Astronomy 16 – Modern Astrophysics
Fall 2014
Prof. David Cohen

Class Announcement

Class and lab meeting times: We will meet from 9:55 to 11:10 AM on Tuesdays and Thursdays in the Physics and Astronomy seminar room (SC 113). We have lab meetings on Wednesday nights, generally from 8 PM to 11 PM. Lab meetings will often (especially if the weather is bad!) at least begin in SC 187 (which is near the stairs/elevator up to the Observatory, on the Chemistry side of the Science Center). The labs will involve taking, reducing, and analyzing data from the 24-inch telescope on the roof. But a lot of this work involves planning before the data are taken and work with the data after it's taken, and even the observing itself is quite automated, so we will only occasionally be up on the roof actually in the observatory dome with the telescope. Think of SC 187 as your lab room.

We will have four nighttime lab meetings throughout the semester. We'll have to remain a little flexible about the lab scheduling, since we'll be dependent on the weather for some of what we do. We may also have make-up class meetings or exams on Wednesday nights, so we will probably end up meeting on six Wednesday nights throughout the semester. Here is a tentative list of four of the six Wednesday nights that you should keep free for Astro 16 lab etc. meetings:

Sep. 10
Oct. 1
Oct. 22
Nov. 5

Note that it's possible we'll shift one or two of them, but I'll try to keep to this schedule, regardless of the weather. And we'll probably add two more Wednesday night sessions. I'll give you as much warning as possible, but please try not to schedule other activities during the Wednesday night 8 to 11 PM time period *any* week during the semester (except for Sep. 3, 17, Nov. 26, and Dec. 3 on which we will definitely *not* have lab or class meetings).

Class and preparation/work on your own, outside of class: We have a very good textbook, *Foundations of Astrophysics*, by Ryden and Peterson and we will use it to prepare for nearly every class meeting, but I will send out notes (sort of a study guide) at least once per week that will define which topics and concepts are important, and then we'll explore them in our class meetings. We will use the textbook to support your efforts to learn and solidify your understanding of the material, but we will also use in-class work – problem solving both alone and in groups, in-class discussions, and lectures and explanations from me. What we do in class, and what my weekly notes contain will define the material we will study. We will use the textbook to support this effort, but we won't let it dictate exactly which topics we cover.

Students will be expected to do the assigned reading prior to coming to class, but I will very often instruct you to pay different levels of attention to different material in the assigned reading. I will not be aiming to cover all the material in the reading in class, but rather to focus on the most important things, and also on those things that students are struggling with, to demonstrate applications of concepts, and to discuss how various concepts are related.

I will generally provide one reading assignment, along with some notes indicating which concepts and pieces of information in the

reading are the most important, each week, rather than for each individual class meeting. And each week I will include one or two problems that you probably won't be able to answer right away, but after you've learned that week's material, you likely will be able to answer. These questions will help you see why we're studying the particular material that week.

There will sometimes be brief assignments due the night before class. These are intended to help me understand what we need to discuss in class the next day. And also to help students understand which new concepts they need to think about more.

We will cover a lot of material, learn a lot of new things, and see how concepts we already know about relate to each other and can be connected to help us understand astrophysical systems. More than many of your science classes, Astro 16 will require you to take charge of your own learning. But I will be very active in providing help and guidance for you. The most important thing – apart from doing the assigned reading and preparation prior to coming to class – is that each student be willing to talk in class and ask questions.

Material we will cover: Astronomy, historically, is the study of the heavens (everything above the Earth's atmosphere). Astrophysics is a 20^{th} century term that emphasizes the application of physics to the study of astronomical objects. All scientific study of the heavens today involves physics (and math, of course) in one way or another. In fact, the development of modern science itself was catalyzed by astronomy, around 1600, with the observational innovations of Tycho Brahe (the most precise observations possible, without a telescope), the theoretical innovations of Kepler (mathematical modeling of quantitative trends in Tycho's data on the orbit of Mars; he actually demanded that theory explain observations to within the errors), the experimental innovations of Galileo (his

invention of experimental science and his startling telescopic discoveries), and, finally, the synthesis of Newton (universal physical laws and physical models of causation). We will, unfortunately, not be doing much history of astronomy, as such, in this class, but I'll try to give the historical context for some of the facts and concepts we're learning. Our reading during the first week of the semester does include a chapter on historical astronomy.

Astronomy, as practiced before the end of the 19th Century, was primarily positional astronomy and classification – what types of objects are visible in the sky? Where are they? How do they move? Occasionally predictive, quantitative explanations were developed during the 17th, 18th, and 19th centuries; especially for the 'how do they move?' question. Ole Roemer's use of Jupiter's moons to determine that light has a finite speed and to measure that speed (accurately to within 30%), and the prediction and discovery of Neptune are two examples of this. But modern astrophysics was really born in the mid- to late-19th Century with the application of spectroscopy to stellar astronomy and the subsequent theoretical investigations of stellar structure. The intertwining of physics and astronomy was cemented in the 1930s with the discovery of the source of energy production in the center of stars – nuclear fusion. At the same time, astronomers were beginning to get a picture of the structure of our own Galaxy, the gas and dust between the stars, and the universe as a whole. Soon after that, the invention of the radio telescope (an outgrowth of the development of radar during World War II) ushered in the era of non-optical astronomy – astronomy across the electromagnetic spectrum.

In our class this semester, we will focus on the application of quantitative physics to the understanding of astronomical phenomena. We will concentrate on stellar astrophysics, as it is the most mature subfield, with the most precise data (compared to, say, galaxies and distant cosmological objects) and with the most

secure physical understanding of the key phenomena. But we will also study some solar system astronomy, and the interstellar medium, galaxies, and – if our pace and time permit – some cosmology. Stars and the processes they drive play integral roles in these other subfields, too.

Although a branch and application of physics, astrophysics is different than most other sciences in that it is rarely experimental – rather it is observational. It is more phenomenological than most other branches of physics, but the rich phenomenology can often be explained by relatively simple physical principles. There are many connections to specific physics topics, including gravitation, atomic physics, thermal physics, and dynamics, among others.

We will sometimes cover physics topics that you have not yet learned in physics class, and we will generally apply them and work to understand their key principles and effects even though we do not rigorously derive them from first principles. We will do a lot of algebra and some calculus, but often make approximations and even order-of-magnitude estimates, with a goal of explaining the primary characteristics of the observed phenomena and their *basic physical causes*.

And we'll see the detective work required to learn anything at all about objects that are so remote from us. We'll see the beauty of the physical processes and objects in the universe; the incredible diversity of objects and phenomena that are produced by such a small number of physical principles and ingredients; the fact that nature is so complex and yet works so simply and automatically. One example of this is nucleosynthesis—the process by which new elements are made. The Universe, when it began, contained hydrogen and helium (and a tiny amount of lithium). All heavier elements, including the calcium in our bones, the carbon, oxygen, and nitrogen in our tissues, and the iron in our hemoglobin, were

made inside stars and then ejected back out into space, to be incorporated in a new generation of stars, planets, and, ultimately, us.

Now for the practical stuff

Class etiquette: I expect you to come to class prepared. It's great if you have questions and I encourage all students to ask questions in class. This can be done in an informal manner.

We have a lot of material to cover – let's make a strong effort to be ready to go right at 9:55 each day.

There is absolutely no cell phone use of any kind in class. Please do not even take your phones out in class. Keep them put away.

I feel very strongly that taking notes by hand is more useful than taking notes on a computer. This is especially true in classes like Astro 16 where your notes will contain a lot of equations and diagrams, but is more generally true: writing something by hand uses more of your brain than transcribing on a keyboard and you will think more about what you're writing and retain the information better if you write by hand. Consequently: no laptops or tablets in class.

Contact: My office is SC 125 and I will hold regular office hours there. I will announce the days and times during the first week of classes. Check the website. But I'm usually in my office (or my lab across the hall) and if I'm not too busy, will be glad to talk with you most any time. Don't hesitate to send me email at any time.

The class webpage (astro.swarthmore.edu/astro16) is a primary means for communication as well. All assignments, announcement, solutions, etc. will be posted there. (After a week, they are moved to the "old announcements" and "old assignments" sections, linked from the main page.) There are also links to useful information on the right side of the page.

You should check the website regularly; certainly at least once every weekday. When in doubt about something – ask.

As I will sometimes ask you to answer a short question or two the night before class, you must check your email and the class website sometime after 8:00 PM on Mondays and Wednesdays.

Labs: We will be using the telescope – the Peter van de Kamp Observatory – on the roof of the Science Center, for our labs. But as noted above, we will often be doing work in SC 187 during our lab meetings, which will take place on four different Wednesdays throughout the semester, from 8:00 PM to 11:00 PM.

You will have some work to do ahead of time to prepare for some of the labs. Several of the labs will be related to each other, in that techniques and procedures learned in one lab will be used in subsequent labs. For most labs, you will do a write up, which you will hand in for a grade.

Textbook: We will be using Ryden and Peterson's *Foundations of Astrophysics* as our primary text. It is a quite dense book, with lots of information and background, and a nice voice, I think. The book has a good sense of humor and proportion. There are copies on reserve at Cornell Library (you have to ask for it at the front desk).

Let me know if you'd like to know more about a particular subject, and I'll recommend some supplementary resources.

This may seem weird coming from a professor, but I want to urge you to use *Wikipedia* when you want to find out some facts about an object or class of objects, a physical phenomenon, or remind yourself about a particular math concept. Also useful is the *Astronomy Picture of the Day* website (and its search capability and copious links). There are also useful reference books, like the

Encyclopedia of Astronomy and Astrophysics, in the reference section of Cornell.

Grades, exams, etc.: We will have two midterms (the first one will be early in the semester, probably on Thursday, September 18, in class. The second one will be in late October or early November and we'll have a final exam as well.

You'll notice below that homework counts for a significant portion of your final grade. There's really no excuse for not racking up the points on your homework assignments. I'm always happy to help and you should feel free to ask the astro majors in the junior and senior class for help. I strongly encourage you to work with each other on homework assignments, but, of course, the *work you hand in must be your own*. And it should be *neat* and *clear* and you should *always label variables with units*.

Labs, exams, and other out-of-class activities which are missed without prior permission will not be made up. You will get a zero if this happens. If you've got a conflict, scheduling problem, family emergency, etc., get in touch with me ahead of time and we'll make an arrangement.

I will not give extensions for homework. If homework is handed in after the specified time it will count as late.

I will accept late homework assignments, no questions asked and no excuses given, within two days of the due date, but you will be docked 20% of the total number of points for that assignment. Anything later than two days will also be accepted, but it will only be checked for completeness and given a flat 50%.

One time per semester I will accept a homework assignment that's late but not count it as late as long as it's in the mailbox when I arrive in the department the next morning.

We will have short homework assignments nearly every week. Note that we will from time-to-time have short pre-class assignments (usually given out the night before class). When these are assigned, we will always discuss them the next day in class. These will count toward your grade but only in terms of participation – you'll get credit for doing a reasonable job of preparing them, but they won't be graded.

Your **final grade** will be based on the following breakdown:

Homework/problem sets 35%
Midterms 25%
Labs and class participation15%
Final 25%

Note how much the homework counts for. And note that I'm happy to help you with your homework during office hours.

I reserve the right to make small modifications to the grade component breakdown based, for example, on the number of labs we actually end up writing up or problem sets we end up having. I will certainly let you know ahead of time if there are changes.

Accommodation: If you believe that you need accommodations for a disability, please contact Leslie Hempling in the Office of Student Disability Services (Parrish 113) or email lhempli1@swarthmore.edu to arrange an appointment to discuss your needs. As appropriate, she will issue students with documented disabilities a formal Accommodations Letter. Since accommodations require early planning and are not retroactive,

please contact her as soon as possible. For details about the accommodations process, visit the Student Disability Service Website at http://www.swarthmore.edu/academic-advising-support/welcome-to-student-disability-service.

You are also welcome to contact me privately to discuss your academic needs. However, all disability-related accommodations must be arranged through Leslie Hempling in the Office of Student Disability Services.