Topics: the objects in the Solar System, their properties, their lay-out, and their motions – patterns in the Solar System; angular measure and determining the sizes and distances of objects we can't touch; Moon phases

Reading:

- Read the introduction of Ch. 8 and §8.1 of *Ryden and Peterson*, carefully; paying special attention to Fig. 8.1 on p. 195; then skim the first few pages of §8.2.
- Watch the short (9 minutes) classic movie *Powers of Ten* to get a sense of the scale of the Solar System (and the rest of the universe) and also to inspire your thinking about logarithms and logarithmic scales. There is a link on the class website (*Assignments* section).
- Continue to (or start to!) look at the crescent Moon in the evening sky, and prepare to discuss in class how its location and appearance changes over the course of several nights. Study Fig. 4.10 on p. 98 of Ryden and Peterson. Well...it likely will be too cloudy Sunday and Monday nights (but maybe not!).

Recall that there are multiple copies of the textbook on reserve behind the front desk at Cornell Library.

Summary of work to submit:

- You will hand in your answers to the first problem embedded in the text below, in class on Tuesday, after we go over them. I will look over your responses, write some comments, and return your work to you the next day. Credit will be given simply for doing a complete and thoughtful job, not necessarily having the right answers.
- You will also email me an image of a Solar System object along with a short statement about why you like that particular image. You will email that to me by midnight on Monday.

Note that the questions embedded in the text below are things you should answer for yourself and be prepared to discuss in Tuesday's class, but you aren't expected to hand in answers to those questions. It's the numbered problems/questions (echoed by the bullet points here) that you have to hand in.

Overview:

Our first class will focus on the objects in and layout of the Solar System, with an emphasis on the *patterns* we see and also on beginning to think about how we can *measure* the interesting properties of these objects. We will do some hands-on exercises related to measuring angles and also to the cause of the moon's phases. You will also solve a couple of problems, together, in class.

Pretty quickly (like, by Thursday's class) we'll start discussing the background physics (mechanics, gravity, orbits, radiation/light) that we'll need to understand in order to learn about the Solar System and cosmology. But I thought we'd start with some actual astronomical information about the Solar System. After starting in on the physics at the end of the first week and continuing through the third week, we'll return – in depth – to the properties and formation of the Solar System.

Commentary on the reading, viewing, and other preparation:

You probably learned about the eight (nine?) planets in elementary school, if not in a children's book at an even younger age. They (including the Earth), along with numerous moons orbiting many of these planets (including our own Moon), and very importantly, asteroids, comets, meteors, etc. all of which orbit the Sun, compose what we call the Solar System. Though the size scale is vast by human standards, it is small by astronomical standards. The Sun is a star and the next nearest star is more than 10,000 times farther from the Sun than Neptune, the most distant planet in the Solar System, is. As you read §8.1, think about the distinction between terrestrial and Jovian planets; what their key differences are. Also think about the overall patterns in the Solar System. What do the planets *all* have in common in terms of their locations and motion?

Pay special attention to Fig. 8.1. What is plotted on the x-axis in non-jargon-y language? What does it mean, specifically, that the axes are logarithmic?

Problem 1

Look at the y-axis of Fig. 8.1. Which tickmark is halfway (in distance, like millimeters, measured directly on the axis of the graph) between the one labeled 0.01 and the one labeled 100? What is the logarithm (base ten) of 0.01? Of 100? What number is halfway between your two answers? What is 10 raised to that number? Does that value agree with your answer to the first question in this paragraph? (Should it?)

Okay, now let's repeat these questions, but for tickmarks that are an odd power of ten apart. Which tickmark is halfway (in distance, like millimeters, measured directly on the axis of the graph) between the one labeled 0.01 and the one labeled 1000? (You can use a ruler and/or take advantage of the unlabeled, minor tickmarks on the axis.) What is the logarithm (base ten) of 0.01? Of 1000? What number is halfway between your two answers? What is 10 raised to that number? Does that value agree with your answer to the first question in this paragraph?

If I asked you to compute the total mass of *all* the objects plotted in the figure, to *two* significant figures, which objects would you have to include (what's the minimum number of objects you'd have to include)?

Please write down answers to every question in this problem; every sentence with a question mark.

As you start to read and then skim the first few pages of §8.2, think about what quantities/properties we can measure for objects in the Solar System. Remind yourself of things like the definition and units of density and the numerical value of the density of water. And you can start to think about gravity and how properties of orbits can be used to determine the masses of objects.

Problem 2

Each student should pick one Solar System object (planet, specific moons, comets...even things like zodiacal dust – look it up!) and look for images of that object online (*Astronomy Picture of the Day*, linked from the right side of the class website is an excellent resource), find one you especially like, and email it to me (image plus link) along with a sentence or two telling me *why* you like that image (not what it is necessarily or anything scientific, just why you like the image). Please email me your "answer" to this problem by midnight on Monday.

And, once you choose an object, enter your name and the object in the shared Google doc linked from the class website, right near the assignment. This is to make sure everyone has a different object.

As you watch *Powers of Ten* think there too about logarithmic scales. If it takes, say, 4 minutes to go from the picnic in Chicago (scale 1 meter) to the farthest reaches of the universe (scale 10^{24} meters), then when you are 2 minutes (half-way) into the journey, what fraction or percentage of the way to the edge of the universe are you? And as you watch, try to notice at what scales the universe is mostly empty space and at what scales things are more tightly packed together. And of course, think about the point the enthusiastic narrator makes about the universality of sub-atomic particles (and the laws of physics) and how that makes the universe and nature knowable and also at a philosophical level provides a connection between the very small and the very large and also situates us – humans – as part of the universe and part of nature, not outside of it.

Finally, let me give you a little information about the cultural place of the film and its creators. They were a married couple who were both designers, architects, and artists. They made *Powers of Ten* in 1977, near the end of their careers. Several decades earlier, they were well known for designing what at the time was a highly unusual house in California and an iconic chair:

I've put a link to some information about them on the website, too.

The Moon – like planets and indeed all objects in the Solar system – is visible only by virtue of its ability to reflect sunlight. (That's true at least as far as visible light goes; later we'll see that objects emit infrared light simply by virtue of their non-zero temperature.) Changes in Moon phases are caused by our changing view of the Moon as it makes its approximately month-long orbit around the Earth. When you look at Figure 4.10, think about how the top part of the figure is a "top view" (as seen from above) of the Earth and Moon (with the Sun off the right side of the figure). Note that the Sun is so far away from the Earth and Moon that its rays of light are *parallel*. Stop and think about that. What would those rays (arrows) look like if the Sun were just barely off the right side of the image? The bottom part of the figure shows the view of the Moon from the perspective of an observer on the Earth. Think about how you could describe to someone who had no idea how Moon phases work what the process is for going from a given (labeled with a capital letter) Moon phase in the top part of the figure to the corresponding view in the bottom part. You might think about the fact that from the Earth, you can always see exactly half of the Moon. And that the Sun always lights up exactly half of the Moon. Think about where you'd put a stick figure representing yourself on the Earth at the time around dusk you observed the Moon. What direction along its orbit in that figure is the moon moving? How does the *angular separation* between the Moon and Sun as seen from the Earth change from night to night when there's a waxing Moon?