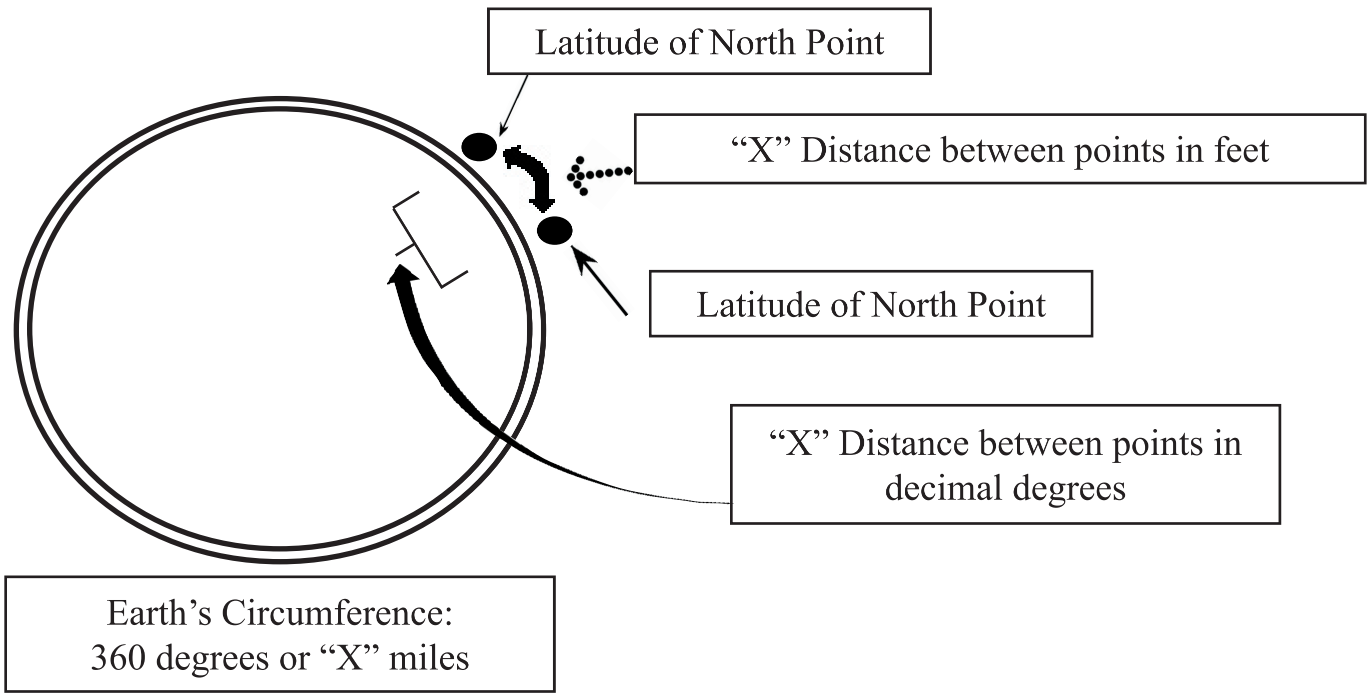
# Measuring the Earth – Advantage of Technology

Students should be familiar with Latitude and Longitude and have an introduction to GPS technology and the particular GPS unit they will be using prior to doing this exercise.

A short talk about the experiment to determine the circumference of the earth done by Eratosthenes of Cyrene (273-192 BC) would be beneficial. While Eratosthenes used angles of the sun's rays between two locations a measured distance apart, this exercise will use modern GPS technology to determine the circumference of the earth. A GPS will be used to determine the latitude of two points that are north and south of each other.

The distance between these north and south points will also be measured using a tape measure (or other devise of your choice). These two measurements – the difference between the latitude values of the north and south points and the distance in feet or meters between them – form the basis for a "simple" ratio problem. That is, if you know that there is 360 degrees in a circle and you determine the number of decimal degrees and for a measured number of feet or meters, you can determine the earth's circumference. (see equations in exercise).




As part of this exercise you can also discuss accuracy, precision, errors, error propagation, significant decimal places and the difference between using Latitude or Longitude. You can also use it to learn conversion of units on a GPS.

1. Find a place that is out of traffic that allows you to walk in a north/south direction for at least 500 feet - the longer the better.

2. Use a compass or GPS to determine the north/south path and locate a "point" at the north and south end. Use a measuring tape (or another device) to determine the distance between your two end points and record the exact "distance in feet" (note: you could make this a metric exercise and collect data in meters).

3. Take a GPS reading at the north end and south end of the path. Record the Latitude and Longitude for each end point in decimal degrees. If you can "average" the points or do differential GPS, do so. You may want to bring your data into an ArcView project to

extend this exercise using different map projections and measuring tool units in ArcView, you may also do a "track" between the end points by taking a Latitude and Longitude reading every 25 feet or automatically if your GPS allows you to collect this data.

4. Subtract the Latitude reading for the south point from the Latitude reading from the north point to find the "distance in decimal degrees" between the two points.

   X.XXXXX – X.XXXXX = X.XXXXX

5. Use the ratios below and the conversion factor for feet to miles and then solve the prob lem to find unknown "X" which is the Circumference of the earth:

$$\frac{\text{“distance in decimal degrees”}}{\text{360 degrees}} = \frac{\text{“distance in feet”}}{\text{“X” feet}}$$

   5280 feet = 1 mile

   Solve the above equation for unknown X feet and cancel units

$$\text{X feet} = \text{“distance in feet”} \times \frac{\text{360 degrees}}{\text{distance in decimal degrees}}$$

   Use the feet to miles conversion factor to get "your value" in miles.

6. If the true value of the circumference of the earth is 24,819 miles, what is the error between "your value" and the "real value"? Determine the percent error using:

$$\text{X\% error} = \frac{\text{(“your value” in miles – “real value” in miles)}}{\text{“real value of circumference in miles”}} \times 100$$

7. What are sources of error – you should be able to name at least 4 sources:

8. How could you improve your measurement and reduce the error?

9. What would happen to the values if you measured the distance East and West instead of North and South? Does a decimal degree have the same "distance" in feet for Latitude and Longitude at your location?

10. You can extend this exercise by creating an ArcView project and bringing in your Latitude and Longitude data for your end points and path. You could then try different map projections, measuring units, etc. to see what happens to the path and the distance measurements.

11. You can also set up "teams" of students using different GPS equipment or measuring techniques to "compete" for the best (least) error.

This exercise was modified from one created by Houston Community College, Houston, TX, under an NSF Grant for GIS Workplace Exercises.