Navigation Lesson Plan Using GPS

Target Class: Advanced Algebra – primarily consisting of sophomores and juniors.

Overview: This lesson is being used primarily as an introduction to GPS and some of its uses and as a graphing exercise. I will conduct this lesson within the first two weeks of the year as a refresher/review exercise in graphing, and as an introduction to a new technology. Since some of the exercise will be conducted out of the classroom, early in the school year works best for weather conditions also.

Materials: 24 GPS Units
Graph paper

Vocabulary: GPS, latitude, longitude, triangulate, elevation angle, waypoint

Focus Question: What is GPS, how is it used and why is it useful?

Sources: Soumis, Corey. *Personal discussion.*


Objectives: Students will be able to:
1) Operate a GPS Unit
2) Understand how GPS works and some of its limitations
3) Have a better understanding of the history of GPS
4) Have an understanding of longitude and latitude
5) Map a course using longitude and latitude on the x- and y-axis
Standards:  

**Standard I.1** Students recognize similarities and generalize patterns, use patterns to create models and make predictions, describe the nature of patterns and relationships, and construct representations of mathematical relationships.

**Standard II.1** Students develop spatial sense, use shape as an analytic and descriptive tool, identify characteristics and define shapes, identify properties and describe relationships among shapes.

**Standard II.2** Students identify locations of objects, identify location relative to other objects, and describe the effects of transformations (e.g., sliding, flipping, turning, enlarging, reducing) on an object.

**Standard III.1** Students collect and explore data, organize data into a useful form, and develop skill in representing and reading data displayed in different formats.

**Standard III.2** Students examine data and describe characteristics of a distribution, relate data to the situation from which they arose, and use data to answer questions convincingly and persuasively.

**Standard IV.1** Students examine data and describe characteristics of a distribution, relate data to the situation from which they arose, and use data to answer questions convincingly and persuasively.

**Standard VI.2** Students investigate practical situations such as scheduling, routing, sequencing, networking, organizing and classifying, and analyze ideas like recurrence relations, induction, iteration, and algorithm design.

Procedure:  **DAY ONE**

I will begin the first day by giving the students a pre-test on GPS. I will explain to them that the pre-test is NOT graded, but used as a reference to see what knowledge is gained throughout the lesson.

The pre-test is as follows:

**GPS Questions:**

1. *What is GPS? Describe the three major components of GPS.*

2. *In what field conditions will the use of GPS be limited and why? Because of such situations, what should a GPS user have in addition to a GPS unit? List at least three items of importance.*
3. What are latitude and longitude? How are they used?

**GPS Answers:**

1. The Global Positioning System (GPS) is a navigation system first thought of by the U.S. Department of Defense in 1960. The system became operational in 1995 and has since been adopted by the civilian sector. The system consists of a network of 24+ **GPS satellites** orbiting the Earth day and night emitting radio signals towards the Earth. Users receive the radio signals with a **GPS receiver**. Four signals must be received in order to triangulate and time synchronize the user’s position, or orientation, on the Earth. The third major component of GPS is the **GPS ground control**. Ground stations monitor the position of the GPS satellites, control the satellites, and maintain the system.

2. Several conditions can interfere with the radio signals emitted by the GPS satellites and therefore render the GPS receiver useless. One condition that many people misunderstand is that weather affects GPS... weather does not affect GPS as the radio signals can penetrate through clouds, rain, snow, and just about any weather condition that a user might encounter. Conditions that do affect the reception of the GPS satellite radio signals are dense canopy cover such as in the rainforest, or in dense foliage and cover of some Upper Peninsula forests. The GPS radio signals cannot penetrate rock, block, brick or any related substances and therefore a GPS cannot be used inside a building and may become limited when in deep canyons of mountainous regions. A third major area where GPS becomes limited is in areas of large building such as city streets or between two or more substantial buildings. The radio signals must be able to reach the GPS receiver in order to orient the user’s position on Earth.

Because of these situations there are several items of importance that a GPS user must have in addition to the GPS receiver. First and foremost is common sense... the person must at all times be considering his or her position in relation to landmarks so that the person is familiar with the surroundings and where he or she is. Related to this is to let someone know where you are going and how long you plan on being gone for... this includes letting your administration know where you are going when taking a group of students out in the field. Other major items of importance include a compass. A compass is a basic tool of orientation and navigation whose importance must never be underestimated. The basic compass does not require batteries and will work in nearly all conditions. In fact, many recommend that a person have one compass for continuous use when going into parts unknown and a second backup compass stashed away in a backpack or clothing pocket. A map of the area is important, as it will have landmarks printed on it to help the user find his or her way and orient themselves to their surroundings. In particular, a topographic map is important to have when going out in the natural field. In addition, a GPS receiver requires
electrical energy to function, so either an AC adaptor if you are in a vehicle or extra batteries are highly recommended in case the batteries lose their charge when out in the field.

3. Any location on Earth is described by two numbers – its latitude and longitude.

**Latitude** - Imagine the Earth was a transparent sphere (actually the shape is slightly oval; because of the Earth’s rotation, its equator bulges out a little). Through the transparent Earth (drawing) we can see its equatorial plane, and its middle the point is $O$, the center of the Earth. To specify the latitude of some point $P$ on the surface, draw the radius $OP$ to that point. Then the **elevation angle** of that point above the equator is its latitude. On a globe of the Earth, lines of latitude are circles of different size. The longest is the **equator**, whose latitude is zero, while at the poles—at latitudes $90^\circ$ north and $90^\circ$ south (or -90°) the circles shrink to a point.

**Longitude** - On the globe, lines of constant longitude ("meridians") extend from pole to pole, like the segment boundaries on a peeled orange. Every meridian must cross the equator. Since the equator is a circle, we can divide it—like any circle—into 360 degrees, and the **longitude $\phi$ of a point** is then the marked value of that division where its meridian meets the equator. What that value is depends of course on where we begin to count—on where **zero longitude** is. For historical reasons, the meridian passing the old Royal Astronomical Observatory in Greenwich, England, is the one chosen as zero longitude. Located at the eastern edge of London, the British capital, the observatory is now a public museum and a brass band stretching across its yard marks the "prime meridian." Tourists often get photographed as they straddle it—one foot in the eastern hemisphere of the Earth, the other in the western hemisphere.

**DAY ONE CON’T**: After going over the answers to the pre-test, the rest of the first day can be spent introducing the students to what GPS is. Here is a key point that I need to make sure the students understand:

- GPS receivers take signals from several different satellites to "triangulate" their position.

I will then bring the kids to the courtyard to practice using the GPS units. I will have them write mark as waypoints, the corners of the buildings, the bottom of the staircases leading into the inter-connect, and the flagpole.
When all groups have marked the waypoints described above, we will go back to the classroom to discuss the results. This will be a perfect time to illustrate to the students that the GPS units are not perfect; they have error in their results. By looking at the different results from each group, this point will be made clear.

Homework – Each person in the class will take the GPS unit home. On their way home, they must mark a minimum of 40 waypoints. They will be using this information tomorrow to form a map of their trip from school to their house.

**DAY TWO**

Students will make a map of their trip home using the waypoints they recorded earlier in the week. Longitude will be on the x-axis, and latitude will be on the y-axis. It will be the student’s responsibility to set up the axes in a way that maximizes the space on the graph paper, but all waypoints fit on the map. At the end of the hour, students will turn in their map with all 40 waypoints labeled, and their list of waypoints used (latitude and longitude readings). The map will be worth **20** points and will be graded as follows:

- 40 waypoints used and labeled - 10 points
- Map maximizes space, has a title and compass directions - 5 points
- Clarity and neatness - 5 points