Astronomy 121
Research Techniques in Observational Astronomy
Spring 2014

The course meets Thursday, 1:15–4:15 PM, in the Physics & Astronomy department seminar room (Science Center 113).

You contacting me:

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Office hours: I will *not* be available on Tuesday mornings, or most of the day on Friday. Other than that, I should be around most of the time; in particular, I will plan to be in my office and available for questions all afternoon on Mondays and Tuesdays, on most of the day on Wednesday (except for lunch). You should feel free to stop by my office any time to see if I'm around, but at times I may ask you to come back later. Sometimes I may be in my research lab, Science Center 122.

E-mail is a good way to contact me; I'm usually logged in during the day (and often in the evening), and I try to respond to e-mail relatively quickly. I check my e-mail much more often than my voice mail.

Me contacting you:

I expect you to read your e-mail at least once a day since I may clarify problems, announce extra or changed office hours, etc.; it will definitely be to your advantage to keep up with your e-mail. If you prefer to use a different e-mail address than your standard campus address, please send me an e-mail message to that effect.

Academic honesty:

All work that you turn in for any part of the course (weekly problem sets, observing exercises, exams, anything) must be your own, and any use you make of others' work or ideas (classmates, books, information/solutions you find on the web) must be properly acknowledged. Sometime you will take data together; when you do, always state clearly who was in your group and who did what in the data taking and reduction. I encourage you to work together, but when it's time to write up your final solutions to turn in, you really must sit down *by yourself* and write them up. Doing otherwise, even with the best intentions, often leads to unacceptably similar wording of solutions. If you have *any* questions about what is or isn't appropriate, please err on the side of citing things, and please talk to me about it.

Course texts and other resources:

No textbook is perfect, so we'll use a variety of books. Our primary text is *To Measure the Sky*, by Fred Chromey, which contains a lot of good information about a variety of topics, primarily focusing on visible-light astronomy. To supplement that book, we will pick and choose from a variety of readings from books and from the astronomical literature. Sometimes I will post links to resources on the web, and sometimes you will find readings on the honors reserve shelf in Cornell Science Library. (This shelf is on the opposite side of the low wall that's just to your right when you enter Cornell. Please be sensitive to the fact that we only have one copy of these books, and be sure not to monopolize them. Feel free to e-mail each other if you can't find a book when you need it.

You will find it necessary to be able to do some calculations, data manipulation, and graphing on the computer. I will set up accounts on the Astro lab Linux machines for any of you who don't already have them, and get you keys to my research lab and the telescope area. In subsequent assignments, we will be learning a bit of IRAF, which is a standard program for astronomical data reduction. If you already know IDL (another data analysis language that is commonly used in astronomy) or Python, you may find those useful for some of the assignments, since a large number of astronomy-specific routines are available for your use. If you have a Mac or a Linux computer and would like to install both IRAF and Python for your own use, check out the Ureka project from Space Telescope Science Institute, http://ssb.stsci.edu/ureka/ - a free distribution of IRAF and Python together (including many astronomy-related python modules. You can download it from that site, or I have an install DVD you can borrow. (Sorry, there's no Windows version of IRAF, though you can install Python.)

There is a course web page at http://astro.swarthmore.edu/astro121 that will contain versions of most of the handouts and assignments given in class, as well as links to other sites of interest. If you lose a copy of something handed out in class, you will probably be able to find it there (though of course you should feel free to ask me for another copy).

Working in the seminar format

Since the seminar format we use here at Swarthmore is different from how our lower-level courses are taught, and since each person in our department runs his or her seminars a little differently, here are some explicit thoughts about what I expect from you in this class.

As in any course, the goal is for you to come away from the course with an understanding of a body of material. However, unlike a traditional lecture course, I will generally not spend much (if any) time explicitly presenting material to you in a given week. Instead, I'll give you some problems and questions that I'd like you to be able to answer. In general, if you can answer those questions, you have a decent understanding of the material. Thus, my job is not to present the material to you explicitly, but rather to give you the resources you need to learn the concepts we're covering. Your job is to use those resources to try to understand those concepts and to work the problems. One of those resources (though not the one you should turn to first) is talking to me. I'm more than willing to talk to you about problems you're having with the assignment—but not before you've done some work on your own, and not at noon or 1:00 PM on the day of a 1:15 PM seminar.

So what exactly do I expect you to do? At *minimum*, my expectations are that, before coming to seminar:

- You have done the reading;
- You have tried to do every problem by yourself;
- You have talked to others in your class about solving the problems;

- You have come to my office to talk to me about any problem that you had significant difficulty with (i.e. that you got stuck on enough that you couldn't complete a significant part of it).

I would say that I expect you to do those things in that order, and to start enough in advance that you can get to the last thing (coming to see me) if necessary.

You will turn in your problem solutions to me **by 9:00 AM on Thursdays**. These should be complete solutions (or at least attempts at complete solutions), but they will be evaluated primarily for effort and completeness, not for correctness. I will look through your solutions before seminar, which will give me a better sense of what we need to discuss in seminar. I'll return them to you by the beginning of seminar, so you can (briefly) look them over to see what you still need to have clarified in seminar.

So what's the point of coming to class if you're learning everything yourself? There are several reasons. First, note that the list does *not* include having the perfect solution to each problem. You should strive for that, but we will spend the seminar time going over those problems and discussing your solutions, which will give you a chance to see how others have solved the problems, and will allow us to discuss other interesting issues surrounding the topic. Second, sometimes each of you will be assigned to research and present a different aspect of the topic of discussion that week. When this is the case, you'll need to hear everyone's presentation to get the whole picture of the material for that week. Finally, and most importantly, on those times when you *do* have the perfect, elegant solution to a problem, you'll want to present it to your classmates so that they can learn from you. Explaining something to someone else really does help you clarify your own thinking and solidify your understanding of a problem. In my opinion, this is the major strength of the seminar format.

Thus, there are two goals for seminar each week: preparing as well as you can beforehand by making use of all the resources available to you, and learning as much as you can during the seminar session itself. The grading for the course will reflect both of these things. I will ask you to turn in a copy of your work on that week's problems on Thursday of each week, and some weeks you will also have a chance to turn in revised solutions to some of the problems after our Thursday seminar meeting. I will also assign part of your grade based on your participation in our seminar discussions; this part of the grade is not based on "having the right answer" to any given problem, but rather on whether you participate in the class discussion, and whether your participation indicates that you have spent time thinking about and preparing for class that week. Note that the ultimate goal of participation is helping one's classmates to understand something, not demonstrating (directly) to me that you understand. But if you accomplish the former, you will certainly accomplish the latter at the same time.

Grading:

The grading breakdown will be as follows:

Written problem solutions handed in before seminar	25%
Class preparedness/presentation/participation	10%
Larger observing projects (smaller data analysis exercises will be part of weekly problem assignments above)	20%
Midterm exam (tentatively the week of March 3–7)	15%
Oral final exam	30%

Late or missing assignments:

If you turn in your seminar problem solutions late (i.e. after 9:00 AM Thursday) but still before seminar, you will lose 20% of the points for that assignment. Work turned in after the beginning of seminar will receive a flat 50% credit (assuming it is reasonably well done) but I will not make any comments on it. Work that is more than a week late will receive no credit.

I will be firm and consistent about this policy. Late work, like everything else, has consequences, and since you know the consequences in advance you can act accordingly when trying to juggle a heavy workload. Note, however, that in the seminar format, not having your work completed by seminar time will affect not only your grade for that written work, but also your ability to participate in seminar.

However, if you become extremely ill, suffer a death in the family, or something of similar magnitude occurs, please let me know as soon as possible and we can work out appropriate arrangements for you to complete your work. The sooner you let me know of a problem, the greater the chance that we can work out a solution. In particular, you must do everything you can to inform me of any problem *before the assignment is due*.

Tentative schedule of topics:

Week 1 – Astrophysics review; very quick intro to CCD detectors

Week 2 – Astronomical statistics; intro to IRAF and starting to use the telescope to take data

Week 3 – Astronomical coordinate systems (finding things in the sky); time keeping in astronomy; some spherical trigonometry

Week 4 – Nomenclature of astronomical objects; on-line databases and research tools

Week 5 – CCD characteristics; measuring CCD properties in the lab

Week 6 – Basic ideas of photometry; differential photometry

Week 7 – Telescopes, imaging, optics

Week 8 – Adaptive optics and the Earth's atmosphere

Week 9 – *Midterm exam*

Week 10 – Absolute photometry; measuring magnitudes in particular photometric systems; correcting for atmospheric extinction

Week 11 – Spectroscopy part 1 – basic principles of spectrographs and gratings

Week 12 – Spectroscopy part 2 – spectrograph design, echelle spectrographs, spectroscopy data reduction

Week 13 – Infrared observations (characteristics of the atmosphere, telescope optimization, observing strategies, detector characteristics)

Week 14 – X-ray and gamma-ray telescopes and detectors; basic principles of Bayesian data analysis.