CATCH ME IF YOU CAN:
Understanding the **G**lobal **P**ositioning **S**ystem

The global positioning system (GPS) is able to determine the location of anyone or anything which has a receiver. The complete global positioning system consists of 29 satellites and a GPS receiver which can decode signals from the satellites. The GPS receiver is what we can purchase in stores here on Earth. Each GPS satellite transmits radio signals which contain the current time. The GPS receiver uses the time stamp to determine how long it takes the signal to travel between the satellite and the receiver. In this manner the receiver can determine the distance to each satellite. Once the distance is known between the receiver and several satellites, the location of the receiver can be constructed. In addition, the Global Positioning System can determine the velocity of the receiver by calculating the distance between two locations, and how long it takes for the receiver to travel between the two locations.

In this activity students will reconstruct a two dimensional map of another student's journey with the same reconstruction methods used by the Global Positioning System. Students will also calculate the average velocity of the traveller between different positions along the journey.

1 Materials

To complete this activity each student (or group) will need the following materials:

- GPS Coordinate Grid Worksheet (attached)
- Advanced GPS Log Sheet (attached)
- Drawing Compass
- String (approximately 12 inches long)
- Pencil
- Colored Pencils
- Ruler
- Calculator
- 2 dice

2 The Journey

In this activity student Travellers will make a journey in several stages. Travellers will mark their positions along the way, recording their distance from three different GPS satellites. At each position along the journey students will roll two dice and will take the product of the numbers on the dice to indicate the time (in minutes) it took to travel to that position.

In the second part of the activity, student Mappers will use only the recorded distances from the GPS satellites to reconstruct the Travellers' journey. The Mappers will also calculate the average velocity of the Travellers between positions on the journey.

- Students may work individually or in groups. Each student (or group) should start with a blank copy of the GPS Coordinate Grid worksheet and a blank copy of the Advanced GPS Log Sheet. The students should write their names on the GPS Coordinate Grid and check

the box next to Traveller. The students should write their names under Travellers' Names on the Advanced GPS Log Sheet.

- Start by marking your starting location (position 1) with a dot someplace on the grid.
- Measure the distance from your starting location to GPS satellite #1 using a ruler. Always use the center of the black bullseye at the corner of each satellite image as the point you are measuring to. Record this distance on the Advanced GPS Log Sheet next to position 1, under GPS satellite #1.
- Next, measure the distance from your starting location to GPS satellite #2 using the ruler. Record this distance on the GPS Advanced Log Sheet next to position 1, under GPS satellite #2.
- Now, measure the distance from your starting location to GPS satellite #3 using the ruler. Record this distance on the GPS Advanced Log Sheet next to position 1, under GPS satellite #3.
- Mark a second point on the GPS Coordinate Grid, this will be the second position on your journey. Draw a straight line, with an arrow, from the starting position to the second position to indicate which direction you traveled.
- Roll two dice and take the product of the numbers on the face of the dice. Record the product on the Advanced GPS Log Sheet next to position two. This number indicates the time (in minutes) it took to travel from the starting position to position two. Do not fill in the last two columns on the Advanced GPS Log Sheet, they will be filled in later by the Mappers.
- Measure the distance from the second position to each GPS satellite as you did before and record these distances on the GPS Advanced Log Sheet next to position 2, under the appropriate satellite number.
- Repeat this process for as many positions as you would like to make on your journey (7 is a nice number). Measure carefully the distance from each position to each of the GPS satellites and record the information on your Advanced GPS Log Sheet.
- Roll the dice at each new position and record on the GPS Advanced Log Sheet the product of the numbers on the dice. This product represents the time (in minutes) it took to travel to that position from the previous one.
- Keep the map of your journey hidden from your fellow classmates. You classmates are going to try and reconstruct your journey next, and you wouldn't want them to know what it looks like ahead of time.

3 Which Way Did They Go, and How Fast Are They Running?

The information on the Advanced GPS Log Sheet constructed in Section 2 will be used to reconstruct a map of the journey taken by the those who made the log. In this portion of the activity the students will determine the location of the Travellers with the same reconstruction methods used by the Global Positioning System. Students will also determine the average velocity of the Travellers between each position along the journey.

- Each student (or group) should start with a blank copy of the GPS Coordinate Grid and a Advanced GPS Log Sheet which has already been completed by another student (or group). The students should write their names on the GPS Coordinate Grid and check the box next

to Mapper. The students should write their names under Mappers' Names on the Advanced GPS Log Sheet.

- Using a drawing compass and the GPS Coordinate Grid, construct a faint arc which is centered on GPS satellite #1 and has a radius equal to the distance indicated on the Advanced GPS Log Sheet from GPS satellite #1 to the starting position. You can use a ruler to measure the opening distance of the compass.

  If the compass will not open wide enough, use a string instead. Tie one end of the string to your pencis and use the ruler tomeasure a lenght of string equal to the distance indicated on the GPS Log Sheet. Use the string to construct a faint arc which is centered on GPS satellite #1 and has a radius equal to the distance indicated on the GPS Log Sheet from GPS satellite #1 and the starting position.

- Using a compass (or the string), construct a faint arc which is centered on GPS satellite #2 and has a radius equal to the distance indicated on the Advanced GPS Log Sheet from GPS satellite #2 to the starting position.

- You may notice that if you were to complete the compass circles around each of the first two satellites, they would cross in two different locations. This would make it difficult to know which is the position of the traveller. We can solve this problem, just as the Global Positioning System does, by using a third satellite.

- Using a compass (or string), construct a faint arc which is centered on GPS satellite #3 and has a radius equal to the distance indicated on the Advanced GPS Log Sheet from GPS satellite #3 to the starting position.

- The point where these three arcs cross is the only point on the grid which satisfies the distance requirements recorded on the Advanced GPS Log Sheet. Do to reconstruction errors, the three arcs may not touch exactly in one point. You can approximate the starting point by choosing the point in the center of the area where the three arcs overlap. This is the starting position of the journey you are trying to reconstruct. Mark this crossing point on the GPS Coordinate Grid with a colored pencil. If you have drawn the arcs lightly you may leave them in place, or you may carefully erase them.

- Repeat the process above to locate the second position on the GPS Coordinate Grid using the distances indicated on the Advanced GPS Log Sheet.

- Once you have located the second position, use a colored pencil to draw a straight line with an arrow from the starting position to the second position to indicate the direction of travel.

- Let the scale of the grid be 1/4 inch = 1/4 mile. Measure the distance between the starting position and position two with a ruler. Record this distance, in miles, on the Advanced GPS Log Sheet.

- The average velocity of the Traveller between the two positions you have recorded is the distance travelled divided by the time it took to travel that distance. Calculate the average velocity in miles/minute of the traveller between the starting position and position two and record it on the Advanced GPS Log Sheet.

- Repeat the above steps to locate all positions on the journey. Make sure to connect each position with a straight line and an arrow, to indicate the direction traveled. Measure the distance travelled, and use the recorded time to calculate an average velocity between each position.

- When you have completed reconstructing the journey from the information on the Advanced GPS Log Sheet, compare your map with the original map made by the student (or group) who constructed the Advanced GPS Log Sheet in the first place. How did you do? Were you able to figure out the path they took on their journey?

4 Activity Extensions

There is a less advanced version of this activity which has the students reconstruct the Travellers journey without calculating the average velocity between positions along the way. See the CHICOS website for a copy of this lesson. Other activity extension ideas are listed below.

- **A journey through town.** Copy the GPS Coordinate Grid onto a clear piece of acetate (overhead transparency). Lay the grid over a map of your town, or any town map. Now, as the students construct their journey they can mark the position at specific places in town. The next group, which reconstructs the journey, can indicate where the Traveller stopped (e.g. toy store, ice cream shop, local park).
- **An interdisciplinary extension.** Once this activity is complete have the students write a short story describing their adventures along the journey. Or, have them draw a map around the journey path on the GPS Coordinate Grid indicating where they went and what they saw along the way.
- Using the calculated velocity information, students could work into their story (or map) explanations as to why the Traveller was moving at a slow, or quick, pace during different legs of the journey (e.g. Traveller comes across grizzly bear and has to run, Traveller sprains ankle and hobbles along).

GPS Coordinate Grid

GPS
Satellite #1

GPS
Satellite #2

DATE:

NAME:

◇ MAPPER

◇ TRAVELLER

GPS
Satellite #3

Advanced GPS Log Sheet

Position Number	GPS Sat #1 Distance	GPS Sat #2 Distance	GPS Sat #3 Distance	Travel Time Δt	Travel Distance Δx	Average Speed v

TRAVELLERS' NAMES: _____

MAPPERS' NAMES: _____

DATE: _____