

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 believe the earth to be flat. It is interesting to notice that in 240 B.C. Eratosthenes, a Greek geographer, believed the earth to be round and made an accurate estimate of the earth's circumference. Besides believing that the earth is round, he also assumed that the sun's rays essentially parallel.

In this lab you will use Eratosthenes' indirect method for finding the circumference of the earth.

Objective:

You will learn a method for determining the earth's circumference.

Vocabulary:

Circumference - _____

Ratio - _____

Altitude - _____

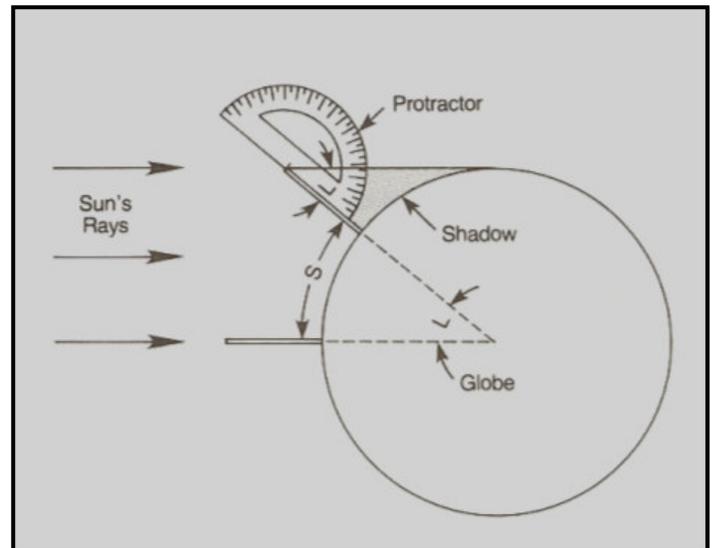
Shadow angle - _____

Eratosthenes Method used the following equation to indirectly determine the circumference of the earth.

$$\frac{S}{C} = \frac{L}{360}$$

S = Distance between sticks
 C = Circumference of a sphere
 L = Shadow angle

The shadow of the 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 L in the diagram.



Eratosthenes Numbers

Distance between sticks = 500 miles

Shadow angle = 7.3°

Calculated circumference = 24,663 miles

Actual Circumference = 24,863 miles

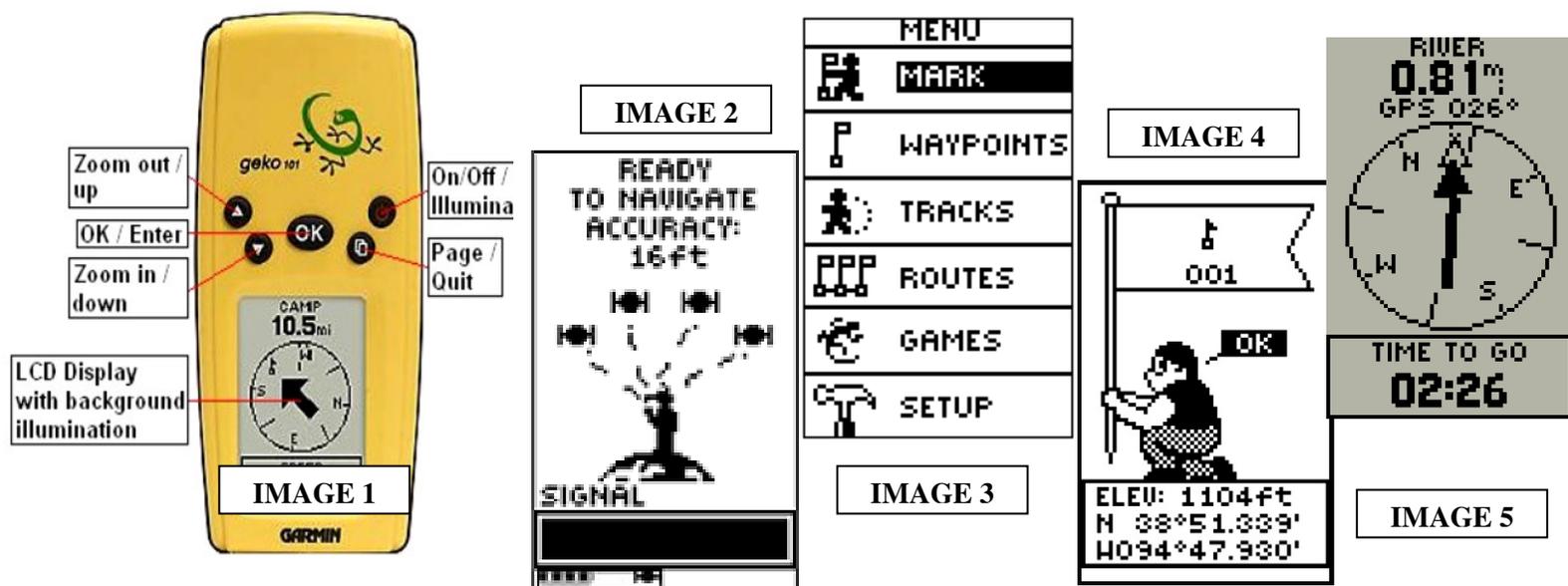
Percent Error = _____

$$\% \text{ Dev} = \left[\frac{\text{Difference in Values}}{\text{Accepted}} \right] * 100$$

Procedure A - GPS:

Directions for Using the Garmin Geko GPS Unit

1. Power on GPS unit with the red “On/Off” button. (**Image 1**)
2. Wait for Satellites to Acquire Data (**Image 2**)...wait for the little person to have four “swiggly lines” and alien space ships (ok, satellite images) around his/her head. ☺ Then proceed to the next step.
3. Using the “Page” button, keeping pushing the page button until you find the “Menu” page (**Image 3**).
4. On the Menu Page, select “Mark” and hit the “OK” button. Then hit the “OK” button a second time to actually place your first mark.
5. On the “**REPORT SHEET**” of your lab in **TABLE 1**, RECORD the Latitude and Longitude for your **starting point (Image 4)**. Be sure to note the compass direction, degrees, minutes and decimal minutes.
6. Using the “Page” button, change the screen until you get the compass. (**Image 5**)
7. Using the “Zoom Down” button, press it until you get “Location” on the image and are able to see the Latitude and Longitude.
8. At this point, start walking in a relatively straight line where the Longitude value stays the same...adjust as you walk to BE SURE it stays the same (yes, this is the one with the “W” in front of it... learn your latitude and longitude, quickly!).
9. Trying to walk as far as you can, when you stop – RECORD the final location **latitude and longitude** to the nearest decimal minute in **TABLE 1**.
10. Pressing the “Page” button, go back to the “Menu” screen (**Image 3**), scroll down with the “Zoom Down Button” and go to the “Waypoints”. Hit “OK”.
11. A new image will come up (hopefully) and select “Nearest”. Hit “OK”.
12. RECORD the distance between the starting and final location in **meters** on the REPORT SHEET, #1. Hit “OK”.
13. Determine the difference in minutes of latitude between the starting and final location. Take this number and divide it by 60 to convert it to degrees. RECORD on REPORT SHEET, #2.
14. Then move the “Zoom/Up” key to “delete”, hit “OK”. Power Off. Yea, you did it!!



REPORT SHEET

TABLE 1	Latitude	Longitude
Starting Location		
Final Location		

1. Distance between Starting & Final Location: _____ (m)
 Convert to km: _____ (km)
2. Difference in minutes between Starting Location & Final Location: _____
3. Angle between Starting & Final Location (#13 on GPS Directions): _____

Estimating Circumference Using Field Data:

Calculate Earth's Circumference using the data you collected.

Estimate for Earth's Circumference _____

Procedure B:

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

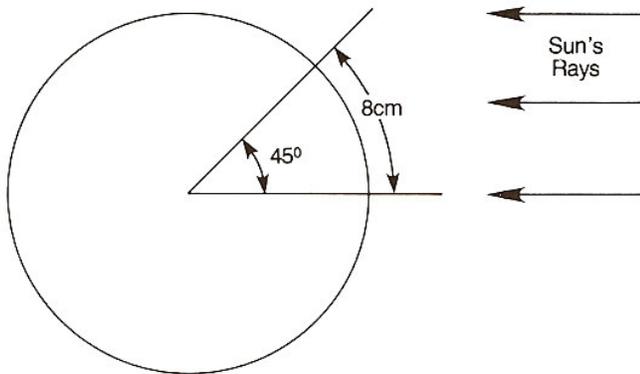
$S = 15 \text{ cm}$

$L = 35 \text{ degrees}$

Calculate the circumference
(show work)

Answer: _____

2. Calculate the circumference of the sphere in the diagram below (the diagram is not drawn to scale).



Calculate the circumference
(show work)

Answer: _____

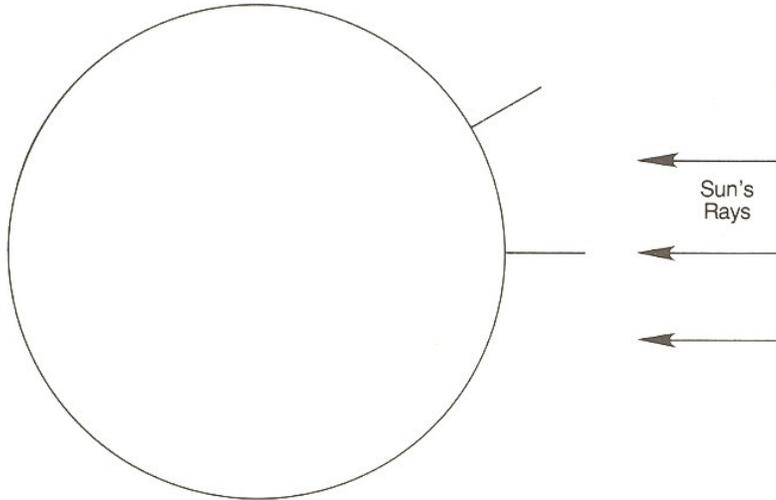
3. Assuming that the accepted value for the globe's circumference in procedure B2 above is 75 cm, calculate your percent error.

Calculate your percent error
(show work)

Answer: _____

4. Using a protractor and a flexible ruler, calculate the circumference of the globe shown below. Determine the circumference in km (use a scale of 1 cm = 1,000 km).

Calculate the circumference
(show work)



Answer: _____

Questions:

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. The Tropic of Cancer is 23.5° N 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 the circumference of the earth using this information. (HINT: one degree of latitude is approximately equal to 111 km)
4. What would be the change in the calculated circumference if you measured the angle larger than it really is?

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