

Focused Learning Lesson
Science
Grades 9-12
SI-H-B3

Overview:

This lesson enables students to examine global positioning satellite technology used in the study of the Earth and describe its impact on society.

Duration: This lesson takes one or two 40-45 minute class periods.

Benchmark:

SI-H-B3 communicating that scientists rely on technology to enhance the gathering and manipulation of data

SI GLE: 14. Cite examples of scientific advances and emerging technologies and how they have affected society.

Benchmark:

SI-H-A3 using technology and mathematics to improve investigations and communications

SI GLE: 5. Utilize mathematics, organizational tools, and graphing skills to solve problems.

Objectives:

1. The learner will use the Internet to become acquainted with the Global Positioning System.
2. The learner will simulate the use of Global Positioning System technology to recreate a hike taken on a vacation.
3. The learner will construct a map that traces the stops on the hike as recorded in the hiker's log.

Teacher Preparation:

This lesson introduces learners to the technology of identifying location through the use of the Global Positioning System. (See Attachment 4 for Introduction to GPS) The lesson is divided into two parts, each requiring one class period of 45 minutes. The first part is optional, depending upon access to the Internet, and provides an introduction to the second part of the lesson.

The activity in this lesson can be effective with individual or small group participation.

Materials/Equipment/Resources:

Attachment 1, copies of all three pages

Drawing compass

Pencil

Metric ruler

Lesson Procedures:*Set or Opener for DAY 1:*

1. Ask learners if they have ever gotten lost, either while playing outdoors as a child, or on a vacation, or in any other situation. Choose one or two who respond to briefly describe how they either found their own way back or were rescued.
2. Briefly discuss with class how lost hikers or boaters or a downed aircraft or a stolen vehicle could be located. Allow learners to describe any methods of location they know.
3. Ask learners if they have heard of the “Global Positioning System” and allow a brief opportunity for them to offer what they already know.
4. Tell them that they will be using the Internet to find out more about the Global Positioning System before they will be asked to participate in a very important activity tomorrow.

Body of Lesson DAY 1:

1. Distribute student handout one. Divide the class into groups of 3 or 4, depending upon class size and how many Internet-ready computers are available.
2. Instruct learner groups to follow the instructions on handout one and to visit each web site on the list in order to gather the required information about the Global Positioning System (GPS). Each learner in the group will complete his own handout.
3. Group members may discuss and come to agreement on the answers or may choose to answer the questions individually.

Closure:

Each group can share several facts or pieces of information they learned about this technology and discuss any questions they still have about it.

Set or Opener DAY 2:

1. Tell learners that today they will use a simulation of the Global Positioning System to follow the trail of a group of lost hikers.
2. Spend a few minutes reviewing the major points about the GPS that they learned yesterday before moving to the activity.

Body of Lesson DAY 2:

1. Distribute student handout two, pages 1, 2, and 3, to each learner. Divide the class into groups of 3-4 learners, depending upon class size and available materials.
2. Review the instructions with the class. Remind learners that safety with the use of the drawing compass is very important.
3. Demonstrate the correct way to open a drawing compass, placing the pointer on the zero on the ruler and opening the compass until the point on the pencil arm is at the desired length. It may also be necessary to remind learners to use the metric edge of the ruler and that every numbered centimeter on the ruler contains

- 10 millimeters. Using “Metric only” rulers or placing opaque tape over the edge of the ruler with the inches will eliminate many mistakes.
- Each learner will construct his or her own map. Maps within a group can be compared for accuracy of measurement.
 - Groups of learners can discuss the analysis questions and answer them as a group.

Closure:

Conduct a whole-class discussion on the value of this technology to society and a compile a list of potential uses for the Global Positioning System.

Attachments:

- Attachment 1: Student Handout 1, Student Handout 2, pages 1, 2, and 3
- Attachment 2: Key for Handout 1
- Attachment 3: Map Key
- Attachment 4: Introduction to the Global Positioning System

Sample Assessment Items

- Locating a position using the Global Positioning System requires a minimum of how many measured distances?
A. 3 B. 4
C. 5 D. 6
- Which of the following would **not** be possible using the Global Positioning System?
A. Tracking the path of a hurricane
B. Following the trail of an animal
C. Tracing the route of an airplane
D. Locating Venus in the night sky

Key:

- A is the correct answer because the arcs drawn using at least three distances will intersect at or very close to a single point. If only two distance arcs are used, the arcs will intersect at two points. The use of more than three arcs increases accuracy.*
- D is the correct answer. It is not possible to use GPS to locate an object that is not at or relatively near the earth’s surface.*

Reference Links and Technology:

This activity is adapted from *The Borealis High Altitude Balloon Project*, Montana Space Grant Consortium, <http://www.physics.montana.edu/borealis/Classroom/gps2.asp>

<http://gps.faa.gov/GPSbasics>

This site provides basic operational information for the GPS and excellent graphics and animations.

<http://www.trimble.com/gps/what.html>

This site includes an animated overview of the components that make up GPS and how they work together to enable location of any point on the globe.

http://cfa-www.harvard.edu/space_geodesy/ATLAS/gps.html

This site includes a very thorough explanation of the science behind the GPS and links to a community and global mapping project in which schools can participate.

Attachment 1: Student Handout 1

Instructions: Visit the websites listed below and answer the questions that accompany each one.

1. Go to <http://www.garmin.com/aboutGPS/>
 - How many satellites make up the GPS network?
 - How many satellite signals must a GPS receiver have in order to get a 2-D (or on the ground) location? How many are needed to add altitude to the location?
 - Put your cursor over the image of the Street Pilot III and click on the image. From the menu on the right side of this web page under the heading of *Interactive Demo*, click on 360° Product View. What image is on the screen of the GPS receiver?
 - Click on the features listed to the right of the Street Pilot III. Describe how two of the features of this kind of GPS receiver would be useful.
2. Go to http://www.wildway.org/compass_gps.php#gps
 - Scroll down the page to the *GPS Systems* section. What three functions does the GPS receiver provide the user?
3. Go to <http://electronics.howstuffworks.com/gps1.htm>
 - What do people usually mean when they refer to GPS?
 - How is that different from what the GPS really is?
 - Scroll down the page until you get to the image of the NAVSTAR satellite. How are the satellites powered?
 - Scroll further down until you get to the artist's concept of the GPS constellation. The satellites orbits' are arranged so that signals from how many can be received from any one spot on the earth?
 - Scrolling further down the page, why is it necessary to receive signals from at least three satellites in order to pinpoint your position on the earth's surface?

*Optional section (for early finishers)

4. Among all of the important uses for the GPS there is also a new "sport" which Uses the receivers and has become very popular all over the world. Go to <http://www.geocaching.com/faq/> to find about *Geocaching*.
 - What is *geocaching*?
 - What is the approximate size of the area identified by the GPS?
5. Go to <http://www.pbs.org/wgbh/nova/longitude/gps.html>
 - Click on *Play GPS: The New Navigation* (either with or without the Flash Plug-in)
 - Play the game as instructed.

Attachment 1: Student Handout 2

Page 1

Global Positioning System Simulation

Following the Trail: Read all directions before starting the activity.

Materials:

Global Positioning System (GPS) Coordinate Map (student handout page 2)
Global Positioning System (GPS) Hike Log Sheet (student handout page 3)
Drawing Compass
Pencil
Ruler
Colored pencils (optional)

Instructions:

1. Use your pencil to darken a small dot in the upper *left* corner of the coordinate map. Label this corner dot “GPS Satellite #1”.
2. In the upper *right* corner darken a small dot and label it “GPS Satellite #2”.
3. In the *lower* right corner darken a small dot and label it “GPS Satellite #3”.
4. You will use the information on the GPS Hike Log Sheet to recreate the route taken by a group of hikers.
5. Place the pointed end of your compass on the zero mark on your ruler. Open the compass until the point of the pencil end is at 114 millimeters. This is the distance from position 1 to GPS Satellite #1. Remember that millimeters are the very tiny increments on the ruler and that there are 10 millimeters in each centimeter.
6. With the drawing compass open to 114 mm, set the point of the compass on the dot labeled Satellite #1 and lightly draw an arc on the map.
7. Use the ruler to measure the opening of your drawing compass to the distance in millimeters (mm) from position 1 to GPS Satellite #2 .
8. With the drawing compass open to that measurement, set the point of the compass *on the dot labeled Satellite #2, and lightly draw an arc on the map.*
9. Follow this procedure to draw an arc from position 1 to Satellite #3. The point where the three arcs intersect is the location of position 1. Darken a small triangle over the point at which the three arcs intersect. Label it Position 1. After you have located position 1 and labeled it, erase the arcs you drew on the map.
10. Use the data on the hiking log to repeat steps 5-9 for each of the other four positions.
11. Mark each identified position with a small, darkened triangle and its position number. Join the triangle positions with a line to trace the path the hikers followed.
12. Compare maps with other members of your group. Discuss any discrepancies.
13. Discuss and answer the analysis questions.

Attachment 1: Student Handout 2

Page 3

Global Positioning System (GPS) Hike Log Sheet

Position Number	GPS Satellite #1 Distance	GPS Satellite #2 Distance	GPS Satellite #3 Distance
1	114 mm	90mm	116mm
2	113mm	114mm	114mm
3	101mm	125mm	125mm
4	127mm	167mm	125mm
5	150mm	150mm	84mm

Analysis Questions:

1. Why were three satellite distances necessary to locate each position?
2. How would knowledge of more than three satellite distances affect location of each position?
3. Who would benefit from this kind of technology?

Attachment 2 Key for Handout 1

Suggested answers to Attachment 1/Handout 1

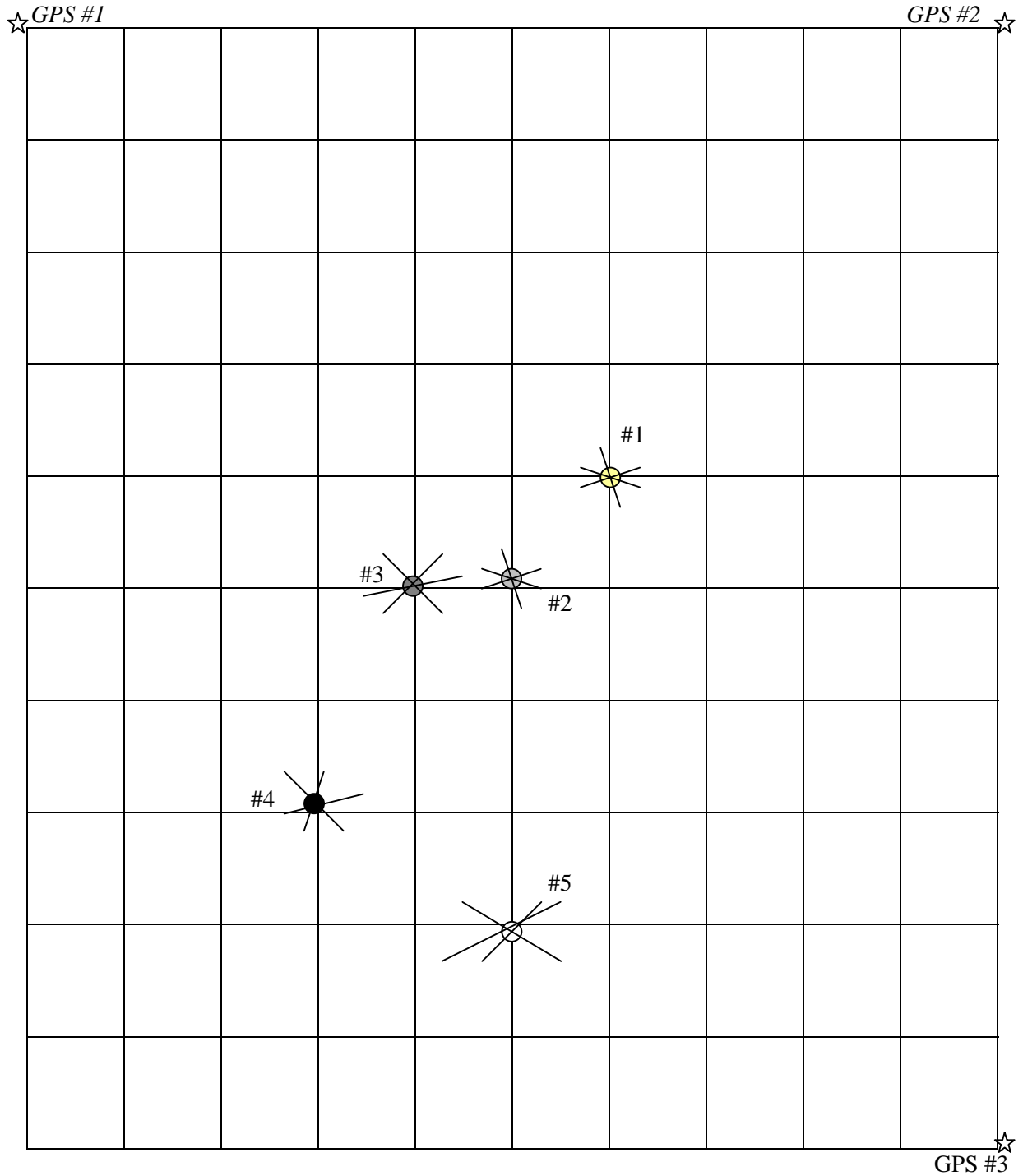
1. *See possible answers below.*
 - *24 in service, 3 in reserve*
 - *3 for ground location and a fourth to include altitude*
 - *a street map*
 - *answers will vary – brief descriptions of any two of the following listed features are acceptable*
volume adjustment for external speaker
high-contrast, backlit display
adjustable, movable antenna
waterproof
external power and speaker connections
one-handed operation
zoom in/out keys
2. *Pinpoint a location, navigate to predetermined destination, follow a complex route.*
3. *See possible answers below.*
 - *They are usually referring to the receiver.*
 - *The GPS is really the 24 satellite network.*
 - *The satellites are solar powered.*
 - *A minimum of 4 and a maximum of 8 at any one time and place*
 - *Three signals are needed so when the circles that extend from each signal overlap it will be at a single point or location. (Using only two signals would mean the circles would overlap at two points and a third is then needed to pinpoint the location).*
4. *See possible answers below*
 - *Geocaching is a hunt for a hidden cache of items. It involves using location clues and a GPS receiver.*
 - *Between 6 and 20 feet*
5. *Follow on-screen instructions to play the navigation game.*

Suggested answers to analysis questions:

1. *At least three satellite distances are required to locate the position to a single point. Use of only two satellite distances results in the two arcs intersecting at two points. The third satellite distance arc intersects the other two at a single location point.*

2. *Use of more than three satellite distances further refines the intersection of the arcs at a single point and confirms accuracy of the distance measurements.*
3. *The applications of this technology for the general public include:*
 - *Aviators*
 - *Bicyclists/motorcyclists*
 - *Skiers*
 - *Joggers*
 - *Fishermen*
 - *Hot air balloonists*
 - *Kayakers*
 - *Surveyors*
 - *Astronomers*

Attachment 3: Map Key Global Positioning System Coordinate Map



Note to Teacher: Due to variations in the quality and accuracy of compasses and student abilities, the compass arcs that come within a few millimeters of a single point and thus form a small triangle at their nearest meeting point should be considered accurate. The arcs do not have to intersect perfectly.

Attachment 4

Introduction to Global Positioning System Technology

The Global Positioning System (GPS) is a satellite navigation system made up of three parts: the satellites, the receiver, and the ground monitoring stations. Each component contributes valuable information that allows precise location of any position on the earth.

The satellite component is made up of 24 orbiting satellites that form a “constellation” of satellites surrounding the earth. Each satellite completes one orbit every 12 hours at an altitude of 11,000 miles above the earth’s surface. Each satellite transmits its current time and location information toward the earth constantly. Because of the arrangement of the satellites in their orbits, their signals form overlapping circles on the earth’s surface, and a GPS receiver can detect and decode signals from several satellites simultaneously.

The receiving stations, some as small as a cellular telephone, use the travel time of the radio waves transmitted from the satellite and detected by the receiver to calculate distance. When the receiver compares the signals from three or more satellites, it can pinpoint a location with amazing accuracy.

The third part of the Global Positioning System is the set of ground monitoring stations. The five widely distributed ground-monitoring stations are spread across the globe, where they constantly assess altitude, speed, and overall health of the satellites. At any given time a single ground-monitoring station can detect between four and eight satellites. This data is fed to the Colorado Springs, Colorado, master control station, where necessary corrections are calculated and uplinked to the satellites. Because of the high altitude of the satellites, very small clock errors can result in unacceptably large location errors on the earth’s surface. Checks are made twice a day to keep the satellite data stream to the receiving devices within tolerable limits.

GPS receivers are found in navigational systems on ships, airplanes, and in some personal vehicles. They have become standard issue with emergency rescue personnel, and they are increasingly popular with recreational boaters, fishermen, and other outdoor enthusiasts. When combined with cellular telephone technology, they offer the public security in unfamiliar surroundings.

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