Astro 32 - Galactic and Extragalactic Astrophysics|Spring 2025

This class is aimed at students majoring in the physical sciences (e.g. astrophysics, physics, any engineering or computer science majors). The goal is for you to learn both some of the theoretical grounding of modern astrophysics, but also to learn some of the tools professional astronomers use including data analysis, coding, collaboration on projects.

The class meets **Mondays and Wednesdays 9:00-10:15am**

In person:
Room 401
CLIC building (574 Boston Ave, Medford)

Instructor:

Professor Anna Sajina
Office: 312F in the CLIC building
email: Anna.Sajina@tufts.edu

Office Hours:

Mondays 10:30-11:30am,
Wednesdays: 1:00-2:00pm or by appointment (i.e. email me if you can't make these, I can set up in person or Zoom meetings as needed)
Location: my office but if more than 1-2 people show up, I'll move the office hours to the landing area on the 3rd floor.

Teaching Assistant:

TBD if we have one

Class structure:

The class is structured as follows:

1) There will be 11 short reading quizzes (typically 5 multiple choice questions) which are low pressure as worth only 10% total but are there to encourage you to read the book prior to covering the concepts in class.

2) Asking and answering questions in class is strongly encouraged (which also requires class attendance!). There are also Discussion boards for each Module where you can post and answer questions (which is less pressure than doing so in class). I'll review these boards before class and bring up for general discussion any major point of confusion!
Participation in class or on the Canvas Discussion boards is part of your grade!

3) There are 6 homework assignments. These include concepts, problem solving as well as computational problems.
In this class you'll learn python, if you haven't already. You'll also learn some basic data science techniques such as data visualization, statistics and model-fitting.

6) We have 2 exams (an in-class midterm and 1 final exam). The questions on the exams will focus on concepts rather than mathematical problem solving. For practice, I'll pose similar conceptual questions during each lecture. Please note these are generally low stakes exams. Therefore if you do say average 75% (a C) on the exams but 95% (an A) on all lower stress assessment (participation, quizzes, HW, term project) then you'll still get an A.

7) Finally, the class includes a computational term project which is in essence a mini research project involving some analysis for a data set I will provide. The skills needed to do this will be learned gradually throughout the semester via the computational homework problems. You'll be working with a partner and will produce individual term project reports. The details of the project requirements will be posted on Canvas separately.

The detailed class schedule is given at the end of this syllabus.

Grading:

Participation: 5%
Reading quizzes: 10%
Homework assignments: 30% — Note the lowest HW score will be dropped!
Midterm Exam: 10%
Final Exam: 15%
Term project: 30%

A = 90-100%
B = 80-89.99%
C = 70-79.99%
D = 60-69.99% (<60% is F)

How to succeed in Astro32:

Success will depend on coming to class, doing all assigned work in a timely fashion, and most of all **SEEK HELP WHEN YOU NEED IT!**

Textbook:

"An introduction to Modern Astrophysics" 2nd edition, by Caroll & Ostlie

Note: if you took Astro31 already, or plan to in the future, we use the same textbook, except Astro31 covers the "stellar" chapters, while Astro32 covers the "galactic" chapters.

This book is readily available second hand as commonly used throughout the US and is also available as an e-book. Both are somewhat cheaper options.

Please contact me if you are having issues getting the book!

Computing:

The default software we will be using is **python**.
An introduction to the basics of python will be given during the week of January 23 (time/place TBD). There are also multiple online resources that you will find helpful.

Here is a good place to start:
https://www.python.org/about/gettingstarted/

Specifically, **we'll be using Jupiter Notebooks as our python platform** — these are very flexible and modular and may be somewhat familiar to many of you if you've ever run for example Matlab. There are two options here:

1) If you want to install and run these on your own laptops, I suggest you do so via Anaconda which works on any Mac, Windows and Unix machines. Here's a link to get you started.
https://docs.anaconda.com/ae-notebooks/4.2.2/user-guide/basic-tasks/apps/jupyter/

2) If you are having issues installing this on your own laptop you can alternatively write and execute Notebooks using the online Google Colab platform. See link below.
https://colab.research.google.com/notebooks/intro.ipynb

Class schedule:

Module I: Preliminaries

(these topics are not covered in full detail here as they are the subject of Astro31 "Stellar Astrophysics" instead)
Reading Quiz#1:
Section 13.1 (skip derivation of Schonberg-Chandrasekhar limit)
Section 13.2, 13.3

January 15: Lecture 1: Introduction to the class, basic astronomy concepts

January 20: MLK day — NO CLASSES
January 22: Lecture 2: Stellar properties, opacity, blackbody radiation (Monday schedule)
January 27: Lecture 3: Stellar evolution 1, **Reading Quiz#1 due by 9am.**

Week of January 20 will schedule a python tutorial during a time that the most people can attend — if you cannot make the tutorial come to office hours or set up an alternative appointment.

January 29: Lecture 4: Stellar evolution 2
HW #1 (covers Lectures 1-4) due January 29 by midnight

Module II: The Milky Way

Reading: Quiz#2 Section 24.1 (skip differential and integral star counts), Section 24.2
Quiz#3. Section 12.1
Quiz#4 Section 24.3 (skip differential rotation and Oort constants), Section 24.4

February 3: Lecture 5: Morphology of the Milky Way 1, **Reading Quiz #2 due by 9am**

February 5: Lecture 6: Morphology of the Milky Way 2
February 10: Lecture 7: Interstellar medium 1, **Reading Quiz #3 due by 9am**

February 17: Presidents' Day — NO CLASSES
February 19: Lecture 8: Interstellar medium 2
February 20: Lecture 9: Rotation curve+dark matter halo (**Monday schedule**) **Reading Quiz #4 due by 9am**

February 24: Lecture 10: Galactic Center+supermassive black hole
HW #2 (covers Lectures 5-9) due February 24 by midnight

Module III: The nature of galaxies

Reading: Quiz#5 Sections 25.1, 25.2, and 25.4
Quiz#6 Section 25.3

February 26: (Substitute Monday's schedule on Thursday) Lecture 11: The Hubble Sequence **Reading Quiz #5 due by 9am**

March 3: Lecture 12: Properties and scaling relations of galaxies
March 5: Lecture 13: Orbits of stars **Reading Quiz #6 due by 9am**

March 10: Lecture 13: continued — a review of material so far
HW #3 (covers Lectures 10-13) due March 10

March 12: **Midterm on MODULES I-III (12 lectures)**

MARCH 15-23 Spring break

Module IV: Galactic Evolution

Reading: Quiz#7 Section 26.1, Section 26.2

March 24: Lecture 14: Galaxy mergers and interactions **Reading Quiz #7 due by 9am**

March 26: Lecture 14: continued

Module V: Structure of the Universe

Reading: Quiz#8 Section 27.1, 27.2
Quiz #9 Section 27.3

March 26: Lecture 15: Formation of galaxies **Reading Quiz #8 due by 9am**

March 31: Lecture 16: Hubble Law and the expansion of the Universe **Reading Quiz #9 due by 9am**

HW #4 (covers Lectures 14-16) due March 31

April 2: Lecture 17: Large scale structure and Clusters of galaxies

Module VI: Active Galaxies

Reading: Quiz#10 Sections 28.1, 28.2 and 28.3 (skip superluminal motion)

April 7: Lecture 18: Observations of active galaxies, **Reading Quiz #10 due by 9am**

April 9: Lecture 19: Radio galaxies

HW #5 (covers lectures 17-19) due April 9

Module VII: Observational Cosmology

Reading: Quiz#11 Sections 29.1, 29.2, 29.4

April 14: Lecture 20: Newtonian cosmology, **Reading Quiz #11 due by 9am**
April 16: Lecture 21: The Cosmic Microwave Background

April 21 — Patriots' Day — NO CLASS

April 23: Lecture 22: Observational tests of cosmology

Term Project reports due April 23

April 28: Lecture 23: ***Course review***

HW #6 (covers Lecture 23-25) due April 28

FINAL EXAM will cover only MODULES IV-VII (11 lectures)