Astronomy 1120: Stars, Stellar Structure, and Stellar Evolution

Course Syllabus

Tu & Th, 11:00-12:15 in 106 Allen Hall

Course Instructor

Professor Andrew Zentner is the instructor for the course. I am a member of the Department of Physics and Astronomy at the University of Pittsburgh. The most effective way to reach me outside of class is through email. My email address is `zentner@pitt.edu`. My office is 401D on the fourth floor of Allen Hall. My campus phone number is 412-624-2752.

Please do not hesitate to contact me with any questions or concerns about this course. I want to work with my students to make this course interesting and fun and allow my students to learn a lot. All too often, students wait until the end of the semester to express concerns, but by that time I cannot change anything. There is **no** question too insignificant and there is no need to wait until it is too late to express a concern. Of course, I have to abide by University and Department rules and I have to work within the Physics & Astronomy curriculum, so I cannot accommodate all requests, but my intention is to make this course as fun and productive as possible.

Office Hours

I will hold regular office hours from 2:00 to 4:00 PM on Mondays and from 1:00 to 2:30 PM on Tuesdays. If you cannot make either of these times, please contact me and we can arrange to meet at another time.

I am happy to use office hours to help in any way I can, including with the preparation of homework sets. If you come to office hours for help with an assignment, please be prepared to demonstrate that you have put some effort into the problem(s). In particular, be prepared to describe your thought process and the point at which you are stuck. Not all problems may be simple, and most will require significant thought. I **will not** help with homework problems if you cannot first describe to me how you tried to solve the problem, and why or how you know that your strategy was incorrect.

If you need further help or would prefer to seek help from a tutor, the University of Pittsburgh Department of Physics and Astronomy maintains a Physics Resource Room in

312 Thaw Hall that is staffed by tutors between 9AM and 5PM on weekdays throughout the semester.

Course Description

This course will consist of a treatment of the observed properties of stars, the structure of stars and the evolutionary phases of stars at the advanced undergraduate level and is intended primarily for those students majoring in Physics and Astronomy. Therefore, this course will be based on a lot of problem solving and you will be graded on your logical and algebraic steps as well as your understanding of the factual content of the lecture materials. I will assume familiarity with calculus, differential equations, basic linear algebra, and introductory physics including a basic knowledge of the ideas of quantum mechanics and thermal physics. I will review as much as possible; however, I will generally use basic mathematics and physics freely and without any apologies. If you feel weak in any of these areas, you should consider coming to see me and reviewing these subjects on your own.

In this course, I intend to cover the basic physics that describe stars and their structures. I intend to cover basic observational properties of stars and the Hertzsprung-Russell diagram, the basic properties of matter and the transfer of heat within stars, nuclear burning within stars, the structure of stars, the atmospheres of stars, and stellar evolution. I intend to discuss the extreme endpoints of stellar evolution, including white dwarfs, neutron stars, and black holes. Time permitting, I will discuss helioseismology as a way to study the Sun in detail. There are two goals of this course. The first is to develop a detailed understanding of the workings of stars. The second is to cultivate the skills of (1) solving problems in an efficient manner and (2) synthesizing a variety of physical and mathematical concepts toward a new application.

Course Grades, Exams, and Rules

Most of the graded work in this course will be based on long-form problems. There will be approximately ten homework sets due throughout the course of the semester as well as a mid-term exam and a final exam. All of these will be used to determine your final grade in the course. Each exam will account for **one quarter** of your final grade, for a total of **one half** of your final grade determined by the two exams. The other **half of your grade** will be based on your performance on the homework sets. Notice that there are only two exams. Homeworks will be a **very significant** part of your grade. The reason for this, in turn, is to focus on problem solving in an environment more like that which practicing scientists are familiar with, rather than regurgitation during timed exams. As a consequence, the homeworks will be challenging. One benefit of this approach is that it will be difficult to do very poorly in this class if you do a good job on the homework

assignments.

Both exams will be open book exams. The midterm exam will take place in class on Thursday, October 22, 2009. Notice that October 30 will be the last day to submit for monitored withdrawal from the class and I will be sure to have your grades well before this date. Arrangements for make-up exams must be made well in advance of the exam. Acceptable excuses for missing an exam include being out of town for a verified university-related activity and illness. If you miss an exam due to illness, be prepared to provide a signed letter from your doctor or from the university health service.

In both homeworks and exams, the focus will be on having the correct reasoning. **No credit** will be given for a correct answer without the reasoning being clearly explained. A great deal of the credit for a problem may be given if the reasoning is correct, but the detailed answer is incorrect for one reason or another. For all problems please give a detailed statement of the problem and give a detailed explanation of your reasoning in order to get full credit for the problem. Occasionally, you may find your answer to be obviously incorrect. For example, say you derived the distance to the Sun to be three miles. In such a situation, you can still get partial credit for the problem simply by recognizing that the answer obviously does not make sense *and* explaining why the answer is manifestly incorrect. **No credit** will be given for a numerical answer if it does not have the appropriate units.

SOME SPECIFIC EXAM & HOMEWORK RULES

- You **may** bring books, calculators, and notes to exams but you may not share these materials with other students during the exam.
- I will post new homework assignments on the CourseWeb and I will not hand them out in class. It is your responsibility to check the site and obtain these materials.
- You may discuss homework problems with other students in the course, but you must hand in a unique solution that is your own.
- Late homeworks will be accepted with a 50% penalty for the point value of the homework up until the time that I post the solutions on the CourseWeb site for the course. No homework will be accepted after this time unless by prior arrangement and no make-up assignments are possible unless by prior arrangement. I may post the solutions any time after the due date without warning.
- Problem solving skills are of utmost importance and you must show all of your work, including all logical and algebraic steps used in deriving your answers in order to earn full credit.

- You **may not** refer to algebraic steps performed by a calculator or by a computer software package (Mathematica, Maple, etc.) for derivations. You must perform and show each step yourself.
- If a numerical answer is required, you may use a calculator to obtain the relevant number, but you must still show all of the logical and algebraic steps you took to arrive at the answer and the answer must have the correct units in order to receive credit.
- Throughout the course, I will give problems where you may need to know a piece of information (for example, the radius of the Sun) that it is not included in the problem statement. I will assume you can look this up in some reputable source (such as our textbook, or a reputable web site), but please indicate your source if you are at all suspicious of your number.

Course Topics in Detail

Here is a rough outline of what will be covered in the course. This plan may be modified according to student interests and questions that may arise during the course and the pace at which we proceed. The pace I have chosen in this outline is ambitious, but I will allow for modifications if the need arises.

- Week 1: Basic Astronomy, Observations of Stars, the Laws of Radiation, and the Hertzsprung-Russell Diagram
- Week 2: A Basic Overview of Stars and Star Clusters
- Week 3: Basic Thermal Physics
- Week 4: The Properties of Matter and Radiation
- Week 5: The Transfer of Heat in Stars
- Week 6: Basic Quantum Mechanics and Nuclear Processes
- Week 7: Thermonuclear Fusion in Stars
- Week 8: Thermonuclear Fusion and **First Exam, Thursday, October 22**.
- Week 9: Stellar Structure and Stellar Masses
- Week 10: Astronomical Observations in More Detail
- Week 11: Stellar Atmospheres

- Week 12: Endpoints of Stellar Evolution: White Dwarfs and Neutron Stars
- Week 13: Endpoints of Stellar Evolution: Black Holes, & Helioseismology
- Week 14: Helioseismology, Course Summary, and Final Exam Review
- FINALS WEEK: **FINAL EXAM**

I intend to hold review sessions before each exam at a time to be determined.

Textbook

The textbook for this course will be the second edition of "The Physics of Stars" by A. C. Phillips. This is published by J. Wiley and Sons, Ltd., copyright 1999. This book should be available in paperback at a relatively reasonable cost (I've seen it used for as little as $28 recently). This book is relatively clear, concise and self-contained, so it is manageable in a one-semester course. Many of your homework problems will be taken from this book, but many others will be of my own design.

For you convenience, I will try to stick to the textbook as closely as possible. However, Stellar Physics is a large subject that calls upon many areas of physics. As such, I will have to augment my lectures with material that is not contained within the primary text for this course. Particular examples of this include astronomical observations and stellar atmospheres. The following books may prove useful and I have placed them all on reserve for this course in the Engineering library.

- "Astrophysics in a Nutshell" by D. Maoz
- "An Introduction to Modern Astrophysics" by Carroll and Ostlie
- "Basic Concepts in Relativity and Early Quantum Theory" by Resnick and Halliday
- "Principles of Stellar Evolution and Nucleosynthesis" by D. Clayton
- "An Introduction to the Theory of Stellar Structure and Evolution" by D. Prialnik
- "Introduction to Stellar Astrophysics" by E. Bohm-Vitense
- "Stellar Structure and Evolution" by Kippenhahn and Weigert
- "Thermal Physics" by Kittel and Kroemer
- "Introduction to Quantum Mechanics" by Griffiths

- "Black Holes, White Dwarfs, and Neutron Stars: The Physics of Compact Objects" by Shapiro and Teukolsky

The vast majority of my notes will be hand-written on the board in a traditional lecture style. At times, I will use slides and other electronic media to facilitate lectures and I will make all of these materials available on the CourseWeb Blackboard web site for this course at `http://courseweb.pitt.edu`. Please let me know if you have any problems retrieving this material and I will do my best to rectify the problem.

The Department of Physics and Astronomy

As students at the University of Pittsburgh, you have access to a Physics and Astronomy Department that is highly recognized and is performing world-class research. The Department of Physics and Astronomy wants you to feel welcome. If you are interested in further study of physics or astronomy please talk to your instructor or another faculty member. If you think you may be interested in getting involved in a career in Physics or Astronomy or in research in Physics or Astronomy, please feel free to contact the instructor or other faculty members. You may be interested in the research pages for Dr. Zentner's group at `http://mookie.phyast.pitt.edu/cosmowiki`.

You may make use of the undergraduate lounge off of the mail room on the second floor of the Old Engineering Hall. This is a good place to meet with classmates to discuss problem sets and course material. You might also meet physics majors here that can help you, discuss other classes with you, or inform you about the major program. The Department also hosts a doughnut and coffee hour every Wednesday at 4PM in Allen Hall which is designed to encourage discussion. Please feel welcome. The University of Pittsburgh's Astronomy research group hosts seminars on topics of current interest in astronomy and astrophysics each Friday at Noon. The talks are typically at an advanced level, but eager students can learn a great deal about contemporary astronomy and astrophysics by attending.

Students with Disabilities

If you have a disability, please speak to the as early in the semester as possible. We will make any necessary arrangements to support a successful learning experience, and provide documentation through your disabilities coordinator.