



# GPS on the Move



<b>Unit Topic:</b>	Navigation
<b>Grade Level:</b>	7 <sup>th</sup> grade (with suggestions to scale for grades 6 to 8)
<b>Lesson No.</b>	9 of 10
<b>Lesson Subject(s):</b>	The Global Positioning System (GPS), Using GPS receivers to navigate
<b>Key Words:</b>	GPS

## Lesson Abstract —

GPS technology is becoming very popular in cars and buses, sporting goods, cell phones, and many other commercial and professional products. In this lesson, students will learn how to use a hand-held GPS receiver in a scavenger hunt to find nearby locations. In the previous lesson, students explored two of the key aspects of GPS positioning: measuring distance by timing signals and finding location by measuring the distance to several known locations. This unit allows students to see a GPS receiver in action.

Teachers can request assistance from the Institute of Navigation to find nearby members with experience in using GPS and in locating receivers for their use. Check the ION website for links to local ION sections and member contact information ([www.ion.org](http://www.ion.org)).

(Please note: Mention of specific receiver manufacturers or brands does not constitute an endorsement by the Institute of Navigation or the University of Colorado.)

The activities include:

- [Activity 1: GPS Receiver Basics](#) – Students will familiarize themselves with the receiver operation, look at satellite visibility, walk in different directions and see their progress on a map. They will enter waypoints and use the GPS to guide them back to the marked spots.
- [Activity 2: GPS Art](#) – Students will write out a word or picture on a field, walk the path, and log GPS data. The results will show their art.
- [Activity 3: GPS Scavenger Hunt](#) – Students will use the receivers to find their way to waypoints and report back on what they found. They can compute distances between waypoints based on the latitude and longitude, and compare with the distance the receiver finds.

## Lesson Opening Topics / Motivation —

In the last lesson, we explored two of the key technologies that enable GPS to work. Today, when people use GPS to navigate, they really do not have to think about what is going on inside the receiver, but they do have to know how to use one correctly. Receivers come in all shapes, sizes, and price ranges with a wide range of uses. The ones in cars to help you navigate around

unfamiliar areas have built-in maps with voice prompts to guide you to a location. New receiver modules embedded in cell phones are used to report your position for emergency 911 calls, but most of the time you will not even know the receiver is there.

One of the most popular uses for GPS is for personal navigation. Handheld receivers that work with a few AA batteries are sold at many sporting goods stores at prices from \$100-\$500. These receivers are pretty easy to use for hiking, biking, and other outdoor activities. In this lesson, we will learn how to use a handheld GPS receiver, and in the activities students will actually try them out.

### **Lesson Desired Student Outcomes —**

Students will understand how to use a handheld GPS receiver to find their way around. They can explore how the receiver is affected by nearby buildings and people.

**Science:** Students should be able to:

- Predict (hypothesize). (1)
- Evaluate data from other students to formulate conclusions. (1)
- Describe how using and understanding maps and compasses can help determine your location. (5)

**Math:** Students should be able to:

- Use numbers to count, measure, label, and indicate distances on a map. (1)
- Identify grid coordinates. (2)
- Scale graphs. (4)
- Simplify fractions. (1)
- Create a bar graph. (3)
- Know compass directions and that there are 360 degrees in a circle. (3)
- Measure (or estimate) angle measurements in 45-degree increments. (5)

### **Colorado State Standards Met —**

<http://www.mcrel.org/compendium/search.asp>

- Science Standard 1, 5.
- Math Standard 1, 3, 4, 5.

### **Lesson Background & Concepts for Teachers —**

#### **Overview**

The following topics will be discussed:

- Basic Receiver Operation – what you can expect from a handheld GPS.
- Satellite Visibility - how the receiver shows you which satellites are visible and tracked.

- Waypoints and Tracks – how to mark locations and keep track of where you have been.
- Map Page – a graph of where you have been.
- Compass Page – directions on how to get somewhere.

## Basic Receiver Operation

Each GPS manufacturer and model works a little bit differently; but just like a VCR or TV remote control, they all have some common features. The receiver will include a built in antenna, sometimes under the plastic cover and sometimes one that flips up. To work properly, the antenna has to be able to have a clear view of the sky. Almost all GPS receivers will not work indoors. So the first step is to go outside in a relatively clear area and turn on the receiver. They will work fine in any weather conditions and any time of day. Figure 1 illustrates some examples of current (2003) handheld receivers from several manufacturers.



Figure 1. Examples of Handheld GPS Receivers

The receiver has a permanent memory that remembers its position from the last time that it was turned on, the time, and an almanac of the locations (actually orbits) of the GPS satellites. If your receiver was used relatively recently in a location not too far away, this information will be valid. So, when the receiver is powered up it will begin looking for the satellites that should be visible at the current time at your location. Once it acquires 4 satellites, it will begin showing your current location and the current time. At this point, it will show an indication that it is in 3D navigation mode. The time it takes to get to 3D navigation will typically be less than 1 minute, but it can sometimes take a bit longer, especially if you are not out in an open area.

If you have a brand-new receiver or you are located far from the position stored in the memory, the receiver will eventually go into what is called a “cold-start” mode. It may ask you to set an initial position by selecting a country or state from a list, or it can also begin searching for all possible satellites. Cold-start can take only a couple of minutes or as much as 10-12 minutes, depending on whether the receiver has a valid almanac. Again, once it tracks 4 satellites it will

begin 3D navigation. Depending on the receiver, it may switch screens/displays once navigation begins.

## Satellite Visibility

When the receiver is first turned on, it will display some type of satellite visibility page. Figure 2 below illustrates the Satellite page on the eTrex® receiver.

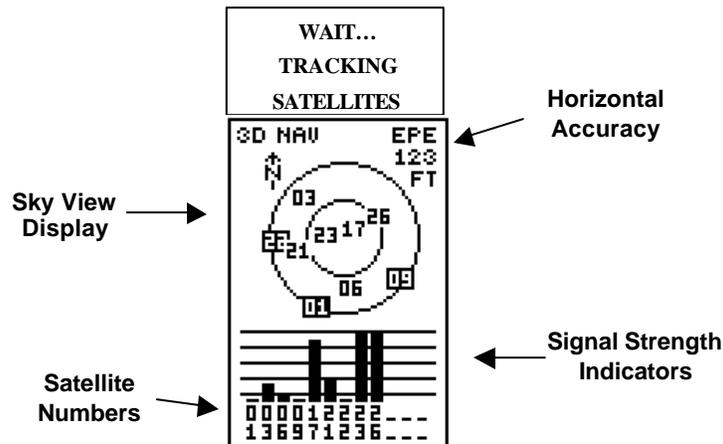


Figure 2. eTrex ® Satellite (Visibility) Page

The Satellite Page shows the satellites that the receiver thinks are currently visible from your location. The GPS constellation of satellites will always have a total of at least 24 satellites. Sometimes there are as many as 28 operating at the same time. This means that from any point on earth there should be at least 4 available in the sky above you at all times. The GPS satellites travel in orbits around the earth each with a period of 11 hours and 58 minutes. So depending on the time of day you go outside your receiver will see different satellites overhead. The same satellites will appear each day but their pattern in the sky will shift 4 minutes earlier each day. When a new satellite is launched or an old satellite is turned off, the receiver will be notified as soon as it tracks one of the other satellites in the constellation.

Each GPS satellite has a unique number that identifies it, sometimes called a PRN (pseudo random noise code number). The satellite number is shown on the bullseye plot and on the bottom of the screen.

The bullseye represents the sky above you. Satellites shown in the center are directly overhead. Satellites shown near the outermost ring are near the horizon. North is typically at the top of the screen, so in the example in Figure 2, Satellites 17 and 23 are high in the sky above and Satellite 01 is low on the horizon in the SSW direction. Satellite 06 is at an elevation of about 30 degrees to the south.

At the bottom of the screen are some bars that show the strength of each received satellite signal. A taller bar indicates a stronger signal. If you are close to a building that blocks part of the sky you'll see that the signals for satellites in the direction of the building will show a lower signal or possibly not be present at all.

When the receiver tries to acquire a satellite its number will be shown on the bullseye plot as white on black and the strength bar at the bottom will not be shaded. Once the satellite is tracked

and its data downloaded, the bar will become shaded and the number on the graph will change to black on white

## Waypoints and Track

GPS receivers allow you to enter and mark waypoints, and will keep track of the path you have traveled, also called the “Track.” Waypoints are a location of interest. They can be downloaded to the receiver from a computer, entered manually using the keypad, or “marked.” Marking a waypoint is the most straightforward. Let’s say you are at your car, about to start on a hike. Turn on the receiver and wait until it lets you know that it has a 3D position. If you MARK a waypoint, the receiver will record or save the current location and allow you to name the stored location. You might use the word “CAR” or any other convenient designation. Once a waypoint has been marked you can see it on the Map Page and use the Compass Page to get directions on how to get there. Different receivers will have differing capacities for storing waypoints. The eTrex® can store up to 500 waypoints.

Waypoints can also be transferred or downloaded to the receiver using a personal computer. To do this you need a serial cable and a computer program that can talk to the receiver. The cable will plug into the RS-232 port of the computer and on the other end in the to RS-232 port on the back of the receiver (usually under a cover of some type). A convenient program to use is “Easy GPS” available free of charge online. This program is described in more detail in the scavenger hunt activity. Most receivers will also accept waypoints from mapping software that is GPS – compatible.

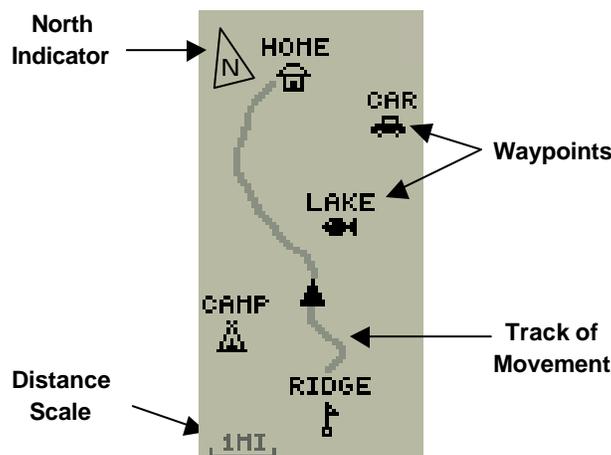


Figure 3. eTrex ® Waypoint Page

Figure 3 illustrates the waypoint page for the eTrex® receiver. When you enter a waypoint you can select the icon to be used to display it and the waypoint identifier (a name or number). You can also view the elevation, latitude, and longitude. Entering digits for the waypoint names can be a little tedious with the up/down arrows.

The receiver also keeps a record of where you have been. This is usually called the “Track.” The receiver automatically selects an interval of time or distance between points to provide a pretty smooth representation of your path without filling up the memory too quickly. The eTrex allows up to 1536 track points to be stored. This gives you several hours and many miles of path. The track is convenient for finding your way back to a location. You can also see your progress on

the map display. It is a good idea to enter waypoints along your path to identify points of particular interest, rather than just relying on the track.

## **Map**

The Map Page shows a schematic of your surroundings including nearby waypoints and your track. Waypoints are points of interest that you have entered or collected into the receiver. The track is a representation of your path sometimes called a “breadcrumb trail.” The up and down arrow buttons on the receiver allow you to zoom in and out depending on the distances you are traveling. The smallest size is 200 ft., which is most useful for foot travel. The largest size goes all the way out to 800 mi. for cross-country trips.

In general, the biggest difference between very low cost receivers (in the \$100 range) and the next step up (\$200-\$400) is the inclusion of maps. The very low cost receivers will generally not include any built-in or downloadable maps. By using receivers at the next price level you can expect to have some stored maps, possibly only of major highways, and some ability to input more localized maps from your personal computer or PDA. For this exercise we assume that you are using a receiver without local maps. If you have better models available, the screens showing your position on the map will be more useful and interesting.

## **Compass Page**

Once you have entered a waypoint, you can use the compass page to tell you how to get there. First you go to the waypoint page and pick the one you want to go to. After you enter it, go to the compass page where you’ll see a compass indicating the direction you need to take to get to the waypoint, the distance to go, and time at your current speed. The compass will only indicate the right direction while you are moving. It does not contain a magnetic compass, but rather figures out the direction of travel relative to true north based on your motion.

## **Lesson Vocabulary List —**

- **GPS or Global Positioning System** – This is a system that allows anyone with a receiver to determine their location. It is based upon a series of satellites that broadcast information down to the earth’s surface. A receiver (available to the public) picks up these broadcasts to determine its location.

## **Activity Attachments —**

[Activity 1: GPS Receiver Basics](#) – Students will familiarize themselves with the receiver operation, look at satellite visibility, walk in different directions and see their progress on a map. They will enter waypoints and use the GPS to guide them back to the marked spots.

[Activity 2: GPS Art](#) – Students will write out a word or picture on a field, walk the path, and log GPS data. The results will show their art.

[Activity 3: GPS Scavenger Hunt](#) – Students will use the receivers to find their way to waypoints and report back on what they found. They can compute distances between waypoints based on the latitude and longitude, and compare with the distance the receiver finds.

## Lesson Closure and Follow-up —

Ask students what they thought about using GPS. How would the waypoint functions be useful for hiking or other outdoor activities? (They can let you find out the location of bridges, waterfalls, picnic areas, trail junctions, campsites, etc) What extra features would you like to see in a receiver? (Up-to-date maps, an MP3 player, a camera, a cell phone) Would you like to have a receiver with you when going to an unfamiliar area? What about on a trip that you have done many times before? (Yes- it is possible to get lost in many places- the trail could be blocked, a snowstorm could suddenly cover your tracks, somebody could get hurt and need to be taken out in the quickest possible route, etc)

## Lesson Extension Activities —

Use the Internet to investigate different types of receivers and their features. What differences do you find in capabilities and costs? Are the extra features worth it?

## Lesson Assessment and Evaluation —

### Pre-Lesson Assessment

- Discussion Question: Solicit, integrate, and summarize student responses.
  - How do you find your way to an unfamiliar place? How do you find your way back? (Answer: See Lesson Opening Topics/Motivation section above.)

### Post-Introduction Assessment

- Voting: Ask a true/false question and have students vote by holding thumbs up for true and thumbs down for false. Count the number of true and false and write the number on the board. Give the right answer.
  - True or False: A GPS receiver will always work within two minutes after it has been turned on. (Answer: False.)

### Post-Lesson Assessment

- Flashcards: Each student on a team creates a flashcard with a question on one side and the answer on the other. If the team cannot agree on the answer, they should consult the teacher. Pass the flashcards to the next team. Each member of the team reads a flashcard, and everyone attempts to answer it. If they are right, they can pass the card on. If they feel they have another correct answer, they should write their answer on the back of the flashcard as an alternative. Once all teams have done all the flashcards, clarify any questions. Sample questions follow if you need to help students with ideas:
  - Does the GPS receiver always show you the right way to go?
  - Does the GPS receiver indicate north when you are standing still? How about when you are moving?

## Lesson References —

Handheld receiver manufacturer web pages with online user manuals:

<http://www.garmin.com/outdoor/products.html>

## Lesson 9: Activity 1 - GPS Receiver Basics

This activity is planned for 28 students working in teams of two.

### Activity Materials List —

For each team:

- GPS Receiver
- Paper and ruler

### Activity Cost Estimate —

Minimal (with borrowed GPS receivers)

### Activity Equipment and Tools List —

None

### Activity Attachments —

[Worksheet](#)

Receiver User Guide

### Activity Time Estimate —

30 – 40 minutes

### Activity Procedure —

#### Before the Lesson

Set up all the GPS receivers to the default or common settings. You will need to check the following:

- Clear the current track
- Set the Units to the factory default or to another common setting that you prefer
- Set the time on all receivers to show either local time or UTC time (Greenwich).

#### With the Students

1. Go out into a large open field or park. Turn on the receivers and look at the satellite page. On the eTrex® receiver, make sure that the satellite page is in “advanced” mode.
2. Sketch the satellite visibility picture and point out the directions to the satellites in the sky. Notice any buildings or trees nearby that might block your view.
3. Try covering the top of the receiver with your hand and see that the signal strengths of all the satellites are lost.
4. Uncover the antenna and try moving closer to a building or bunch of trees. Describe what happens to the satellite signals. Can you predict which satellites will be blocked using the satellite display?

5. Estimate the direction along one edge of the field. Begin walking in that direction and watch your motion on the map page. Check your direction on the compass page. How well does the direction match what you estimated?
6. Check your speed on the compass page. How fast are you moving? What happens to the compass page if you stop or move slowly?
7. MARK a location and enter a name for this waypoint. Walk across the field and MARK a second waypoint.
8. Use the GOTO function to tell you how to get from waypoint 2 to waypoint 1. How good were the directions?
9. Now stand still with the receiver. Every once in a while mark your location. Go back and look at your waypoints. How much are they changing even though you are not moving?

### **Math Skills Reinforced —**

6<sup>th</sup>, 7<sup>th</sup> and 8<sup>th</sup>: Students will learn that math is fundamental in technology. Students will measure and calculate values from acquired data. They will also gain a real sense of velocity and distances.

### **Activity Troubleshooting Tips —**

Make sure you have plenty of spare batteries, as the receivers may use them up quickly. If the receiver cannot find satellites pretty quickly, make sure that someone is not blocking the antenna. The antennas are usually located under plastic at the top of the receiver. The receivers are set up so that if you hold them flat in your hand the antenna will have a good view of the sky.

### **Activity Desired Student Outcomes —**

After this activity, students will be able find their way around with a GPS receiver, understanding how their track is shown on the screen. They should also have a good sense for locating satellites in the sky and following the directions given by the receiver.

### **Activity Assessment & Evaluation —**

#### **Pre-Activity Assessment**

- Prediction/Discussion: How accurate do you think the GPS you are using are? What is the minimum number of satellites needed for the GPS to work? (Answer: Four.)

#### **Activity Embedded Assessment**

- Worksheet: Have student complete the [Worksheet 1](#).

#### **Post-Activity Assessment**

- Question/Answer: What is the Satellite Page used for? (Answer: It shows you the satellites in a bullseye.)? Why does it matter? (Answer: The satellites in the center are directly overhead; the satellites in the outmost ring are near the horizon.)
  - Question: How good were the directions given by the receiver to get to your waypoint? (Answer: probably pretty good if the points are far apart, but not very reliable if they are very close together.)

### **Suggestions to Scale Activity for Grades 6 to 8 —**

- 6<sup>th</sup>, 7<sup>th</sup> and 8<sup>th</sup> Grade: Do activity as is.

## Lesson 9: Activity 1, Worksheet 1 - GPS Receiver Basics

Name: \_\_\_\_\_ Date: \_\_\_\_\_

1. Turn on the GPS receiver and look at the satellite page. Sketch the satellite visibility picture below and label the direction to the satellites in the sky.

2. Cover the receiver with your hand. Does the reception change for the better or the worse? \_\_\_\_\_
3. Uncover the receiver and move close to a building or a tree. Describe what happens to the satellite signals as you move closer to the building or tree:  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_.
4. Are you able to predict which satellite signals get blocked by the obstacle? Try moving back and forth to various obstacles. Can you predict them now? Why or why not?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_.
5. Use a compass to determine the direction of one side of the field. Write the direction from the compass here: \_\_\_\_\_.
6. Now, use the GPS receiver. Walk along the edge of the field. Record the direction from the GPS receiver here: \_\_\_\_\_.

7. How well do the GPS receiver and the compass match? Which is more accurate?

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8. Check your speed on the compass page. How fast are you moving when you walk at a normal pace? \_\_\_\_\_ How fast are you moving when you run along the edge of the field? \_\_\_\_\_. What happens to the compass page if you stop repeatedly or walk really slowly? Why?

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9. Time how long it takes you to walk the length of the field or room that you are in, then calculate your speed by using the following formula:

$$\text{Speed} = \text{Distance} / \text{Time}$$

What is your speed? How does it compare to what the GPS calculated?

(Note: 1 foot/sec = 0.3 m/s = 0.68 mph = 1.1 kph)

10. Mark a location in the GPS receiver. Label this waypoint with the first four letters of your name. Walk across the field and label another waypoint with the first four letters of your last name.

11. Use the GOTO function to tell you how to get from waypoint 1 to waypoint 2. Are the directions good? Why or why not? \_\_\_\_\_

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12. Stand in one spot with your receiver. Mark your location- in the SAME spot- on your receiver every three minutes. Does the waypoint change at all? Why? \_\_\_\_\_

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## Lesson 9: Activity 2 - GPS Art

This activity is planned for 28 students working in teams of two.

### Activity Materials List —

For each team:

- GPS Receiver
- Paper and ruler

### Activity Cost Estimate —

Minimal (with borrowed GPS receivers)

### Activity Equipment and Tools List —

None

### Activity Attachments —

[Worksheet](#)

Receiver Users Guide – Should be available with the receivers or online

### Activity Time Estimate —

30 – 40 minutes

### Activity Procedure —

#### Background

GPS has some very serious uses like navigation of ships at sea, airplane landing systems, and search and rescue. It is also used for fun. Farmers today are using GPS to design and plow corn mazes! Figure 1 shows a corn maze designed using GPS and inexpensive software. To make the maze, a GPS engineer took an image of the picture using mapping software to produce a set of coordinates. These were then downloaded into driving instructions on the farmer's tractor-mounted GPS receiver. The farmer plowed the maze following the GPS instructions.



In this activity students will design their own logo or picture and use the handheld GPS receiver to map it out.

### **Before the Lesson**

Set up all the GPS receivers to the time on default or common settings. You will need to check the following:

- Clear the current track.
- Set the Units to the factory default or to another common setting that you prefer.
- Set the all receivers to show either local time or UTC time (Greenwich).

### **With the Students**

1. Sketch a single letter, word or picture that you want to trace with your GPS receiver on a sheet of graph (or quadrille paper). Try keeping it pretty simple (straight lines are much easier to follow than curves).
2. Orient the paper in the direction of an open field where you will do your exercise. Determine the heading or direction of each line segment in your picture.
3. Pick a scale to map your picture to a distance you will walk in the field. Think about how big it has to be for the handheld GPS to be accurate enough to use. You can try a couple of different line lengths and see what works best.
4. Start at the beginning of your picture. Mark the starting waypoint.
5. Head in the direction indicated by your picture for the distance you want. Enter additional waypoints at each turn.
6. When you are done, check out your picture on the map display. How does it look? How well do the edges and corners meet?
7. Put the waypoints together in a route and try to retrace your picture. Did it work?

### **Math Skills Reinforced —**

6<sup>th</sup>, 7<sup>th</sup> and 8<sup>th</sup>: using geometry and scaling in order to draw a sketch.

### **Activity Troubleshooting Tips —**

Make sure you have plenty of spare batteries. Try doing simple letters first like an “H” or “E.” Use the GOTO functions to get you back to an intersection. Make the picture large for best results. If it is too small, the errors in GPS will be very noticeable and you might not get a legible picture.

### **Activity Desired Student Outcomes —**

Students should be able to understand how to use a GPS receiver to “map” an image — in their case their own logo or other created art.

## Activity Assessment & Evaluation —

### Pre-Activity Assessment

- Prediction/Question: What is the biggest size a person can write their name? In the sand for example or in corn crop? How would they do it? What things would they use? Ask them about the ways in which the famous crop circles could have been made? (They might say Aliens!)

### Activity Embedded Assessment

- Worksheet: Have students complete [Worksheet 1](#).

### Post-Activity Assessment

- Question/Answer:
  - Question: How does the satellite page show you where the satellites are? Why does it matter?
  - Question: How good were the directions given by the receiver to get to your waypoint? (Answer: probably pretty good if the points are far apart, but not very reliable if they are very close together.)

## Suggestions to Scale Activity for Grades 6 to 8 —

- 6<sup>th</sup>, 7<sup>th</sup> and 8<sup>th</sup> Grades: Do activity as is.

## Lesson 9: Activity 2, Worksheet 1 - GPS Art!

Name: \_\_\_\_\_

Date: \_\_\_\_\_

1. Sketch a single letter, symbol, or word that you would like to draw with your GPS receiver on the graph paper seen below. While drawing your picture, it is important to NOT lift up your pencil or pen; GPS receivers continuously track the path, and you cannot break the path in one picture. For example, a W is easy, and a lower case I is not. Straight lines are also much easier to follow than curves.



2. Orient the graph in the direction of the open field where you will make your drawing. Determine the direction of each line on your picture and label it.
3. Turn on your receiver, and mark a waypoint. Walk straight down the field while the GPS receiver is drawing your path. Stop as soon as the path reaches from top to bottom of the screen. Write down that distance here: \_\_\_\_\_. That will be your maximum distance vertically. Meaning that if you are doing a T, the long part of the T can be a max of that length. If your screen is a square that distance is also your max horizontally; for a rectangle you will have to make the width smaller. Now, fit a scale for your picture

according to that information; i.e. make the squares on your graph represent a 1-meter by 1-meter square.

4. Start at the beginning of your picture (where your pencil or pen FIRST touched the graph paper), and mark that as your first waypoint. Walk to the end of that line segment and mark it with another waypoint. Turn and follow the next segment, marking the end with another waypoint. Follow this method until your picture is complete!
5. Now, draw your picture as it appears on the display of your GPS receiver.



How good does it look compared to your initial picture? What did you change and why?

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How well do the corners and edges meet on your GPS receiver?

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6. Now, put your waypoints together in a route and try to retrace your picture according to the directions on the receiver. Does it work?

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Draw that picture here.



7. What causes the difference between each picture?

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8. What does this tell you about GPS in general?

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## Lesson 9: Activity 3 - GPS Receiver Scavenger Hunt

This activity is planned for 28 students working in teams of two.

### Activity Materials List —

For each team:

- GPS Receiver
- Paper and ruler

### Activity Cost Estimate —

Minimal (with borrowed GPS receivers)

### Activity Equipment and Tools List —

None

### Activity Attachments —

[Explorers Worksheet: Find Your Own Direction](#)

### Activity Time Estimate —

30 – 40 minutes

### Activity Procedure —

#### Background

GPS receivers are becoming standard equipment for outdoor enthusiasts. In this activity, students will try to find locations using their GPS receivers. We have done this activity on the University of Boulder campus with several student groups. We enter a list of waypoints on the campus, usually for points of interest like the library, the planetarium, student center, etc. The activity is not difficult, but it generally takes the students a while to get around. They like the idea of using the GPS to get somewhere and find their way back. We try to make it a little difficult by picking points that have buildings or other obstacles in between.

Another option for this activity for groups that want more outdoor experience is to do a “Geocaching” exercise. Geocaching groups hide small objects and give you the latitude and longitude of the object. Your task is to find the cache, enter your name in a logbook, and, in some cases, replace the object. Some caches are just signs that you are supposed to find. There are a number of websites listed at the end under resources where you can enter your location and you will receive a list of nearby caches. Watch out that you are using the same coordinates.

#### Before the Lesson

This activity requires a considerable amount of preparation by the teacher or the ION volunteer. You will have to select some interesting waypoints for the students to find, and enter them into one of the receivers. You can then use the EasyGPS® software to load the waypoints on all the other receivers. It can be a little tedious to reset and load each of the receivers. Try to pick some

waypoints that have a clear view of the sky and others where visibility might not be so great. Make sure that they are not too far away (or that students have enough time to make it there and back). We also try to pick some waypoints where you can take a direct path between them and others that have a building in the way.

Students should complete [Activity 1](#) on GPS Receiver Basics before doing this activity.

### **With the Students**

1. Give each group of students a receiver with preloaded waypoints and assign them to find one or more of the waypoints. They are to report back on what the waypoint was (i.e., a specific building, a tree, etc.) or you can hide something for them to find and bring back to the group at the waypoint.
2. Students should take notes on the directions given by the receiver. Are the directions accurate? What happens if you get off track? Does the receiver redirect you properly to the waypoint? Was it easy to find the object or location?
3. Use the trace back to get directions back to your starting location. How does this compare with the directions to a location you had not been to previously?

### **Math Skills Reinforced —**

6<sup>th</sup>, 7<sup>th</sup> and 8<sup>th</sup>: This particular activity highlights the usefulness of applied math in engineering. Students will understand that all types of math is being used when the GPS is guiding them from point to point.

### **Activity Troubleshooting Tips —**

It is a good idea to send an adult along with each group of students if the locations are far apart. Make sure to check battery levels before embarking on the scavenger hunt.

### **Activity Desired Student Outcomes —**

Students should be able understand and use GPS receivers to navigate.

### **Activity Assessment & Evaluation —**

#### **Pre-Activity Assessment**

- Prediction/Question: Do you know enough to use a GPS receiver to find a hidden object?

#### **Activity Embedded Assessment**

- Worksheet: Have students complete the [Explorers Worksheet](#).

#### **Post-Activity Assessment**

- Question/Answer:
  - Question: How did the directions given by the receiver on the way to the hidden object differ from the backtrack?
  - Question: Would you feel comfortable hiking to a location entered in your GPS receiver? Could you find your way back?

- Question: When would you not want to rely on GPS for navigation?

### **Suggestions to Scale Activity for Grades 6 to 8 —**

- 6<sup>th</sup>, 7<sup>th</sup> and 8<sup>th</sup> Grade: Do activity as is.

### **Lesson References —**

<http://www.geocaching.com/> - This is a great website that has lists of caches you can search by location, information on geocaching, and recommendations on GPS receivers.

<http://geocachingworldwide.com/> - An excellent source for geocaching information.

<http://www.easygps.com/> - Link for a free software package for automating the upload of waypoints to your receiver.



**Things to think about:**

Are the directions accurate?

What happens if you get off track?

Does the receiver redirect you properly to the waypoint?

Was it easy to find the object or location?

Answer the following:

1. For what type of activities would you use a GPS?

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2. What are the main limitations of a GPS?

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3. What are the main advantages of a GPS?

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4. How can GPS systems be improved?

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