

# Astronomy 402: Syllabus

## Course Goals:

The goal of this course is to introduce you to the observational, statistical, and computational techniques used by observational astronomers. The course is designed to give you some of the basic skills you need if you decide to pursue a career in astronomy. In order to fully develop these skills you will be expected to do an observational research project and write it up as you would for publication. Many of these skills you will develop in this class are extremely useful in other careers as well as astronomy. In addition, the class is designed to improve your scientific writing and analytical thinking skills.

## Introduction:

In order to learn about the techniques used by observational astronomers we must cover a lot of ground in this course. We will learn about telescopes and detectors, methods for taking, reducing, and analyzing data, and the statistics required for understanding the data and analysis. The course will rely heavily on the use of computers and you will be expected to become proficient in using the Linux environment and data analysis programs. **Because of the quantity and diversity of material that you will need, this class will require substantial time and effort. You must expect to invest a significant amount of time in this class to succeed. The time investment will include time spent at the campus telescope at night for observing.** In return for your effort, I will work hard to help you build these skills. I also hope that this class will be friendly, collaborative, and fun.

This course fulfills the writing-intensive requirement in the astronomy major. It does so through weekly homework and lab-type exercises (approximately 250 words/week), an observing project proposal (at least 1000 words), and a paper about your observing project (at least 2500 words).

## Research Scholarship Course:

This course is designated as a Research and Scholarship Intensive Course, which means that you will have the opportunity to actively participate in the process of scholarship. Several components of this class are linked to the research scholarship goals.

1. *Telescope Proposal:* The telescope proposal is an opportunity to propose the research project you want to do in the context of requesting the telescope time you will need to perform the investigation. The proposal will address several the research scholarship goals including: **(1) Justify that the project intends to be engaging and novel to a particular audience; (2) Articulate and refine the question; and (3) Present their**

**understandings from a scholarly perspective for a specified audience.**

2. *Observing Project and Paper:* The observing project and the associated paper will give you the opportunity to explore a research question making use of telescope observations and data. The results will be summarized in journal format as discussed below. This project will address the following research scholarship goals: **(1) Present their understandings from a scholarly perspective for a specified audience; (2) Articulate and refine the question; (3) Gather evidence appropriate to the question; and (4) Assess the validity of key assumptions and evidence.**
  
3. *Observing Project Presentation:* The observing project presentation will be a presentation of your project including its background, goals, and results to the other members of the class. The presentation will address the following research scholarship goal: **Justify that the project intends to be engaging and novel to a particular audience.**

### **Computers:**

The use of computers is fundamental to astronomical work so they are going to play a very important role in this class. We will use the computers located in the classroom. These computers are all running the Linux operating system with which you will become familiar if you are not already. For data reduction we will use astrolmageJ but for some projects learning and using IRAF, software written for professional optical data reduction, may become necessary. You will also be expected to use a computer for some of the plotting and analysis of data. For this you may use any program with which you are already familiar.

### **ASTRO 402 Lab:**

Astronomy 402 consists of a lecture and laboratory portion of the class. You **must** sign up for both the lecture and the lab at the same time, the laboratory session is an integral part of the class. During the first few weeks of class we will meet for the telescope training and for some group observing sessions during the lab time. Later in the semester, after you have passed your telescope training and have been cleared to observe on your own (although you will always observe at least in pairs), you will be expected to sign up for observing time to collect data for class exercises and ultimately for your class project. The class observing time will always be available for this, but it might not be optimal for your project or weather might interfere. Because of these issues, you might need to have some flexibility in your evening schedule so that you can sign up for observing at other times if that becomes necessary. Using a telescope to make observations for your project is a significant time commitment, a minimum of 3

hours a week are expected to be devoted to the observing/data taking portion of this class.

### **Telescopes:**

Using telescopes is always a bit tricky and never works as you plan it. There will undoubtedly be obstacles to deal with including instrumentation that does not always work as planned and weather that can sometimes be uncooperative. For the observations we also have access to remote telescopes in Chile that we can use if too many problems arise or if they would provide a useful supplement to the campus telescope for your designed investigation. We will spend some of our lab time (particularly if we encounter bad weather) learning to use this remote facility.

**Contact Information:** Jessica Rosenberg

**e-mail:** [jrosenb4@gmu.edu](mailto:jrosenb4@gmu.edu)

**office:** 219 Science and Technology I

**phone:** 703-993-9551

**Office Hours:** By appointment

**Course web site:** <http://physics.gmu.edu/~jrosenb4/observational.html>

### **Recommended Texts:**

Observational Astronomy, by Birney, Gonzalez, and Oesper

An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurement, John R. Taylor

Handbook of CCD Astronomy, Steve B. Howell

### **Accommodations for Disabilities:**

*If you are a student with a disability and you need academic accommodations, please see me and contact the Office for Disability Services (ODS) at 993-2474, <http://ods.gmu.edu>. All academic accommodations must be arranged through the ODS.*

### **Honor Code:**

GMU is an Honor Code university; please see the Office for Academic Integrity for a full description of the code and the honor committee process. The principle of academic integrity is taken very seriously and violations are treated gravely. There will be collaborative projects in this class, for those projects all contributors should be credited. For individual projects on which only your name appears, you are welcome to discuss your ideas but the end result must be yours alone. If you are ever unclear as to the expectations for a part of this class please ask for guidance and clarification.

**Grading:**

	<b>Undergraduate</b>
Class Exercises	35%
Telescope Proposal	15%
Observing project (written)	35%
Observing Project (oral)	15%

## Telescope Proposal

Ultimately for this class you are going to obtain a series of observations that you will then analyze. As astronomers we need to submit a proposal that describes the observations we are going to carry out to get time on a telescope. The format of the proposal is given below. Because this is the writing intensive class for the major the proposal must be **at least** 1000 words long. In general there are 3 important parts of every proposal:

- I. Abstract: The goal of the abstract is to sum up the main justification for the project. You will talk about what you are going to do and why in a paragraph.
- II. Scientific Justification: The scientific reason that you are going to pursue the project. What is it you are going to get out of these data in the end? You will need to look at the literature and really design your project and what you are going to get out of it in the end. Here is where you describe the hypothesis that you are going to test with your observations.
- III. Technical Justification: This section describes the resources you will need (filters, observing times, S/N, weather conditions, number of observing sessions, durations of observing sessions, spacing of observing sessions, etc) to complete the project. When writing this part of the proposal, consider the following:
  - a) Target source (why was this chosen rather than another),
  - b) Time when the target is visible (at the time of the observations, but you can also comment on its observability during the class time – i.e., if the telescope had been available would you have been able to do this project),
  - c) Length of time for which the source is visible at the telescope,
  - d) Filters to be used,
  - e) Number of exposures,
  - f) Length of exposures,
  - g) Time separation of exposures if that is relevant,
  - h) Number and duration of calibration exposures and how they will be used in the data analysis,
  - i) Expected S/N of the observed sources.

## Project Paper

The goal of the project paper is to describe the observations, data reduction, and results of your research project. Again because this is the writing intensive class there is a word limit **minimum** to the paper that is 2500 words. The format for this paper will follow the format of astronomical publications so it may be helpful for you to have a look at the *Astronomical Journal* to see an example of what this format looks like. The audience for the paper will be a scientific audience – it should be written at the level of an *Astronomical Journal* article but with a bit more detail as to your method than might typically be included in such a paper. The primary components of your paper will be:

- 1) Abstract: an overview of what has been done and the results of your project.
- 2) Introduction: explains why this project is of interest and what the goals of the project are. This section will look a lot like your scientific justification section from the telescope proposal (I highly recommend that you look at any comments on your proposal justification and edit this section accordingly).
- 3) Data Reduction: describes the details of the data reduction you have done. This section needs to be very thorough! Discuss all of the observations you have and details including but not limited to: telescope used, types of observations take, duration of observations, step-by-step description of the data reduction procedure including all calibration, photometry, etc. Include figures where they are relevant.
- 4) Results: describes the results of your project. This section should be about the science that was done with the data. Use figures to illustrate your results.
- 5) Conclusions: this section describes how your results fit with the hypothesis that you made in your telescope proposal. More importantly, it places the results in the context of the scientific literature.
- 6) References: bibliography in the style of the *Astronomical Journal*

These projects will be done in groups of 2-4, but the write-up must be your own. You will fail the paper if what you turn in is not original. This doesn't mean that you can't talk about the work that you are doing, it means that what you submit **MUST BE IN YOUR OWN WORDS!** Also make sure that you are the first author on the paper and anyone else that contributed is co-author (if they did a significant amount of work like you partner is expected to have done) or is cited in the acknowledgements if they were part of a useful discussion of the work or contributed a useful idea (but not a significant part of the results).

## Project Presentation

Presenting your research is an important skill as an astronomer. It is also a skill that crosses many disciplines and professions. At the end of the semester we will have a presentation session (or two depending on the number of students) in which each group will present the research they have done over the course of the semester. The talk should be directed at your fellow students (i.e., upper level astronomy students – we may have additional people viewing the talks, but this is still your target audience). Everyone in your group is expected to give part of the presentation so you will need to coordinate what each member of your group is talking about. This means that you will need to work together and ultimately to practice the talk together before this final presentation. Important things to include in the talk:

- Background material explaining what has been done before in this field. This is where you set the stage for the project you have just executed.
- An explanation of why you pursued this particular project, why it is interesting, and what questions you hoped to answer. This is where you lay out the hypothesis that you made.
- A thorough discussion of your observational method, data reduction, and analysis.
- Summary of your results, discussion of whether your results support or negate your hypothesis, discussion of where these results fit within the larger context of the field and the literature. This section could also include a revision of the hypothesis and discussion of possible future work.

<b>Date</b>	<b>Reading/Assignment due</b>	<b>Topic</b>
Aug 30		Introduction, Coordinates and time, Telescopes
Sept 6	Exercise #1 due	Statistics <b>Exercise 2: Statistics</b>
Sept 13	Exercise #2 due	CCD Detectors, dark, bias, and flat field images <b>Introduction to telescope/taking darks, biases, flats</b>
Sept 20	Proposal outline due	<b>Exercise 3: Image calibration</b>
Sept 27	Exercise #3 due	<b>Exercise 4: CCD Processing</b>
Oct 4	Exercise #4 due	Photometry and image calibration (relative vs absolute photometry) <b>Exercise 5: Photometry</b>
Oct 18	Telescope Proposals due	Spectroscopy <b>Exercise 5: Photometry continued</b>
Oct 25	Exercise #5 due	Time allocation committee meeting <b>Exercise 6: Spectroscopy</b>
Nov 1		Radio Astronomy <b>Exercise 6: Spectroscopy continued</b>
Nov 8	Exercise #6 due	<b>Exercise 7: Radio astronomy</b>
Nov 15		Infrared astronomy <b>Exercise 7: Radio Astronomy cont.</b>
Nov 22	Observing Project "draft" due	Interferometry Work on observing project data



Nov 29	Exercise #7 due	Interferometry cont. Work on observing project data
Dec 6	Observing Project Presentations	Observing Project Presentations
Dec 13	Observing Project due	