# Astronomy 16 - Stellar and Planetary Astronomy

Spring 2024

Mon, Wed, Fri 1:30-2:45 pm
Science Center 309
Instructor: Professor John Asher Johnson
Contact: jjohnson@cfa.harvard.edu
Office: P-340, Harvard-Smithsonian Center for Astrophysics (CfA)

**Teaching Fellows**
Elizabeth Yunnerman - elizabeth.yunerman@cfa.harvard.edu
Olga Borodina - olga.borodina@cfa.harvard.edu

**Course Assistants**
Emma Weller - emmaweller@college.harvard.edu
Daria Harabor - dharabor@college.harvard.edu

**Lab and Telescope Manager / Instrumentation**
Wizard Allyson Bieryla - abieryla@cfa.harvard.edu

## Course Description:

This course provides an introduction to the physical principles describing the formation and evolution of stars and their planetary companions. Topics include thermal radiation; radiative transport; telescopes; energy generation in stars; star formation and stellar evolution; orbital dynamics; the Solar system; and exoplanets. This course includes an observational component: students will determine the distance to the Sun and use the Clay Telescope atop the Science Center to study an eclipsing binary system.

## Prerequisites:

An introductory course in mechanics, which may be taken concurrently, satisfied by Physics 11a, Physics 15a, Physics 16, or Physical Sciences 12a.

## Course Aims and Objectives:

This course will guide students through effective problem-solving techniques and the scientific toolset for astronomy and astrophysics. Estimation through order-of-magnitude calculations will be combined with an overview of relevant physical processes to prepare students for further study in any subfield of astronomy. Students will glean an understanding of astronomical topics, objects, and phenomena on the scales of planets, stars, and stellar systems.

## Resources, Questions?

Email your TFs/CA or contact them through Canvas. Be aware that teaching staff cannot instantaneously respond to your request, so leave plenty of time for your questions to be answered before deadlines. We will try our best to get back to you within 24 hours.

The Astronomy Learning Center (TALC) will be held in the Science Center (Days and Times TBD based on scheduling poll). Students are encouraged to use these after-hours sessions to complete the course material with help from the TFs, and to interact with the TFs as they would in traditional office hours.

## Course Policies and Expectations

Astronomy 16 will employ novel learning techniques which give students significant freedom in determining their work and involvement. Students are expected to be highly motivated and take the initiative to use the resources provided to further their learning.

## Texts

An Introduction to the Sun and Stars (2nd Ed.) - Simon F. Green, Mark H. Jones - recommended - Cabot: on reserve

An introduction to modern astrophysics (2nd Ed.) - Carroll & Ostlie - recommended - Cabot: on reserve

Astrophysics in a nutshell - Maoz - recommended - Cabot: on reserve

## List of topics (subject to change)

Week 1: Introduction to the Course, and Fun with Order-of-Magnitude Estimations
Week 2: Flux and Magnitudes
Week 3: Thermal Radiation (Blackbodies)
Week 4: The First Rungs of the Distance Ladder
Week 5: The Celestial Sphere and Telescopes
Week 6: Basic Radiative Transfer
Week 7: Stellar Interiors - Hydrostatic Equilibrium
Spring Break March 9-17
Week 8: Stellar Interiors - Nuclear Fusion and Radiative Diffusion
Week 9: Stellar Interiors - Scaling Relations
Week 10: Exoplanets - Doppler Shifts and Transits
Week 11: Exoplanets - Direct Imaging and Microlensing
Week 12: Exoplanets - Formation and Orbit Evolution
Week 13: Star Formation, Open Clusters and Ages
Week 14: Stellar Deaths and Degenerate Remnants
Last Day of Classes April 24

## Assignments and Grading Procedures:

The course grade will comprise

- attendance (30%)
- class participation, group work, quizzes, and in-class oral quizzes (10%)
- blog entries (20%)
- an oral midterm exam (format details to be discussed; 10%)
- lab write ups (15%)
- a written, take-home final exam (15%)

## Attendance:

Attendance is key to your learning in this course, and a full 30% of your final grade will be based on your attendance (percentage of class sessions attended, excluding excused absences). Attendance will be taken silently by the teaching staff each class period five minutes after the start of class. Students arriving late will need to check in with Prof. Johnson (or the lead instructor in the classroom at the time) in order to receive half credit for attendance. Each student will have one (1) unexcused absence, and two (2) excused absences with expressed permission from Prof. Johnson at least three (3) hours in advance of class (send an email to jjohnson@cfa.harvard.edu), or excused by a note or email from a medical professional.

## Student Blogs:

Rather than turning in writing assignments to a single, anonymous grader, students will maintain individual course blogs. The primary use of the blog is for students to practice technical writing, scientific communication, and to allow the course instructors (and others in the student's community!) to evaluate their learning. Blogs are based on homework questions assigned at the end of each worksheet, and student's work should be based on their individual effort, with credit explicitly given to any assistance given in TALC or by other students. Blogs should be written in a technical, yet pedagogical style for a broad audience. Students will be expected to write at regular intervals, rather than waiting until the deadline. The course instructors will regularly check student blog entries to offer comments, suggest edits, and evaluate final work in order to assign a grade.

## Class Activities:

There will be lectures associated with each worksheet and broad subject area. Some lectures will introduce a new topic, and other lectures will summarize the key learnings from the worksheet. Still other lectures will provide supplemental information about astrophysics topics.

The most important aspect of this course is classroom participation, both through asking and answering questions during lectures and class discussions, and in groups solving problems on the worksheets. Students will spend the majority of class time on active, collaborative learning. Each week will feature a worksheet designed to walk students through key concepts of a specific subject area. Students will work in small groups of 3-5 individuals at a chalkboard or whiteboard, stepping through each problem on the worksheet. TFs, CAs, and the instructor will

be on hand to guide students through the problem-solving process. Any portions of the worksheet not completed in class are considered homework, to be completed outside of class. A typical worksheet will contain 5-7 individual sections/questions, as well as 3-5 homework questions.

## Lab Activities:

There will be two out-of-class lab activities during the semester. In the first lab, we will measure the Astronomical Unit (AU), the distance between the Earth and the Sun. These measurements will take place during the day over the course of 3 weeks before spring break. The lab write-up will be turned in via a blog entry.

The second lab is an evening lab which will take place after spring break. During the night lab, we will use the Clay Telescope atop the Science Center to measure properties of a binary star system. The results for this will be written up as a scientific paper. All lab times will be determined in the first few weeks of class.

There will also be an optional Exoplanet Challenge Lab which will be discussed at the beginning of the semester.

## Exams:

There will be an oral midterm examination on March 4, 2024, and a take-home, written final examination at the end of the term. Collaboration is not allowed on the final exam. Details about the unique format of the midterm will be discussed and decided on in class.

## Academic Integrity:

Any material submitted to meet course requirements—homework assignments, papers, projects, examinations—is expected to be a student's own work. Collaboration on studying and on homework assignments is encouraged, but you must ensure that anything submitted is the result of your own work and reflects your own approach to the topic. Students must make note of any collaborators and sources of outside assistance when submitting work.

## Accommodations for students with disabilities:

Students needing academic adjustments or accommodations because of a documented disability must present their Faculty Letter from the Accessible Education Office (AEO) and speak with the professor by the end of the second week of the term, Friday February 10th. Failure to do so may result in the Course Head's inability to respond in a timely manner. All discussions will remain confidential, although Faculty are invited to contact AEO to discuss appropriate implementation.

## Statement on the use of AI:

We're assuming you took this course to learn astrophysics, as a human, rather than depending on, or demonstrating the artificial learning of an algorithm such as ChatGPT. That said, I'm expected to have an official statement in this syllabus, so here it is:

The course instructional team expects that all work students submit for this course will be their own. In instances when collaborative work is assigned, we expect for the assignment to list all team members who participated. We specifically forbid the use of ChatGPT or any other generative artificial intelligence (AI) tools at all stages of the work process, including preliminary ones. Violations of this policy will be considered academic misconduct. We draw your attention to the fact that different classes at Harvard could implement different AI policies, and it is the student's responsibility to conform to expectations for each course.