

ASTR-2100: Fundamental Concepts in Astrophysics CU Boulder Syllabus (Spring 2023)

Course Times: Tues./Thurs., 11:00 am to 12:15 pm, Duane Physics D142

Instructor: Prof. Steven R. Cranmer, Duane D111 and LASP/SPSC N218

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Course Web Page: https://stevencranmer.bitbucket.io/ASTR_2100_2023/ + *Canvas*

Office Hours: Mondays 1:30-2:00 and Fridays 1:30-2:00 (in-person or Zoom)

OVERVIEW

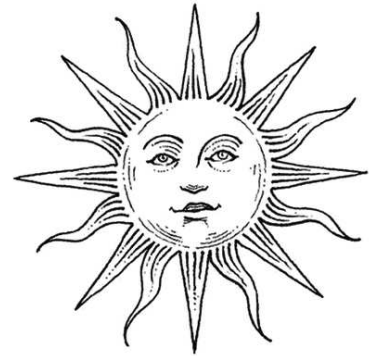
This course covers the topics in modern physics that are required for upper-level astrophysics and planetary science courses, including quantum mechanics, electromagnetic spectra, atomic and nuclear physics, and thermodynamics, in the context of astrophysics, planetary, and space sciences. We will also introduce key topics from beyond first-year calculus (such as vector functions, partial derivatives, multiple integrals, and differential equations) needed to support these topics.

The prerequisites for this course are second-semester introductory physics (PHYS-1120 or PHYS-1125) and calculus (APPM-1360 or MATH-2300). APS majors who intend to follow the Astrophysics/Physics track should probably not take this course, since it does not serve as a prerequisite for upper-level physics classes. These students should instead enroll in third-semester physics (PHYS-2130 or PHYS-2170) and calculus (APPM-2350 or MATH-2400).

COURSE GOALS

Our hope is that a graduate of this course will:

- Be ready to take the full range of upper-level ASTR courses.
- Deepen your sense of awe and wonder about how the physical universe works.
- Develop an appreciation for how physics was revolutionized in the early 20th century, and how these events continue to influence modern astrophysics, planetary science, and solar/space physics.
- Become inspired to share what you've learned with other people (friends, family, or random strangers on the HOP bus).



SCHEDULE OF TOPICS

The dates listed here for each set of topics are not yet certain. As the semester progresses, the web page will be kept up-to-date on the topics to be covered in each class session.

1. Course intro; vectors, coordinate systems, & basic differential equations Jan. 17, 19, 24
2. Gravitational dynamics & orbits Jan. 26, 31; Feb. 2
3. Brief introduction to Einstein's relativity Feb. 7
4. Partial & vector derivatives; multiple integrals Feb. 9, 14, 21, 23
5. Gases, plasmas, & thermodynamics in astrophysical systems Feb. 28; Mar. 2, 7, 9
6. Light & its interaction with matter Mar. 14, 16, 21; Apr. 4
7. Atoms & an introduction to quantum mechanics Apr. 6, 11, 13, 18
8. Understanding astronomical spectra Apr. 20, 25
9. Nuclear physics: radioactivity, fusion, fission Apr. 27; May 2, 4

COURSE MATERIAL

The primary “required readings” are the lecture notes, which ought to contain nearly everything discussed in class. They will be posted on the course web page and *Canvas*. No one textbook covers all aspects of this class, but some good ones are listed below. We are not requiring you to purchase anything, however.

Primary/Free Resources:

- [OpenStax](#) publishes open-source college textbooks that are available online with a range of other study aids. Their *University Physics* ([volume 2](#) and [volume 3](#)) and *Calculus* ([volume 3](#)) textbooks cover a lot of the material of this course.
- *Principles of Astrophysics*, by Charles Keeton (Springer, 2014) introduces most of the astrophysical and planetary applications that we will cover. Available as a free PDF download when you are connected via a colorado.edu domain: <https://link.springer.com/book/10.1007/978-1-4614-9236-8>
- *Modern Physics for Scientists and Engineers*, by John Morrison (Elsevier, 2015) covers the quantum mechanics, atomic & nuclear physics, & relativity topics of this course. Available as free PDF chapters when on colorado.edu: <https://www.sciencedirect.com/book/9780128007341/modern-physics>.

If Money is No Object:

- *Modern Physics*, by Tipler & Llewellyn (Freeman/Macmillan, any edition) is probably the favorite undergraduate textbook of many professors for the quantum, atomic, nuclear, and relativity topics of this course. No free e-book option is available at CU.
- Similarly, *An Introduction to Modern Astrophysics*, by Carroll & Ostlie (Pearson/Addison-Wesley, any edition) is a favorite undergraduate textbook on the astrophysics and planetary topics that we will cover. No free e-book option is available at CU, but you may want to consider buying it anyway, since it may be required for ASTR–3730 and ASTR–3830.

There will also be links to additional online material on this course’s web page.

GRADING

Your final course grade will be assembled from the following components, each of which will be described in more detail below:

5 Homework Sets	50%
Midterm Exams	15%
Final Exam	15%
Final Project	15%
Class Participation (clicker-type questions)	5%

HOMEWORK

There will be 5 problem sets. A detailed schedule of distribution and due dates will be posted on the course web page. Submitting either on paper or online (*Canvas*) is fine, though if you choose the latter, please compile your submission into a single PDF. **Your lowest homework score will be dropped.**

Homework sets are due on the dates listed, but *one* late submission can be arranged if necessary (for a maximum delay of 1 week), as long as the arrangement is made at least 1 day prior to the due date. Any 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 1 week after the due date).

EXAMS

There will be two in-class midterm exams during the semester (tentative dates: Feb. 16 and Mar. 23). **The lower of your two midterm exam scores will be dropped**, so no make-up exams will be given. The cumulative final exam will be held at the university-assigned time and place (so please don't make travel arrangements during finals week before we know the date). For each exam, you will be allowed to bring in one sheet of notes (8.5" × 11", both sides).

FINAL PROJECT

You will have the opportunity to explore a specific topic of your own choosing in a bit more detail, and gain some extra experience with scientific writing. I encourage you to start looking at online resources that cover new discoveries in astronomy. Here are a few that go into more depth than popular-press news stories:

- [AstroBites](#) is a student-run blog that highlights newly published research results.
- [AAS Nova](#) is an online digest of recently published papers from the American Astronomical Society.
- NASA's [Astronomy Picture of the Day \(APOD\)](#) doesn't always link to newly published papers, but it often leads to timely water-cooler discussions about current topics.
- Of course, you can always dive into the deep end: [arXiv/astro-ph](#), the place where roughly 50 new astronomy research papers are posted every day!

Using one or more of these as a jumping-off point, you will dig a bit deeper, research your topic, and write a paper that identifies connections to the topics we cover in class. Additional guidelines, including deadlines for the various stages of completing the project, will be distributed during the semester.

CLASS PARTICIPATION

We will use a (free!) phone-app system for polls & multiple-choice questions. More details provided soon.

IS THERE A CURVE?

Probably? Because some parts of this course are being offered for the first time, it's likely I will add some number of points to everyone's final score at the end (as compensation for testing out this brand-new material on you). After that addition, the final letter grade will be computed from the following scale that is used frequently at CU: A (93 and up), A- (90 to 93), B+ (87 to 90), B (83 to 87), B- (80 to 83), C+ (77 to 80), C (73 to 77), C- (70 to 73), D+ (67 to 70), D (63 to 67), D- (60 to 63), F (below 60).

CLASS POLICIES

You are all mature and responsible adults, and I'll do my best to treat you with respect. On your part, I hope you will do the same for your peers and instructors. For example:

- Please show up to class on time, and be ready to learn when class starts.
- Please don't leave class early, and don't start packing up before class is dismissed. If you know you'll need to leave early, please sit near the back of the room and leave as quietly as possible.
- **Laptops and tablets** can be used in class for note-taking, although I can point to [studies](#) that say writing notes by hand is better for retention! If you use a laptop, please find a seat with nobody behind you (to minimize screen-distraction to other 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.

ACADEMIC INTEGRITY

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code academic integrity policy. Violations of the Honor Code may include, but are not limited to: plagiarism, 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 the Honor Code (honor@colorado.edu; 303-492-5550). Students found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found at the [Honor Code website](#).

What constitutes plagiarism / cheating?

While I encourage you to discuss the assignments and topics with your fellow students, the answers you submit 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. Use the motto **“work together, write separately”** to guide your actions. If homeworks with nearly-identical answers are found, all students involved must receive zero credit for the assignment and may be reported to the Honor Code Office. Don't be that person!

In written work (essays), it is expected that you utilize outside sources in your research. Quoting sources is acceptable with proper attribution, however copy/pasting text from another source as your own is plagiarism and constitutes serious academic misconduct.

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](#).

ACCOMMODATION FOR DISABILITIES

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment, but please contact me to discuss how I can help even for conditions not on their list. Information on requesting accommodations is located on the [Disability Services website](#). Contact Disability Services at 303-492-8671 or by email at 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. The university will not tolerate acts of sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, or protected-class discrimination or harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or by email at 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 made aware of incidents of sexual misconduct, dating and domestic violence, stalking, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about their rights, support resources, and reporting options. To learn more about reporting and support options for a variety of concerns, visit [Don't Ignore It](#).

CLASSROOM BEHAVIOR

Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Those who fail 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 policies on [classroom behavior](#) and the [Student Conduct & Conflict Resolution policies](#).

REQUIREMENTS FOR COVID-19

As a matter of public health and safety, all members of the CU Boulder community and all visitors to campus must follow university, department, and building requirements and all public health orders in place to reduce the risk of spreading infectious disease. CU Boulder currently requires COVID-19 vaccination and boosters for all faculty, staff and students. Students, faculty and staff must upload proof of vaccination and boosters or file for an exemption based on medical, ethical or moral grounds through the [MyCUHealth portal](#).

The CU Boulder campus is currently mask-optional. However, if public health conditions change and masks are again required in classrooms, students who fail to adhere to masking requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to [Student Conduct and Conflict Resolution](#). For more information, see additional policies on [classroom behavior](#) and the [Student Code of Conduct](#). If you require accommodation because a disability prevents you from fulfilling these safety measures, please follow the steps in the “Accommodation for Disabilities” statement on this syllabus.

If you feel ill and think you might have COVID-19, if you have tested positive for COVID-19, or if you are unvaccinated or partially vaccinated and have been in close contact with someone who has COVID-19, you should stay home & follow the further guidance of the [Public Health Office](#) (contacttracing@colorado.edu). If you are fully vaccinated and have been in close contact with someone who has COVID-19, you do not need to stay home; rather, you should self-monitor for symptoms and follow the further guidance of the [Public Health Office](#) (contacttracing@colorado.edu).