UNIVERSITY OF KANSAS
DEPARTMENT OF PHYSICS AND ASTRONOMY
ASTR 391 SPRING 2020
HTTPS://CROSSFIELD.KU.EDU/A391/
INSTRUCTOR: PROF. IAN CROSSFIELD

COURSE SYLLABUS AS OF JANUARY 21, 2020

This is the 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 twofold: (a) 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; (b) 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 will be 4:30-5:30pm on Tuesdays and 1-2pm on Wednesdays.

Textbook and Readings

Our textbook is *Astrophysics for Physicists*, by A. R. Choudhuri (Cambridge University Press, 2010). There will also be other course readings and notes periodically posted on the ASTR 391 course website.

Readings from Choudhuri will be supplemented by readings from papers and other texts which will be posted to the course's website during the semester. Some other potentially useful texts are:

- *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:

- **40%**: There will be roughly one problem sets per week, with the total PSet grade comprising 40% of the total grade. Posting dates and due dates will be posted on the ASTR 391 course website. Problem sets are to be handed in at the beginning of the lecture in which they are due, in the lecture classroom. *Problem sets must be completed to get full credit.* Lateness can only be accommodated **if notification of conflict or problem is provided in advance.** An email requesting extension sent at 1:00 am on the day PSet is due is not acceptable notice.
- **15%**: 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 19 (1%), submit an outline on your preferred topic by Mar 20 (2%), submit a rough but substantially complete draft by April 17 (4%), and submit a final, revised paper on May 6 (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. The initial document is due on Feb 17 (1%), with the revised and final document due March 4 (4%).

- **20%**: There will be two in-class midterms, each worth 10% of the total grade. They will be held on February 24 and April 3.
- **20%**: There will be a comprehensive final exam worth 20% of the total grade. This will be on Monday, May 11, the first day of Finals Week.

Course Outline

The text below gives the planned syllabus for ASTR 391 in Spring 2020. This is a general outline and will likely be updated from time to time to adjust depending on how well we cover the material that I am initially planning to cover.

- 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.
- **SPRING BREAK** (Week of March 26)
- 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.
- Weeks 15-16 : Models of cosmology. Observations of cosmology. The future of the Universe. Review.

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.