ASTR006: The Solar System, Exoplanets, and Life
Syllabus – 2024

Instructor

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Course Details
Meeting Times: Tuesday and Thursday - 1:45 to 3:15
Website: See Canvas (Course ASTR006 2024A)

Grader

Office Hours
Mondays from 10:00 - 11:00, or by appointment

Course Description
This course studies planets and life covering our own Solar System and exoplanets orbiting other stars. Topics include the latest results and theories about: the origin and evolution of planetary systems; the detection of exoplanets; the implications of planetary atmospheres for life; and the search for life on other planets in our Solar System. This course is designed for non-majors -- elementary algebra and geometry will be used but not calculus.

Important physical concepts covered include Kepler's Laws, Blackbody Radiation, Doppler Shifts, Newtonian Gravity, and The Habitable Zone.

This semester there will be an observing activity where students will use the telescopes at DRL to make observations of asteroids or planets. This will be scheduled as weather permits.

Important Note: *SAS has a rule that students may only receive credit for one of ASTR001, ASTR003, and ASTR006. So, if you have already taken ASTR001, you are probably not eligible to take this course for credit.*

Materials Required
The textbook for this class will be "***The Cosmic Perspective***," by *Bennett, Donahue, Schneider, and Voit*.

We will also read parts of one or more of the following books:
The Planet Factory: Exoplanets and the Search for a Second Earth
Tasker, Elizabeth

Imagined Life: A Speculative Scientific Journey among the Exoplanets in Search of Intelligent Aliens, Ice Creatures, and Supergravity Animals
Trefil, James

Five billion years of Solitude
Billings, Lee

Grading

Homework assignments count for **30%** of the course grade. Make sure you put your full name on every page and staple the pages of your assignment. There will be **four homework assignments**.

There will be **three in-class quizzes** (15-20 minutes each). These quizzes are meant to be fairly straightforward if you have done the reading and attended class. The **quizzes** together make up **30%** of the course grade.

The cumulative final exam will be **30%** of the course grade. You will be allowed to bring notes to the exam, along with a calculator.

In-class assignments and participation will make up the final **10%** of your grade. This may include reading quizzes, answers to short reading assignments on Canvas, for which full credit will be given if the assignments are completed.

Final grades will be assigned based on the total possible combined points for each component of the class. Depending on the grade distribution**, we may apply a curve in the conversion of numerical scores to letter grades**. The purpose of the curve would be to ensure that the grades in this class are representative of the overall grade distribution in introductory non-major science classes at Penn.
At the beginning of the semester, students who need special testing accommodations should notify the instructor in accordance with the policies of the University.

Attendance and Religious Holidays
In-class assignments, activities, and participation collectively count for 10% of your grade. There will also be in-class assignments to be completed with your classmates. To obtain an excused absence, contact the instructor **before** the class. Please also fill out a Course Absence Report:

https://www.college.upenn.edu/node/3998

Reasons for excused absence include religious holidays. Please notify the instructor at least seven days prior to any classes scheduled on dates you will be absent to observe a religious holiday.

Late Work and Make-up Exams

Homework will be handed in during (or before) class and will be posted on Canvas. Late homework can't be accepted. In general, we will not allow make up of in-class quizzes. The only exceptions are religious holidays, documented illnesses, or other excused absences with one week advanced notice to the instructor.

Collaboration
Homework assignments must represent your own work. Discussing problems and working together are encouraged, but ***the work and write-up must be your own*** and clearly demonstrate the sequence of steps used to reach each answer. To this end, we will require a short justification of each answer written in **full English sentences**.

Laptops and cellphones
We discourage laptop use during class, as brightly lit screens and noisy keyboards are distracting to everyone sitting nearby. However, if you strongly prefer to take notes on your laptop rather than by hand, please discuss with me, and plan to sit in the back row. No cellphone use, including texting and web browsing, is allowed during class.

E-mailing your instructor and TA/Grader
Please e-mail us from your **university email account** if you want us to receive your message. Please treat email as professional correspondence and use proper punctuation and capitalization. We will aim to respond to emails within 48 hours.

Course Outline
Reading assignments from the texts **The Cosmic Perspective** (**TCP**) are listed for each class. **These should be read prior to each class meeting, except for the first reading assignment, which can be completed following the first class.**

<u>Part 1 - Our Solar System</u>

Class 1 - Introduction and review of class materials and policies. A brief overview of our own solar system and extrasolar planets. **TCP - Chapter 1 (to be read following the first class)**

Class 2 - The history of human exploration of our own solar system. Eclipses, moon phases, and seasons. **TCP - Chapter 2**

Class 3 - The Copernican revolution, the discovery of planets in our solar system, and recent missions to visit other planets in our solar system. **TCP - Chapter 3**

Class 4 - Kepler's laws applied to our solar system.
TCP - Section 3.3

Class 5 - The scale of the solar system and the current inventory of bodies in the solar neighborhood. Overview of inner planets, outer planets, asteroids, and dwarf planets.
TCP - Chapter 7

Class 6 - Gravity and Tides. Newton's Laws and ocean tides on Earth. **TCP - Chapter 4**

Class 7 - The inner planets including their sizes, atmospheres, surfaces, and prospects for the (prior) existence of life. Summary of missions to visit these planets. **TCP- Chapter 9**

Class 8 - Mars. What do we know about the current "climate" on Mars? What have we learned from the Rover missions? Did Mars once have a thicker atmosphere and running water?

Class 9 - Overview of the Earth I, including the atmosphere and oceans, tectonics, the carbon cycle, and conditions on the early Earth. ***TCP - Chapter 10***

Class 10 - Overview of the Earth II, including the atmosphere and oceans, tectonics, the carbon cycle, and conditions on the early Earth.

Class 11 - Overview of the outer planets including their sizes and atmospheres. Moons of Saturn and Jupiter. What is between us and the nearest stars? **TCP - Chapter 11**

Class 12 - The outer reaches of our solar system, including the discovery of Kuiper belt objects and the growing number of dwarf planets. The demotion of Pluto. **TCP - Chapter 12**

Class 13 - Light. The Electromagnetic spectrum, blackbody radiation, and Doppler shifts. **TCP - Chapter 5**

Part II - Exoplanets

Class 14 - The Sun as a star. Overview of the Sun and how it generates energy. The solar system in the context of the Milky Way Galaxy. How many stars are there in the Milky Way and is the Sun "normal"? **TCP - Chapter 14**

Class 15 - Planet formation. How do planets form? Can we observe planet formation in action? The early solar system was a violent place. **TCP - Chapter 8**

Class 16 - Introduction to exoplanet detection techniques (transit, Doppler, imaging). Demonstrate how hard it is to detect exoplanets. Telescopes. Description of current planet surveys. **TCP - Chapter 13**

Class 17 - Exoplanets: The Kepler and TESS space telescopes, planethunters.org and a survey of planets we have found outside our solar system.

Class 18 - Overview of what we have learned about exoplanets and where we have looked. Start regular updates on exoplanet tally. *Homework 3 assigned.*

Class 19 - Results from Kepler. The surprising diversity of exoplanet systems and how they compare to our solar system: “hot Jupiters”, complex systems of planets, planets orbiting binary stars. The search for planets that are more “Earth-like”.

Class 20 - *Quiz in class covering material from classes 11-19*. Overview of our current understanding of exoplanet populations. How common are planets? Is our solar system pretty average?

Class 21 - Observations of individual planets. What are the densities of planets and how do they compare to those of planets in our own solar system? How do you measure the temperature of an exoplanet? What would it be like on some of these planets? *Homework 3 due*.

Class 22 - What can we expect over the next decade of exoplanet exploration? How can telescopes like James Webb help us study planets orbiting nearby stars? How can we detect an Earth-analog? Can we travel to nearby exoplanets? *Homework 4 assigned*.

Part III - Habitability and Life

Class 23 - What is our current understanding of habitability? The Habitable Zone and black body radiation. What about extremophiles here on Earth? **TCP- Chapter 24**

Class 24 - The history of life on Earth and the growth of life compared to cosmic time.

Class 25 - What would the Earth look like if observed by an advanced civilization from far away? Are there molecules in the atmosphere that are indicative of life? The Drake equation how what we have learned so far in class helps us fill in the various unknown terms.

Class 26 - *Quiz in class* covering material from classes 23-25. The scientific search for life outside the solar system. Optical and radio SETI and Dyson Spheres. The “new horizons” projects. *Homework 4 due.*

Class 27 – Discussion of the quest for ‘Mirror Earth’

Class 28 - Review of what we have learned this semester.