Topics: finish up blackbody emission, circular motion, gravity, orbits

Reading:

- Re-read from the top of p. 197 ("The surface temperature...") to the bottom of p. 199, and be prepared to go over the equilibrium temperature of a planet calculation in detail.
- Read about Newton's laws of motion and his law of universal gravitation: pp. 90 - 92, and 98 of Bennet et al.'s *The Essential Cosmic Perspective*, 6th edition (linked on the class website).
- Read two short, approximate proofs of the expression for centripetal acceleration (also on the website).

Summary of work to submit:

- No work to submit.

Overview:

A small object in a circular orbit around a large object is in uniform circular motion. It also is feeling the gravitational force of the large object. The acceleration that force causes is the centripetal acceleration associated with the uniform circular motion. By equating these two accelerations we can derive a fundamental relationship among orbital velocity, size of the orbit, and mass of the object being orbited. By expressing this in terms of orbital period rather than velocity, we have Kepler's third law, which we can use to weigh planets. Look at eqn. 8.1 on p. 196 – we want to understand where that comes from, as well as be able to use it. (Note that we'll read about Kepler's laws themselves next week.)

Commentary on the reading, viewing, and other preparation:

going along with the textbook reading from last time (pp. 197-199):

The concept of *albedo* is introduced in the first paragraph. Can you state its definition? Does your intuition tell you that a planet with a higher albedo will be hotter or colder?

Note how eqn. 8.4 relates the Sun's color (what wavelengths it emits the most light at) to its temperature. We can do the same for the Earth (or any planet). Given the Earth's average temperature of about 290 K, what is the wavelength at which it emits the most light?

The inverse square law is used to find the flux of sunlight at the location of the planet. By the way, we don't *need* eqn. 8.3 and 8.5 since we can just measure the Sun's flux here at the Earth and scale it by the distance to the planet. However, doing it this way allows us to derive a temperature of a planet in terms of the Sun's (or any star's) temperature.

Read the sentence about equilibrium at the top of p. 198 very carefully. What would happen if the two rates were *not* equal?

for today's reading:

The material on Newton's laws (motion and gravity) should be review to you – please let me know if this material seems unfamiliar. If you push two different objects of different masses with the same force, which one will move faster, the low-mass one or the high-mass one? What about if you push them with different forces such that the two forces are proportional to their masses? How will their respective motions compare? Are you okay with the definitions of and relations among position, velocity, and acceleration? If you know the acceleration on an object, how do you calculate its velocity?

What does it mean that the Moon and an apple fall under the same force of gravity? Does that mean that their accelerations are the same?

Are you comfortable with the idea that a spherical object acts as if its mass were concentrated as its center (from the point of view of its gravitational force on an external observer)?

The concept of *uniform circular motion* applies to much more than orbits. We'll be using the expression for centripetal acceleration: $a_{\text{cent}} = \frac{v^2}{r}$ to derive Kepler's third law. Make sure you're comfortable with this expression (check that its units are acceleration) and the way that the acceleration vector points toward the center of the circle. I provided the derivations above (second bullet point) just to help make you comfortable with the expression. You are not responsible for reproducing them. And note that neither is rigorous, though the second one can be made rigorous by changing the Deltas into differentials.