NAME _____ *DATE* _____

INSTRUCTOR _____ *PERIOD* _____ *PARTNER* _____

UNIT 1: Earth's Dimensions

LAB 1-1: EARTH'S CIRCUMFERENCE

INTRODUCTION: Very often we want to know the size of objects that are either too large or too small to measure directly. In these cases an indirect method must be used that usually involves a ratio between the size of something we can measure and the size of the object we are trying to measure.

As recently as the 1400's many people believed Earth to be flat. It is interesting to note that in 240 B.C., Eratosthenses, a Greek geographer, believed Earth to be round and made an accurate estimate of Earth's circumference. Besides believing that Earth is round, he also assumed that the sun's rays are essentially parallel.

In this lab you will use Eratosthenes' indirect method for finding Earth's circumference.

OBJECTIVE: You will learn a method for determining Earth's circumference.

VOCABULARY:

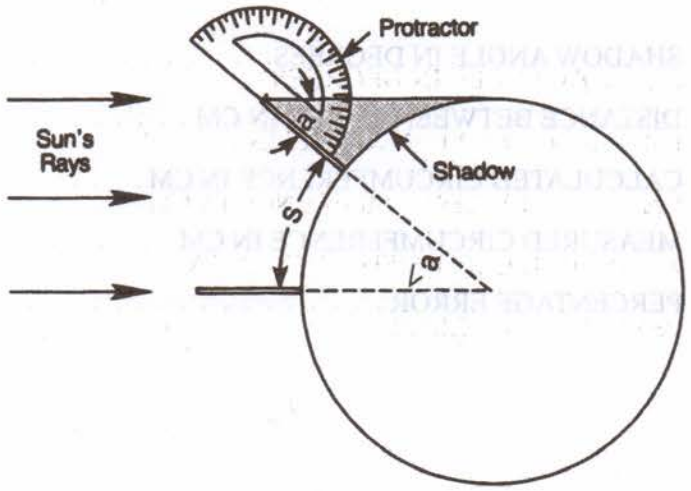
circumference:

ratio:

altitude of a celestial body:

shadow angle:

GEOMETRY OF METHOD



Your instructor will demonstrate Eratosthenes' indirect method for determining Earth's circumference. This method uses the following equation.

$$\frac{\angle a}{360^\circ} = \frac{S}{C}$$

S = distance between sticks
C = circumference of a sphere
$\angle a$ = shadow angle

The shadow of a stick is used to determine the angle between the sun's rays and the stick. This angle is called the shadow angle and is equal to the interior angle **a** in the diagram on the previous page.

PROCEDURE A:

1. Attach two sticks to the globe on the same meridian as indicated by the diagram. Be sure that they point exactly to the globe's center.
2. Placing the globe in direct sunlight, turn the globe until one of the sticks has no shadow. WARNING: TO PREVENT PERMANENT DAMAGE TO YOUR EYES DO NOT LOOK DIRECTLY AT THE SUN.
3. Using a protractor as illustrated in the diagram, measure the shadow angle. Record this value on Report Sheet 1.
4. Using a flexible ruler, measure the distance to the nearest .1 cm between the bases of the sticks. Record this value on Report Sheet 1.
5. Using the given equation, calculate the circumference of the globe. Record this value on Report Sheet 1.
6. Using a string or flexible ruler, actually measure the globe's circumference and record this value on Report Sheet 1.
7. Compare your calculated and direct circumference measurements and determine your percentage of error. Record this value on Report Sheet 1.

REPORT SHEET 1

SHADOW ANGLE IN DEGREES . . . . . _____

DISTANCE BETWEEN STICKS IN CM . . . . . _____

CALCULATED CIRCUMFERENCE IN CM . . . . . _____

MEASURED CIRCUMFERENCE IN CM . . . . . _____

PERCENTAGE ERROR . . . . . _____

PROCEDURE B:

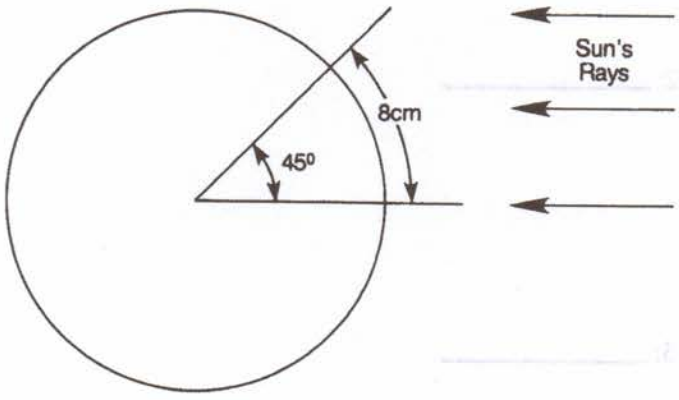
*NOTE: For the following procedures write your answers on Report Sheet 2. SHOW ALL WORK. LABEL ANSWERS PROPERLY.

1. You are given the following information about a sphere.

   S = 15 cm $\angle$ a = 35 degrees

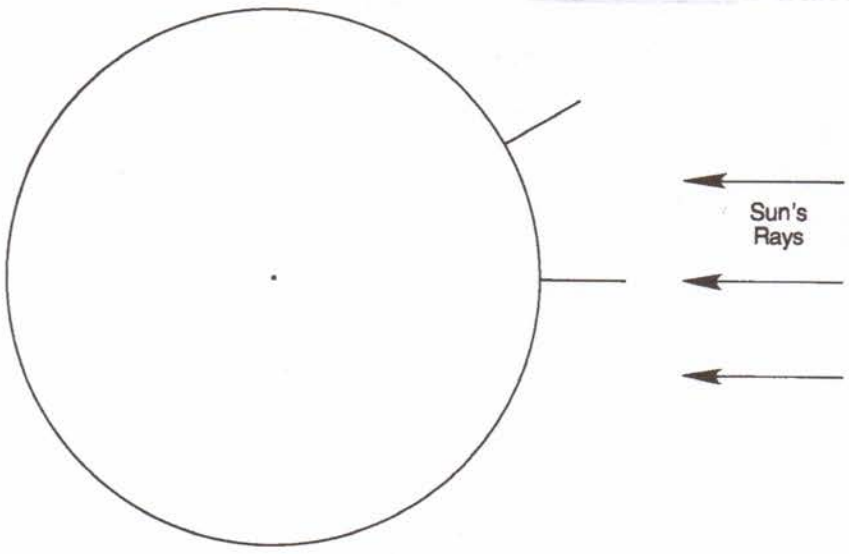
   Calculate the circumference of the sphere.

2. Calculate the circumference of the sphere shown in the diagram below. NOTE: THE DIAGRAM IS NOT DRAWN TO SCALE.



3. Assuming that the accepted value for the globe's circumference in procedure B–2 above is 75 cm, calculate your percent deviation.

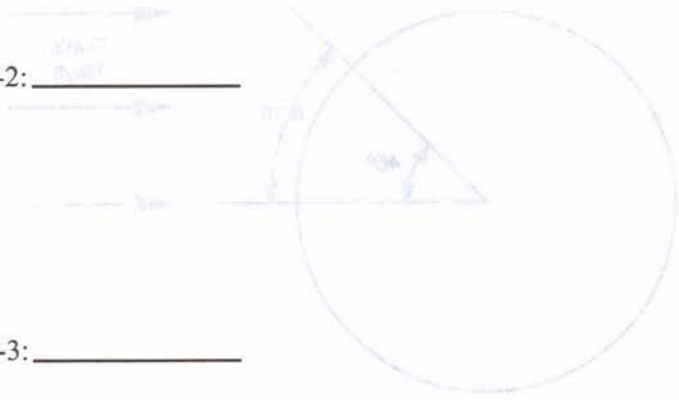
4. Using a protractor and a flexible metric ruler, calculate the circumference of the globe shown below. Use a scale of 1 cm = 1,000 km.



REPORT SHEET 2

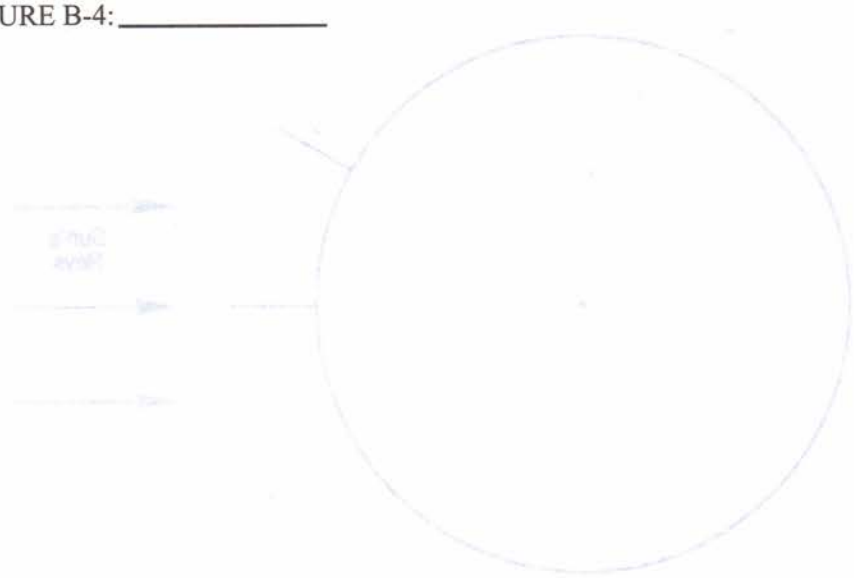
PROCEDURE B-1: _____

PROCEDURE B-2: _____



PROCEDURE B-3: _____

PROCEDURE B-4: _____



DISCUSSION QUESTIONS: *(Answer in Complete Sentences)*

1. Explain why Eratosthenes' method would not work if Earth were flat.

2. What assumption must be made about the sun's rays if you use this method for determining the circumference of a large sphere?

3. Draw a diagram which illustrates this indirect method for determining Earth's circumference. Indicate the following on the diagram: parallel sun's rays, sticks (project them to Earth's center), shadow angle, interior angle a, and the distance between the stick (S).

4. The Tropic of Cancer is 23.5 degrees north of the Equator. On a given day a vertical stick on the Equator casts no shadow while one at the Tropic of Cancer does. Calculate Earth's circumference using this information. (HINT: One degree of latitude is approximately equal to 111 km)

5. What would be the change in the calculated circumference if you measured the angle larger than it really is?

6. What would be the change in the calculated circumference if you measured the arc longer than it really is?

CONCLUSION: Describe how you would actually set up and carry out an experiment using this method to determine Earth's circumference.