

ASTR-2100: Fundamental Concepts in Astrophysics CU Boulder Syllabus (Spring 2020)

Class Times & Location: Tues./Thurs., 11:00 am to 12:15 pm, Duane Physics E126

Instructor: Prof. Steven R. Cranmer (steven.cranmer@colorado.edu)

Office Hours: Duane D111: Mon. 3:00–3:45, Wed. 1:00–1:45, Thurs. 12:30–1:00

Course Web Page: http://lasp.colorado.edu/~cranmer/ASTR_2100_2020/

OVERVIEW

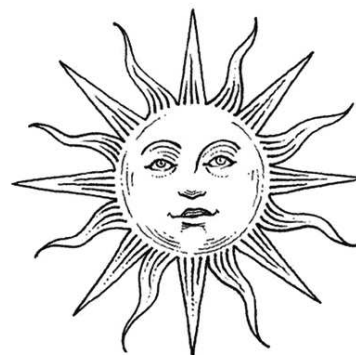
This course covers the topics in modern physics that are required for upper-level astrophysics and planetary science courses, including quantum mechanics, electromagnetic spectra, atomic and nuclear physics, and thermodynamics, in the context of astrophysics, planetary, and space sciences. When necessary, we 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).



GRADING (see last page for COVID–19 updates)

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

5 Homework Sets	5 / 9
Midterm Exam 1 (45 minutes)	1 / 9
Midterm Exam 2 (45 minutes)	1 / 9
Final Exam	2 / 9
Writing Assignment/Project	1 / 9
Total	10 / 9 ⇒ drop lowest: best 9 parts = 100%

Each of these components is described in more detail below. The total score comes to 10 equally weighted parts. However, to produce your final grades I will drop the lowest-graded part. This means that you can do badly on any one homework, or the project, or one of the midterms, and it won’t count. If the final exam is your lowest-graded thing, its score will only count for 1/9 of your total instead of 2/9.

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 (and possibly also *Canvas*) as the semester progresses. No one textbook covers all aspects of this class, but there are quite a few good resources out there. We are not requiring you to purchase anything, so please work your way down this list as far as you like:

Primary Textbooks (Free E-Books):

- *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 C. Morrison (Elsevier, 2015) covers the quantum mechanics, atomic & nuclear physics, and relativity topics that we will study. Available as free PDF chapters when on colorado.edu: <https://www.sciencedirect.com/book/9780128007341/modern-physics> but I’ll find a legal way to provide you with a version that assembles the chapters into a single PDF.

Secondary Resources (Free E-Books):

- **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.

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 online material (e.g., some of the available books listed above, plus lecture notes from other courses) on this course’s web page. Please see me if you have any difficulty in obtaining copies of these books.

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HOMEWORK

There will be 5 problem sets assigned throughout the semester. A detailed schedule of distribution and due dates will be posted on the course web page. Either hardcopy or email submission is fine, though if you choose the latter, please compile your submission into a single attachment.

Homework sets are due on the dates listed, but *one* late submission can be arranged if necessary at some point in the semester (for a maximum delay of 1 week), as long as the arrangement is made at least 1 class 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 closed-book, closed-notes midterm exams held during class (tentative dates: Feb. 18 and Apr. 7). The midterms will last only 45 minutes, not a full 75-minute class. The comprehensive 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 the final, you are allowed to bring in one sheet of notes (8.5" × 11", both sides). Any material from the homeworks, lectures, or assigned readings is potential exam material.

WRITING ASSIGNMENT / 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 blog written by astronomy graduate students (some here at CU Boulder) that highlights newly published research results.
- [AAS Nova](#) is an online digest, from the American Astronomical Society, of recently published papers.
- 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 identify connections to the topics we cover in class. Your final product can be a standard research essay/paper, but you can also think of other creative ways of "packaging" what you have learned (a hyperlinked concept graph? an interactive timeline?). Additional information, including deadlines for the various stages of completing the project, will be distributed during the semester.

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 you being "guinea pigs" on a subset of the material. 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).

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 equationsJan. 14, 16
2. Gravitational dynamics & orbitsJan. 21, 23
3. Introduction to Einstein's relativityJan. 28, 30; Feb. 4
4. Partial & vector derivatives; multiple integralsFeb. 6, 11
5. Gases, plasmas, & thermodynamics in astrophysical systemsFeb. 13, 18, 20, 25
6. Light & its interaction with matterFeb. 27; Mar. 3, 5, 10, 12
7. Atoms & an introduction to quantum mechanicsMar. 17, 19, 31; Apr. 2, 7
8. Understanding astronomical spectraApr. 9, 14, 16, 21
9. Nuclear physics: radioactivity, fusion, fissionApr. 23, 28, 30

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 only for note-taking, but it is discouraged. If you use a laptop, please find a seat with nobody behind you (to minimize screen-distraction to other students).
- **Phones** should not be used during class for any reason. However, if we take a 1–2 minute “stretch break” at the halfway point, a quick phone-check is fine.

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 [academic integrity policy](#) and [Honor Code](#) of this institution. Violations of this policy may include: 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 who are 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 Office 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.

ACCESSIBILITY AND LEARNING NEEDS

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.

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. If you have religious obligations that result in schedule conflicts, please contact me in the first two weeks of class to make alternate arrangements. For full details, see the [campus policy regarding religious observances](#).

DISCRIMINATION AND HARASSMENT

The University of Colorado Boulder (CU Boulder) is committed to fostering a positive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct (including sexual assault, exploitation, harassment, dating or domestic violence, and stalking), discrimination, and 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 the OIEC, university policies, [anonymous reporting](#), and the campus 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, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about options for reporting and support resources.

CLASSROOM BEHAVIOR

Students and faculty each have responsibility for maintaining an appropriate learning environment. 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. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. For more information, see the policies on [classroom behavior](#) and the [Student Code of Conduct](#).

Post-Spring-Break (COVID-19) Update

The last five weeks of this course will necessarily be a bit different from what we had planned back in January. You already know that all in-person lectures, office-hours, and help-room sessions have been cancelled. Our lectures will now be presented on this course's [dedicated YouTube channel](#), and I'll do my best to respond in a timely way to any questions you send me by email or online comment.

I'm also making the executive decision to get rid of all remaining timed closed-book exams. There's really no way to make them work online with such short notice, and you didn't sign up for the fully-online testing experience anyway. We'll do a few things to compensate:

- Instead of just one more homework, there will be two...

Homework 5: assigned Thurs., April 2, and due Thurs., April 16.

Homework 6: assigned Thurs., April 16, and due Thurs., April 30.

...and they will be "hybrids" of the formats of previous homeworks and exams. These homeworks will also be designed so they can be more easily submitted and graded online.

- The Independent Project ([see modified guidelines here](#)) will count as the Final Assessment for the course, and it will now be due on Monday of Finals Week (May 4, 2020).

Thus, the revised breakdown of your final course grade is as follows:

6 Homework Sets	6 / 8	
Midterm Exam 1	1 / 8	
Independent Project	2 / 8	
Total	9 / 8	⇒ drop lowest: best 8 parts = 100%

As before, I will drop the lowest-graded part, which means you can do badly on any one homework or the midterm, and it won't count at all. If the project is your lowest-graded thing, its score will only count for 1/8 of your total instead of 2/8. It's also likely that the conversion from numerical to letter grades will end up being a bit more generous than the system described above.

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Please stay safe, and keep up on COVID-19 updates from various sources:

<https://www.colorado.edu/aps/aps-covid-19-resources>

<https://www.colorado.edu/coronavirus>

<https://www.coronavirus.gov/>