

## **Lesson Title: Where Am I? Trilateration**

### **County name and Author:**

Washington County, Oklahoma / Gary Layman

### **Skills used in lesson:**

Measuring length using the SI system  
Arithmetic

### **Objective:**

To demonstrate how GPS systems operate by modeling the operation of a GPS receiver.

### **Background Information:**

Orbiting above the earth are a number of Global Positioning System (GPS) satellites that help us determine positions on Earth. The concepts behind GPS positioning are very simple, but the application and implementation require amazing precision.

GPS positioning works on two basic mathematical concepts. The first is known as “trilateration” which means “positioning from three distances.” The second is the relationship between distance traveled, the rate (speed) of travel, and the amount of time spent traveling, or:

$$\text{Distance} = \text{Rate} \times \text{Time}$$

In GPS positioning the rate is how fast the radio signal travels, which is equal to the speed of light or 299,792,458 meters per second. Time is determined by how long it takes the signal to travel from the GPS satellite to a GPS receiver on earth. With a known rate and time, we can solve for the distance between satellite and receiver. Once we have a distance from at least three satellites, we can determine a 3 dimensional position on the surface of the earth.

### **Materials needed per group:**

Laminated Map with a 1 inch = 16 miles scale \*\*  
Tape  
Calculator(s)  
Push Pin or Thumb Tack  
1 piece of cotton string (approximately 1 meter in length)  
Metric Ruler with cm markings (at least 50 cm in length)  
4 different colors of Vis-a-vis wet erase markers (fine tip)

\*\*Note - This activity is based on the official Oklahoma state road map (2008) with a scale of 1 inch =16 miles. To use a different map scale, see the Excel calculation spreadsheet that accompanies this lesson.

### **Advanced Preparation:**

Laminate the maps. We also trimmed the maps to remove the excess printing and attached them to two pieces of white poster board before laminating. This provided several inches of white space around the map to mark satellite locations and made the maps sturdier.

Choose a location to be determined by the participants. It is usually more interesting if the chosen location is NOT the same as the location of the activity. For example, if the activity is being done in Madill, you might choose the state capitol as the location to be determined (or a major university).

Using one of the metric rulers and a black Vis-à-vis marker, mark the position of Satellite A. Measure the EXACT distance from your chosen location as indicated in the following Table \*\* and make a small dot and labeling it with the letter of the satellite. Continue marking satellite locations B, C and D, choosing a different direction for each new satellite. If all satellites are placed in the same direction, accuracy will suffer (as is true with actual satellites).

Satellite A	41 cm
Satellite B	37 cm
Satellite C	43 cm
Satellite D	35 cm

\*\*If you would like to use different distances, see the Excel calculation spreadsheet that accompanies this lesson

### ***Step by Step Activity:***

See Student Handout

### **Wrap Up Questions:**

Why don't all of your lines cross in exactly the same spot?

*Inaccurate measurement of string*

*String was stretched*

*Rounding error*

Take a look at how close you came. What would you say about your level of accuracy?

*Answers will vary*

### **P.A.S.S. Objectives:**

High School Math

*Process Standard 4.1 – Link mathematical ideas to the real world (e.g., statistics helps qualify the confidence we can have when drawing conclusions based on a sample).*

*Process Standard 4.2 - Apply mathematical problem-solving skills to other disciplines.*

High School Physical Science

*Process Standard 4.1 - Select appropriate predictions based on previously observed patterns of evidence.*

*Process Standard 6.3 - Use a variety of technologies, such as hand tools, measuring instruments, and computers to collect, analyze, and display data.*

**Additional information resources:**

<http://oceanservice.noaa.gov/education/kits/geodesy/welcome.html>

Based on an activity developed by the National Ocean Service for a National Science Teachers Association Symposium, NSTA National Conference on Science Education, St. Louis, Mo, March 31, 2007. Similar lesson available on the Ocean Service website as “I Know Where You Are!”