ASTR UN2910
Introduction to Research Skills in Astrophysics
Spring 2025

Time: Fridays from 10 AM - 1 PM
Location: Pupin 1332
Credits: 1

Instructor	Advisory instructor	Teaching assistant
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Course description

Participation in research is an essential component of a complete undergraduate science education, and research experience is mandatory for students who want to pursue a PhD. This course is designed to introduce students to doing astronomy beyond the classroom. Students will learn essential research skills – including finding and reading astronomy research papers, retrieving publicly-available data from international archives, and conducting basic data analysis with Python – and apply these skills to completing a semester-long research project. Along the way, we will also discuss career paths and the softer skills that constitute the "hidden curriculum" of academia: communicating your science, finding research opportunities as an undergrad, networking at conferences, and more. By the end of the course, students should be prepared to enter a summer research internship and make the most of their time there.

Learning objectives

After taking this class, you'll be able to:

1. Describe the typical stages of an astronomy research project and conduct simplified versions of each to address a question of your choosing.
2. Name and describe the major subfields of astronomy research, including open questions and current/upcoming facilities relevant to each.
3. Find, read, and synthesize astronomy papers to gain understanding of a research topic.
4. Communicate astronomy concepts in a clear and engaging way using a variety of written and spoken formats.
5. Retrieve different types of astronomical data from public databases and use Python to conduct basic analysis of that data.
6. List different career paths in astronomy (both academic and non-academic) and develop a plan for pursuing your desired path.

How this course works

We'll meet once per week for 3 hours each time. A typical class session will include at least 2 of the following:

1. An interactive presentation on a technical skill or topic
2. An interactive discussion or presentation on a "soft" skill or topic
3. An activity involving group work OR coworking time to work individually on in-class assignments

We'll take short breaks between each activity/presentation or at least every hour. Please feel free to use the break time for anything personal (stretching, checking your texts, etc.) so that you can be as focused and engaged as possible during scheduled activities.

There will be only one major assessment in this course: a semester-long research project (see Semester-long project), completed in stages that align with the content covered in class. My goal is for you to have enough in-class working time to complete the project during our weekly sessions. I encourage you to take full advantage of this time, since you'll be able to get immediate help from me if any questions come up while working!

Throughout the course, you'll also complete smaller assignments intended to provide opportunities to (1) practice new skills and (2) reflect on your journey as a potential astronomer. These will mostly be assigned in-class, but you will occasionally be asked to complete a small task on your own outside of class. These assignments will be graded based on effort and evaluated as part of your participation grade (see How you'll be assessed).

Communication

Using Slack: Slack is an instant messaging platform commonly used by astronomy research groups. In this class, Slack will be used to discuss/ask questions about assignments, share resources, coordinate with your classmates for group work, and more. Slack messages don't need to be as formal as emails usually are – colloquial language, jokes, and emojis are welcome! However, please use respectful language when messaging me and your peers.

You should have received an invite link to join the class Slack in my welcome email. If you didn't receive the email or weren't able to join the Slack, please notify me right away.

Announcements: Course-wide announcements will be communicated via both Slack and email. Please make sure to check at least one of these channels daily.

Contacting me: If you need to contact me outside of class, I strongly encourage you to send me a direct message on Slack. It might feel awkward to message your teacher, but I promise it's good practice for your future astronomical career! You can send me a message at any time (even late at night), and you should feel free to write it like a message, not an email (i.e. no formal greeting/closing needed). Of course, you can also contact me via email if needed.

I'll do my best to respond to emails and Slack messages within 24 hours during the week and by Sunday night on the weekends (prioritizing Slack messages). If you don't hear back from me after that time, please feel free to send me a reminder.

Technology

Please bring your laptop to each class for viewing course materials and completing in-class activities. If you don't have access to a laptop that you can use for this course, please contact me ASAP so I can make alternate arrangements.

During the semester, I'll ask you to install a few pieces of software on your laptop that are commonly used for astronomy research. If you continue in research, having this software installed should only be beneficial. If you ever have questions/reservations about installing certain software, please contact me so we can discuss and figure out a workaround.

During class time (excluding break periods), I ask that you refrain from using your laptop or other devices for anything other than class-related activities. If you have to answer a text, email, or call, please do so quickly and discreetly to minimize disruption.

Required materials

You don't need to purchase anything for this class. All required texts and materials are freely available or will be provided by the instructors.

Extra materials

This course is intended to introduce you to foundational research skills, but full mastery of these skills is impossible to achieve in just one semester! In recognition of this, I will frequently provide extra materials (readings, exercises, suggestions for related courses, etc.) that expand/enhance the content of this course. You aren't required to engage with these materials, but if you *choose* to do so, I'm happy to discuss them further or provide feedback on your work!

Office hours

By the end of the first week of class, I'll schedule up to two weekly office hours based on your responses to an availability poll. My goal is for everyone to be able to attend at least once per week. If you need to meet with me but cannot attend the scheduled office hours, please email me to arrange an alternate time.

Office hours are meant to provide an opportunity for you to seek individual support and feedback. They're a great opportunity to ask questions about the course content, but you don't need to have a specific question in mind to attend. I'm also happy to chat about deciding whether or not you like research, planning for grad school, finding research opportunities, navigating the Columbia astronomy department, or anything else you want to discuss (even if it's not related to astronomy). You'll be required to check in with me at least once during the semester (see Required check-in), but you should feel free to come as often as you'd like outside of that required visit!

Office hours will be held in [redacted] (the astronomy graduate student lounge). The room will be reserved during office hours and should offer complete privacy when needed. I'm happy to chat one-on-one or in small groups. If you want to ensure our conversation is private, please just let me know ahead of time and I'll reserve a portion of office hours for you.

How you'll be assessed

This is a pass-fail course. To earn a passing grade, you must:

1. Attend all classes, with no more than one unexcused absence (see Attendance)
2. Check in once with me during office hours before spring break (see Required check-in)
3. Demonstrate sufficient engagement in the class (see Participation)
4. Complete and submit all project milestones (see Semester-long project)

Though they will not be graded quantitatively, you are also expected to complete and submit all in-class and pre-class assignments. Your performance in this area will be evaluated as part of your participation grade (point 3 above).

Feedback from me

Coding assignments and project milestones will receive written feedback within a week of submission, and other assignments will receive comments as needed. All written feedback will be posted on Courseworks.

There will also be dedicated in-class check-ins after each project milestone is announced. During these check-ins, I'll meet with you one-on-one to discuss your plans for the milestone and provide verbal feedback on your progress in class.

If you'd ever like additional feedback, please reach out! You're always welcome to come to office hours or schedule an alternate time to meet.

Attendance

Attendance is required. If you have to miss class for any reason, please let me know in advance. You don't need to disclose sensitive information for why you are missing class – just a brief notice is fine. (In emergency situations, it's perfectly fine to contact me afterwards!) If you miss class, you should plan to attend the next scheduled office hours to catch up on the content and assignments you missed.

Absences will be excused automatically if you (1) notify me and (2) catch up on what you missed. More than one *unexcused* absence will result in automatic failure of the course.

Required check-in

You're required to have at least one 15-minute check-in with me during the semester. This is *not* the same as the in-class check-ins mentioned in Feedback from me. For this check-in, I'll ask you a few questions about your career goals and past experiences, with the goal of connecting you to personalized resources to help you succeed in astronomy research (or whatever career path you're interested in pursuing). This is also a great opportunity for you to ask me any questions that you might have about research or astronomy in general.

These check-ins must be completed by the end of the week before spring break (3/14). Please reach out to me in advance to schedule the check-in (ideally during office hours).

Participation

Participation in this course includes preparing for class in advance, listening actively during lectures, contributing to discussions, and working with your peers on in-class activities. There will never be quantitative participation requirements (like speaking a certain number of times), but I do expect that you participate as much and as often as you are able.

Participation will be evaluated using the single-point rubric shown below, which describes the standards you should aim for. Halfway through the semester, I'll send you a copy of this rubric with feedback in each category (which we can discuss further in office hours if needed). Your final participation grade will be assigned based on your progress over the course of the semester. Only a complete lack of engagement and progress will result in a failing grade.

Areas that need improvement	Standards for performance	Areas of success
	Preparing for class You come to class having completed the assigned pre-class work and with questions in mind to ask during the day's discussion. When needed, you attend office hours (or schedule an alternate time to meet) to address issues with installation of software or other pre-class work *before* the weekly class session.	
	Active listening during lecture Your attention is primarily focused on the lecturer. You mainly use technology for taking notes or clarifying points raised in lecture. When something mentioned is confusing or unclear, you ask clarifying questions.	
	Discussion You offer input to class discussions in the form of comments or questions. (These contributions can be made verbally or submitted ahead of time on Slack.)	
	In-class activities and group work You make your best effort to contribute to in-class activities and group work. You remain on task for the duration of the activity/working period, share responsibility with peers to create a cohesive final product, and aim to finish the work during the assigned time. If you aren't able to finish in class, you complete and submit any assignments before the next meeting.	

Semester-long project

Throughout the semester, we'll discuss the different stages of a typical astronomy research project and practice the skills necessary to complete each stage. To put your new skills to the test, you will simultaneously complete a research project on a topic of your choice. This project must be completed independently.

The project will consist of four stages (described below). After each of the three milestones is announced, you'll check in with me to receive feedback on the previous stage and discuss next steps. These check-ins will happen during co-working time in class. You're also welcome to come to office hours to discuss your project further!

Topic selection

During the first two weeks of class, we'll introduce and explore the various subfields of astronomy research. For most major subfields, I'll provide several open-ended questions that can be answered with the datasets we worked with in class, as well as suggested reading related to each question. Your task is to select a subfield and a question that you're interested in exploring further. Your project will be focused around this question.

If you have your own idea for a research question, either in one of the subfields covered or in an entirely different one, you may propose it as a final project option; please contact me ASAP in this case so I can work with you to make sure the scope of your idea is appropriate.

Milestone 1: Literature review

During the third week of class, we'll discuss how to read astronomical papers and conduct a literature review. Following this, you'll find and read at least two papers related to the question you chose: one (1) review article and one (1) journal article. You will create a storyboard for both papers (the template for which will be provided in class) to be submitted for credit.

Milestone 2: Data analysis

The middle portion of the course will be devoted to exploring the technical tools needed to be an astronomer, from Python to working with online databases and various types of data. You'll produce an original Python script/notebook that uses one of the datasets we discussed in class (or another dataset of your choice) to investigate your chosen question and present the results in the form of plots or tables. The script/notebook will be submitted for credit.

Milestone 3: Presenting your results

After completing their analysis, astronomers shift their focus to communicating their work in various written and verbal formats. You will practice both of these, starting by writing a short abstract describing the work you have done so far. The abstract will be submitted for credit.

To wrap up the course (and your project!), you will prepare a short presentation for me and your peers that includes (1) relevant background to your question of interest; (2) analysis methods used to answer the question; and (3) the results you obtained from your analysis. These presentations will be given in-person on the last day of class for credit.

Course calendar

Date	What to expect in class	What to do before class
1/24	• Course overview • Introductions • Presentation: What is astronomy research? • Activity: Astronomy subfield map	• Review syllabus
1/31	• Presentation: Academic/non-academic career paths • Activity: Reflection (What are your career goals?) • Discussion: Exploring astronomy subfields	• Read about subfields that interest you
2/7	• Presentation/activity: How to read scientific papers • Presentation: Where to find scientific papers • Introduction to Milestone 1	• Choose topic for semester-long project
2/14	• Presentation: Intro to the terminal/Unix • Presentation/activity: Intro to Python 1 • Co-working time on Milestone 1 • One-on-one check-ins	• Install Anaconda Navigator • Submit choice of papers for Milestone 1
2/21	• Presentation: Research as an undergrad • Presentation/activity: Intro to Python 2 • Co-working time on Milestone 1	• Complete and submit Python exercises 1
2/28	• Discussion with panel of current graduate students • Presentation/activity: Intro to Python 3 • Presentation/activity: Making and reading plots	• Complete and submit Python exercises 2
3/7	• Presentation: Astronomy in the era of large surveys • Presentation/activity: Photometry, astrometry, and working with Gaia data • Introduction to project Milestone 2	• Submit Milestone 1 *(by end of day)* • Complete and submit Python exercises 3
3/14	• Presentation/activity: Spectroscopy and working with GALAH data • Co-working time on Milestone 2	
Spring break!		
3/28	• Presentations from Project BUILD mentors • Discussion: Week in the life of a grad student • Co-working time on Milestone 2	
4/4	• Discussion: Funding and proposals in astronomy • Presentation/activity: Theoretical astronomy and simulations • Co-working time on Milestone 2 • One-on-one check-ins	

Date	What to expect in class	What to do before class
4/11	• Discussion: Making the most out of a summer research experience • Presentation/activity: Working with FITS files • Co-working time on Milestone 2	• Install DS9
4/18	• Discussion: Creating a CV/resume • Presentation: Scientific writing and publication • Introduction to project Milestone 3 • Co-working time on Milestone 2	• Submit Milestone 2 *(by end of day)*
4/25	• Presentation: Attending scientific conferences • Presentation/activity: How (not) to give a talk • Co-working time on Milestone 3 • One-on-one check-ins	
5/2	• Activity: Reflection (What are your next steps?) • Final presentations • Celebration and exit survey	• Submit Milestone 3 *(by end of day)*

Additional policies

Academic integrity

Students are expected to adhere to Columbia's guidelines on academic integrity. In a nutshell, this means that all work that you submit should be your own, and any outside resources that you use must be properly cited.

For coding assignments, you may discuss general strategies and pseudocode with your fellow students, but you should NEVER copy each other's code. Unless otherwise stated in the assignment description, you should also refrain from using online resources like StackOverflow and ChatGPT to solve coding problems – this is the best way to ensure that you develop the basic intuition needed for research. When you *are* allowed to use these resources, you should always provide links to the information you used in your final submission.

Accommodations

If you have an Accommodation Letter from Disability Services, please contact me or come to my office hours by the end of the second week of class to confirm your accommodation needs. If you don't have a letter but feel that you require accommodations, please contact Columbia Disability Services and notify me that you are in the process of obtaining accommodations.