ASTRON 0113/0413: Introduction to Astronomy

Term: 2181 (Fall 2017)
Credits: 3
Prerequisites: MATH 0020 or any MATH greater than or equal to MATH 0031 (Min Grade: C) or MATH PLACEMENT SCORE (61 or greater)
Meeting Time: Tuesdays and Thursdays, 01:00-02:15 PM, 104 Thaw Hall

Honors section (ASTRON 0413): 4 credits, same meeting times (Tuesday/Thursday 01:00-02:15PM), plus 12:00-12:50 PM on Tuesdays, 210 Thaw Hall.
Prerequisites for honors section: MATH 0230 or 0235, and PHYS 0110 or 0174 or 0475.

Instructor: Prof. Rachel Bezanson

`rachel.bezanson@pitt.edu` (email is the best way to get in touch with me!)
Office: 308 Allen Hall
Phone: 412-624-9013

Background I just joined the Department of Physics and Astronomy at the University of Pittsburgh. I am an observational astronomer and my research focuses on the formation and evolution of galaxies through cosmic time.

Goals My main goal is to work with students to make this course engaging, interesting, and fun. Do not hesitate to contact me with **any** questions or concerns, either by email or by coming to office hours. I need your feedback in order to improve your learning experience! Please let me know if you have issues with the course material, or you would like me to cover some topic that you are particularly interested in. Of course, I have to abide by University and Department rules and I have to work within the Physics and Astronomy curriculum, so I cannot accommodate all requests, but I will do my best. I am looking forward to a great semester!

Logistics I will hold regular office hours on Mondays between 1:30 and 2:30 PM and Thursdays between 3:30 and 4:30 PM in 308 Allen Hall. If you cannot make these times, please contact me and we can arrange to meet at another time. If you need further help or would prefer to seek help from a tutor, the Department of Physics and Astronomy maintains a Physics Resource Room in 312 Thaw Hall that is staffed by tutors between 9 AM and 5 PM on weekdays throughout the semester. Please take advantage of this service.

Course Description:

This course is an introduction to astronomy and astrophysics at the beginning undergraduate level, intended for students that are majoring in science or engineering. Broad familiarity with basic physical concepts such as force, energy, momentum, and temperature will be assumed, as well as college level mathematics. Algebra, geometry, and trigonometry will be used extensively throughout the course and will be needed to complete the homework sets and exams. Familiarity with calculus will be very helpful, but it is *not* required and will *not* be needed to complete any assignments or exams in this course outside of the honors section.

This is a self-contained course focusing on astronomical objects that lie beyond the solar system and the nature of the Universe as a whole. The main topics are the properties and life-cycle of stars including their birth, death and the formation of remnants such as black holes and neutron stars, the nature and evolution of galaxies, including exotic objects such as quasars, and the origin and ultimate fate of the Universe (cosmology).

Important note: If you are uncomfortable applying algebra and geometry, or you are not interested in studying astrophysical systems in detail, you may want to consider taking ASTRON 0087, 0088, or 0089, which are not designed for science majors and do not assume mathematical proficiency. Please contact me if you have any questions about your level of preparation.

Course Objectives:

This course has two primary objectives:

- To provide a basic knowledge of the Universe outside the Solar System, sufficient to prepare students for more advanced astronomy courses.
- To help students gain skills in solving scientific problems, including the use of approximation techniques and other methods of obtaining rough solutions.

Modern astronomy has become a vast field of study encompassing atomic and molecular physics, planetary science, the study of galactic structure, and much more. It would be impossible even to survey the subjects that most practicing astronomers would consider "basic knowledge" in a single semester. Therefore, some choices have to be made. This semester, ASTRON 0113 will cover the following areas: (1) basic problem solving using approximation techniques; (2) the law of gravity, the process that lead to our contemporary understanding of gravity, and its application to physical problems; (3) the fundamental properties of light, and their importance in astronomy (4) basic stellar physics and stellar classification; (5) the structure of galaxies; and (6) the evolution of our entire Universe (cosmology). The solar system is probably the astronomical system most familiar to beginning students and I will address the solar system only briefly in the first part of the course. This is a course designed for students who plan to continue in the sciences, and the emphasis will be on scientific thinking and problem solving. If there is a particular subject related to astronomical science that you find interesting, please let me know and I will try to cover it as part of the course if there is sufficient interest. In the past, students have requested lectures on black holes, supernovae, planets around stars other than the Sun, searches for extraterrestrial intelligence, space flight, and other subjects. My intention is to make this course as fun and productive as possible.

At the end of the course, you should be able to explain, among other things:

- How we can measure the properties of distant stars and galaxies using observations from the Earth and space.
- Why the Sun shines, and why it will not do so forever.
- How most chemical elements are synthesized in stellar cores through nuclear fusion.
- How the Sun and other stars form and die.
- How the Milky Way Galaxy we live in is similar to (or different from) other galaxies.
- Why we believe many galaxies have black holes at their center.
- What the main constituents of the Universe are, how it began, and what its ultimate fate will be.

Textbook:

This course is more detailed than the standard introductory surveys of astronomy for non-science majors such as ASTRON 0087, 0088, or 0089, yet not so advanced that sophisticated mathematical tools (such as calculus) can be brought to bear on astronomical problems. Unfortunately, there is no textbook available that is particularly appropriate for this level. *21st Century Astronomy* by Kay, Palen, and Blumenthal (the Stars and Galaxies edition is sufficient) is a very good introductory book that makes only limited use of mathematics and has many excellent illustrations, but we will cover some topics in more detail than is given in this book. *Astrophysics in a Nutshell* by Maoz is a book that I like a lot. It provides an excellent introduction to most of the topics we will cover in this course including Light, Stellar Physics, Galaxies, and Cosmology. However, this book makes heavy use of calculus and therefore is a bit too advanced for ASTRON 0113. Other good textbooks are *Universe* by Freedman and Kaufmann (some math) and *Astronomy and Astrophysics* by Zeilik and Gregory (more math, including calculus). Homework problems will not be taken from any specific textbook and no specific textbook will be necessary to complete this course. I will make some effort to follow the sequence of subjects discussed in *21st Century Astronomy*, but I recommend *Astrophysics in a Nutshell* for the more mathematically-inclined students.

As there is no textbook for the course, attendance in class and taking good notes during lectures will be of critical importance. It will be a good idea to arrange with others in the class to share notes should you miss all or part of any class for some reason. I will not answer questions in office hours about lecture materials if you miss a lecture without an acceptable excuse or if you have made no effort to obtain the lecture materials through other means first. In order to compensate for the fact that we will not follow any specific textbook closely, I will post slides from all the lectures on the CourseWeb web site (`http://courseweb.pitt.edu`). Please check it often for updates, and let me know if you have any problems downloading the files.

Grading Policy:

There will be approximately ten homework sets due throughout the course of the semester as well as a mid-term exam that will be given during class on **Thursday, October 12** and a final exam that will take place during finals week on **Monday, December 11, at 2 PM**. Homework assignments and exams will be used to determine your final grade in the course. Each exam will account for one quarter of your grade, for a total of 50% of your final grade determined by the two exams. The other 50% of your grade will be based on your performance on the homework sets. The reason for this emphasis on homework sets is to hone your problem solving skills in an environment that mimics what practicing scientists do, where you have ample time and resources to accomplish a given task. If you want to get a high grade in this course, I advise you to set aside enough time to work on the homework assignments - you will need it. 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.

Exams will be open book exams – any class notes/textbooks/calculators will be allowed, computers, phones, and other internet-connected devices will be strictly prohibited. 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 or illness. If you miss an exam for any reason, be prepared to provide a signed letter from your doctor, from the university health service, or from your coach or person responsible for the University-related activity.

In both homework assignments and exams, the focus will be on showing 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 numerical answer is incorrect for one reason or another. To get full credit for a problem, you must give a detailed statement of the problem and a brief but complete explanation of your reasoning. Occasionally, you may find an answer that is 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 an answer that has incorrect units unless you comment on the fact that your answer is wrong and take a guess where you may have gone wrong. For example, if you expect an answer that should have units of length (inches, meters, miles, etc.) but give an answer of 25 seconds you will get no credit unless you comment on this. Finally, your work must be legible. You are not saving the environment by cramming all of your work onto one sheet of paper. **NO CREDIT** will be given for work that either the course grader or Dr. Bezanson find illegible. **NO CREDIT** will be given if either Dr. Bezanson or the course grader find it difficult to follow the sequence of steps. Your work must flow sequentially from left to right across the page and from the top to the bottom of the page. It is your responsibility, and yours alone, to make sure that your work is legible and orderly. You may discuss problems with others on your homework sets, but the solutions you hand in must be your original work. Homework must be turned in *at the beginning of class* (first 5 minutes) on the day that they are due. Late homework will be accepted for 1/2 credit. I will post all solutions to homework sets, usually within a couple of days after the due date and without prior warning. Once I have posted a homework set solution on CourseWeb, no credit may be obtained for handing in the homework.

The grader for this class is Nathan Herring. His email is `nmh48@pitt.edu`. He will be grading most of the homework.

Course Topics in Detail:

Here is a rough outline of what will be covered in ASTRON 0113. This plan may be modified according to student interests, to accommodate questions that may arise during the course, and to adapt to the pace at which we proceed.

Week 1: Aug 29, 31	Introductory Material; Astronomy as a Science; Order of Magnitude
Week 2: Sept 5, 7	Force, Motion and The Law of Gravity; Energy and Gravitation
Week 3: Sept 12, 14	Conservation Laws and Orbits; Light as an Electromagnetic Wave *Add/drop period ends September 8*
Week 4: Sept 19, 21	Temperature and Radiation; Telescopes
Week 5: Sept 26, 28	The Sun, Introduction to Nuclear Physics; Stars
Week 6: Oct 3, 5	Hertzsprung-Russell Diagram; Introduction to Stellar Evolution
Week 7: Oct 12	(no class on Tuesday), **Midterm Exam, Thursday, Oct 12**
Week 8: Oct 17, 19	Stellar Life Cycles: Birth and Death
Week 9: Oct 24, 26	Supernova Explosions; Neutron Stars, Black Holes, and Relativity
Week 10: Oct 31, Nov 2	Introduction to Galaxies; The Milky Way
Week 11: Nov 7, 9	Dark Matter; Galaxy Formation and Evolution
Week 12: Nov 14, 16	Supermassive Black Holes; Galaxy Classification
Week 13: Nov 23	Cosmology: The Expanding Universe, Evolving Galaxies
Week 14: Nov 28, 30	Cosmology, The Big Bang; Large-Scale Structure of the Universe
Week 15: Dec 5, 7	The Final Fate of the Universe
Finals Week	**Final Exam: Monday, December 11, 2 PM**

CourseWeb:

The University of Pittsburgh provides a web based resource called Courseweb, which is a portal to web sites for individual courses. A Courseweb site for this course has been created and there you can view announcements, send email to the instructor or the TAs, and download course material such as the syllabus and lecture slides. Reading and homework assignments will all be announced on Courseweb. To access Courseweb go to `http://courseweb.pitt.edu`. Use your Pitt email username and password to login to Courseweb. If you have forgotten your username and password or need to set up an account, contact the help desk at 412-624-4357, or 4-HELP. Once you have logged into the system simply click on the link for this course to access the available material.

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 or research in physics or astronomy please talk to me or any other faculty member.

The Department of Physics and Astronomy provides free assistance for all students. The **Physics Exploration Center** allows students to operate some simple experiments and demonstrations. Within the Exploration Center is the **Physics Help Room**, staffed with TAs who can answer homework related questions, explain basic concepts and help you with the math. This is a free service and you are encouraged to use it. The Physics Exploration Center and the Physics Help Room are both located in Thaw 312, and a detailed schedule is posted here: `http://www.physicsandastronomy.pitt.edu/resource_room`. In addition, tutoring is available through the Academic Support Center (WPU 311). You may also 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 and astronomy majors here that can help you, discuss other classes with you, or inform you about the major program. The Department hosts a doughnut and coffee hour every Wednesday at 4PM, which is designed to encourage discussion. The Astrophysics group within the Department hosts seminars on topics of current interest in astronomy and astrophysics every other 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. You can find the talk schedule in the Department web site: http://www.physicsandastronomy.pitt.edu. We also hold bi-weekly coffee discussions on several astronomy-related topics that are regularly attended by faculty, graduate students, and undergraduate students who are completing guided research projects in the astronomy group. Please ask me to provide you with updated information about these events if you want to attend.

Academic Integrity:

The integrity of the academic process requires fair and impartial evaluation on the part of faculty and honest academic conduct on the part of students. To this end, students are expected to conduct themselves at a high level of responsibility in the fulfillment of the course of their study. It is the corresponding responsibility of faculty to make clear to students those standards by which students will be evaluated and the resources permissible for use by students during the course of their study and evaluation. The educational process is perceived as a joint faculty-student enterprise which will perforce involve professional judgment by faculty and may involve - without penalty - reasoned exception by students to the data or views offered by faculty.

Cheating/plagiarism will not be tolerated. Students suspected of violating the University of Pittsburgh Policy on Academic Integrity, from the February 1974 Senate Committee on Tenure and Academic Freedom reported to the Senate Council, will be required to participate in the outlined procedural process as initiated by the instructor. A minimum sanction of a zero score for the quiz or exam will be imposed. For details, refer to the University Guidelines on Academic Integrity (https://provost.pitt.edu/sites/default/files/academic_integrity_guidelines.pdf).

Diversity and Inclusion:

I consider this class to be a place where you will be treated with respect, and I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability - and other visible and non-visible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class.

Disabilities:

If you require special accommodations or classroom modifications, please notify both your instructor and Disability Resources and Services by the end of the first week of the term. The office of Disability Resources and services is located in 140 William Pitt Union, (412) 648-7890, drsrecep@pitt.edu, (412-228-5347 [voice or TDD]), and their website is at http://www.drs.pitt.edu. If you have a physical, learning, or emotional disability, please let me know as early as you can so that appropriate accommodations can be made.