ASTRON 0088: Stonehenge to Hubble
Course Syllabus

Revised February 11, 2020

Basic Course Information

Term: Spring 2020 (2204)
Units: 3
Prerequisites: Basic mathematics. Any MATH Course or MATH PLACEMENT SCORE (61 or Greater) or SAT HIMAT SCORE (620 or Greater) or ACT HIMAT SCORE (27 or Greater)
Meeting Time: Mondays, Wednesdays and Fridays 11:00 to 11:50 AM, Alumni Hall room 343

Instructor: Prof. Carles Badenes

Office: 309 Allen Hall (3rd floor)
Office Hours: Mondays 1:30-2:30 PM, Thursdays 3:30-4:30 PM (or by appointment)
Email: badenes@pitt.edu (email is generally the best way to contact me)
Website: https://carlesbadenes.github.io/
Office Phone: (412) 624-9039

Background I am an Associate Professor at the Department of Physics and Astronomy at the University of Pittsburgh. I hold a Ph D in astrophysics, and my research specialty is stellar evolution, in particular supernova explosions.

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 on Thursdays between 3:30 and 4:30 PM in 309 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.

Grader: Bob Caddy

Office Hours: Thursdays 3:00 to 5:00 PM.
Email: r.caddy@pitt.edu

Bob Caddy is a Ph.D student in the Department of Astronomy and Physics who is studying computational astrophysics. He is currently researching galactic winds using the Cholla code written by Dr. Evan Schneider.

Course Description

This course is a self-contained historical introduction to astronomy for students not majoring in the physical sciences. Astronomy is a vast field of study, and it is impossible to even mention all of its major areas in a single course, so ASTRON 0088 is very general and mostly descriptive in nature. Some of the lectures will make use of simple arithmetic and geometry because astronomy is a *quantitative* science. My primary goals are to cultivate an understanding of the scientific method and an appreciation for critical thought that students can apply well beyond this course, to develop an interest in astronomy, and to have fun! The course aims to give an historical perspective of astronomy, beginning with a discussion of the earliest views of the Universe and the role of astronomy in primitive civilizations. The course proceeds with the development of our current understanding that we live on a planet in one of many solar systems, on the edge of a galaxy that contains billions of stars, and is but one of a hundred billion galaxies in the observable Universe. The underlying theme will be the process of scientific discovery and advancement. Understanding the nature of scientific discovery remains critically important in the world of today, especially because science is often misrepresented or described incorrectly in the media, popular literature, and public debate.

Course Outline

The material will be roughly divided in three major sections. The first section will describe the evolution of humankind's early belief in an Earth-centered Universe to a cosmic view of a Sun-centered Universe developed during the 16th and 17th centuries by Copernicus, Galileo and others. From this, we continue through the time of Isaac Newton, the development of the modern scientific method, and its application to astronomy. This marks the beginning of modern, empirical science and the closely-related fields of physics and astronomy.

We will continue with a brief study of some simple practical topics in astronomy, including phenomena that can be readily observed with the unaided eye or a small telescope: seasons, tides, phases of the moon, eclipses, the motions of the planets, other solar system objects, constellations, stars, nebulae, and galaxies. We will briefly discuss the use of small telescopes for astronomical observations.

We will end with a discussion of our modern view of the Universe. Much of this will require an attempt to understand the scales involved in astronomical investigations. For example, the distance between the Earth and the Sun, though vast compared to distances encountered in our everyday lives, is sixty billion times smaller than the distance across our galaxy. From the realization that the Sun is not the center of the Universe, we have successively discovered that the Sun is not at the center of our Milky Way galaxy, that the Milky Way is not at the center of the Universe, and that in fact the Universe has no discernible center. Instead, we live in an expanding Universe of more than one thousand billion galaxies that originated 13.8 billion years ago in an event we refer to as the Big Bang. We will review how we have pieced together the evidence for the Big Bang, and how successive generations of stars formed since then have synthesized the chemical elements that make up our bodies and all living things found on Earth. We will also discuss some topics of active current research by professional astronomers like the evidence for the existence of unfamiliar forms of matter called dark matter and dark energy; black holes at the centers of galaxies; planets around other stars; space exploration; and the search for life elsewhere in the Universe.

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, global warming, solar power, and many other subjects. Remember, I want you to have fun and be interested in this course.

Textbook

The official textbook for his course is *Discovering the Cosmos, 2 nd edition* by Robert Bless, which captures the philosophy of ASTRON 0088 quite well. However, the book is not required and should be regarded only as a useful reference if you want to have the lecture material reinforced by another source. A book I highly recommend is *Coming of Age in the Milky Way*, by Timothy Ferris. This is a book for popular audiences, not a textbook, but

it covers a great deal of the material for the course in a clear and engaging way. Finally, a basic level astronomy textbook that I like is *21st Century Astronomy* by Kay, Palen, and Blumenthal. This book provides a careful and accurate description of the logic of the scientific method.

The lecture slides, assignments, and additional materials will cover all of the content you are responsible for in this class, so it will be important to attend the lectures, take notes, and work through the additional materials on your own. I will post all these materials on the Canvas site at https://canvas.pitt.edu. Please check it often for updates, and let me know if you have any problems downloading the files.

Grading Policy

The grading policy for undergraduate classes at the Department of Physics and Astronomy states that the final letter grade should reflect the mastery of the learning objectives demonstrated by each student. Specific learning objectives will be stated for each unit (roughly equivalent to a week of class, usually three lectures), and an updated file listing all the learning objectives of the course will be available on Canvas. The largest part of the grade will be tied to direct assessment of these learning objectives through exams, quizzes, and assignments. The remainder of the grade will be tied to indirect assessment of these learning objectives through lecture participation and attendance to the Allegheny Observatory trip. The final grade will be computed from these components according to the following percentages:

- **5%** for a trip to the Allegheny Observatory.
- **15%** for lecture participation as measured by your answers to clicker questions.
- **20%** for assignments and quizzes.
- **60%** for the sum of grades on three exams. Each exam is worth 20% of your final grade.

Each of these items is explained in more detail below. A final letter grade of C or higher will indicate a satisfactory performance in the course, while a grade of C- or lower will indicate an unsatisfactory performance.

Allegheny Observatory Visit

The University of Pittsburgh's own Allegheny Observatory is a facility with a rich history that has been used in a number of important astronomical discoveries. The Allegheny Observatory continues to be used for research today, primarily to observe planets around nearby stars (other than the Sun). As part of ASTRON 0088, you will have the opportunity to visit the observatory on an evening during the course, and, if the weather is clear, to make observations of celestial objects. **At least one trip to the Allegheny Observatory is mandatory**. The first trip is scheduled for March 17 - buses depart from Allen Hall in the evening and return to campus about three hours later. Detailed information about the available visit dates and bus schedules can be found in this website.

Lectures

Fifteen percent of your final grade will be based upon your participation in lectures. Beginning the second week of class, all lectures will contain a series of clicker questions. Answering these questions correctly should not be a source of stress. You will receive 1 point for each correct answer and 0.8 points for each incorrect answer. During the semester, there will be between two and four clicker questions in each lecture. You can earn 15% toward your final grade by getting 80% of the possible clicker points. For example, you can earn the full 15% by answering all of the questions incorrectly! Alternatively, you can earn the full 15% by answering 80% of the questions correctly and not answering the remaining 20% at all. Of course, there are a number of different combinations that get you to 80%. If you earn less than 80% of the total points, credit will be allocated in proportion to the number of points you have earned.

Assignments and Quizzes

This course has no recitation section. I will provide additional material on Canvas to support each thematic unit (roughly equivalent to three lectures, ore one week of classes). You should work through this material on your own, and use it to address the issues that are unclear from the lectures or need to be expanded or reinforced. I will *expect* you to have worked through the additional material before I answer any questions about assignments, quizzes, or exams.

I will post **assignments** on Canvas, beginning the first week of class. These assignments are designed to emphasize the learning objectives of the lectures and serve as practice for the course exams and quizzes. The assignments are not mandatory. However, if you do not complete the assignments, you will probably not do well on the quizzes or the in-class exams. The solutions for each assignment will be posted on Canvas after the due date. If you submit solutions to the assignments, you may have your cumulative assignment grade (the average of all assignments throughout the semester) replace your two lowest quiz grades. Notice that if you fail to complete an assignment on time, there will be no opportunity for a make-up assignment and you will receive a grade of zero for that assignment. Such a grade will significantly lower your cumulative assignment score.

I will also post between 6 and 10 **quizzes** on Canvas. These quizzes will be administered and graded entirely through Canvas, and you will have a limited time to answer them. Your final quiz grade will constitute 20% of your final grade, and it will be calculated as the average of your quiz grades after dropping the two lowest grades. In addition, if you choose to turn in assignments. you may use your homework grade to replace two more quiz grades. Because you can have up to four quizz grades dropped if you are completing assignments, **there will be no make-up quizzes**, except under extremely exceptional circumstances.

Exams

There will be three exams in this course. **Students must bring their Pitt ID card to all exams**. The use of books, notes or other written materials, computers, cellular phones, and all devices that can render documents, graphics, or connect to the internet are absolutely prohibited. Each exam will cover approximately one third of the course material. However, the material covered later in the course will often rely on the material covered earlier in the course, so it is difficult to do well on the later exams if you allow your understanding of the early material to deteriorate significantly. Each exam be comprised of approximately 40 to 60 multiple choice or true/false questions. The focus of this course will be on a qualitative understanding of astronomical subjects and sound reasoning in addressing scientific questions. Each exam will constitute 20% of your final course grade. The three exams taken together will constitute 60% of your final grade. Make-up exams will only be given under extremely special circumstances, such as illness or University-approved travel, and will require a written confirmation from, for example, a medical doctor. The exam dates are:

- **First exam: Friday, February 7 (in class).**
- **Second exam: Friday, March 6 (in class).**
- **Third exam: Friday, April 17 (in class).**

Course Topics in Detail

Here is a rough outline of what will be covered in ASTRON 0088. This plan may be modified according to student interests, to accomodate questions that may arise during the course, and to adapt to the pace at which we proceed.

Week 1: Jan 6, 8, 10	Introduction: our place in the Universe, the Scientific Method
Week 2: Jan 13, 15, 17	The first astronomers: Archaeoastronomy, the Greeks, the Middle Ages *Add/drop period ends Jan 17*
Week 3: Jan 22, 24	The Renaissance: Copernicus, Tycho Brahe, Johannes Kepler *Jan 20 is MLK day; extended drop period ends Jan 24*
Week 4: Jan 27, 29, 30	The Renaissance II: Kepler's Laws of Planetary Motion, Galileo Galilei
Week 5: Feb 3, 5, 7	The Enlightenment: Isaac Newton **First Exam: Friday, February 7**
Week 6: Feb 10, 12, 14	The basics of astronomy: the night sky, matter and radiation
Week 7: Feb 17, 19, 21	The basics of astronomy II: flux and luminosity, distances, and telescopes
Week 8: Feb 24, 26, 28	Stellar astronomy I: the Sun
Week 9: Mar 2, 4, 6	Stellar astronomy II: life cycles of stars **Second Exam: Friday, March 6** *Monitored withdrawal deadline is Mar 6* *Spring break is Mar 9 to 13*
Week 10: Mar 16, 18, 20	Stellar astronomy III: white dwarfs, neutron stars, and supernovae; the origin of the chemical elements
Week 11: Mar 23, 25, 27	Galactic astronomy: William Herschel, the Milky Way, other galaxies
Week 12: Mar 30, Apr 1, 3	Relativity: black holes and time warps
Week 13: Apr 6, 8, 10	Modern cosmology: the expanding Universe, the Big Bang, cosmic Microwave Background, and the large scale structure of the Univers
Week 14: Apr 13, 15, 17	The large scale structure of the Universe, Cosmic evolution in perspective, and back to Earth **Third Exam: Friday, April 17**

Canvas

ASTRON 0088 will be hosted in the new Canvas Learning Management System (LMS). Canvas is replacing Blackboard (Courseweb) for all courses starting Summer 2020. Faculty such as myself volunteered to be Early Adopters of this new system. There may be some bumps along the way, and I appreciate your understanding.

To get started with Canvas, go to https://canvas.pitt.edu. This link appears on my.pitt.edu but you may wish to bookmark it. Log in with your Pitt User ID and password, and click on the course card for this class. Our class materials will not be available in Blackboard (CourseWeb), only in Canvas.

To aid in your use of Canvas, I suggest familiarizing yourself with the new LMS through the short, helpful Canvas Student Tour video series, which you can find here. I also encourage you to try the Canvas mobile app for Android and iOS devices. The full Canvas student guide can be found here.

If you experience any issues using Canvas, you can click the Help button within Canvas, which includes 24/7 chat or telephone support. If you are having issues logging in to Canvas, call the University Help Desk at 412-624-HELP [4357].

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. 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, 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.

Disabilities and Medical Absences

If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services (DRS), 140 William Pitt Union, (412) 648-7890, drsrecep@pitt.edu, (412)228-5347 for P3 ASL users, as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course.

Unless you are going to miss a substantial number of lectures, there is no need to let me know about absences for medical or personal reasons or due to athletic events. The one exception is on the exam dates. If you are sick or incapacitated on the day of the exam, and you want to reschedule the exam, make sure you see a doctor and provide me with a note as described in the University policy for medical absences:

https://www.studentaffairs.pitt.edu/shs/medical/medical-excuses/

Syllabus Addendum: Natural Science General Education Requirement

This course fulfills one Dietrich School of Arts and Sciences Natural Science General Education Requirement (GER) as described for the GERs starting Fall 2018 (term 2191). That GER reads as follows:

Three Courses in the Natural Sciences:
These will be courses that introduce students to scientific principles and concepts rather than offering a simple codification of facts in a discipline or a history of a discipline. The courses may be interdisciplinary, and no more than two courses may have the same primary departmental sponsor.