

Introduction to Astrophysics

AS231 – Fall 2023

(Updated 9/5/23)



Class Times: MWF 10:00-10:50am

Location: Mudd 311

Professor: Brian DiGiorgio Zanger (he/him)
(call me Brian)

Contact: bzanger@colby.edu

Office hours: Mon 3-4pm, Wed 11am-12pm, Fri 2-3pm
or by drop in/appointment (Mudd 403)

Lab Instructor: Michaela Allen

Office hours: Mon 10:30-11:30am, Wed 11am-12pm,
Fri 10-11am (Mudd 401)

Contact: mballen@colby.edu

TAs: Grace Gouin, Nithun Sentil Seltha Murugan

Help sessions: TBD

Contact:

Textbook: *An Introduction to Modern Astrophysics* (2nd edition), Carroll & Ostlie (978-0805304022)

Course Summary

This class will give you all of the theoretical and experimental background you need to make and understand real observations of the night sky. In the classroom, we will focus on the properties of the night sky, from the positions of objects in the sky and the light they give off, to the astrophysical mechanism behind stars, their formation, and their evolution that lead to us seeing them in the first place. You will have the chance to apply this knowledge in theoretical forms through our regular homework assignments and assessments, as well as in practical settings during your lab sections where you will obtain and analyze real astronomical data.

Course Goals

- 1. Students will be able to use a system's observational properties to determine its theoretical and astrophysical properties.** In this class, we will discuss the physics behind planets, stars, and clusters, learning about the fundamental laws of the Universe from only astronomical observations.
- 2. Students will be able to plan, execute, and analyze an observation on a research-grade telescope to achieve astrophysical goals.** We are lucky at Colby to have access to an extremely capable telescope, and this class will train you to use it for scientific observation and extract physical insights from your data.
- 3. Students will present their work in a professional, complete, and deliberate manner.** In both your homework solutions and your lab writeups, you will to communicate like a scientist and to present your work formally.

Class Structure

The weighting of assignments will be calculated as follows:

- **40%: Homeworks**
- **20%: Midterm Exams**
- **15%: Final Exam**
- **15%: Lab Reports**
- **10%: Final Lab Report**

At the end of the course, I will assign you a final grade based on the performance of the class as a whole. **This**

is not a traditional “curve,” and will not result in your grade going down. This simply allows me to give credit for understanding even if my assessments are difficult.

We will grade and return assignments **within a week and a half of the stated due date**. This means that a homework due on Tuesday will be returned by Friday the week after. Late assignments may not follow this schedule.

Your participation grade will be a combination of your completion of in-class worksheets as well as your engagement with classroom activities. You don't necessarily have to raise your hand or participate in all-class discussions if that makes you uncomfortable (although it is certainly encouraged); **if you regularly attend class, complete your worksheets, and participate in group work, you will get full participation credit.**

Course Expectations

Attendance

Attendance is not mandatory for this class, and I will not be taking attendance ever. **You do not have to notify me in any way if you will be missing class.** I understand that things come up, and I trust you to make the decision that is best for you.

However, **I strongly recommend that you attend every class.** The readings will not cover all of the content you will be required to know in the course, so coming to the lectures and taking notes will be beneficial to your learning.

I will do my best to help students who must miss a class by posting my notes from class on Moodle and offering help during office hours and over email.

Nighttime Observing Labs

The core of observational astronomy is of course using telescopes to make observations. **Throughout this course, there will be three nights of required observing for you to obtain the data used in your labs.** Since weather in Maine is often cloudy and unpredictable, **you must be available any night Monday through Thursday, and you are required to attend observing nights regardless of conflicts.**

Observing sessions are usually held **between 8pm and 11pm in roughly hourlong sections**, which should allow for flexibility in attending evening classes. **The decision to observe or not will be made on the evening of the observation**, and you will be notified by Michaela as soon as possible when the decision is made.

Afternoon Labs

Before any nighttime observing can happen, you must first plan out the observation, and after you obtain your data, you must then analyze it. For this reason, **we will also have required afternoon labs** in addition to the nighttime labs to support your observing. **You will be required to prepare your observations and analyze your data with your partner, but your lab writeups must be completed by yourself.** Your writeups will be similar in format to scientific journal articles, meaning all sources must be attributed. **Submitting a writeup with identical text to another student will be considered academic dishonesty** even if you are using the same data.

Programming in Python

Throughout this course, there will be a number of times that **you will be expected to analyze data using the Python programming language.** Most importantly, this will be required for your labs, where you will use Python to analyze your observations. **No prior Python experience is necessary**, and most of the code will be pre-written for you already.

You will need to have access to a computer that has a Python environment with the necessary packages. The easiest place to do this is in the astronomy computing lab where you will already be, but you may also set up your own computer as well (follow the instructions [here](#) to install Anaconda) or on [Google Colab](#) to do it online without having to install anything.

In-Class Behavior

Participation in class is also highly encouraged. Actively engaging with the material through questions and group work will greatly facilitate your learning.

I understand that you are a living, breathing human being, so **you are allowed to eat, drink, and take bathroom breaks whenever you need** (you don't need to ask me). I would prefer if you could do these things between classes, but I understand that that may not be how your body or class schedule works. Please be courteous to your classmates by not bringing in anything too distracting for your classmates, and wait until after class if your neighbors find you to be disruptive.

Class rosters are provided to each instructor with the student's legal name. **I will gladly honor your request to address you by an alternate name and/or gender pronoun.** Please advise me of this early in the semester so that I may make appropriate changes to my records.

Discussion Guidelines

During this class, we will have regular discussions in small groups and as a class. During these discussions, I ask you to use the following guidelines:

1. **Respect the knowledge and experiences of your peers.** Don't interrupt or accost your classmates. Don't invalidate other people's lives, including identity and pronouns.
2. **Be an equitable group member.** Don't dominate the conversation. If someone is quiet, make sure they can say what they want to say. Make sure everyone understands before moving on.

Assignments

Due Dates and Resubmission

Every due date in this class is a recommended due date, meaning that **if you need to turn something in late, there will be no penalty for up to one week, after which they will receive a zero.** I recognize that things may come up in your life that may prevent you from completing an assignment on time, and there is no need to notify me ahead of time. Assignments due by near the end of the class must be turned in by the start of the final exam period. **Assignments not turned in by their recommended due date will be deprioritized for grading and will not be eligible for resubmission.**

However, **I strongly recommend you stick to the recommended due dates as closely as possible.** The due dates are spread out in such a way to make the workload manageable and the learning experience

productive, so if you put off a bunch of assignments, you will only be hurting yourself by worsening your comprehension and concentrating your work.

To incentivize you to keep the schedule, **all assignments turned in by their recommended due date can be resubmitted and will receive full credit for all mistakes fixed.** My assignments are designed to help you learn the material, so I would rather reward you for putting in the effort to learn and get things right the second time than penalize you for not understanding something immediately. **You will have 1 week from the time an assignment is graded and returned to resubmit the assignment, and you will only be allowed one resubmission per assignment.**

Assignments turned in after their recommended due date are not eligible for resubmission.

Turning In Assignments

The preferred modes for turning in assignments are either in class at the front of the room or through the corresponding assignment listing on Moodle. If for some reason neither of these options work for you, you can also reach out to discuss other methods.

If submitting electronically, please use a standard file format (preferably .pdf, but I will also accept .jpg, .png, .odt, or .docx). Please do not use proprietary/nonstandard formats like .pages or .heic, as they make grading much more difficult.

Readings

For each class day, you will be assigned readings in our textbook. I highly encourage you to do the reading because educational research shows that learners retain information better when they see it multiple times and in multiple modalities, and the book also contains details that I will gloss over in class. There will be no formal verification of whether you have done the reading, but **you may be assessed on material that is covered in the reading but not in class.**

Weekly Homework

An important part of understanding how the Universe works is to actually work through problems. **Homework is the main learning tool for any physics-based class**

as it allows you to work through and apply the concepts on your own.

Each week, you will be assigned a set of problems to be turned in the following Tuesday. **Your homework will be graded for correctness, but significant partial credit will be given for showing your work.** If you don't know how to answer a question, write everything you know anyways and we'll probably find something to give you points for. **Solutions that contain only the answer with no accompanying work/justification will not receive full credit.**

You will receive grades and feedback on your answers and **you will be able to resubmit your homeworks** with the mistakes corrected to earn back full points. I highly encourage all students to do this because learning from your mistakes is key to cementing your understanding of a topic.

You are encouraged to work on these problems in groups, but **you must understand and be able to reproduce everything you write down and turn in.** Don't copy work from someone else verbatim. I have caught plagiarism in every astronomy class I have ever graded for, so I will be able to tell and you will receive a 0 on the whole homework.

Homework Writeups

A large part of being a successful scientist is presenting your work to others, so you will be expected to communicate your work in this class clearly and deliberately. **Your homework solutions should resemble a textbook example, giving the reader not only the answer to the question but also a detailed narrative for how you arrived at the answer.** I will give examples of complete writeups for you to base your work on, and I will also give feedback throughout the course.

Learning to write up your thoughts in this manner takes practice, so you will not be penalized for unprofessional writeups immediately, but **over the course of the class, more and more points on each homework will be based on the quality of your writeup.** You will be informed on each homework assignment how many points the writeup quality will be worth.

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If submitting electronically, please use a standard file format (preferably .pdf, but I will also accept .jpg, .png, .odt, or .docx). Please do not use proprietary/nonstandard formats like .pages or .heic, as they make grading much more difficult.

Midterm and Final Oral Exams

We will have two midterm exams during the semester and one final exam during finals week. Communicating scientific results is usually done in real time in front of peers, so to give you practice in that environment, **all exams in this course will be administered orally.** You will sign up for a timeslot to come to Brian's office and you will be asked a few questions, and you will answer them in real time in front of me, using a whiteboard for any mathematical reasoning.

All exams will be open note/textbook, though I will also answer any questions you have and give you hints and push you in the right direction if necessary. The goal of these exams is not to see you solve a problem perfectly on the first try but to see your problem solving strategy in person and evaluate you more holistically.

You should still study for these exams in the same way you would study for a normal written exam so you can easily make connections and solve problems on the spot. **If you require any accommodations for working in real, answering verbal questions, or writing on a whiteboard, let me know as soon as possible** so we can make alternate arrangements.

Accessibility

Accessibility During Class

I like to teach with an active learning style, meaning I will often ask for physical participation from students in some way. Below are the tasks I will be incorporating into my lessons. **If any of these tasks will cause difficulties for you, please let me know as soon as possible** so

we can work out a way for you to participate equitably in class.

- Seeing and interpreting colors
- Engaging in class discussions without voice amplification
- Reading a blackboard and a projector

Accessibility for Assignments

When it comes to learning in this class, I will assume that **difference is the norm**. I have attempted to design the assignments in this class to be as flexible as possible in the timing, content, and method for completion, but if you encounter some aspect of the course that is not accessible for you, **please bring it to my attention so we can work out something that will help you learn**. I also honor any accommodation letters that you would like to confidentially bring to my attention. I encourage all students to utilize any and all of the accommodations available to you.

If you are a student with a disability, or think you may have a disability, you are also welcome to initiate this conversation with the Dean of Students Office. The Dean of Students Office works with students with disabilities and faculty members to identify reasonable accommodations. Please visit their website for contact and other information:

<https://www.colby.edu/studentadvising/student-access-and-disability-services/>.

If you have already been approved for academic accommodations, please connect within the two weeks of the start of the semester so the office can develop an implementation plan.

Conflicts with Class

Athletics: In the case of overlapping commitments between class and athletic competitions, **you must meet with me as soon as possible to discuss these overlaps**. You may request permission to miss class and make up the missed work, but I retain final authority either to grant or to withhold permission.

Mental health: If you are in need of reasonable flexibility due to an emotional situation or an ongoing mental health issue, **please communicate as openly as possible with your Class Dean**, and/or members of the

office of Access and Disability Services, preferably in advance of the need, so that we can discuss how your circumstances interface with course requirements. Together, we will consider what is needed and what is possible. If we can discuss the situation, we can manage the situation together.

Religious Holidays: If I have inadvertently scheduled an exam or major deadline that creates a conflict with your religious observances, **please let me know as soon as possible** so that we can make other arrangements. Colby College is supportive of the religious practices of its students, faculty, and staff. The College is committed to ensuring that all students are able to observe their religious beliefs without academic penalty.

Additional Learning Resources

Successful students often use a wide variety of resources when learning. To supplement our readings and in-class content, please consider the following options for further learning:

- **Before or after class or during breaks:** I encourage you to approach me at the front of the room to ask any questions
- **Brian's office hours:** We are happy to discuss any ideas you feel uncomfortable with or help you with any assignments you are confused about. I am also happy to set up a separate meeting or Zoom if you cannot attend office hours
- **TA help sessions:** Our TAs Grace and Ben are available to help with your homework questions regularly, and attending help sessions can connect you with other classmates seeking help
- **Your classmates:** Reach out to your classmates to ask for their help

Additional Support Resources

Colby Counseling Services: College is a stressful time for everyone, so please do not allow academic responsibilities to prevent you from getting help you need. Our Colby Counseling Services staff (207-859-4490) and the staff in the Dean of Studies office (207-859-4560) are available to connect with you. The safety of my students and every member of this community is paramount. If you or someone you know is struggling with thoughts of suicide or may be a danger to themselves or others, please call the on-call counselor immediately (207-859-4490, press '0')."

Sexual Misconduct: Colby College prohibits and **will not tolerate sexual misconduct or gender-based discrimination of any kind**. Colby is legally obligated to investigate sexual misconduct (including, but not limited to, sexual assault and sexual harassment) and other specific forms of behavior that violate federal and state laws (Title IX and Title VII, and the Maine Human Rights Act). Such behavior also requires the College to fulfill certain obligations under two other federal laws, the Violence Against Women Act (VAWA) and the Jeanne Clery Disclosure of Campus Security Policy and Campus Statistics Act (Clery Act). To learn more about what constitutes sexual misconduct or to report an incident, see: www.colby.edu/studentlife/handbook-section/f-sexual-misconduct/.

Confidentiality: I am committed to all Colby students feeling safe, accepted, and included in all aspects of their college experiences, including this course. Colby prohibits and will not tolerate sexual misconduct or gender based discrimination of any kind and is obligated, by federal and state laws, to respond to reports and provide resources to students. **As your professor I am considered a "responsible employee" which requires me to report incidence of sexual assault, sexual harassment, dating violence, or stalking to the Title IX Coordinator.** If you wish to access confidential support services, you may contact the Counseling Center (207-859-4490), the Title IX Confidential Advocate, Emily Schusterbauer (207-859-4093), the Office of Religious and Spiritual Life (207-859-4272), or Maines's 24/7 Sexual Assault Helpline (1-800-871-7741).

Academic Honesty

What is Plagiarism?

This class is built on a foundation of collaboration and group work, so the barrier between “working together” and “plagiarizing” can sometimes become blurred. Here is how I define it:

Plagiarism is turning in work that you could not reproduce on your own if asked.

You are encouraged to work with fellow classmates when solving problems for worksheets or homework, but **you must understand everything you write down**. Here are some examples of practices I consider to be plagiarism:

- Copying a friend’s homework without understanding what they did
- Writing out a solution from the internet/AI without any modification
- Turning in anything you did not write with your own hand

You are allowed to consult sources other than your class notes and the textbook (in fact, I encourage it). This includes sources like other books, Youtube videos, AI, and whatever else you find on the internet. However, **you cannot simply copy what these sources say word for word**.

Don’t rely too much on math aids like Wolfram Alpha or a calculator. I encourage you to use them in order to make difficult calculations and conversions easier, but **you must still show your work** or I may take points off.

How to Avoid Plagiarism

Graders like me, Grace, and Ben are good at spotting plagiarism. If your work looks too similar to the work of another student, we will notice and compare your assignments in detail. Let me tell you **how to keep us from catching you**:

- Change the formatting of your work
- Change the wording you use if you’re answering a written question
- Write different steps when solving equations

If you do these things, we will probably give you the benefit of the doubt and let it pass.

Why am I telling you how to skirt around our plagiarism checks? Because **changing your writeup so it’s not plagiarism requires you to understand the material!** You have to know what you’re doing to modify an answer so that it’s different but still correct.

Plagiarism Consequences

I will follow the required academic dishonesty policy laid out by the Colby administration. For minor offenses (e.g. non-malicious copying of an answer on a homework), you will receive an “academic negligence”, which will be reviewed by the Academic Integrity office and **result in you getting a 0 on the whole assignment and your final grade in the class being lowered by a full letter grade**. If you receive more than one negligence in your time at Colby, you will be required to meet with the Academic Integrity Coordinators.

If you commit a more serious offense (e.g. copying an entire assignment or violating the rules of an exam), **you will automatically fail the course and receive a mark on your Colby transcript until 6 years after your graduation for everyone (including graduate schools and employers) to see**. Subsequent offenses can lead to suspension or expulsion.

Course Outline

Below is an outline of what we will be covering in class. All of this is subject to change, and it will be updated regularly to reflect the current course plan.

1. Positional Astronomy Celestial Coordinates
 - b. Sidereal Time
 - c. Angular Distances on the Sky
2. Properties of Light
 - a. Wave-Particle Duality
 - b. Brightness measurements
 - c. Magnitude scale
 - d. Blackbody radiation
 - e. Effects of Dust
3. Celestial Mechanics
 - a. Orbits
 - b. Newtonian physics
 - c. Conservation laws
 - d. Kepler's laws of planetary motion
 - e. Virial theorem
4. Interaction of Light and Matter
 - a. Kirchoff's laws
 - b. The hydrogen atom
 - c. Quantum mechanical effects
5. Stellar Astrophysics
 - a. Spectral Classification and the Hertzsprung-Russell Diagram
 - b. Ideal gas law and Maxwell-Boltzmann velocity distribution
 - c. Strength of spectral lines from excitation and ionization states
 - d. Spectral line profiles
 - e. Radiation transfer theory
6. Star Formation
 - a. Jeans instability criteria
 - b. Timescales: free-fall, Kelvin-Helmholtz
 - c. Initial Mass Function
7. Stellar Evolution
 - a. Nucleosynthesis
 - b. Main sequence turn-off point
 - c. Compact stellar remnants and black holes
8. Cosmology (time permitting)
 - a. Extragalactic distance ladder
 - b. Expansion of the Universe
 - c. Big Bang and Inflation
 - d. History of the Universe