ASTR 503: Observational Astronomy

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Lecture: Astro 134, Tue & Thur, 1400 – 1530
: https://github.com/gnarayan/ast503_2024_Fall
Office Hours: Astro 129, Swing by if my door is open, or Teams

COURSE DESCRIPTION & LEARNING GOALS

This course will cover observational techniques in astrophysics with a decidedly practical applications perspective - i.e. you'll be coding, you'll be doing data analysis, and you probably won't be doing much deriving. ASTR 310 or strong familiarity with Python is required. We'll be covering gamma ray, x-ray, ultraviolet, visible, infrared, sub-mm, mm, and radio astronomy; photometry, imaging, spectroscopy, and polarimetry; gravitational waves; cosmic rays; neutrinos; positional astronomy; noise; statistics; data analysis; optics, and writing proposals to use the facilities we'll talk about.

The TA is **Joseph Weller** (Office hours TBD).

PREREQUISITES

Undergraduate calculus or analysis, undergraduate statistics, undergraduate linear algebra, and *comfort* with programming in Python. You can (and indeed are encouraged to) work together, but if you are asking people how to cross match two lists of coordinates to within some tolerance, or make a scatter plot with errorbars in matplotlib with a minimum chi-squared line indicated, you are going to be in for a rough semester.

You will also need a computer with a working `conda`/`mamba` and `git` installation for much of the coursework. Ideally, this is your own laptop but you can use the UIUC campus cluster. Request access at https://campuscluster.illinois.edu/new_forms/user_form.php.

TEXTS & READINGS

There is no required textbook for this course, however I've found these references to be useful:

- Astronomy Methods: A Physical Approach to Astronomical Observations by Hale Bradt, Cambridge University Press, 2004 (ISBN-10: 0521535514). This is the typical standard textbook for this kind of course. It's a classic, which is to say I used it in grad school...
- To Measure the Sky: An Introduction to Observational Astronomy by Frederick Chromey, Cambridge University Press, 2010 (ISBN-10: 0521747686) is the typical textbook for undergraduate version of this course. It does a good job on optical astronomy and is a good general reference.
- Electronic Imaging in Astronomy: Detectors and Instrumentation by Ian McLean, Wiley, 2004 (ISBN-10: 3540765824). McLean does the best job on instrumentation, imaging, and CCDs. He goes into the most details on optical and near-infrared instruments.
- Data Reduction and Error Analysis for the Physical Sciences by Bevington and Robinson, McGraw-Hill, 2004 (ISBN-10: 0072472278). Bevington is a useful reference text for data analysis and statistics.

We can't tell you to do anything illegal of course, but should you be unable to find these books on a large vendor such as Amazon, I recommend talking to your TA (which is sensible advice in general).

Other Resources:

The LSST Data Science Fellowship Program has a huge collection of worked notebooks and video lectures: `https://github.com/LSSTC-DSFP/LSSTC-DSFP-Sessions`.

If you need some help with Python, you'll find cheat sheets in my ASTR 596 repository here: `https://github.com/gnarayan/ast596_2023_Spring` (look under "help") and more detailed examples on Wes McKinney's Python for Data Analysis, which is free.

GRADING

Your grade is determined from a combination of assignments, midterm and a final project. Policies for each are below. Attendance is at your own discretion, and there are no planned opportunities for extra credit. You are welcome to discuss your grades and your work in the course with me during office hours (which basically means message me on Teams).

Points:
- Assignments (≈ 8 over the semester): 50%
- Midterm: 20%
- Final: 30%

This course (like every other one at UIUC...) uses a plus ($+$) and minus ($-$) grading scale for course grades.

97-100=A+; 93-96=A; 90-92=A-; 87-89=B+; 83-86=B; 80-82=B-; 77-79=C+; 73-76=C; 70-72=C-; 67-69=D+; 63-66=D; 60-62=D-; 0-59=F

COURSE POLICIES

I've outlined standards for this course below. Times listed in this syllabus are US/Central throughout. If something is not covered by my policies, please discuss it with me. My contact information is at the beginning of this syllabus.

Assignment & Exam Policies: Assignments, as well as midterm examination are open book and take home. The last assignment will see you preparing a 30 min in-class presentation, so certainly open book etc, but obviously not take home... since you are presenting in class. You'll draw the topic for that assignment randomly.

You may work in groups, and may discuss the assignments and ways to tackle it, but you must write/code your solution independently. This means you get to talk with each other, discuss how you'd solve a problem, but come up with your own solution, but not share your solutions. Over the course of the last three semesters, a total of 5 students thought I'd not catch that level of cheating. They all failed.

The final will see you writing a telescope proposal yourself, so you can indeed talk with each other and use whatever resource you like, but you'll be drawing the facility to submit your proposal randomly, so you are very likely on your own.

Assignments will be posted to the course GitHub repo on Thursdays. Make a fork of the repo, create a folder with your name for your work, write/code up your solution as directed in the assignment, commit, and open a pull request when you are satisfied with your work before Noon the following Wednesday. You are allowed to drop ONE assignment from your total, for whatever reason, no questions asked (and if you don't elect to, I'll drop your lowest).

Keep up with the homework assignments. They're the largest chunk of your grade. All grades for the course are due to the Provost by Dec 23, 2024, and I cannot provide extensions beyond that date, unless there are absolutely extenuating circumstances (see next section).

The midterm will be posted online on Oct. 10, 2024 and will be due on Oct. 17, 2024 by Noon. We will skip class on Oct. 15 - you'll need the time (you can insert your impression of me cackling maniacally at 2 something in the morning while planning the midterm here if you feel the need to swear). The midterm will include all material covered prior, and will require a more substantial time commitment that the weekly assignments.

There is no makeup or alternative midterm exam. Plan accordingly.

On Dec. 5, 2024, you'll randomly draw a facility from a list for your final exam, which is to craft a convincing telescope proposal, complete with a science justification with figures, experimental setup, exposure time estimates, compute estimates, FTE estimates, and a timeline. You'll have to figure out the proposal system for that facility, and submit a fully formatted proposal by Dec. 17, 2024.

Grades of Incomplete: Incomplete (I) grades are given only in situation where unexpected emergencies prevent you from completing the course and the remaining work can be completed the next semester. Documentation must be provided, and the instructor is the final authority on whether you qualify for an incomplete. Incomplete work must be finished by the 10th day of instruction in the Spring 2025 semester, else the "I" will automatically be recorded as a "F" on your transcript.

Late or Missed Assignments: All work is assigned on Thursday and due the following Thursday before class begins. If you know that you will be turning an assignment in late please notify me in advance. A full letter grade will be deducted for each day an assignment is late until a "F" grade is achieved, unless you have a documented medical excuse or you have notified me of other extenuating circumstances. Remember that you may drop ONE assignment from your total, for whatever reason, no questions asked.

Accessibility Accommodation: It is my goal that this class be an accessible and welcoming experience for all students, including those with disabilities that may impact learning in this class. If the design of this course poses barriers to you effectively participating and/or demonstrating learning in this course, please meet with me, with or without an Accessibility Services accommodation letter, to discuss reasonable options or adjustments. You are welcome to talk to me at any point in the semester about course design concerns, but it is always best if we can talk at least one week prior to the need for any modifications.

During our discussion, I may suggest the possibility/necessity of your contacting the Office of Disability Resources and Educational Services (1207 S. Oak St., Champaign, IL 61820; 217-333-1970) disability@illinois.edu; `http://disability.illinois.edu/`) to talk about academic accommodations.

Plagiarism: Don't. You are going to be using GitHub for assignments, so there's a record of your commits, and it is trivial to check if chunks of your work match someone else. You may work in groups together, and may discuss the assignments and ways to tackle it, but you must write/code your solution independently. Read the University of Illinois' policy on plagiarism.

Plagiarism and cheating of any kind on an assignment or examination will result at least in an "F" for that work, and may also lead to an "F" for the entire course. Plagiarism and cheating subjects a student to referral to the Senate Committee for Student Discipline for further action.

I am confident in each of your ability to tackle the course work. My group work policy is designed to encourage you to learn how to collaborate, but the assignments are designed to test YOUR grasp of the material. If you feel you need help with material, come see me any time my door is open.

Classroom Behavior: I expect you to live up to your roles as student-scholars. Students must follow the University of Illinois' standards for personal and academic conduct. Proper conduct entails creating a **positive** learning experience for all students, regardless of sex, race, religion, sexual orientation, social class, or any other feature of personal identification; therefore, **sexist, racist, prejudicial, homophobic, or other derogatory remarks will not be tolerated.**

Syllabus Amendment: This syllabus may be amended or modified in any way upon notice, with the version on GitHub being authoritative. Most such changes will affect the tentatve schedule, but be sure that you know if any due dates change.

Important Dates:

- Aug. 27, 2024: First day of class
- Oct. 10, 2024: Midterm Exam Assigned (due Oct. 17 by Noon)
- Dec. 10, 2024: Last day of classes (though it's more likely to be Dec. 5 in practice)
- Dec. 5, 2024: Final Exam Assigned (due Dec 17 by Noon)
- Dec. 24, 2024: Grades available for viewing on Student Self-service portal

CLASS SCHEDULE (subject to revision)

- **WEEK 0**
  First steps, light and radiation, wavelength, the atmospheree
- **WEEK 1**
  Luminosity, flux, distances, noise, statistics
- **WEEK 2**
  Fourier Transforms, optics, telescopes, astrometry
- **WEEK 3**
  Photons and matter, detectors in the UVOIR
- **WEEK 4**
  High-energy and coherent detectors and experiments
- **WEEK 5**
  Dark Matter and Gravitational Waves
- **WEEK 6**
  Working with image data
- **Oct. 10th**
  Midterm Assigned.
- **WEEK 7**
  Working with spectroscopy (no class Oct. 15, and not on Midterm)

- **Oct. 17th**
  Midterm due by Noon
- **WEEK 8**
  Interferometry and Map-making. Pick topics for in-class presentations.
- **WEEK 9**
  A survey of ground- and space-based facilities
- **WEEK 10**
  Instrumentation
- **WEEK 11**
  Surveys
- **WEEK 12**
  The landscape of astrophysics for the next decade
- **WEEK 13**
  Class presentations on special topics #1
- **WEEK 14**
  Class presentations on special topics #2. Pick facility/instrument for Final Exam Proposal Development
- **Dec. 17th**
  Final Proposal due by Noon.