

Instructor: Prof. Steven R. Cranmer (steven.cranmer@colorado.edu)
 Office: Duane Physics D111, LASP/SPSC N218 (east campus)
Course Times: Mon., Wed., Fri., 9:05–9:55 am, Duane Physics room E126
Course Web Page: https://stevencranmer.bitbucket.io/ASTR_5700_2024/
Office Hours: TBD dates, times, & modes (in-person or virtual)

SUMMARY

Stars are the basic building blocks of the universe, and they are responsible for the production of most elements via nucleosynthesis. In this course, we will explore the physical principles that govern stellar interiors, evolution, and atmospheres, with the Sun and its heliosphere often being used as the closest and best-studied example of a star. The course will cover energy generation and transport in stars, principles of stellar structure, stellar rotation, pulsation, and evolution up to the supernova and compact object stages. The course will also include radiation transport in stellar atmospheres, and (if there is time) the physics of chromospheres, coronas, and winds. We may occasionally touch on topics in planetary science, especially in areas where the boundary lines between stars, brown dwarfs, and planets become a bit ambiguous.

This course is an elective for APS graduate students. Strongly recommended pre-requisites include upper-level undergraduate astrophysics and E&M. The catalog says that a recommended pre-requisite or co-requisite is Radiative & Dynamical Processes (ASTR–5120), but I won’t assume students have taken it.

COURSE MATERIAL

The primary “required readings” are the lecture notes, which ought to contain everything discussed in class. They will be posted on the course web page as the semester progresses. My web page will also provide a list of other books and lecture notes (many of which are available for free online) that are useful as supplements, and I’ll also post all of these resources on Canvas, too. I also recommend the following:

- *The Fundamentals of Stellar Astrophysics*, by George W. Collins II (originally published by W. H. Freeman in 1989; revised [online edition](#) published in 2003).
- *Stellar Structure and Evolution*, comprehensive [lecture notes](#) by Onno Pols from Utrecht University.
- The [Open Astrophysics Bookshelf](#) hosts a growing number of freely available textbooks on stellar physics, star formation, and astrophysical processes.

I will also provide a reference document with [useful math formulas & physics units](#) that you can use for all work in this class. Please see me if you have any difficulty obtaining any of the recommended materials.

GRADING

The final course grade will be assembled from the following components:

Homework (Problem Sets)	55%
Take-Home Midterm Exam	15%
Class Participation	5%
Final Project & Presentation	25%

Each graded aspect of this course will be described in more detail below.

SCHEDULE OF TOPICS

The dates listed here for each set of topics are approximate. The web page will be kept up-to-date on the topics to be covered in each class session. The third column gives recommended readings for each topic, with book chapters referring to Collins (C) and Pols (P).

Introduction & Overview	Jan 17, 19	C1; P1
I. Stellar Interiors		
Thermodynamic properties of stellar gases/plasmas	Jan 22, 24, 26	C1,2; P2,3
Sources & sinks of energy in stars	Jan 29, 31; Feb 2, 5, 7	C3; P6
Energy transport from core to surface	Feb 9, 12, 14, 16, 19	C4; P5
Spherical stellar model interiors	Feb 21, 23, 26, 28	C2,4; P4,7
Non-spherical effects: e.g., rotation	Mar 1, 4	C7,8; P10
II. Stellar Evolution		
Star formation & the interstellar medium	Mar 6, 8, 11, 13	C5; P9
Pre-main-sequence stellar evolution	Mar 15, 18, 20	C5; P9
Main-sequence (MS) & post-MS evolution	Mar 22; Apr 1, 3, 5	C5; P10,11,12
Stellar death: supernovae & compact objects	Apr 8*, 10, 12, 15	P13
III. Stellar Atmospheres		
Radiative transfer & the full atmosphere problem	Apr 17, 19, 22	C9,10,11
Non-LTE processes & spectral line diagnostics	Apr 24	C12,13,14
Overview of stellar winds	Apr 26	—

* No in-person class on April 8, 2024. Go see the [total solar eclipse](#) if you can! I'll provide a pre-recorded lecture for this day.

HOMEWORK

There will be five problem-set homework assignments, each worth 11% of the course grade, that will involve combinations of analytic and computational exploration of the topics of this course. Submitting these homeworks either on paper or electronically (on Canvas) is fine, though if you choose the latter, please compile your submission into a single PDF. Problems will be due on the dates listed, but one late submission can be arranged if necessary (for a maximum delay of one week), as long as the arrangement is made at least one class prior to the due date. Other late problem sets will incur a penalty of a 5% lower grade per weekday that it is late. Submissions are no longer possible after answer keys are distributed (usually when graded homeworks are returned, about 1 week after the due date).

As of the start of the semester, the due-dates for the first four homeworks have been set, and are posted on the web page. The due-date for the fifth homework will be determined later in the semester—depending on how the class chooses to proceed regarding the final projects; see below.

MIDTERM EXAM

The format will be a take-home exam with problems having a similar scope as the homework problem sets; the primary difference being that collaboration is not allowed for the exam. Completed exams will be due one week after they are given to you, and exact dates will be given on the course web page and Canvas.

CLASS PARTICIPATION

For me, a perpetually unsolved problem is “*How does one assign grades for in-class engagement?*” for classes that do not use clickers or other straightforward ways of quantifying participation. I’m never going to take attendance in a graduate course, and it would be impossible (and a bit unfair) to count the number of times students raise their hands to ask questions in class. Thus, this semester, I’m trying a smörgåsbord approach, in which you can gather participation credit in a number of different ways. Each time you do any of the following things, you’ll get one point:

- Come to Office Hours with specific course-relevant things to ask or chat about.
- Post a question (or any course-relevant thoughts) to the Canvas Discussion Board, or answer someone else’s question in that forum.
- Ask a question in class that requires me to go off and do some extra research to determine the answer.
- Actively work on one of the few in-class exercises that we will do (the dates of which I’ll try to announce well in advance).
- Provide written feedback on a student project presentation (on which I’ll give specific guidance when the time comes).

Repetitions in any category are allowed. Accumulate 5 points, and you’ve got full participation credit.

FINAL PROJECT & PRESENTATION

In lieu of a final exam, there will be a project that will count for 25% of the final grade. This will enable you to explore a chosen topic in a bit more detail and gain some extra experience with scientific writing, scientific computing, and presenting your work in front of a group. In the first few weeks of the semester, we will discuss various options for these projects. Right now, I envision two paths that we could take:

1. **Individual Review Papers & Presentations:** The traditional idea is for each student to delve into a topic that’s relevant to this course—and that also goes well beyond the material discussed in class—and write a review paper on that topic. Papers like this usually involve conveying the background (i.e., how did we come to understand the topic) and motivation (i.e., why is it relevant) to non-experts, as well as searching the literature to get a ~complete sense of chronological progress. The written component of the project should end up around 2,500 words, not including the (required) bibliography.

You will also prepare short presentations on what you have learned about this topic, and we will devote a few days of class to hearing these presentations. Students can decide on whether their presentations will be high-tech (Powerpoint or Keynote) or low-tech (whiteboard only). The rest of the class will be encouraged to ask questions, request more in-depth derivations, and so on. I’ll provide Google Forms for students to submit written feedback and questions on each presentation as well. Your final project papers should include a section that responds to this crowdsourced peer-review.

2. **Group Projects that Lead to a Published Paper:** I’ve got the seeds of a few ideas—mostly involving the physics of gravitational collapse/contraction/accretion in various sub-fields of stellar physics—that might make for an interesting pedagogical paper in, say, *The American Journal of Physics*. All contributing students would be coauthors. Depending on the size of the class, we could divide up the tasks between several groups of students who take on various pieces of the whole puzzle. Will there be in-class presentations, too? Probably! Note that this would be a bit of an experiment, and there may not be enough time in the semester to really make this happen. Still, if there’s sufficient enthusiasm, we can dream big and **dare mighty things!**

More details will be provided soon. Please feel free to discuss your ideas with the instructor any time.

ACADEMIC INTEGRITY

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the [Honor Code](#). Violations of the Honor Code may include, but are not limited to: plagiarism (including use of paper writing services or technology [such as essay bots]), cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution (honor@colorado.edu, 303-492-5550). Students found responsible for violating the Honor Code will be assigned resolution outcomes from Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member. Visit [Honor Code](#) for more information on the academic integrity policy.

For this course, I encourage you to discuss the assignments and topics with your fellow students. However, everything that is written up and submitted must be your own independent work. If you do collaborate with other students, a good time to split off from the group is when you start to write up your answers. If someone were to ask you questions about your work, you should be able to explain everything about how & why you did it the way you did. The APS Department also provides some [additional guidance](#) on coursework collaboration.

CLASSROOM BEHAVIOR

Students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Failure to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the [classroom behavior policy](#), the [Student Code of Conduct](#), and the [Office of Institutional Equity and Compliance](#).

The policy of the Department of Astrophysical and Planetary Sciences is to ban any use of electronic devices (cellphones, tablets, laptops) in class except as an approved accommodation granted by Disability Services, or as explicitly authorized by the instructor. *In this course* I authorize the use of tablets and laptops for note-taking, but in-person students doing so must do their best to seat themselves with nobody behind them.

REQUIREMENTS FOR INFECTIOUS DISEASES

Members of the CU Boulder community and visitors to campus must follow university, department, and building health and safety requirements and all public health orders to reduce the risk of spreading infectious diseases.

The CU Boulder campus is currently mask optional. However, if masks are again required in classrooms, students who fail to adhere to masking requirements will be asked to leave class. Students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct & Conflict Resolution. Students who require accommodation because a disability prevents them from fulfilling safety measures related to infectious disease will be asked to follow the steps in the “Accommodation for Disabilities” statement on this syllabus.

For those who feel ill and think you might have COVID-19, or if you have tested positive for COVID-19, please stay home and follow the [further guidance of the Public Health Office](#). For those who have been in close contact with someone who has COVID-19 but do not have any symptoms and have not tested positive for COVID-19, you do not need to stay home.

ACCOMMODATION FOR DISABILITIES

[Disability Services](#) determines accommodations based on documented disabilities in the academic environment. If you qualify for accommodations because of a disability, submit your accommodation letter from Disability Services to your faculty member in a timely manner so your needs can be addressed. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition or injury, see the guidelines for [Temporary Medical Conditions](#) on the Disability Services website.

PREFERRED STUDENT NAMES AND PRONOUNS

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

MISCONDUCT, DISCRIMINATION, HARASSMENT, AND/OR RETALIATION

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits [protected-class](#) discrimination and harassment, sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, and related retaliation by or against members of our community on- and off-campus. These behaviors harm individuals and our community. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who believe they have been subjected to misconduct can contact OIEC at 303-492-2127 or email cureport@colorado.edu. Information about university policies, [reporting options](#), and other support resources can be found on the [OIEC website](#).

Please know that faculty and instructors have a responsibility to inform OIEC when they are made aware of incidents related to these policies regardless of when or where something occurred. This is to ensure that individuals impacted receive an outreach from OIEC about their options for addressing a concern and the support resources available. To learn more about reporting and support resources for a variety of issues, visit [Don't Ignore It](#).

RELIGIOUS OBSERVANCES

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments, or required attendance. For full details, see the [campus policy regarding religious observances](#).

MENTAL HEALTH AND WELLNESS

The University of Colorado Boulder is committed to the well-being of all students. If you are struggling with personal stressors, mental health or substance use concerns that are impacting academic or daily life, please contact [Counseling and Psychiatric Services \(CAPS\)](#) located in C4C or call 303-492-2277. Free and unlimited telehealth is also available through [Academic Live Care](#). The Academic Live Care site also provides information about additional wellness services on campus that are available to students.

.....
I try to provide a positive and supportive learning environment for everyone, and it's always helpful for me to hear what works best for you. Have a great semester!