UNIVERSITY OF KANSAS
DEPARTMENT OF PHYSICS AND ASTRONOMY
ASTR 391 SPRING 2024
INSTRUCTOR: PROF. IAN CROSSFIELD
HTTPS://CROSSFIELD.KU.EDU/A391_2024A/

COURSE SYLLABUS AS OF JANUARY 13, 2024

This is a one-semester, calculus-based introduction to astronomy and astrophysics. Topics will include fundamental concepts used by astronomers, including planetary systems, the Kepler problem, stars, exoplanets; stellar structure and evolution; dead stars (white dwarfs, neutron stars, and black holes); radiation; classification and properties of our Milky Way galaxy and other galaxies; and cosmology and the large-scale structure of the universe.

The purposes of this class are threefold: (1) to provide potential astronomy majors (BA or BS) and Astronomy/Astrobiology minors with a better foundation in astronomy than one can normally obtain in ASTR 191; (2) to build your confidence in scientific arithmetical calculations involved in "order of magnitude" estimations; and (3) to provide those with a stronger background in math and/or science (MATH 125 is a prerequisite for this class) with a more challenging and inviting learning experience than can be found in ASTR 191. Hence, the designation as an Honors class.

The course is structured and paced for undergraduate students who have minimal previous exposure to astronomy (though previous experience will help). We will assume a background equivalent to a KU sophomore with previous exposure to basic calculus and physics, including mechanics, gravitation, and electricity & magnetism. As needed we may occasionally touch on thermodynamics, quantum mechanics, and relativity, but no prior familiarity with these topics is assumed.

Crossfield's office hours are TBD.

Textbook and Readings

There is no single, ideal textbook for this course. We will therefore make use of a wide array of reading selections that will be made available to you online. It is your responsibility to read the associated readings *before* any course section touching on that topic. Other potentially useful texts include:

- *An Introduction to Modern Astrophysics* by B. W. Carroll and D. A. Ostlie, 2nd ed. (Addison-Wesley, 2007). The classic 'BOB' (Big Orange Book). Mostly comprehensive and with much astronomical lore, though scant detail to some topics, and at a slightly lower level.
- *Astrophysics in a Nutshell* by D. Maoz (Princeton University Press, 2007). A concise physics-oriented overview, similar to Choudhuri, but at a slightly more elementary level.

Grade Breakdown:

- **35%**: There will be roughly one problem set per week or two, with the total PSet grade comprising 35% of the total grade. Posting dates and due dates will be posted on the ASTR 391 course website. Problem sets are to be turned in:
  - On time;
  - With your first and last name prominently displayed;
  - Showing complete work;
  - Using appropriate units and significant figures;
  - With answers circled, boxed, or otherwise highlighted.

  Late assignments can be turned in anytime during the semester (up to the last day of lecture) for a maximum of 70% of their initial credit value. Late PSets can be accommodated for full credit **if notification of conflict or problem is provided in advance.** (E.g.: an email requesting extension sent the night before the PSet is due is not acceptable notice.)

- **10%**: Students will complete a five-page 'review paper' on a topic of interest that is relevant to the course. These papers will give you a chance to delve more deeply into one of the topics or questions covered in class. In the course of summarizing the background, current status, and open questions in your topic of choice, you will need to conduct a review of the topic using reference texts, technical articles (Scientific American: yes — Buzzfeed: no), or primary sources. journal articles. As part of the process, you will: submit a list of three topics of interest by the Feb 14 (1%), submit an outline on your preferred topic by Mar 25 (2%), submit a rough but substantially complete draft by April 13 (4%), and submit a final, revised paper on May 4 (8%). The full effort will therefore be worth 15% of the total grade.
- **5%**: Students will complete a CV/resume suitable for applying to technical internships or research positions. An initial document (1%) will first be due, and a revised and final document due at a later date (4%).
- **5%**: Students will complete a 500-word summary and report on a professional **astronomy** research talk. This may be a talk given at KU's Physics & Astronomy Department colloquium series, at the Astronomy/Space Seminar series, or an online presentation given during this semester (i.e., not some ancient recording).
- **20%**: There will be two in-class midterms, each worth 10% of the total grade. They will be held on or around the end of February and the start of April.
- **20%**: There will be a comprehensive final exam worth 20% of the total grade on Monday, May 6 at 0730 Kansas Time.

Course Outline

The text below gives the planned topical schedule for ASTR 391 in Spring 2024. This is a general outline, with a more detailed and up-to-date schedule kept on the course web site.

- Weeks 1-2 : Introduction. Orders of magnitude, fundamental scales, distances. Basic stellar properties.
- Weeks 3-4: Orbits and the Kepler two-body problem. Binary systems. Introduction to radiation. Observations of stars via photometry and spectroscopy.
- Weeks 5-6 : Stellar structure, atmospheres, and interiors. Timescales characterizing stellar processes and the equations of stellar structure.
- Weeks 7-8 : Modeling stars. Stellar cores, nuclear fusion, and stellar evolution.
- Weeks 9-10 : End of stellar life, stellar remnants. Supernova energetics and observations; white dwarfs; neutron stars; pulsars; black holes. Exoplanets.
- Weeks 11-12 : Observations of galaxies. Dissecting the Milky Way. Interstellar medium. Galaxy classification and properties. Supermassive black holes.
- Weeks 13-14 : Active galactic nuclei. Local Group, galaxy clusters, and large-scale structure. Intergalactic medium. Expansion of the Universe. Fundamental principle of cosmology. The future of the Universe. Review.

Contacting the Professor

The best way to contact Prof. Crossfield is always by email at ianc@ku.edu. Emails should contain "ASTR 391" in the subject line so that I know to respond promptly to them. Note that "Hey" is not an appropriate salutation in formal communication.

General Advice for ASTR 391

The design of the course and my approach to it are tied to the belief that your attitude toward the work is fundamentally different from that of the typical ASTR 191 student. It is assumed that you are in this class because you look upon this course as an initial step toward a career in or related to astronomy, physics, or other technical fields *or* because, as a student in the honors program, you prefer a more challenging class than ASTR 191. It is assumed that because of this, I can place more responsibility for your work in your hands, without the need to pressure or threaten you. This means

that if I give a problem set, it will be done on time in advance of the class, not attempted and written up in the last hour before it is due. If I give a reading assignment, it will be read on time, hopefully more than once, and you will come to class prepared to ask and answer questions about the reading material. If we are to prevent this class from becoming simply another straight lecture class, it is crucial that you remain an active participant in the class. I expect that, unless you have a medical excuse, you will be in attendance at every class, arriving prepared and on time. In a class of this size, it is a trivial matter to take note of who attends and who doesn't. Failure to attend will seriously damage your grade.

To emphasize a fact of life that I make clear to all my classes: how much you learn or understand depends entirely upon you. Depending on how competent or incompetent you feel that I am, I can make your path to understanding easier or harder. Simply speaking, my only interest is in making sure that you leave this class with a much greater understanding and appreciation of science in general and astronomy in particular. However, in the end, I can't make you learn the material.

If you don't already do so, get used to asking questions in and out of the classroom. My office hours are times when I can guarantee that I will be available; if you can't make it at these times, let me know what time would be best for you. Simply reading the book will be insufficient many times when attempting to answer the questions. If that is the case, you might try looking at the same material in another textbook at Anschutz or you can see me and see if I can put you on the right track. If you are faced with a problem and are unable to get started, shrugging your shoulders, handing in a blank or negligible solution, and saying that you didn't understand the problem is not acceptable. In short, you should begin to have a more mature, professional attitude toward your education. What you do in class can, and often does, have a long-term impact on your future, despite what you may think. Don't waste the opportunity.