Ay 10 - Problem Set #4
Due: September 27, 11am

Please write your full name, section number, and GSI's name at the top of your homework. Also, be sure to put your homework in the correct box in the basement of Campbell Hall. There is a 20% penalty per day for the late submission of assignments, however you do get one "freebie" (see course syllabus for more info).

Remember to always show your work; no credit will be given for just a final answer. However, if you get most of the question right but get the final answer wrong, you will get most of the points. Use a calculator where necessary and dont forget units if the answer requires them.

If you use any resource besides the textbook, lecture, or section (*e.g.* a web site), be sure to include proper attribution for the reference. Feel free to work with other students in the class, but remember that all work turned in must be your own (*i.e.* don't just copy the work of another student).

1. **(7 points)** NASA decides they want to do science on the Moon and asks radio astronomers how an Earth-Moon interferometer might help them. The Earth-Moon interferometer would have one dish on the surface of the Earth and one dish on the surface of the Moon.

   (a) What is the improvement in resolution of the Earth-Moon interferometer compared to the VLA? Express the improvement in resolution as the ratio of the new resolution to the old resolution. Assume that the VLA has maximum distance between the dishes of 2 km, and take the distance between the Earth and the Moon to be roughly 3.8×10^5 km. Does the ratio of improvement in resolution depend on wavelength?

   (b) Suppose we are using the Earth-Moon interferometer to image a binary star system (2 stars orbiting around each other) where the stars are separated by 100 AU. What is the maximum distance that the binary star system could be away from us if we can distinguish the stars in an image using the Earth-Moon interferometer?

2. **(5 points)** Explain why total lunar eclipses can only happen when the Moon is full. Draw a diagram of the Earth-Moon-Sun configuration of a lunar eclipse in your explanation.

3. **(5 points)** The Moon completes one orbit around the Earth in about 28 days.

   (a) About how many degrees around the Earth does it move per day?

(b) We know that the Moon traverses a large distance on the sky as it rises and then sets. So why does the Moon appear to move across the sky much further than your answer in (a) every night?

4. **(5 points)** The Moon is slowly getting farther from the Earth. Imagine that at some point in the future, the Moon is twice as far from the Earth as it is now.

   (a) If the current diameter of the Moon on the sky is 0.5 degrees, what will be the size of the Moon on the sky when the Moon is twice as far away?

   (b) Draw a diagram of what a solar eclipse might look like to an observer when the Moon is twice as far away.

5. **(8 points)** We know that the Earth's orbit is not perfectly circular, but rather elliptical. We also know that Earth is tilted at an angle of 23.5 degrees relative to the plane of its orbit (i.e., a straight line from the north pole to the south pole is not perpendicular to the plane of Earth's orbit, but has a tilt of 23.5 degrees). It turns out that the Earth is closest to the sun when it's winter here in Berkeley.

   (a) If the Earth is closest to the Sun in Berkeley's winter, why is winter colder?

   (b) When it's winter in Berkeley, is it also winter in Australia? Explain why or why not.

   (c) What are two reasons why is it generally colder in locations farther away from the equator?

   [The relevant material for this question will be covered in lecture on Tuesday, Sept 26. In the meantime, refer to pages 13-16 of your textbook.]