis, McGraw-Hill Book Company, 1968.
2. R.S Khandpur, Handbook of Analytical Instruments, Tata McGraw-Hill, 3rd Edition, 2006.
3. B.K Sharma, Instrumental Methods of Chemical Analysis, Krishna Prakashan Media, 1st Edition, 2011.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE –: CMOS Digital Integrated Circuit Design (INDSE7B)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
CMOS Digital Integrated Circuit Design (INDSE7B)	04	03	-	01	Course admission eligibility	Digital electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- To explain the operation of different MOS transistors and their characteristics.
- Design and Analyze CMOS Logic Gates.
- Develop Combinational and Sequential Logic Circuits.
- Understand and Apply Memory Design Principles.

Learning Outcomes

After successful completion of the course, students will be able to:

- Design and analyze CMOS logic gates and circuits.
- Create combinational and sequential logic circuits, demonstrating an understanding of their behaviour and functionality.
- Design and assess memory elements, such as SRAM and DRAM cells.
- Skilfully use simulation tools to model and analyze CMOS digital circuits.

SYLLABUS OF DSE

UNIT – I **(10 hours)**

CMOS Inverter: Basic CMOS inverter, Switch model of Inverter, Static behaviour, Voltage transfer characteristics, Switching threshold, Noise margin, and Gain calculation.

UNIT – II **(11 hours)**

Combinational CMOS Logic Circuits: CMOS logic gates – NOR & NAND gate, CMOS adder and subtractor, CMOS multiplexer, CMOS transmission gates, Designing with Transmission gates

UNIT – III **(12 hours)**

Sequential CMOS Logic Circuits: SR Latch, Clocked latch and flip-flop circuits, CMOS D latch and edge-triggered flip-flop

UNIT – IV **(12 hours)**

Memories: Introduction to Memory, Memory Classification, Memory architecture and building blocks, Read-Only Memory, SRAM, DRAM.

Practical component (Hardware OR Simulation): **(30 hours)**

1. To design and plot the static (VTC) of a digital CMOS inverter.
2. To design and plot the dynamic characteristics of a digital CMOS inverter.
3. To design and plot the dynamic characteristics of 2-input NAND using CMOS technology.
4. To design and plot the dynamic characteristics of 2-input NOR, logic gates using CMOS technology.
5. To design and plot the characteristics of an Adder/subtractor.
6. Design and simulation of a D flip-flop or a latching circuit
7. Design and simulation of SRAM cell.
8. Design and simulation of DRAM cell.

Essential/recommended readings

1. CMOS Digital Integrated Circuits Analysis and Design – Sung-Mo Kang, Yusuf Leblebici, TMH, 4th Edition.
2. Digital Integrated Circuit: A Design Perspective-Rabaey, Chandrakasan and Nikolic, Pearson,2nd Edition.
3. Digital Integrated Circuit Design – Ken Martin, Oxford University Press, 2011
4. CMOS VLSI Design: A Circuits and Systems Perspective -Neil H. E. Weste and David Harris, Pearson,4th Edition
5. Essentials of VLSI Testing for digital, memory and mixed-signal VLSI Circuits - Bushnell and Agrawal, Kluwer Academic Publishers.

Suggestive readings

1. Analog Integrated Circuit Design" by David A. Johns and Ken Martin, Wiley,2nd Edition.
2. Fundamentals of Digital Logic with Verilog Design -Stephen Brown and Zvonko,TMH, 3rd Edition.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE ELECTIVE COURSE: Advanced Electronic Instrumentation (INDSE7C)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Electronic Instrumentation (INDSE7C)	04	03	-	01	Course admission eligibility	Analog Electronics-

Learning Objectives

- To provide in-depth knowledge about instrumentation amplifier.
- Discussion of different types of Optical Transducers and display devices. .
- To have extensive knowledge about different measuring instruments

Learning Outcomes

After successful completion of the course, students will be able to:

- Understand and apply the principles of Instrumentation Amplifiers.
- Analyze and implement analog-to-digital and digital-to-analog conversion systems.
- Understand the working and applications of specialized measuring instruments.
- Demonstrate proficiency in modern instrumentation techniques.

SYLLABUS OF DSE

UNIT – I **(12 hours)**

Instrumentation Amplifier & its applications: Instrumentation system, Instrumentation Amplifier using Transducer bridge, Applications of Instrumentation Amplifier-Temperature Indicators using Thermistor and Analog Weight Scale.
Convertors-D/A convertor with Binary-weighted resistors and with R & 2R resistors, Successive approximation A/D converter using Operational Amplifiers.

UNIT – II **(10 hours)**

Indicators: Electrodynamometer, Moving-Iron, Induction type, Electrostatic type.
Display devices: LED, LCD, Dot Matrix Display, Electro-Luminescent Displays

UNIT – III **(12 hours)**
AC measuring Instruments: Digital Capacitance Meter, Electrodynamic type Wattmeter, Reactive power meter, Power factor meter, Watthour meter, Digital Phase meter
Measuring Instruments: Source measuring unit (SMU): working, construction and Applications, Megger

UNIT – IV (11 hours)
Measurement of microwave frequencies: Wavemeters-Resonant Coaxial, Cavity Type and Lumped Type Wavemeter
Measurement of RF power: Bolometer: working principle, Construction and types

Practical Component (Hardware/ Software) **(30 hours)**

1. Designing of Basic Instrumentation Amplifiers using op-amp.
2. Designing of Instrumentation Amplifier using Transducer bridge
3. Designing of D/A convertor with Binary-weighted resistors
4. Designing of D/A convertor with R & 2R resistors
5. Measurement of power using wattmeter
6. Study of Watthour meter and measurement of electricity consumption in different conditions.
7. Study and analyse the operation of Source measuring unit (SMU).
8. To study diode characteristics using SMU.
9. Measurement of the Q-Factor of a Cavity (Virtual Lab)

Essential/recommended readings

1. BKG: Basic Electronics and Linear Circuits by N. N. Bhargava, D. C. Kulshreshtha and S. C. Gupta. Technical Teachers training Institute, Tata McGraw Hill Publishing Company Limited.
2. H & C: Modern Electronic Instrumentation & Measurement Techniques by Albert D. Helfrick & William D. Cooper (PHI) Edition.
3. K: Electronic Instrumentation by H. S. Kalsi, 2nd Edition, Tata McGraw Hill.
4. T: Digital electronics by G. L. Tokheim (6th Edition) (Tata Mc Graw Hill).
5. H. Cooper, Modern electronic instrumentation and measurement techniques, Pearson Education (2015).
6. R.A. Witte, Electronic test instruments: Analog and digital measurements, Tata Mc Graw Hill (2004).

7. S. Wolf and R.F.M. Smith, Student Reference Manual for Electronic Instrumentation Laboratories, Pearson Education (2004).
8. David A. Bell, Electronic Instrumentation and Measurements, Prentice Hall of India, 2nd edition.

Suggestive readings

1. H & H: The Art of Electronics, by Paul Horowitz & Winfield Hill (2nd Edition).
2. U.A. Bakshi and A.V. Bakshi, Electronic Measurements and Instrumentation, Technical Publications.
3. Joseph J Carr, Elements of electronic instrumentation and measurement, Pearson Education (2005).
4. C.S. Rangan, G.R. Sarma and V.S. Mani, Instrumentation Devices and Systems, Tata McGraw Hill (1998).

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

DISCIPLINE SPECIFIC ELECTIVE COURSE : VLSI Fabrication Technology (INDSE7D)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
VLSI Fabrication Technology (INDSE7D)	04	03	-	01	Course admission eligibility	semiconductor devices

Learning Objectives

The Learning Objectives of this course are as follows:

- Understanding of Semiconductor Materials and Properties.
- Understanding of Cleanroom Practices and Safety Protocols.
- Understanding the principles of photolithography, Etching and Thin-Film Deposition.
- Analyze Ion Implantation and Annealing.
- Describe Oxidation and Annealing and explore Chemical Mechanical Polishing (CMP).

Learning Outcomes

After successful completion of the course, students will be able to:

- Follow cleanroom practices and safety protocols in a controlled laboratory or cleanroom environment.
- Explain the principles of photolithography and how it is used in semiconductor fabrication.
- Perform or simulate basic etching and thin-film deposition processes.
- Describe ion implantation, annealing, and oxidation processes in semiconductor manufacturing.
- Construct process flows for specific semiconductor manufacturing steps, including process integration.

SYLLABUS OF DSE

UNIT – I **(07 hours)**

Introduction to VLSI Technology: Evolution from early transistors to integrated circuits, Moore's Law in driving the miniaturization of devices. Overview of the semiconductor industry.

Cleanroom Practices and Safety: Cleanroom protocols and contamination control, Safety measures in a cleanroom environment.

UNIT – II **(15 hours)**

Lithography: Photolithography fundamentals, Step-by-step lithography process, Advanced lithography techniques (e.g., EUV). **Etching and Film Deposition:** Chemical and physical etching processes, Thin-film deposition techniques (CVD, PVD, ALD), Plasma processing.

UNIT-III **(15 hours)**

Ion Implantation: Introduction to ion implantation, Doping profiles, and implantation techniques. **Oxidation and Annealing:** Thermal oxidation of silicon, Annealing processes for activation and diffusion.

UNIT – IV **(08 hours)**

Wafer Fabrication Steps: Wafer cleaning and preparation, Photomask and reticle fabrication, Pattern transfer processes, Advanced Process Integration, Multiple patterning and self-alignment techniques. Process flow for CMOS technology.

Practical component (TCAD Software/Virtual Labs/ Hardware) **(30 hours)**

1. Demonstration of semiconductor fabrication facility or cleanroom to observe the cleanroom environment, equipment, and safety protocols.
2. Virtual Fabrication of a P-N Junction Diode.

3. Virtual Fabrication of a NPN Transistor.
4. Virtual Fabrication of PNP Transistor.
5. Virtual Fabrication of N-channel MOSFET.
6. Virtual Fabrication of P-channel MOSFET.
7. Virtual Fabrication of a Silicon Photovoltaic (Solar) Cell.
8. Industry visit

Essential/recommended readings

1. "Introduction to Microfabrication" by Sami Franssila 2nd Edition, published in November 2010 by Wiley.
2. S.K.Gandhi, VLSI Fabrication principles,2nd Edition, published in April 1994 by Wiley-VCH
3. S.M. Sze, VLSI Technology, 2nd Edition, published in July 2017 by McGraw Hill Education
4. W.R. Runyan, Silicon Semiconductor Technology, 2nd Edition, published in 1990 by McGraw Hill.
5. P.Van Zant, Microchip Fabrication, A Practical Guide to Semiconductor Processing, 6th Edition, published in January 2014 by McGraw Hill.

Suggestive readings

1. BenG. Streetman, Solid State Electronic Devices, Prentice Hall.
2. "Microchip Fabrication: A Practical Guide to Semiconductor Processing" by Peter Van Zant
3. "Fundamentals of Semiconductor Manufacturing and Process Control" by Gary S. May and Costas J. Spanos
4. "Advanced Semiconductor Fundamentals" by Robert F. Pierret
5. "Semiconductor Manufacturing Technology" by Michael Quirk and Julian Serda
6. "Semiconductor Devices: Physics and Technology" by Simon M. Sze and Kwok K.Ng
7. "Process Technology for VLSI and ULSI" by C. Y. Chang and S. M. Sze

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE – : Measurement Technology (INDSE7E)

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Measurement Technology (INDSE7E)	04	03	-	01	Course admission eligibility	Industrial instruments

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide in-depth knowledge about various techniques used for the measurement of industrial parameters and processes.
- Discussion of different types of speed and acceleration measuring instruments and their application in various Industrial processes.
- To have adequate knowledge of construction and working of various pressure measuring instruments
- Exposure to construction and working of various flow and level measurement devices used for industrial purposes.
- To have extensive knowledge about the calibration of various industrial instruments

Learning Outcomes

After successful completion of the course, students will be able to:

- Apply pressure measurement techniques using Bourdon gauges, manometers, and vacuum systems in practical settings.
- Explore various flow measurement devices such as orifice plates, rotameters, and ultrasonic flow meters for accurate flow rate measurements.
- Measure speed and acceleration using tachometers and accelerometers, and document data using recorders and printers.
- Implement humidity and moisture measurement systems including hygrometers, psychrometers, and infrared systems in diverse environments.

Syllabus of DSE

UNIT-I **(12 hours)**

Pressure measurement: Units of pressure, Manometers-different types, elastic type pressure gauges, Bourdon type, bellows, diaphragms, measurement of vacuum, McLeod gauge, Pirani Gauge, thermal conductivity gauges, Hot cathode Ionization gauge, dead weight tester. Vacuum pumps- rotary and diffusion pumps.

UNIT-II **(12 hours)**

Flow Measurement: Introduction, definitions and units, classification of flow meters, Mechanical type flowmeters, orifice plate, venturi tube, Rotameter, thermal mass flow meter, Principle and constructional details of electromagnetic flow meter, ultrasonic flow meters, laser doppler anemometer systems, vortex shedding flow meter, guidelines for selection of flow meter.

UNIT-III **(11 hours)**

Measurement of Speed and Acceleration: Tachometers, Mechanical, Contact-less, Stroboscopic tachometers. Accelerometers, Elementary, Seismic and Practical accelerometers. Recorders: strip chart, circular and XY. Printers: Dot matrix, inkjet and laser.

UNIT-IV **(10 hours)**

Measurement of Humidity and Moisture: Basic principles, hygrometers, psychrometers, humidity charts, dew point, measurement systems for humidity, Infrared moisture measuring systems, radioactive moisture measuring systems.

Practical component: **(30 hours)**

1. Flow rate measurement using orifice plate flowmeter.
2. Calibration of pressure gauge using dead weight calibrator.
3. To find out the level of water using level transmitters.
4. Measurement of conductivity of test solutions using electrical conductivity meter.
5. To find the flow rate using electromagnetic flowmeter
6. To find the flow rate using an ultrasonic flowmeter.
7. To record the temperature variations using Circular chart recorder

Essential/recommended readings

1. Process Measurement and Analysis, 4th Edition (1995), Liptak B. G., Chilton Book Company, Pennsylvania.
2. Principles of Industrial Instrumentation, 3rd Edition (1997), D.Patranabis, Tata McGraw Hill Publishing Co., New Delhi.
3. A Course in Electrical and Electronic Measurements and Instrumentation, (2005), A.K. Sawhney, Dhanpat Rai & Co.
4. Mechanical and Industrial Measurements, 3rd Edition, Tenth Edition (1996), R.K. Jain, Khanna Publishers.
5. Measurement Systems: Application and Design, 5 th Edition (2003), Doeblin E. O, McGraw Hill, Singapore.
6. Instrumentation Measurement and Analysis, 4th Edition (2017), B.C. Nakra, K.K. Chaudhry, McGraw Hill Education Pvt. Ltd.
7. Instrumentation and Control Systems: 1st Edition (2016), K. Padma Raju, Y.J. Reddy, McGraw Hill Education Pvt. Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

DISCIPLINE SPECIFIC ELECTIVE COURSE-: Materials Science for Instrumentation and Sensor Development (INDSE7F)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Materials Science for Instrumentation and Sensor Development (INDSE7F)	04	03	-	01	Course admission eligibility	Basic knowledge of semiconductor

Learning Objectives

The Learning Objectives of this course are as follows:

- Understand the basics of materials science and its relevance to sensor development.
- Explore the properties of materials and their applications in instrumentation.
- Explore the role of functional materials in developing modern sensors.
- Understand the properties of advanced materials.
- To make students aware about the measuring instruments and the methods of measurement and the use of different sensors.
- Explore smart electronics materials for sensing applications.

Learning Outcomes

After successful completion of the course, students will be able to:

- To understand different sensing materials properties
- To understand the working of different characterization instruments for sensing
- To understand different preparation method for sensing materials
- To understand about smart materials for sensors

SYLLABUS OF DSE

UNIT-I **(11 hours)**

Introduction to Materials Science: Role of materials in instrumentation and sensors, Brief Introduction of different types of materials used for sensing applications

Material Properties for Sensing Applications: Electrical properties, Mechanical properties, Thermal properties and Optical properties.

Material Characterization Techniques: Basics of X-ray diffraction (XRD), scanning electron microscopy (SEM) and spectroscopy techniques.

UNIT-II **(12 hours)**

Semiconducting Materials: Silicon based material**,** Compound, Ternary, Quaternary, Materials, Metal oxides (ZnO, TiO_2)

Polymers and Organic Materials: Conducting polymers (e.g., polyaniline, polypyrrole).

Organic materials for flexible and wearable sensors.

UNIT-III **(12 hours)**

Piezoelectric Materials: Principles of piezoelectricity and applications in force and vibration sensing, Examples: Quartz, PZT, and polymer-based piezoelectrics.

2D Materials for Sensors: Introduction to graphene and Transition Metal Dichalcogenides (TMDs), Applications in gas, strain, and chemical sensing.

UNIT-IV **(10 hours)**

Smart Materials: Introduction to Smart Material Systems; Overview of smart materials, Perovskite materials, Multiferroic materials, Shape memory alloys (SMA): Magnetostrictive materials, Magnetoresistive materials

Practical component: (Hardware/Software/Demo based/Virtual lab) **(30 hours)**

1. Measurement of electrical properties of sensing materials using a two-point probe method.
2. Measurement of electrical properties of sensing materials using a four-point probe method.
3. Measurement of different electrical properties of sensing materials using Hall sensor apparatus.
4. Measurement of piezoelectric response using vibration sensors.
5. Measurement of Dielectric constant of unknown material by using variable capacitor technique.
6. Learning Basics of Scanning Electron Microscopy: Secondary Electron and BSE imaging mode (Virtual Lab).
7. To understand electron diffraction for various materials (Virtual Lab).

Essential/recommended readings

1. D. J. Leo, Engineering Analysis of Smart Material Systems, John Wiley & So ns, Inc., 2007 (available online via MSU Library)
2. Agrawal, D.C., 2013. *Introduction to nanoscience and nanomaterials*. World Scientific Publishing Company.
3. Robertson, J. H. (1979). Elements of X-ray diffraction by BD Cullity.
4. Callister, William D., and David G. Rethwisch. *Materials science and engineering: an introduction*. Vol. 9. New York: Wiley, 2018.
5. Pavia, Donald L., Gary M. Lampman, George S. Kriz, and James A. Vyvyan. *Introduction to spectroscopy*. Cengage learning, 2014.
6. Egerton, Ray F. *Physical principles of electron microscopy*. Vol. 56. New York: Springer, 2005.

Suggestive readings

1. Raghavan, Viswanatha. *Materials Science and Engineering: A first course*. PHI Learning Pvt. Ltd., 2015.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE-: MEMS Technology and Applications (INDSE7G)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MEMS Technology and Applications (INDSE7G)	04	03	-	01	Course admission eligibility	Basic electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- Understand and apply fundamental concepts and techniques in the design and fabrication of nano/micro-systems from an engineering perspective.
- To introduce the basic concepts of micro systems and advantages of miniaturization.
- Micro-scale systems are compared with meso-scale systems and their mechanical, electrical, and optical properties are discussed.

Learning Outcomes

After successful completion of the course, students will be able to:

- Able to understand the operation of micro devices, micro systems and their applications.
- Able to design the micro devices, micro systems using the MEMS fabrication process.
- To study the various materials and their properties used for micromachining techniques.
- To teach the fundamentals of pressure sensors and accelerometer sensors through design and modeling.
- To give exposure to different MEMS devices.

SYLLABUS OF DSE

UNIT – I **(12 hours)**
Materials for MEMS, Thin film deposition, lithography and etching. Bulk micromachining, surface micromachining and LIGA process.

UNIT – II **(12 hours)**
MEMS devices, Engineering Mechanics for Micro System Design, Micro Pressure Sensor, Micro accelerometer. Electronic interfaces, design, simulation and layout of MEMS devices using CAD tools.

UNIT – III **(12 hours)**
Introduction, An approach to MEMS design, Basic introduction to fabrication, Process Integration. Energy conserving transducer, Mechanics of membranes and beams.

Electrostatic Actuation and Sensing, Effects of electrical excitation. Design of Micro pressure sensor and Micro accelerometer

UNIT – IV **(12 hours)**
Applications of MEMS: Pressure Sensors**-** Piezoresistive Pressure Sensor: Sensing Pressure, Piezoresistance- Analytic Formulation in Cubic Materials-Longitudinal and Transverse Piezoresistance -Piezoresistive Coefficients of Silicon- Structural Examples-Signal Conditioning and Calibration.
Capacitive Accelerometer: Fundamentals of Quasi-Static Accelerometers, Position Measurement with Capacitance- Circuits for Capacitance Measurement Demodulation Methods- Case Study- Specifications- Sensor Design and Modeling Fabrication and Packaging.

Practical component: (Software or Hardware) **(30 hours)**

1. Design and fabrication process of MEMS devices.
2. Determination of Capacitance change in Capacitive Pressure Sensor.

3. Design and Construction of different types of Accelerometer and determination of its natural frequency
4. Design and Analysis of Piezoresistive Accelerometer
5. Design and Analysis of Comb drive type Capacitive Accelerometer.

Essential/recommended readings

1. Tai Ran Hsu, "MEMS & Microsystems Design and Manufacture", Tata McGraw Hill, New Delhi
2. Marc Madou, "Fundamentals of Microfabrication", CRC Press
3. Julian W. Gardner and Vijay K. Varadan, "Micro sensors, MEMS, and Smart Devices", John Wiley & Sons Ltd

Suggestive readings

1. Michael Wilson, KamaliKannangara, Geoff Smith, Michelk Simon, "Nanotechnology: Basic Science and Emerging Technologies".
2. M.H.Bao "Micromechanical transducers: Pressure sensors, accelerometers and gyroscopes", Elsevier, New York, 2000.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

DISCIPLINE SPECIFIC ELECTIVE COURSE : Biosensors and Nanotechnology (INDSE8A)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Biosensors and Nanotechnology (INDSE8A)	04	03	-	01	Course admission eligibility	Basics of semiconductor materials

Learning Objectives

The Learning Objectives of this course are as follows:

- Understand the working principles of biosensors and their components.
- Identify different types of biosensors based on sensing mechanisms and applications.
- Gain knowledge about the materials and techniques used in biosensor fabrication.
- Learn about the interfacing and signal processing involved in biosensors.
- Understand the principles of nanomaterials.
- Explore their integration into biosensing devices.
- Explore the role of nanotechnology in enhancing biosensor performance.

Learning Outcomes

After successful completion of the course, students will be able to:

- Develop a deep understanding of Biosensors and their Applications.
- Develop understanding of nanoscience and nanomaterials.
- Correlate properties of nanostructures with their size, shape and surface characteristics.
- Gain the improvements in drug delivery systems using nanotechnology.

SYLLABUS OF DSE

UNIT-I **(10 hours)**

Biosensors: Introduction to Biosensors, Definition, components and working principles

Classification of Biosensors: Based on transduction mechanism: Electrochemical, optical, piezoelectric and mass sensors.

Based on biorecognition elements: Enzyme-based, DNA-based and immunosensors.

Key Performance Parameters: Sensitivity, specificity, stability, response time and detection limit.

UNIT-II **(11 hours)**

Transducer Materials and Bioreceptors: Conducting polymers, nanomaterials, and biomaterials, Immobilization techniques: Adsorption, covalent bonding, entrapment, and cross-linking.

Signal Transduction and Amplification: Concepts of signal conversion and amplification, Noise reduction techniques in biosensors.

UNIT-III **(14 hours)**

Introduction to Nanotechnology: properties of nanomaterials: Optical, electrical, and mechanical. **Types of nanostructure:** Zero dimensional, One dimensional, Two dimensional and three-dimensional nanostructured materials, Quantum Dots shell

Synthesis of Nanomaterials: Top-down and bottom-up approaches, Techniques: Sol-gel method and nanolithography.

UNIT-IV **(10 hours)**

Nanostructured Materials in Biosensors: Use of nanoparticles, nanowires, nanotubes and quantum dots, Role of nanomaterials in signal enhancement and detection sensitivity. **Advanced Nano biosensors:** Plasmonic biosensors, Nano sensors for drug delivery and point-of-care diagnostics.

Practical component:(Hardware/Software/Demo/Virtual Lab) **(30 hours)**

1. Detection of Glucose Using a Commercial Glucose Sensor
2. To study the performance of Biosensor (Pulse measurement technique) (Virtual Lab)
3. To study the piezoelectric properties of ZnO thin films for biomolecule detection.
4. To study capacitive biosensor using a semiconductor material for detecting biomolecules.
5. Project on biosensors

Essential/recommended readings

1. Chemical Sensors and Biosensors; Brian, R Eggins; Wiley; New York, Chichester, 2002.
2. Biosensors: A Practical Approach, J. Cooper & C. Tass, Oxford University Press, 2004.
3. Nanomaterials for Biosensors, Cs. Kumar, Wiley – VCH, 2007.
4. Smart Biosensor Technology, G.K. Knoff, A.S. Bassi, CRC Press, 2006.
5. Nanotechnology - Enabled Sensors, Kourosh Kalantar-zadeh and Benjamin Fry, Springer (2008).

Suggestive readings

1. Biosensor: A Practical Approach, J. Cooper & C. Tass, Oxford University Press, 2004.
2. Nanomaterials for Biosensors, Cs. Kumar, Wiley-VCH, 2007.
3. Smart Biosensor Technology,G.K. Knoff , A.S. Bassi, CRC Press, 2006.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

Discipline Specific Elective-: Medical Image Processing and Healthcare Management (INDSE8B)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Medical Image Processing and Healthcare Management (INDSE8B)	04	03	-	01	Course admission eligibility	Basic Mathematics and MATLAB/ Scilab

Learning Objectives

The Learning Objectives of this course are as follows:

- This course aims to provide a detailed introduction to image & its processing.
- To understand & to know how an image model is developed and processed.
- To develop a capacity to analyse the image through various segmentation techniques.
- To develop a capacity to apply these processes in medical applications.

Learning Outcomes

After successful completion of the course, students will be able to:

- Recognize and analyse image acquisition storage, processing, communication & display.
- Understand the formation of image models & basic enhancement techniques.
- Learn the image segmentation processing in detail.
- Understand the basic applications of image processing in medical systems.

SYLLABUS OF DSE

UNIT – I **(12 hours)**

Introduction to biomedical Image Processing: Image acquisition, storage, processing, communication and display.

Visual perception: Structure of the Human Eye, Image formation in a human eye, brightness and contrast, adaptation and discrimination, Block's Law and critical fusion frequency photographic film characteristics.

UNIT – II **(11 hours)**

Image Model: Uniform and non-uniform sampling, quantization, Image enhancement: Image smoothing, point operators, contrast manipulation, histogram modification, noise clipping image sharpening, spatial operators, frequency domain method, low pass and high pass filtering, homomorphic filtering, median filtering.

UNIT – III **(11 hours)**

Medical Image Segmentation: Histogram-based methods, Region growing and watersheds, Markov Random Field models, active contours, model-based segmentation. Multi-scale segmentation, semi-automated methods, clustering-based methods, classification-based methods, atlas-guided approaches, and multi-model segmentation.

UNIT – IV **(11 hours)**

Introduction to Healthcare Management: Health and Development: Social Determinants of Health, Environment and Health Sustainable Development, Health Policies, Healthcare Financing, Organizational Behaviour in Healthcare and Hospitals, Healthcare processes and Clinical pathways, Medical ethics and medical negligence.

Practical component: **(30 hours)**

1. To represent basic signals (Unit step, unit impulse, ramp, exponential, sine, and cosine).
2. To develop a program for obtaining Fourier transform & inverse Fourier transform.
3. To develop a program for obtaining Laplace transform & inverse Laplace transform.
4. To develop a program for obtaining z- transform & inverse z-transform.
5. To develop a program for discrete convolution.
6. To develop a program for discrete correlation.
7. To develop a program for converting an RGB image to a GRAY scale.
8. To develop a program for obtaining a histogram of an image.
9. To develop a program for adding & removing salt and pepper noise.
10. To develop a program for performing filtering operations on images.
11. To develop a program for blurring & sharpening of an image.

Essential/recommended readings

1. Rafel C Gonzalez, Richard E Woods, “Digital Image Processing”, 4th ed., Addison - Pearson Publishing Company, 2017.
2. William R Hendee, E. Russell Ritenour, “Medical Imaging Physics”, 4th ed., John Wiley & Sons, Inc., New York, 2002.
3. Gonzalez, R., and R. E. Woods. “Digital Image Processing”, 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 2002. ISBN: 9780201180756.
4. Epstein, C. L. “Mathematics of Medical Imaging”, Upper Saddle River, NJ: Prentice Hall, 2003. ISBN: 9780130675484.
5. Webb, S. “The Physics of Medical Imaging”, 2nd ed. New York, NY: Taylor & Francis, 2012.

6. Hospital Administration and Human Resource Management: DK Sharma and RC Goyal, PHI Learning Pvt. Ltd., 01-Aug-2017.
7. Hospital Information Systems: A Concise Study: AS Kelkar, PHI Learning Pvt. Ltd., 2010.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

DISCIPLINE SPECIFIC ELECTIVE COURSE: Semiconductor Device Modeling and Simulation (INDSE8C)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Semiconductor Device Modeling and Simulation (INDSE8C)	04	02	-	02	Course admission eligibility	semiconductor devices

Learning Objectives

The Learning Objectives of this course are as follows:

- Students will develop in-depth understanding of semiconductor device physics, operation, and behaviour.
- Students will grasp the fundamentals of semiconductor fabrication processes and how to model them effectively.
- Students will learn to use modeling tools and techniques for simulating semiconductor devices and processes.
- Students will be able to analyze simulation results, extract relevant data, and interpret the implications for device and process performance.

Learning Outcomes

After successful completion of the course, students will be able to:

- Describe the fundamental principles of semiconductor devices.
- Model and simulate semiconductor fabrication processes, such as oxidation, diffusion, deposition, and etching, using appropriate software tools.

- Use numerical methods to solve semiconductor device and process equations, and understand the mathematical foundations of modeling.
- Analyze and interpret simulation results to draw meaningful conclusions about device and process performance.
- Explain the importance of TCAD in semiconductor manufacturing and design.

SYLLABUS OF DSE

UNIT – I **(8 hours)**

Introduction to Semiconductor Device Modeling: Importance of device modeling in semiconductor industry

Fundamental Equations: Poisson's equation, continuity equation, drift-diffusion equation

UNIT – II **(8 hours)**

Device Modeling Techniques: Physical Models: Solving Poisson's and continuity equations. Compact Models**:**Shockley model for Diodes and Gummel-Poon model for BJTs.

UNIT – III **(6 hours)**

Simulation Tools and Techniques: Introduction to state-of-the-art simulation tools used for nanoscale device analysis, including TCAD (Technology Computer-Aided Design) software, Standard industry TCAD tools

UNIT – IV **(8 hours)**

Device Simulation: Techniques for optimizing device structures and scaling advanced devices for high performance. Simulation of emerging devices (e.g. FinFETs, nanoscale devices)

Practical component: (TCAD software) **(60 hours)**

1. Simulate and model diode using software.
2. Simulate and model NPN transistor using software.
3. Simulate and model PNP transistor using software.
4. Simulate and model N-channel MOSFET using software.
5. Simulate and model P-channel MOSFET using software.
6. Explore the effect of temperature on N-channel MOSFET characteristics.
7. Explore the effect of gate oxide thickness on N-channel MOSFET characteristics
8. Explore the effect of temperature on P-channel MOSFET characteristics.
9. Explore the effect of gate oxide thickness on P-channel MOSFET characteristics
10. Utilize TCAD tools to simulate semiconductor fabrication processes, such as oxidation, diffusion, and etching.

11. Explore the modeling of advanced semiconductor devices, such as FinFETs

Essential/recommended readings

1. "Introduction to Semiconductor Device Modelling" by B. Van Zeghbroeck,3rd Edition, 2011
2. "Semiconductor Device Fundamentals" by Robert F. Pierret.1st Edition, published in 1996 by Pearson.
3. "Process Technology for VLSI and ULSI" by C. Y. Chang and S. M. Sze.2nd Edition, published in 1997 by Wiley.
4. "Process Simulation" by Robert E. King 1st Edition, published in 1997 by McGraw-Hill.
5. "Numerical Simulation of Submicron Semiconductor Devices" by Mark Lundstrom and Jing Wang.1st Edition, published in 2006 by Springer.
6. "Nanoscale Transistors: Device Physics, Modeling, and Simulation" by Hong Guo, Mark Lundstrom, and Jing Guo.1st Edition, published in 2006 by Springer.
7. "Numerical Methods for Engineers and Scientists" by Amos Gilat and Vish Subramaniam.3rd Edition, published in 2014 by Wiley.

Suggestive readings

1. "Semiconductor Device Modeling with Spice" by Giuseppe Massobrio and Paolo Antognetti
2. "Technology CAD — Computer Simulation of IC Processes and Devices" by Wolfgang M. Olthoff

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

DISCIPLINE SPECIFIC Elective COURSE: Optoelectronic Devices and Applications (INDSE8D)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Optoelectronic Devices and Applications (INDSE8D)	04	03	-	01	Course admission eligibility	Basic electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide a detailed exposure to the physics, principle of operation, design, and characteristics of widely used optoelectronic devices for applications in Optoelectronics, Optical Communication and Optical Signal Processing.
- Specific emphasis will be on optical amplifiers, sources, detectors, and modulators, which also lead to the realization of Photonic Integrated Circuits.
- Understand how the fundamental concepts affect the performance of practical optoelectronic devices

Learning Outcomes

After successful completion of the course, students will be able to:

- Describe the optical absorption and emission characteristics of a given semiconductor material under certain excitation conditions
- Predict the most fundamental performance characteristics of a given optoelectronic device design.
- Choose the most appropriate optoelectronic device for a specific application and understand possibilities and limitations offered by that particular device.
- Perform measurements to investigate the basic properties of optical fibre and detecting devices.

SYLLABUS OF DSE

UNIT – I (10 hours)

Wave Nature of Light – Conceptual Overview

Wave Equation, Refractive index, group and phase velocity, Pointing vector, Snell's law, Fresnel's equations, Optical Resonators, Optical Tunneling, Coherence

UNIT – II (12 hours)

Optical Waveguides and Fibers

Optical waveguides and their classifications, Fiber optic components: fiber Bragg gratings, directional couplers, Fiber optic wave-plates, Optical Amplifier.

UNIT – III (12 hours)

Polarization and Modulation

Polarization, propagation in anisotropic media, birefringent devices, integrated optical modulators, acousto-optic modulators, magneto-optic modulators, nonlinear effects.

UNIT – IV

Optical Devices and Detector (11 hours)

Laser Diodes, Semiconducting Laser Amplifiers, LDR science and operation, Photodiode science and operation, avalanche and heterojunction photodiodes, phototransistors, photoconductive gain.

Practical component: (30 hours)

1. Study of Characteristics of phototransistors.
2. Study of Characteristics of laser diode.
3. Study of Characteristics of photodiodes.
4. Study of Characteristics of LDR.
5. Study of Characteristics of opto-couplers.
6. Study of Measurement of beam characteristics of lasers.
7. Measurement of losses- attenuation, bending in optical fibers.
8. Measurement of power gain in an optical amplifier.

Essential/recommended readings

1. Ajoy Ghatak, Optics, **8th Edition**, published in **August 2024** by McGraw Hill Education
2. S. O. Kasap, *Optoelectronics and Photonics: Principles and Practices*, Prentice Hall, 2012.
3. P. N. Prasad, *Nanophotonics*, John Wiley & Sons, 2004.
4. J. Singh, *Optoelectronics: An introduction to materials and devices*, McGraw-Hill, 1996.
5. Fiber Optic Sensors, An introduction for Engineers and Scientists, Eric Udd and W. B. Spillman, 2nd Ed, Wiley,2012, New Jersy, USA.
6. Kathryn M. Booth, The Essence of Optoelectronics, Prentice Hall, 2007

Suggestive readings

1. Optical Fiber Sensors: Systems and Applications, Ed. B. Culshaw and John Dakin, Artech House, Inc., 1989, Noewood, USA.
2. Fundamentals of Optical Fiber Sensors, Z. Fang, K.K.Chin, R. Qu, H. Cai, Wiley,2012, New ersy, USA.
3. G. P. Agrawal, *Fiber optics communication system*, John Wiley & Sons, 2011.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

DISCIPLINE SPECIFIC ELECTIVE COURSE –: Advanced Process Control (INDSE8E)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced	04	03	-	01	Course	Basics of

Process Control (INDSE8E)					**admission eligibility**	**Process Control**

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the fundamentals of process control and its role in industrial systems.
- To comprehend the dynamic behavior of various processes like flow, temperature, pressure, and level control systems.
- To explore different control strategies, such as feedback, feedforward, and cascade control.
- To familiarize students with essential control hardware (sensors, transmitters, controllers, and actuators).

Learning Outcomes

After successful completion of the course, students will be able to:

- Understand and analyze the dynamic behavior of first-order, second-order, and higher-order processes, focusing on key parameters like time constant, transient response, and steady-state error.
- Develop mathematical models for open-loop and closed-loop control systems and classify their structure and functionality.
- Implement and evaluate control strategies, including feedback, feedforward, and cascade control, to mitigate process disturbances.
- Identify and understand the roles of sensors, actuators, controllers in industrial automation.
- Use tools like MATLAB/Simulink to model, simulate, and analyze process control systems, and apply these concepts to real-world industrial processes.

SYLLABUS OF DSE

UNIT – I **(12 hours)**

Basics of Process Control, Process Dynamics, Types of processes, Control Strategies: Feedback control, Feedforward control, Cascade control. Introduction to Control Hardware and Software: Overview of sensors, transmitters, controllers, and actuators

UNIT – II **(11 hours)**

PID Control forms and closed loop tuning and direct synthesis method, Internal Model Control, IMC based PID procedure, control actions, Tuning methods, Controller Design, Controller Implementation

UNIT – III **(11 hours)**

Advanced Control Strategies: Ratio control, Adaptive control, and Inferential control, Concept of Model Predictive Control (MPC) and its applications, Multivariable Process Control, Nonlinear and Optimal Control: Concept of nonlinear systems and need for nonlinear control.

UNIT – IV **(11 hours)**

Industrial Process Control Applications, Case Studies and Simulation Projects, Current Trends in Process Control: Introduction to Industry 4.0 and Smart Process Control, Role of IoT, AI, and ML in predictive and self-tuning controllers, Emerging trends in sustainable and green process control systems.

Practical component: **(30 hours)**

1. Analysis of First-Order Dynamic Systems: Response to Step, Impulse, and Ramp Inputs.
2. Analysis of Second-Order Dynamic Systems: Response to Step, Impulse, and Ramp Inputs.
3. Design, Implementation, and Performance Analysis of P Controller for Process Control Systems.
4. Design, Implementation, and Performance Analysis of PI Controller for Process Control Systems.
5. Design, Implementation, and Performance Analysis of PD Controller for Process Control Systems.
6. Design, Implementation, and Performance Analysis of PID Controller for Process Control Systems.
7. Design and Implementation of a Cascade Control System.
8. Analysis of Multivariable Control Systems Using Relative Gain Array Method.
9. Design, Simulation, and Performance Evaluation of a Model Predictive Controller.

Essential/recommended readings

1. Chemical Process Control: George Stephanopoulos, Prentice Hall India Pvt. Ltd. January 2015
2. Process Systems Analysis and Control: Donald Coughanowr, McGrawHill, Inc.3rd edition, 2017
3. Process Control and Instrumentation: Prof. R. P. Vyas, Central Techno Publications, 8th Edition, Jan 2015

Suggestive readings

1. Process Dynamics and Control: D. E. Seborg, T. F. Edgar, D. A. Mellichamp,4th Edition, published in 2016 by Wiley.

2. Control System Design: Graham C. Goodwin, Stefan F. Graebe, Mario E. Salgado, Prentice Hall,1st Edition, published in 2015 by Pearson Education India.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

DISCIPLINE SPECIFIC ELECTIVE COURSE: Pneumatic and Hydraulic Systems (INDSE8F)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Pneumatic and Hydraulic Systems (INDSE8F)	**04**	**03**	**-**	**01**	**Course admission eligibility**	**Basics of Electric Circuits**

Learning Objectives

The Learning Objectives of this course are as follows:

- Understand the concept, importance, and real-world applications of pneumatic and hydraulic systems.
- Identify and describe the components of a fluid power system, including actuators, valves, pumps, compressors, and reservoirs.
- Develop foundational knowledge of the working principles of hydraulic and pneumatic systems.
- Differentiate between hydraulic and pneumatic systems based on their operational principles, advantages, and limitations.

Learning Outcomes

After successful completion of the course, students will be able to:

- Define the concept of fluid power and explain its role in industrial applications.
- List and describe the key components of a fluid power system and their respective functions.
- Differentiate between hydraulic and pneumatic systems, citing examples of where each is used.

- Apply the basic principles of fluid mechanics, such as Pascal's Law, to understand system pressure and force transmission.
- Illustrate the layout and components of a basic fluid power system.

SYLLABUS OF DSE

UNIT – I : Introduction to Pneumatic and Hydraulic Systems (10 Hours)

Basics of Fluid Power Systems: Definition, importance, and applications in industry. Components of fluid power systems: Actuators, Valves, Pumps, Compressors, and Reservoirs. Fundamentals of Hydraulics, Fundamentals of Pneumatics.

UNIT – II: Components and Design of Hydraulic Systems (12 Hours)

Hydraulic Actuators: Types of hydraulic actuators, Hydraulic cylinders, Hydraulic motors, Hydraulic Valves, Pressure control valves, Flow control valves and Directional control valves. **Hydraulic Circuits:** Regenerative circuits and their applications. **Accumulators:** Types, working, and applications

UNIT – III: Components and Design of Pneumatic Systems (12 hours)

Pneumatic Actuators: Types of pneumatic actuators, Pneumatic cylinders, Pneumatic motors.

Pneumatic Valves and Accessories: Types of control valves, Valve actuation, Pneumatic Circuits, Compressor Systems: Types of compressors, Air storage and distribution, Maintenance and troubleshooting of pneumatic systems.

UNIT – IV: Control, Troubleshooting, and Applications (12 hours)

Control Systems in Pneumatic and Hydraulic Systems: Control logic for automated systems. Role of proportional, servo, and electrohydraulic systems in automation. Troubleshooting and Maintenance. Applications of Pneumatic and Hydraulic Systems

Practical component: (Hardware/ Software) (30 hours)

1. Modeling and Simulation of a Hydraulic/Pneumatic System Using MATLAB Simulink
2. Write a MATLAB script to calculate flow rate and pressure drop using the Hagen-Poiseuille equation.
3. Design and simulate the operation of hydraulic actuators.
4. Design and analyze the working of pressure control valves.
5. Design a regenerative hydraulic circuit and analyze its performance.
6. Design and simulate pneumatic actuators and cylinders.
7. Design a pneumatic control system for sequential operations.
8. Design a hydraulic system for controlling the position of an actuator.
9. Industrial visits for applications of hydraulic and pneumatic systems and their

reports.

Essential/recommended readings

1. Anthony Esposito, "Fluid Power with Applications", 7th Edition, published in February , 2024.
2. Majumdar S.R., "Oil Hydraulics Systems- Principles and Maintenance", Tata McGrawHill, July 2017.
3. Anthony Lal, "Oil hydraulics in the service of industry", Allied publishers, 1982.
4. Dudelyt, A. Pease and John T. Pippenger, "Basic Fluid Power", Prentice Hall, 1987.

Suggestive readings

1. Majumdar S.R., "Pneumatic systems – Principles and maintenance", Tata McGraw Hill, 1995
2. Michael J, Prinches and Ashby J. G, "Power Hydraulics", Prentice Hall, 1989.
3. Shanmugasundaram.K, "Hydraulic and Pneumatic controls", Chand & Co, 2006
4. Andrew A. Parr, Hydraulics and Pneumatics, Elsevier Science and Technology Books

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

DISCIPLINE ELECTIVE COURSE –: Sustainable Energy Technologies (INDSE8G)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Sustainable Energy Technologies (INDSE8G)	04	02	-	02	Course admission eligibility	Basics Knowledge of Physics

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide sound knowledge about different sustainable resources.

- Discussion of different types of solar thermal systems and solar photovoltaic systems.
- To have adequate knowledge of construction and working of various types of wind energy systems and micro-hydro power systems
- To have sound knowledge about bioenergy systems

Learning Outcomes

After successful completion of the course, students will be able to:

- Acquire the knowledge about sustainable energy and its different types
- Be conversant in construction and working of concentrated solar power systems and Solar Photovoltaic systems
- Be conversant in construction and working of different wind energy systems and different micro-hydro systems.
- Understand different bio-energy systems

SYLLABUS OF DSE

UNIT – I **(8 hours)**
Introduction to sustainable energy and Energy Fundamentals: Sustainable energy, Alternative energy sources: Primary, secondary and tertiary sources, Introduction to different types of sustainable energy resources-solar energy, wind energy, water energy and biomass energy.

UNIT – II **(8 hours)**
Classification of Solar Photovoltaic systems: Grid connected, off-grid, stand-alone systems. Photovoltaic cells: Types, merits and demerits, Different types of panels, Battery and other accessories, Recent trends and promotional schemes

UNIT – III **(8 hours)**
Wind energy systems and Micro-hydro Power systems
Types of wind energy systems: Large and small, commercial and domestic, grid connected and stand-alone, Small Horizontal axis and vertical axis wind turbines: construction, working, specifications and maintenance procedure.
Micro hydro power systems**:** Classification, Layout, construction and working, Installation: procedures and precautions, operating procedures and maintenance.

UNIT – IV **(6hours)**
Bio-energy Systems
Classification of biofuels: biogas and biodiesel, Biomass power plants: Layout, construction and principle of working and specification, Applications of various bio-fuels: Domestic and commercial

Practical component: (Hardware/ Software) **(60 hours)**

1. Identify the components of solar flat plate collector.
2. Use pyranometer for measurement of solar radiation flux density.
3. Assemble a solar PV system with and without battery connection.
4. Measure heat output, Maximum power, power output efficiency of solar PV panel.
5. Use vane anemometer for measurement of different locations for site selection for wind mill.
6. Industrial visit
7. Project based on sustainable technologies.
8.

Essential/recommended readings

1. C. S. Solanki, *Solar Photovoltaics*. PHI Learning Pvt. Ltd., 2015.
2. Solar energy, 4th edn , January 2017 by S P Sukhatme and J K Nayak
3. T. Ackermann, *Wind Power in Power Systems*. John Wiley & Sons, 2012.
4. D. P. Kothari, *Renewable Energy Sources and Emerging Technologies*. 2022.
5. V. C. Nelson, *Introduction to Bioenergy*. CRC Press, 2017.

Suggestive readings

1. K. Lovegrove, *Concentrating Solar Power Technology*. Elsevier, 2012.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

GENERIC ELECTIVE COURSE: Instrumentation and Control (INGE7A)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Instrumentation and Control (INGE7A)	04	03	-	01	Course admission eligibility	Basic instrumentation

Learning Objectives

The Learning Objectives of this course are as follows:

- To study about how to analyse the stability and response of the closed and open loop systems
- To teach students about how to develop the mathematical model of the physical systems
- To study about how to analyse performance characteristics of system using Frequency response methods
- To study how to compute gain and phase margins from Bode diagrams and Nyquist plots and understand their implications in terms of robust stability

Learning Outcomes

After successful completion of the course, students will be able to:

- Analyze the stability and response of the closed and open loop systems
- Develop the mathematical model of the physical systems
- Analyze performance characteristics of system using Frequency response methods
- Compute gain and phase margins from Bode diagrams and Nyquist plots and understand their implications in terms of robust stability
- Handle different types of controller like electronic, pneumatic and hydraulic

SYLLABUS

Unit-I **(13 hours)**

Basic concepts of Instrumentation: Generalized Instrumentation systems, block diagram representation, scope of instrumentation in Industrial organization.

Transducers: Active and Passive transducers, Mechanical transducers and Electrical transducers, Introduction to Resistive, Capacitive, Inductive, light (Photo-conductive, Photo-emissive, Photo-voltaic), Temperature transducers (RTD, thermocouple).

Unit-II **(12 hours)**

Signal Generators-Audio oscillator, Function generators, Pulse generators, RF generator, and Random noise generator.

Controller Hardware: Electronic pneumatic and hydraulic controller's implementation, single and composite modes of controller

Unit-III **(10 hours)**

Basics of control system: Open loop and closed loop control systems, mathematical modeling of physical systems, transfer function. Effect of feedback on control systems.

Time – Domain Analysis and Stability: Time domain performance criteria, transient response of first and second order systems. Asymptotic stability and conditional stability, relative stability analysis.

Unit-IV **(10 hours)**

Frequency Domain Analysis: Correlation between time and frequency response, frequency domain specifications.

Final Control Elements: Control valves types, actuators, Solenoid, I/P P/I converters, stepper motors.

Practical Components **(30 Hours)**

Some of the experiments mentioned can be simulated on software (MATLAB/MathCAD/LabVIEW/SciLab)

1. Study and operation of Multimeters (Analog and Digital), Function Generator, Regulated Power Supplies, CRO, DSO.
2. To measure displacement using capacitive transducer
3. To measure displacement using LVDT
4. Measuring change in resistance using LDR
5. Measurement of Temperature using Temperature Sensors.
6. To study position control of DC motor
7. To study speed control of DC motor
8. To study time response of first and second order systems.
9. To study the effect of the damping factor on performance of second order systems.

Essential/Recommended readings

1. K. Ogata, Modern Control Engineering, PHI 2010, 5th Edition by Pearson.
2. B. C. Kuo , “Automatic control system”, 2002, 8th Edition by John Wiley & Sons.
3. I. J. Nagrath& M. Gopal, Control System Engineering, New Age International, 2017, 5th Edition.
4. Nakra &Choudhary, Instrumentation Measurements and Analysis, Tata McGraw-Hill, 4th Edition (2016).

Suggestive readings

1. Johnson .C.D., Process Control Instrument Technology, Prentice Hall Inc, 8th Edition (2006).

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

GENERIC ELECTIVE COURSE: Photovoltaic Technology and Applications (INGE7B)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Photovoltaic technology and applications (INGE7B)	04	03	-	01	Course admission eligibility	Familiarity with electronic components and circuit designing

Learning Objectives

The Learning Objectives of this course are as follows:

- Students will develop a fundamental understanding of solar cells, its working, and characteristics.
- Students will be able to develop basic solar cells and calculate its efficiency.
- Students will learn about various generations of solar cells.
- Students will be able to recognize the various applications of solar cells.

Learning Outcomes

After successful completion of the course, students will be able to:

- Describe the fundamental principle and working principle of solar cells.
- Describe the evolution of solar cells and different generations of solar cells.
- Learn various techniques to develop solar cells.
- Analyze and interpret efficiency of solar cells and draw meaningful conclusions about device and process performance.
- Explain the applications of photovoltaics in industries.

SYLLABUS OF GE

UNIT – I (12 hours)

Energy and its Sources, Introduction to Solar Energy, Absorption spectra, Band Theory, Energy Band Diagram, Charge Carrier Dynamics in Semiconductor, Solar cell working principle, Current-Voltage Characteristics of Solar Cell, Equivalent Circuits of Solar Cells

UNIT – II (12 hours)

1st and 2nd Generation solar cells: monocrystalline Silicon solar cell, polycrystalline Silicon solar cell,amorphous Si solar cells, Cadmuim telluride Solar Cells,Copper indium gallium selenide (CIGS) solar cells

UNIT – III (11 hours)

3rd and 4th Generation solar cells:CZTS solar cells,Organic materials (OSC) solar cells, Perovskites (PSC) solar cells,polymer solar cells,hybrid solar cells,Multi-junction photovoltaic cells,nanocrystalline solar cells,Quantum dots (QD) photovoltaic cells,Dye-sensitized (DSSC) photovoltaic cells.

UNIT – IV **(10 hours)**

Installations techniques, cost effectiveness, Applications of solar cells of Industry, household, military, solar farms, remote locations, space, transportation, building integrated systems, power generation rural areas.

Practical component: **(30 hours)**

1. To calculate various parameters of solar cells.
2. To synthesize, dye synthesis solar cells and calculate its efficiency.
3. To develop and characterize thin film.
4. To study absorption spectra of different materials for solar cells.
5. To develop a project using solar panels.
6. Simulate and model basic solar cells using software.
7. An industrial visit for exposure to the photovoltaic industry.

Essential/recommended readings

1. Semiconductors for Solar Cells" by H J Moller,1993 published by Artech House.
2. The Physics of Solar Cells" by J Nelson,2019 published by World Scientific.
3. Photovoltaic Solar Energy: From Fundamentals to Applications" by Angèle Reinders and Pierre Verlinden,2024 published by Wiley

Suggestive readings

1. "Semiconductor Device Modeling with Spice" by Giuseppe Massobrio and Paolo Antognetti
2. "Technology CAD — Computer Simulation of IC Processes and Devices" by Wolfgang M. Olthoff.

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GENERIC ELECTIVE COURSE-: Machine Intelligence (INGE7C)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title	Credits	Credit distribution of the	Eligibility	Pre-requisite

& Code		course			criteria	of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Machine Intelligence (INGE7C)	**04**	**02**	**-**	**02**	**Course admission eligibility**	**Basics of statistics**

Learning Objectives

The Learning Objectives of this course are as follows:

- To apply machine intelligence techniques in applications which involve perception,
- reasoning and learning.
- To acquire knowledge of real-world knowledge representation
- To use different machine learning techniques to design AI machine and enveloping
- applications for real world problems.

Learning Outcomes

After successful completion of the course, students will be able to:

- Apply machine intelligence techniques in applications which involve perception,
- reasoning and learning
- Acquire knowledge of real-world knowledge representation
- Use different machine learning techniques to design AI machines and enveloping applications for real world problems.

SYLLABUS OF GE

UNIT – I (8 hours)

Components of AI, Human Intelligence vs. Machine Intelligence, Knowledge Acquisition, Representation and Organization, Structured Knowledge Representation using Semantic Networks and Frames, Expert System , and Functions of Expert Systems.

UNIT – II (8 hours)

Structure and Function of a Single Neuron, Artificial Neuron Models, Types of Activation Functions, Neural Network Architectures, Neural Learning, Supervised Learning, Unsupervised Learning and Application Areas of Neural Networks.

UNIT – III (8 hours)

Introduction to Fuzzy Logic, Fuzzy Sets and Systems, Membership Functions and Fuzzification, Knowledge and Rule-Based Systems, Decision-Making Logic and Inference Systems, Defuzzification and Applications of Fuzzy Logic.

UNIT – IV **(8 hours)**

Genetic Algorithm (GA) Concepts, GA Operators and Techniques, Applications of Genetic Algorithms and Hybrid Systems.

Practical component: **(60 hours)**

1. Simulate simple AI components like perception (input gathering), learning (pattern recognition), and reasoning (decision making).
2. Build a decision tree for a simple classification task. Implement depth-first search (DFS) to explore the tree.
3. Use a dataset to implement a basic machine learning model (e.g., k-NN or Decision Tree) that simulates human-like decision-making.
4. Compare the results of a machine learning model (e.g., classification) with human decisions on the same dataset, and analyze the differences.
5. Implement an expert system with a knowledge base for medical diagnosis. Simulate decision-making based on user inputs.
6. Create a semantic network and frames to represent and query knowledge. Visualize relationships between concepts.
7. Develop a basic expert system, focusing on constructing the knowledge base and implementing a simple inference engine.
8. Implement forward and backward chaining inference methods to derive conclusions from a knowledge base.
9. Implement a rule-based fuzzy logic expert system for decision-making, such as diagnosing conditions based on input parameters.
10. Create a model of a single artificial neuron, focusing on inputs, weights, and activation functions (e.g., Sigmoid).
11. Implement and visualize common activation functions (Sigmoid, ReLU, Tanh). Compare their output behaviors.
12. Build and simulate a basic feedforward neural network. Implement simple tasks like classification.
13. Train a neural network using the backpropagation algorithm. Use it to classify a simple dataset.
14. Implement basic fuzzy logic operators (AND, OR, NOT), applying them to sample fuzzy sets and visualizing the results.
15. Implement a genetic algorithm (GA) to solve an optimization problem, such as function maximization or finding optimal parameters for a model.

Essential/recommended readings

1. Timothy J. Ross, Fuzzy logic with Engineering Applications , McGraw Hill, New York, 4th Edition (2016),**Published by** Wiley
2. S. Rajasekaran, G. A. VijayalakshmiPai Neural Networks, Fuzzy Logic And Genetic, 2017, Published by PHI Learning.

Suggestive readings

1. Algorithm: Synthesis and Applications, PHI Learning Pvt. Ltd., 2003, 1st Edition.
2. Martin T. Hagan, Howard B. Demuth, Mark H. Beale, Neural Network Design,PWS Publishing Company, Thomson Learning, 1st Edition 4. N.P. Padhy, Artificial Intelligence and Intelligent Systems, Oxford University Press, 1st Edition

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GENERIC ELECTIVE COURSE-: Robotics (INGE8A)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Robotics (INGE8A)	04	02	-	02	Course admission eligibility	Basic programming.

Learning Objectives

The Learning Objectives of this course are as follows:

- After completion of this course students should be well versed in programming a microcontroller.
- They should be able to use various sensors and make the microcontroller respond to the external environment.
- Students would be in a position to make a rudimentary robot which is capable of moving along a predetermined path, follow a drawn line and equivalent applications.

Learning Outcomes

After successful completion of the course, students will be able to:

- Understand the history, concepts and key components of robotics technologies.
- Understand the control systems related to robotics.
- Analyze of various robot sensors, Actuators and their perception principles that enable a robot to analyses their environment

- Analyze the robot motion, kinematics, navigation and path planning.
- Design the programming principles for robot control systems.

SYLLABUS OF GE

UNIT-1 **(8 Hours)**

Introduction to Robotics: Brief history of robotics, future perspectives of robotics, classification of robots,basic components of robot, Degrees of freedom of robots, Robot configurations and concept of workspace, human system and robotics, safety measures in robotics, social impact, advantages and disadvantages of robots, Robotics applications **.**

UNIT-2 **(8 Hours)**

Basic components for Robotic Applications

Actuators: DC Motors, Gearing and Efficiency, Servo Motors, Stepper motors, Motor Control and its implementations

Sensors: Sound Sensor, Gas Sensor, Ultrasonic Sensor, IR Sensor, LDR, Temperature Sensor, PIR Sensor, contact Sensor, Proximity sensor , pressure sensor .

Indicators: LCD, LEDs, Buzzer, Relays

UNIT-3 **(8 Hours)**

Programming Environments: Integrated Development Environment (IDE) for microcontrollers, free IDEs like AVR Studio, WIN AVR. Installing and configuring for Robot programming, In System Programmer (ISP), loading programs on Robot. Languages used in Robotics (Basic concept)

UNIT-4 **(6 Hours)**

Programming and interfacing . Programming Robot to follow a given path; Direction controlled movements of Robot using sensors like LDR/IR sensors and sound Sensor, Line Follower Robot. Wired RS232 (serial) Communication, Application of USART in commanding Robot using Bluetooth, WiFi modules etc.

Practical Component **(60 hours)**

Software /hardware based practicals (Microcontroller/Arduino/RobotStudio/ or any available software)

1. Program to blink LED
2. Program to display decimal numbers on Seven segment display
3. Program to interface LCD and display messages .
4. Program to interface sound sensor /IR sensors/Ultrasound sensor
5. Program to interface motors (DC/stepper/Servo).

6. Program to interface Camera/Relay
7. Buzzer interfacing
8. interfacing with Zigbee
9. Write a program to do object detection with Robots.
10. To design White line follower Robot.
11. Programming using USART.
12. Project

Essential/recommended readings

1. Saha, S.K., Introduction to Robotics, 2nd Edition, McGraw-Hill Education, 3rd Edition (2025)
2. R.K. Mittal, I.J. Nagrath, Robotics & Control, Tata McGraw & Hills, 2005. M P Groover, Industrial Robotics, Tata McGraw & Hills, 2nd Edition 2012
3. S R Deb and Sankha Deb, Robotics Technology and Flexible Automation, Tata McGraw & Hills. 2nd Edition 2017.

Suggestive readings

1. Craig. J. J, Introduction to Robotics- Mechanics and Control, Pearson Education India, 3 nd Edition. 1999

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GENERIC ELECTIVE COURSE-: Augmented and Virtual Reality (INGE8B)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Augmented and virtual reality (INGE8B)	04	02	-	02	Course admission eligibility	Basics of programming language

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the relevance of this course to the existing technology through demonstrations, case studies and applications with a futuristic vision along with socio-economic impact and issues.

- To understand virtual reality, augmented reality and using them to build Biomedical engineering applications.
- To know the intricacies of these platforms to develop PDA applications with better optimality.

Learning outcomes

After successful completion of the course, students will be able to:

- Analyse & design a system or process to meet given specifications with realistic engineering constraints.
- Identify problem statements and function as a member of an engineering design team.
- Utilise technical resources
- Propose technical documents and give technical oral presentations related to design mini project results.

SYLLABUS OF GE

UNIT – I **(8 hours)**

Introduction to Virtual Reality (VR), The Three I's of Virtual Reality, Commercial VR Technology, Five Classic Components of a VR System, Input Devices – Trackers, Navigation and Manipulation Interfaces, Gesture Interfaces, Output Devices – Graphics, Sound, and Haptic Feedback

UNIT – II **(8 hours)**

Introduction to VR Development Process, Geometric and Kinematics Modelling, Physical Modelling in VR, Behaviour Modelling, Model Management in VR, Content Creation Considerations for VR, User Performance Studies in VR, Health, Safety, and Usability Issues in VR

UNIT – III **(8 hours)**

VR on the Web, VR on Mobile Devices, JavaScript for VR, Frameworks for VR Development, Google VR for Android, Mobile VR Development, Teleporting, Spatial Audio, and Interaction, Assessing Human Parameters and Designing Haptics.

UNIT – IV **(6 hours)**

Medical applications-military applications-robotics applications- Advanced Real time Tracking- other applications- games, movies, simulations, therapy.

Practical component: **(60 hours)**

1. Design and implement basic interaction scenarios focusing on immersion, interaction, and imagination.

2. Develop a program to demonstrate simple navigation in VR, utilizing a basic 3D environment.
3. Implement gesture recognition using Python and OpenCV for simple VR interactions.
4. Build a basic VR environment with graphics output using Python and OpenGL.
5. Simulate sound and haptic feedback using Python libraries.
6. Implement simple 3D models using Python libraries.
7. Design basic behaviors and interactions of objects in a VR environment.
8. Implement user tracking in a VR simulation to assess interaction and performance.
9. Build a basic WebVR environment using JavaScript with Python-based backend integration.
10. Set up Python environments for mobile development.
11. Integrate Python and JavaScript for interactive VR experiences on the web.
12. Simulate simple mobile VR interactions and assess user experience using Python.
13. Develop a simulation of a medical procedure or virtual therapy using VR.
14. Create a VR environment for military training or robotics simulation.
15. Develop a simple VR game or simulation that integrates multiple VR components (navigation, interaction, feedback).
16. Any one of the following mini projects or on similar concepts: VR Environment Simulation, Interactive Gesture-Based VR Interface, VR Interaction Simulation, User Interaction Evaluation, Mobile VR Experience, WebVR Application, Medical VR Simulation, Robotics in VR.

Essential/Recommended readings

1. C. Burdea & Philippe Coiffet, "Virtual Reality Technology", Third Edition, Gregory, IEEE Press and Wiley, August 2024
2. Jason Jerald. 2015. The VR Book: Human-Centred Design for Virtual Reality. Association for Computing Machinery and Morgan & Claypool, New York, NY, USA.
3. Augmented Reality: Principles and Practice (Usability) by Dieter Schmalstieg & Tobias Hollerer, Pearson Education (US), Addison-Wesley Educational Publishers Inc, New Jersey, United States, 2016. ISBN: 9780321883575

Suggestive readings

1. Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR (Usability), Steve Aukstakalnis, Addison-Wesley Professional; 1 edition, 2016.

2. The Fourth Transformation: How Augmented Reality & Artificial Intelligence Will Change Everything, Robert Scoble & Shel Israel, Patrick Brewster Press; 1 edition, 2016.

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Generic Elective COURSE: 3D Printing and Design (INGE8C)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
3D Printing and Design (INGE8C)	04	02	-	02	Course admission eligibility	Mathematics

Learning Objectives

The Learning Objectives of this course are as follows:

- To know the importance of 3D printing in manufacturing
- To know the different 3D printing technologies
- To select suitable material for 3D printing
- To understand the applications of 3D printing

Learning Outcomes

After successful completion of the course, students will be able to:

- Knowledge of the 3D Printing approach and basic terminology
- Knowledge of the main 3D Printing processes, their advantages, and limitations
- Knowledge of materials in 3D Printing
- Knowledge of STL file format and advantages and limitations of 3D Printing for different applications

SYLLABUS OF GE

UNIT – I (8 hours)

Introduction: Introduction to 3D printing technologies, Process, Classifications, Advantages, Additive v/s Conventional Manufacturing processes, Applications.

3D Printing Process chain: Steps in Additive Manufacture, Variations from one 3D printing machine to another, maintenance of equipment, Design for 3D .

UNIT – II **(8 hours)**

Powder Bed Fusion Processes: Introduction, SLS process description, material, advantages, and disadvantages.

Extrusion-Based Systems: Introduction, Basic principles, plotting and path control, materials, limitations of FDM.

UNIT – III **(8 hours)**

Design for 3D Printing - Design for Manufacturing and Assembly, Core DFM for 3D Printing Concepts and Objectives, Design Tools for 3D Printing. Guidelines for Process Selection - Selection Methods for a Part, Challenges of Selection, Preliminary Selection, Production Planning, and Control.

UNIT – IV **(6 hours)**

Software for 3D Printing - Preparation of CAD Models – the STL File, STL File Manipulation. Product Quality: Inspection and testing, Defects and their causes

Practical component: **(60 hours)**

(For simulation: OpenSCAD/Free CAD/Meshmixer and or any available software)

1. To simulate the anatomy of a 3D Printer, to get in-depth knowledge of the mechatronics of a 3D printer.
2. To simulate the construction of a cartesian 3D printer and to get in-depth knowledge of the mechatronics of polar 3D printers.
3. To simulate the construction of a polar 3D printer and to get in-depth knowledge of the mechatronics of a polar 3D printer
4. 3D Modelling of a single component.
5. Assembly of CAD modelled Components.
6. Exercise on CAD Data Exchange.
7. Generation of .stl files.
8. Inspection and defect analysis of the additively manufactured product.
9. To simulate the stereolithography (SLA) process.
10. To simulate the Fused diffusion modelling (FDM) process.
11. Simulation of powder binding and jetting process.
12. Simulation of pre-processing in additive manufacturing
13. Simulation of post-processing in additive manufacturing

Essential/recommended readings

1. Ian Gibson, David W Rosen, Brent Stucker., “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2010

2. B. Redwood, The 3D Printing Handbook. 2017.
3. L. W. Kloski, Getting Started with 3D Printing. Maker Media, Inc., 2016.
4. H. (Electrical Richard, 3D printing for dummies. Hoboken, NJ: John Wiley & Sons, 2017.

Suggestive readings

1. B. van den, 3D Printing. Springer, 2015.
2. J. Micallef, Beginning Design for 3D Printing. Apress, 2015.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time