

Name \_\_\_\_\_

Astronomy H161 – An Introduction to Solar System Astronomy  
Winter Quarter 2009 – Prof. Gaudi  
Homework #2

**Due Wednesday, January 21 in class**

**No late homework will be accepted.**

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A “flying saucer” lands on your front lawn. Curious, you and your significant other go out to investigate. Suddenly, spaghetti shaped aliens jump out of the ship and grab you both. They abduct you and take you to their own World. Fortunately for you, their World is a beautiful “Garden of Eden” where food grows plentifully on trees and where there is no sickness because disease-bearing germs have long ago been eliminated.

Unfortunately for you, the reason you have been brought here is that the aliens are planning to perform a series of ghastly medical experiments on you.

Unfortunately for the aliens, their disease-free environment has left them with virtually no immune system. Within a few hours, your captors are so ill from bacteria to which you are immune, that they abandon their experiments. Within days, the entire alien population is dead. You and your significant other settle down to enjoy your new home.

Your most urgent priority is to measure the size of your new solar system. You first repeat the experiment of Eratosthenes to measure the diameter of your World, which, remarkably, you find to be exactly the same size as the Earth. You notice that your world has a large moon, which you name “Luna”. You measure the angular diameter of Luna to be 1 degree, about twice the angular size of the Earth’s moon. Then you notice that your World is about to eclipse Luna. Anxiously, you set about to

- 1) Determine the physical size of Luna.
  - a) Figure 1 shows the eclipse of Luna at a certain point in time. The outermost circle represents the edge of Luna. The innermost circle is dark because that is the part of Luna that is totally eclipsed by World. The middle size circle is gray because that is the region that is partially eclipsed by World. Use a ruler to measure the

diameters of the three circles in centimeters. Record your answers.

- b) You recall from the work of Aristarchus of Samos that the projected diameter of the eclipsing body is equal to the average of the diameters of the totally and partially eclipsed regions. Find this average (from your results in *1a*) and record your answer (in centimeters).
- c) Draw a circle of this diameter in Figure 1, between the circles representing the full and partial eclipses.
- d) Compare this circle (which is the size of World) with the size of the circle representing Luna. Which is bigger?
- e) What is the ratio of the diameter of Luna to the diameter of World? That is, write

$$\frac{D_L}{D_W} = ?$$

where  $D_L$  is the diameter of Luna and  $D_W$  is the diameter of World. (Note that, although you have measured the drawings of circles in centimeters, the ratio of their sizes is dimensionless, and so applies equally well to Luna and World themselves, which are much bigger than the drawings!)

- 2) Determine the distance to Luna.

- a) You recall the formula for long triangles with long sides  $d$  and short side  $a$ :

$$\theta = 57 \text{ deg} \times \frac{a}{d}$$

where  $\theta$  is measured in degrees. In this case,  $\theta$  is the angular diameter of Luna,  $a$  is the physical diameter of Luna, and  $d$  is the distance to Luna. Write down the value of  $a$  ( $=D_L$ ) (using your result from part *1e*). Write down the value  $\theta$  from the introduction to the problem.

- b) Use the long-triangle equation to determine the distance to Luna,  $d$ . Record your answer (in units of  $D_W$  or in units of kilometers, whichever you prefer).

- 3) Now you want to measure the distance to Stella, the central star in your new solar

system. You wait until exactly half of Luna is illuminated by Stella. See Figure 2.

- a) You recall from the arguments of Aristarchus of Samos that at this point, the angle World-Luna-Stella must be a right angle. Identify this angle in Figure 2.
  - b) You measure the angle Luna-World-Stella between Luna and Stella and find it to be 83 degrees. Identify this angle in Figure 2.
  - c) Complete the triangle Luna-World-Stella in the Figure. (Remember, a triangle has 3 straight sides!). Determine the ratio of the distances to Stella (the line segment World-Stella) and to Luna (the line segment World-Luna). Record your result.
  - d) Use the ratio of distances (in part 3c) and the actual distance to Luna (in part 2b) to determine the distance to Stella in World diameters ( $D_W$ ). Record your answer.
- 4) Now you are back on Earth! Recall from class that the path of the Moon through the stars is very similar to the path of the Sun (i.e. the ecliptic). Use this fact to determine the times of year when (as seen from Columbus)
- a) The full moon gets farthest from the horizon.
  - b) The full moon remains closest to the horizon.
  - c) The first quarter moon gets farthest from the horizon.
  - d) The third quarter moon remains closest to the horizon.
- 5) A simple sundial reads noon when the Sun crosses the meridian. Explain why a wall clock generally doesn't read noon at this time. Approximately what time of year would the sundial read the earliest when the clock reads noon? What time of year would the sundial read latest when the wall clock reads noon?