ASTR 13300 Introduction to Astrophysics

Spring 2019, University of Chicago

Class Hours: T/Th 2.00-3.20 pm
Class Room: Kersten 105

Instructor: Prof. Chihway Chang
Office Hours: W 2.00-3.00 pm (ERC 451)
Contact: Please contact via Canvas

TAs: Emily Gilbert, Lindsay Berkhout
Office Hours: T 3.30-4.30 pm (ERC 564)
M 1.30-2.30 pm (ERC 545)
Contact: emilygilbert@uchicago.edu
lmberkhout@uchicago.edu

Syllabus last updated 06/02/2019. Subject to change. Please read the entire document, which outlines the requirements and expectations of the course.

Prerequisite(s):

PHYS 131, 132

Course Description

The course is intended for first-year students intending to major in Astrophysics as an introduction to the range of important physical processes that operate in astrophysical environments, and how these govern structures across a wide range of scales, from planets to superclusters to the Universe. Throughout the course, we will see that similar physical principles (gravity, radiation, particle physics) come in at different stages and systems (planets, stars, galaxies, the Universe). We will also incorporate into each class relevant current active research areas in Astrophysics, especially focusing on connection with research in the department. We anticipate a highly interactive class with a large number of group activities, demos and discussions.

Required Materials

Course Website

https://canvas.uchicago.edu/courses/20924

Textbooks

1. *Astronomy: A Physical Perspective*, 2nd Edition (Kutner): We will be primarily using this book as a basis, though the course only covers some chapters in the book. You are expected to know the content in the chapters listed in the Course Schedule. You can buy the book online, at the book store, or there are copies in the library on reserve.

2. *An Introduction to Modern Astrophysics*, 2nd Edition (Carroll & Ostlie): This is the ultimate reference if you want to learn about certain topics in more depth. We will have two chapters scanned and posted on canvas for those that are interested, but you are not expected to read everything. There are also copies in the library on reserve.

Course Learning Goals

For each lecture:

1. **Week 1:** dimensions and units; develop ability to do dimensional analyses and order-of-magnitude problems; scales in the Universe; Kepler's Law; virial theorem.
2. **Week 2:** photometry; parallax; the EM spectra; blackbody radiation; spectroscopy; telescopes; CCDs and spectrometers; observing in different wavelengths.
3. **Week 3:** energy source for stars; stellar structure; stellar evolution on main sequence; Cephieds; planetary nebulae; white dwarfs; supernovae; pulsars.
4. **Week 4:** binary stars in circular and elliptical orbits; stellar mass and size; the Sun's structure; the solar system; the Earth and the Moon.
5. **Week 5:** basic characteristics of the inner and outer planets; Pluto, astroids, comets, meteoroids; exoplanets and observational techniques.
6. **Week 7:** extinction; interstellar medium (gas, dust and molecules); star formation; observational traces for recent star formation; determining the structure and rotation curve for the Milky Way; the galactic center.
7. **Week 8:** galaxy classification (properties of ellipticals, spirals and irregulars); star formation; dark matter in galaxies; active galaxies; distribution of galaxies.
8. **Week 9:** expansion of the Universe; Friedmann equation; the ΛCDM model; the CMB; the Universe's thermal history.
9. **Week 10:** final class walk-through; gravitational waves and LIGO.

Overall:

1. Have a broad view of what topics are covered in astronomy.
2. Apply the laws of physics in a wide range of astrophysical processes.
3. Can name some ongoing research topics and experiments in astronomy.
4. Learn how to read papers and extract information, think critically.
5. Learn how to present your own or others' work.

Course Structure

Each class is 80 minutes and will be divided into 40-45 min **Lecture** + 5-10 min break + 30 min **Activity**. We also have **Reading** and **Homework** every week. There will be one **Midterm Exam** in the format of group presentations and one written **Final Exam**. Details for each of the items listed above is explained below.

Lecture: This will be a pretty standard 40-45 min lecture with (mainly) slides and some blackboard derivations. We will try to be interactive and encourage questions in class.

Activity: This will be a 30-min time slot where the class engages in an (oftentimes) group activity: discussion of a topic and present results, discussion over a recent important paper, performing an analysis, or others. Most of the weeks we use the first week to go over a paper relevant to the field. In the second week usually there will be a guest (postdocs who are experts in that field) that comes to lead the activity.

Reading: There will be reading material that corresponds to each class. It is **not** required that the students read all of the material, just the particular material that is also covered in class. However, the full reading material will help the student understand the class a lot better.

Homework: There will be homework every week. Homework will be posted on Canvas Thursdays and should be submitted in paper form (i.e. *not* electronically) by the following Thursday in class. Students are encouraged to discuss them but should complete them on their own.

Midterm Presentation: We plan to have the midterm in the form of a poster session presentation – you will work in groups to design, print and present a poster on a topic of your choice. Your task is to find a good way to present the topic and answer any questions people may have. We will have 10-12 groups, each group with 3-4 people. Half the groups will present on Tuesday and half on Thursday. In addition, a short ($<$ 15 pages) written report on the subject is required. In the report the students must spell out the contributions from each of the group members. Students are encouraged to come up with their own topics (but please consult with the instructor or the TAs), but below are some ideas. The TAs will help you with the poster printing, and the the written report should be submitted electronically on Canvas by the end of the week after midterm (May 19, midnight Chicago).

- Adaptive optics
- The Yerkes Observatory and history of astronomy in Chicago
- Searching for Planet X
- Microlensing
- The Event Horizon Telescope
- Dwarfs and stellar streams
- Supernova progenitors
- Galaxy simulations (e.g. Illustris, FIRE, EAGLE)
- The Cosmic Microwave Background

- Intensity mapping and SPHEREx
- Distance ladder and inverse distance ladder

Final Exam: We will have a written final exam.

Assessments

Grading

Homework (15%), Attendance (5%), Activity participation (10%), Midterm exam (20% for presentation and 20% for report), Final exam (30%).

Policies on Late Assignments

Late assignments will be accepted for no penalty if a valid excuse is communicated to the instructor or TA before the deadline. After the deadline, assignments will be accepted for a 50% deduction to the score up to 2 days after the deadline. After this any assignments handed in will be given 0.

Attendance Policy

If you have an unavoidable conflict at the time of the class, let the instructor or the TAs know before the class. In extenuating circumstances, valid excuses will be accepted after class.

Class Climate

Computers will be allowed in class only for activities related to the class. Phones are prohibited as they are rarely useful for anything in the course. Eating and drinking are allowed in class but please refrain from it affecting the course. Try not to eat your lunch in class as the classes are typically active.

Course Schedule

	Lecture 1	Lecture 2
Week 1 4/2 4/4	**Units, scales, OOM problems** *Reading:* Ch 1, extra material *Activity:* The Universe in chalk	**Basic concepts** *Reading:* C&O Ch 1 *Activity:* Midterm project discussion
Week 2 4/9 4/11	**Observables** *Reading:* Ch 2,3 *Activity:* Analyzing spectra	**Telescopes** *Reading:* Ch 4 *Activity:* Digital films for telescopes [Amy Lowitz]
Week 3 4/16 4/18	**Stars I** *Reading:* Ch 9 *Activity:* Stellar evolution	**Stars II** *Reading:* Ch 10,11 *Activity:* What is a poster session?
Week 4 4/23 4/25	**Binary stars and the Sun [Maria Weber]** *Reading:* Ch 5,6 *Activity:* Tracking the solar cycle with sunspots [Maria Weber]	**The solar system I** *Reading:* Ch 22,23 *Activity:* The Parker probe [Maria Weber]
Week 5 4/30 5/2	**The solar system II** *Reading:* Ch 24,25,26 *Activity:* Paper discussion	**Finding extra-solar planets [David Martin]** *Reading:* Extra material *Activity:* Walk through of the discovery of a planet from start to finish [David Martin]
Week 6 5/7 5/9	**Midterm presentations I**	**Midterm presentations II**
Week 7 5/14 5/16	**The Milky Way I** *Reading:* Ch 14,15 *Activity:* The Orion nebula	**The Milky Way II** *Reading:* Ch 16 *Activity:* Globular clusters [Alex Drlica-Wagner]
Week 8 5/21 5/23	**Galaxies I** *Reading:* Ch 17 *Activity:* The Great Debate	**Galaxies II** *Reading:* Ch 18,19 *Activity:* Galaxy properties [Christine Simpson]
Week 9 5/28 5/30	**Cosmology I** *Reading:* Ch 20 *Activity:* Estimating H_0	**Cosmology II** *Reading:* Ch 21
Week 10 6/4 6/6	**Overview of class** *Reading:* *Activity:* Gravitational waves, multi-messenger astronomy, and fitting it all together [Reed Essick]	College reading period (no class)

* The schedule is tentative and subject to change.
* Textbook chapters, if not specified, refer to Kutner chapters. C&O refers to Carroll and Ostlie.
* Aside from the first week, homework problem sets are due on Thursday 3.20 pm. The last problem set is due Tuesday, June 4th 3.20 pm.
* Most weeks there are also reading material for the activity in the following week that we will announce at the beginning of class.