Name: _____

Date: _____

Section: _____

Astron 104 Laboratory #4
A More Rounded View of the Earth
Discovery 0.1

More than 2000 years ago, Eratosthenes (276–195 BCE) performed an experiment that showed that the Earth was much larger than previously believed. If the Earth was a sphere, its circumference C (the distance around) and radius R can be related through:

$$C = 2\pi R \tag{1}$$

where $\pi = 3.14\ldots$. In order to compute the size of the Earth, Eratosthenes employed the following logic: If the Earth were flat, sticks placed vertically at various places on the Earth would all simultaneously point directly toward the Sun at noon, and none would cast a shadow. If, however, the Earth was round (a sphere), when the Sun was directly overhead at one location it could not be simultaneously overhead at another location to the North or South.

Eratosthenes worked at the Great Library at Alexandria, Egypt. He read that in Syene, Egypt, at noon on June 21, obelisks cast no shadows and sunlight fell directly down a well. This indicated that the Sun was directly overhead. At noon on the same date, he observed that in Alexandria (located directly north of Syene) the shadow of a pillar indicated that the Sun was about 7.2° south of the zenith (see Figure 1).

1. In Figure 2, you can see the overall situation. Use Figure 2 along with the geometry of parallel lines to determine what angular distance (how many degrees), measured from the center of the Earth, separate Alexandria and Syene.

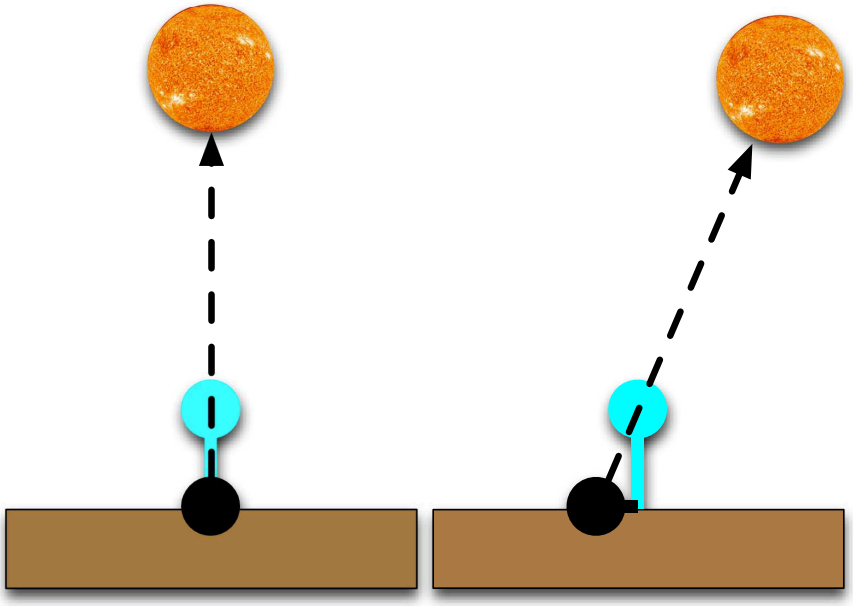

Figure 1: On the left is the situation in Syene on June 21: the Sun is directly overhead and casts no shadow. On the right is the situation in Alexandria, where the Sun is 7.2° south of the zenith.

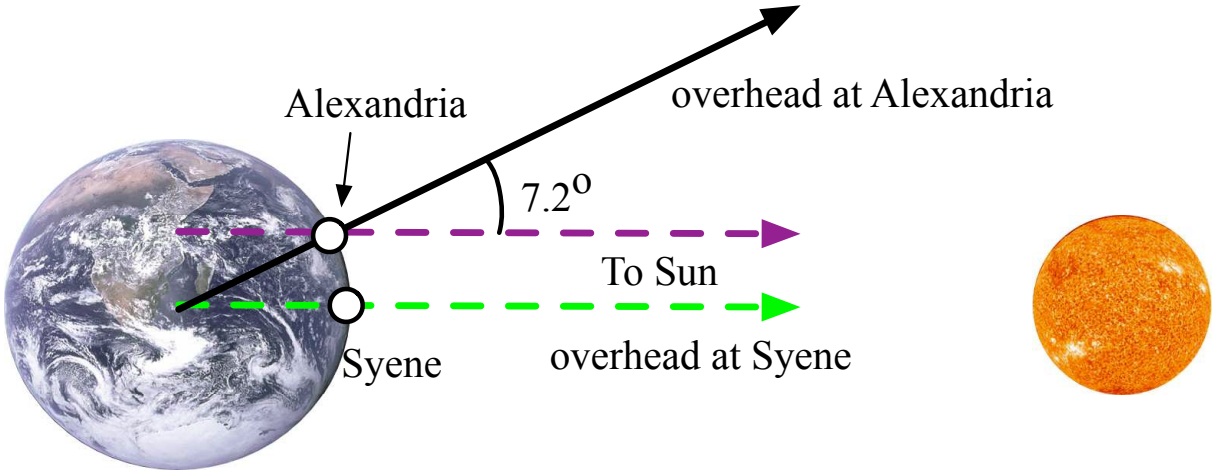

Figure 2: The overall geometry. Lines going to the Sun are parallel.

2. How many of these angular distances are needed to cover an entire circle (360°)?

3. Eratosthenes knew that the distance between Syene and Alexandria was about 5000 stadia (where 1 stadium = 0.16 km). If each of these angular units (the angular distance between Syene & Alexandria) represents 800 km, what are the circumference and radius of the Earth (in km)? Show your work.

4. How close is your answer to the actual circumference of the Earth (40,000 km)? Calculate the relative error, which is given by:

$$\text{Relative Error}(\%) = 100 \times \frac{\text{Observed value} - \text{Actual value}}{\text{Actual value}}$$

5. Please explain why this result is good, bad, or indifferent?

6. In 2011, some UWM students recreated this experiment with help from students at Mississippi State University in Starkville, MS (1,070 km south of Milwaukee). They found that the shadow in Starkville was 9.8° smaller than the shadow in Milwaukee. Use the same procedure that you used above to determine how well the UWM students did in determining the circumference of the Earth.