Astronomy 406: Stellar Structure and Evolution

Professor:
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Class web page: http://www.astro.umd.edu/∼miller/teaching/astr406

Schedule:
Lectures on Tuesdays and Thursdays from 2:00 to 3:15, ATL 1114. Office hours by appointment.

Textbook:
Stellar Interiors - Physical Principles, Structure, and Evolution 2nd Edition, by Hansen, Kawaler, and Trimble. We will also use my online notes on the website.

Other references:
An oldie but goodie is "The Physical Universe", by Frank Shu (Part I for the basic physics and Part II for stars). Also, let's not forget that the Web is vast! Wikipedia, for example, has a lot of good descriptions of concepts, and stackexchange often has useful discussions.

Course Grading
I will grade each problem (in the homework and in the exams) on a four-point scale. One point is awarded if you demonstrate understanding of the physical issues associated with the problem. One point is awarded if you use the correct equations (assuming equations are needed). Two points are awarded for correct solution of the equations.

If you come up with an answer that is obviously incorrect (e.g., a velocity 1000 times the speed of light!), but correctly say why it is incorrect and approximately what the right answer is, you will get one of those possible two points. On the other hand, if you get an obviously incorrect answer and say nothing about it, I'll take more points off; I want you to think about your answers. You have to commit one way or another: saying "I might be wrong" gets you nothing and could lead to subtraction of points if you were actually correct.

The midterm and final will both be in-class, and both will be closed-book and closed-notes.

Homework sets will be available on the class webpage, at least two weeks before the due date. Due dates will be Thursdays, typically two weeks apart (except for the week of the midterm and of spring break). Homework will be due right at the beginning of class, because I want it to be possible for you absorb the content of that lecture instead of worrying about the problems! I will therefore enforce this policy strictly, and will take off points for, e.g., homework turned in at the end of class. I will do my best to return graded homeworks to you, with a solution set, by the next Tuesday. **Note:** if you are observing Passover, I will allow you to turn in the fourth homework by noon on Monday, April 10.

Starting with the second homework, there will be a computational problem per homework. You may use any language you want, and you will send me your code and any instructions needed to compile and run your code (for example, if you use Python you'll need to specify whether you use Python 2 or Python 3). I'm not going to install anything, so your code has to compile and run as

Table 1. Grade weights

Homework	30%
Midterm Exam	25%
Final Exam	30%
Individual Project	10%
Class Participation	5%

is on the astro machines. If you send me your code enough in advance of the beginning of the class, I can give it a try to see whether it works (although I won't tell you whether you have the right answer).

The individual project will be a report on one current topic related to the course material. This will typically be represented by a single short paper in the literature, but it can be more extensive if you want. I'll want you to have selected the topic you'll discuss by the beginning of April, so that we can talk about it and make sure it's a good project. The report will be both a written report (4-5 pages in double-spaced 12pt format) and an oral report, which will be given in class at the end of the semester. For this project you will be graded on both content and presentation in the oral and written reports.

The "class participation" portion involves two components. For the first, I will require that you read the lecture notes for a given class before the class, and by midnight of the day before you need to send me (1) a topic from that lecture that you feel you understand, and (2) a topic from that lecture that you would like elaborated. For the topic you want elaborated, you need to tell me how much you understood and the precise point where the confusion set in; saying that you understood nothing is not acceptable :). This will allow me to customize the lectures to some degree. The second component of class participation involves both your questions to me and answers to my questions during class; I don't expect you to get the "right" answer every time (and indeed in many cases the question I pose will be open) but I do want you to try. As part of this, I will also typically have a group discussion during each class, in which I will ask you to form groups of $3-4$ to discuss a question that I will pose. When you finish your discussions, I will ask you to report on your findings.

Letter Grades

I will guarantee that you will receive no worse than the following letter grades for a given percentage of the total available points: A– for 85% to 100% of the points; B– for 70% to 84% of the points; C– for 55% to 69% of the points, and D– for 40% to 54% of the points. I may grade on a curve if the class average is significantly lower than suggested by the table. There will be no extra credit.

Late Policy and Make-Up Policy

Partial credit for late homework assignments may be given if you give me a valid reason before the assignment is due. No credit will be given for homework turned in after the beginning of the class after the homework is due (i.e., after the beginning of class the Tuesday after a homework Thursday), because I will hand out solution sets then. If you cannot make the midterm or the final exam, then

we can arrange a different time if you tell me at least a week before the exam (to be fair to other students, the alternate time should be before the scheduled time). For adjustments to homework turn-in times please document your reason as much as you can; for the "major grading events" (i.e., exams) university policy dictates that you must document your valid reason.

Academic Integrity

You know the drill by this time in your college careers. If you have any questions, please talk with me and/or look at the University page http://www.studentconduct.umd.edu/

Some general guidelines;

1. I encourage you to work together, but you need to write things up separately. Copied materials, from each other, from previous students, from websites, etc., are a violation of our honor code. If for some reason you feel that it is essential to quote a particular source (this might come up in your term project), put quotes around the quoted part and cite the source there. For example: "If you don't make mistakes, you're not working on hard enough problems. And that's a mistake." (Frank Wilczek) My general advice is to do as much as you can yourself before talking with others or looking up references; that maximizes your learning and won't give you a reputation with others as a freeloader :)
2. If you work in group chats, feel free to discuss general approaches, but do not post detailed solutions or numerical answers to problems.
3. No bullying, please! College is tough enough as it is. You'll all do better if you cooperate constructively. Now, that doesn't have to mean that you agree with each other all the time; a major part of the cooperative aspect of science is the push and pull of robust discussion to get to better answers. But this can be done in a fun and civil way.

How to Succeed in this Class

I know that you have a lot of demands on your time. Suppose, though, that you decide to spend that time to maximize what you can learn in this class and to do as well as you can. My recommendations would then be as follows:

1. Consolidate your knowledge as soon as you can. I recommend that, as soon as possible after a given class, you read through your notes. What are the parts you understood? What are the parts you did not understand? This will help reinforce the key concepts. This will be especially effective if you do this with friends in the class. In particular, if you can have study sessions with others in the class, try to explain the concepts to them. Often this will point out aspects of the concepts that are not as clear as you might like.
2. Do at least one exercise related to each topic, beyond what is in the class problem sets. There are many sources; our textbook, for one, but just Googling "exercises in stellar structure and evolution" will get you many problems to solve. Many times we *think* we understand something, but upon doing a problem we will realize that there are aspects that we didn't quite get.
3. Have fun! Often lost in the grind and confusions of a course such as ours is the amazement at how we can learn so much about such distant things as stars. If you feel that you are bogging down in details, step back a bit: what a privilege it is to be able to study the universe!

Tentative Course Outline

Jan 26 First day of class (Thursday); reasoning, creativity, the Sun
Jan 31 The virial theorem
Feb 2 Equations of stellar structure
Feb 7 Stellar energy sources; gravitation
Feb 9 HW 1 due; basics of thermonuclear fusion
Feb 14 Specific fusion reactions
Feb 16 Equations of state 1: introduction
Feb 21 Equations of state 2: degeneracy and interactions
Feb 23 HW 2 due; equations of state 3: interactions and high density
Feb 28 Polytropes and opacities
Mar 2 Radiative opacities
Mar 7 Other radiative opacities and conduction
Mar 9 HW 3 due; high densities and strong magnetic fields
Mar 14 Midterm
Mar 16 Convection
March 19-26 Spring break
Mar 28 Star formation
Mar 30 Lifetimes and timescales
Apr 4 From collapse to the main sequence
Apr 6 HW 4 due; the Hayashi track
Apr 11 Evolution of intermediate-mass stars
Apr 13 General relativity
Apr 18 Black holes
Apr 20 HW 5 due; Evolution of binary stars
Apr 25 Stellar modeling
Apr 27 The Sun
May 2 Neutrinos
May 4 HW 6 due; Class review
May 9 Presentations 1
May 11 Presentations 2 Last day of our class (Thursday).
May 17 Final exam (Wednesday, 10:30 AM - 12:30 PM)