Astro 14 – Astrophysics: Solar System and Cosmology
Spring 2018
Prof. David Cohen

Syllabus

This semester-long course is a relatively deep (but introductory!) dive into two central topics in contemporary astrophysics, both of which touch on our existence – the nature of our home – Earth its Sun and planetary companions: the **Solar System** – and the nature of the universe as a whole: **cosmology**.

We will introduce and/or review the underlying physics concepts (and mathematical techniques) necessary to study these topics including gravity, basic mechanics, thermal physics, and radiation (light). We'll derive some key physical equations. Basic calculus will sometimes be used. We'll do a few integrals and solve a couple of simple differential equations by integrating them; the occasional derivative will need to be computed. Most important will be working to develop a sense of the correspondence between the math and the physical world of forces, matter, and energy.

The Solar System and the cosmology halves of the class will be pretty different in terms of content and the sorts of physics and phenomenology we'll be thinking about.

We will all work hard to ensure that the class does not revolve around memorization of isolated facts, but rather involves developing integrated understanding of concepts (that then can be applied to different situations, systems, and problems). This will give students a bigger-picture view of the items and systems in the universe and how they fit together. It will also demonstrate how interesting physics concepts students have learned – or are learning – in other classes can be applied to real-world (if cosmic) systems, often in combination with each other.

Classes will include a fair amount of lecture, but also some discussion and in-class student work. Students will be expected to read about the material for a given day's class *ahead of time*, and sometimes to do a pre-class problem or two, based on that reading. Class itself will be for asking and answering questions, solving problems, and delving deeper into material that students will already be thinking about.

We will use a good textbook, "Foundations of Astrophysics" by Barbara Ryden and Bradley Peterson, lightly supplemented by other material. We will cover a bit less than one chapter per week. But! Not all textbook material is equally important. My assignments for each class are the guide to the material that's important. The textbook is but one tool to help learn that material.

We will have a homework assignment roughly once per week. (A subset of the homework problems will be graded, and students will be expected to look over the solutions to the ungraded problems and make sure they can do all the problems,

even the ones that aren't graded. There will be opportunities in class to discuss problems – and their solutions – from the previous week's homework.)

We will have four to six nighttime lab meetings (on Tuesday nights) roughly every other week, on a not-completely-pre-determined schedule. Please leave Tuesday nights from 8pm to 11pm free. We will use the 24-inch telescope in the Peter van de Kamp Observatory on the roof of the science center for these labs. Senior Laboratory Lecturer, Mary Ann Klassen will be running the labs but I will be helping out.

There will sometimes be additional reading from the textbook – on observational techniques and data analysis – (as well as lab manuals), assigned in preparation for the labs. And sometimes the nighttime lab sessions will be used to cover/review material, work on data taken previously (after all, we can only use the telescope when the skies are clear), or even to take midterm exams. Again, students should assume Tuesday nights from 8pm to 11pm will be occupied by Astro 14 activities, but ultimately a few of them will not be used. Please talk to Prof. Cohen as soon as possible if you have known Tuesday night conflicts.

Homework, pre-class problems, and lab work will count for a significant fraction of students' final grades (at least 50%), with two midterms (25% total) and a final exam (25%) composing the remainder.

Resources, information, and assignments (reading and homework, as well as labs) will be available primarily via the class website: astro.swarthmore.edu/astro14/ and Moodle will be used as a secondary resource.

I will accept homework up to 24 hours late and assess a 10% penalty; or up to 48 hours late with a 20% penalty. No permission needs to be asked; no excuses need to be given. If you have a true emergency, please get in touch with me. I will do whatever I can to accommodate you. Students will not be allowed to make up missed labs or exams if they don't talk to me beforehand. Please let me know if I seem unaware of religious holidays and observance that might prevent a student from handing in an assignment on time. I will be glad to accommodate religious observance.

If you believe that you need accommodations for a disability, please contact the Office of Student Disability Services (Parrish 113) to arrange an appointment to discuss your needs. As appropriate, she will issue students with documented disabilities a formal accommodations letter. Since accommodations require early planning and are not retroactive, please contact her as soon as possible. For details about the accommodations process, visit the Student Disability Service website at http://www.swarthmore.edu/academic-advising-support/welcome-to-student-disability-service. You are also welcome to contact me, Prof. Cohen, privately to discuss your academic needs. However, all disability-related accommodations must be arranged through the Office of Student Disability Services.

Topics and Readings
v.1, subject to change/updates, including particular lab nights

week 1:

overview of the Solar System's properties
the Moon and its phases
sky position and motion characterization; angular measure
gravity, mechanics, uniform circular motion

[Ch. 8, sec. 1; parts of Chs. 1, 2, & 3 of R&P, supplemented with a few pages of Bennett]

lab 1: basic use of telescope, camera, and filters

week 2:

shell theorem
Kepler's laws
parallax
inverse square law
electromagnetic spectrum
Doppler shift

[beginning of Ch. 13, parts of Ch. 5]

week 3:

spectroscopy, Kirchoff's laws
blackbody phenomenology
Solar System overview recap
Formation of the Solar System

[Ch. 8]

lab 2: image analysis [some of Ch. 6]

week 4:

The Earth and Moon

[Ch. 9]

week 5:

The Planets

[Ch. 10]

lab 3: finishing up image analysis

week 6:

Asteroids
Comets
Trans-Neptunian objects
Meteoroids and dust

[Ch. 11]

week 7:

The Solar System in perspective
including exoplanets

[Ch. 12]

midterm on Thursday, March 8 in class

spring break

week 8:

Finishing up exoplanets
Starting cosmology

[some of Ch. 20]

week 9:

Large scale structure
Content of the universe

[end of Ch. 22, beginning of Ch. 23]

lab 4: exoplanets part 1

week 10:

Basic cosmological observations
Development of cosmological models

[middle of Ch. 23]

second midterm (Tue night in lab time-slot)

week 11:

Spacetime metrics
The Friedmann equation

[end of Ch. 23]

lab 5: exoplanets part 2

week 12:

The consensus cosmological model

[beginning of Ch. 24]

week 13:

Dark energy and the accelerating universe

[rest of Ch. 24]

(maybe*: lab 6*: variable stars as standard candles)

week 14:

The early universe
Nucleosynthesis