

Introduction to GPS and Geocaching

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Classroom session: 30-40 minutes

Field work: 60-90 minutes

Grade level: 6 - 12

Purpose: To familiarize students with GPS (Global Positioning Systems) and GIS (Geographic Information Systems).

Indiana Geography Academic Standards: 6.3.2: Use latitude and longitude to locate places on earth and describe the uses of locational technology, such as global positioning systems (GPS) and geographic information systems (GIS).

Objectives: Upon completion of this lesson/activity, students will be able to 1) locate their position on an appropriate map (topographic series 1:24,000 scale) by use of latitude and longitude, 2) enter latitude and longitude information into a handheld global positioning system (GPS) receiver, 3) use the GPS unit to locate several caches located in one of the St. Joseph County parks, 4) use this knowledge/skill to locate any position on Earth and tell how far and in what direction to travel to get there.

Background: Students should be familiar with the use of simple grid systems, such as the game “Battleship”, or by arranging classroom desks in rows and columns and finding a particular desk after labeling columns as numbers/latitude and the rows as letters/longitude. Students should also have a basic understanding of using a compass to determine direction.

Materials required:

- GPS receivers: optimal-1 unit for each two students; 1 unit for each 3-4 students. If there are more than 3-4 students per GPS unit, the class should be split into smaller groups and an alternate activity, such as a nature hike, should be planned.
- Compasses: optimal-1 unit for each two students; 1 unit for each 3-4 students.
- Pencils/pens, key rings, Slinky toys, etc.: 2-3 per student to be placed in cache boxes.
- Cache boxes: 3-4 Tupperware containers in which to hide prizes/trinkets. These boxes are hidden in the park by park staff.
- Easel & markers: used in discussion to re-familiarize students with use of latitude and longitude.
- Overhead projector & markers: Could be substituted for easel.

Procedures:

- Prior to student arrival, their chairs should be arranged in a grid and labeled (1A, 2C, etc.).
- When students arrive they will be handed a card with a grid coordinate printed on it (1A, 2C, etc.).
- Students should then find their seats by use of this grid system.
- Instructor will begin session by playing modified game of “Battleships” with students as ships.
- Instructor should show students an aerial/satellite photograph of their location and ask them to find their position. This demonstrates landmark navigation.
- Instructor should then show students an appropriate map of their location and demonstrate how lines of latitude and longitude are used to locate a particular point.
- Instructor then begins discussion of how GPS works (**see attached outline which should be modified to fit grade level**).
- Short recess.
- Instructor then demonstrates how to enter data into handheld GPS units.
- Students then break up into groups of two, three or four depending on class size. Each group is given a card with a letter of the alphabet printed on it.

- Students are then taken by instructors out into the park where they use GPS units to find caches hidden by park staff (four boxes). A different student should lead each segment of the cache hunt. When a cache is located, it will be opened and students will be allowed to take a toy/trinket marked with the letter corresponding to the letter assigned to that group. Cache box also contains coordinates of the next cache box so students will have to enter data to find next cache. When all caches have been located, students will use the GPS unit to return to the start point.
- Lunch or other activity planned by classroom teacher.
- Dismissal.
- If there are special needs students in the group, such as those in wheelchairs, this activity can be done on a large flat playground or parking lot.

Assessment:

- Were all students able to describe how latitude and longitude are used to locate a position?
- Were all students able to locate their position by latitude and longitude?
- Were all students able to enter data in the GPS unit?
- Were all students able to locate cache boxes by using the GPS unit?
- Did all students return to the start point?

Adaptations/Extensions:

- Cache boxes could include directions to observe the surrounding area and note what kinds of trees they see; what kinds of birds they see or hear; what types of natural features they can see.
- A cache could be located close to a historical site and students then would be told about the significance of the spot or area.
- A camera could be included in the cache box to allow students to photograph the area around the cache and place the photos in a cache hunt log book.
- After return to the start point, students could plot the cache locations on an appropriate map and include it in the log book.

Resources:

- GPS Made Easy: Using Global Positioning Systems in the Outdoors 3rd Edition
 - Lawrence Letham, ISBN: 0898868025
- The GPS Store GPS=Global Positioning System www.thegpsstore.com
- Garmin, Inc. www.garmin.com
- How to Read the Universal Transverse Mercator (UTM) Grid www.nps.gov/prwi/readutm.html
- Attached Outline for GPS and Geocaching

Attached Outline for GPS and Geocaching

Introduction

GPS is a satellite system used in navigation that allows us to determine our position 24 hours a day any place on the globe in any kind of weather. It was conceived in 1960 by USAF but in 1974 other military services joined the effort and the project was renamed Navstar Global Positioning System. The cost was \$10 billion and became fully operational in 1995. The system is administered by the US Department of Defense.

- 24 satellites circle the globe at 20,200km (12,552mi) above the earth
- beam radio signals to earth
- received by electronic device and converted into numbers and letters that correspond to a point on a map
- advantage-know position with certainty (accurate to about 15m (49ft)) on a map
 - work in any weather (heavy rain may distort signals)
 - work at night
- limitations-signals cannot penetrate dense vegetation, rocks, buildings, or landforms
 - do not work well in dense jungles or forests, narrow valleys or among skyscrapers
 - do not work underwater or in caves
 - sensitivity of antenna may prevent signal reception therefore no position fix

How GPS works. A short discussion on navigation history provides a background to help you understand the complexity of GPS but the GPS receiver transforms a highly technical system into a user friendly, reliable method to help us navigate in the outdoors.

- Early navigation
 - landscape features, rudimentary observation of stars and detailed knowledge of the local area
 - compass to orient
 - astrolabe, quadrant and sextant made possible determination of latitude
 - chronometer
 - Amerigo Vespucci sailed from Italy in 1499 with an almanac and chronometer. Knew that in Ferrara moon would cross Mars at midnight on Aug 23, 1499. Happened 6.5 hours later where he was, so he used difference in time and Ptolemy's value of the circumference of the earth to calculate his distance(longitude) from Ferrara.
 - accurate chronometer in 1735 helped accuracy but still lots of calculations and accuracy was about 1 mile with clear skies
- Radio navigation
 - equipment for radio navigation in 1912 but not very accurate
 - pulse radar in WWII (radar gun-speed gun)
 - send signals from two or more locations and measure time differences
 - GPS satellites broadcast numbers sequences-receiver has same sequences and knows when satellite started broadcasting-measures time differences and calculates distances from satellite
 - triangulation-know distance from three fixed locations
 - uses intersecting sphere to determine location
 - must have three or more for good fix-one satellite for time synchronization between satellite clock and receiver clock
 - ground station sends information to all satellites with location info, on all

- GPS Gee whiz
 - system tests in 1972 showed worst case accuracy 15m and best case 1 m
 - concern re: enemies of US so two levels of accuracy implemented
 - most accurate military and least accurate for unauthorized(civilian)
 - military specifications 16m but closer to 1m
 - civilian 15m to 100m due to SA (limited accuracy) SA (Selective Availability) was removed in May 2000 accuracy now 15m but often closer to 6.3m.
 - three parts
 - ground control segment-monitor exact orbits kind satellite status
 - space segment-broadcast signals used by receivers to calculate position
 - P code and CA code. P code 7 days: CA code every millisecond
 - satellites broadcast on two frequencies L1 and L2 (P on both and CA only on L1)
 - user segment
 - military uses P code but stores both
 - civilian uses CA which limits accuracy. Prior to May 2, 2000 SA was used to degrade accuracy (changed time CA was broadcast so it was not synchronized between satellites)
 - turn on GPS-downloads almanac from all satellites. Could take 12 minutes for Time to First Fix (TTFF) normally about 1-2 minutes. If not used for more than 6 mos. or moved 300 miles from last fix longer TTFF.
 - P codes are broadcast on two frequencies to determine ionospheric delay. Civilian receivers only get one frequency so estimate delay-affects accuracy.

Why buy a GPS receiver

- GPS receivers excel at three basic tasks
 - it will lead you to a destination you choose from a map
 - it will calculate your present position so you can locate it on a map
 - it will store your present position in memory to help you return at a later time
- Activities in which you might use a GPS receiver
 - hiking
 - ski mountaineering
 - car travel (already in cars)
 - road rally-if GPS rally maps are not allowed (makes them too easy)
 - fishing
 - hunting
 - hang gliding
 - professional outdoor uses
 - kayaking/canoeing
 - search and rescue
 - caving(oops-does not work)
 - geocaching

Backing up your GPS

Manufacturers advertising notwithstanding, GPS do break, batteries fail, signals can be blocked, etc. *t* you should use a compass, map, watch and notebook to backup your navigation.

Why GPS receivers stop working

- dead batteries

- dropped
- water
- weak signal (poor antenna)
- signal turned off (not likely)

About GPS receivers

Lots of models; large for boats and airplanes to handheld units. Prices range from about \$100 to several thousand. Many features available so customer can pick the receiver best suited to his/her particular needs.

Antennas

- quadriplex helix
- patch (microstrip)
- external

Accuracy

- military- 1 m (not available to civilians)
- civilian before SA removed
 - horiz. 15-100m
 - vertical 100-156m
 - US DoD controlled accuracy (such as in the Gulf War of 1991)
- civilian after SA removed
 - horiz. 15m or better
 - vertical 100m

-affected by ionospheric interference, satellite geometry and reflected or multipath signals

- ionospheric interference-two signals sent-civilians get only one
- satellite geometry-like to have the spaced equally around sky and not too high(directly overhead is not good) nor too low on horizon
- reflected or multi-path signals-bounce off buildings/mountains, etc.
- altitude accuracy is not as good as horizontal so if you need altitude accuracy you should buy a good altimeter
- 2D mode less accurate than 3D mode (need 4 satellites to get 3D position fix (one to synchronize clock))

Map Datum

-Maps are drawn so every point is a known distance and height from a standard reference point called a map datum. Important to use proper datum as coordinates can differ depending on datum used.

- WGS 84: World Geodetic System 1984-world defined by GPS
- NAD 27: North American Datum 1927 Continental-Canadian/US maps
- NAD 83: North American Datum 1983 -US future maps
- OSGB: Ordnance Survey Great Britain-Great Britain, Scotland...
- Geodetic Datum 1949-New Zealand

Coordinate Grids

-a pattern of lines drawn on a map to uniquely identify every point. Grid describes a place on a map using letters and numbers called coordinates. Do not buy a GPS receiver that does not support UTM and latitude/longitude because these together cover the world.

- UTM-Universal Transverse Mercator: 11 U 703421m.E. 5662738m.N
- latitude/longitude: 42°4' 55.2"N 114°5' 44.6" W
- OSGB: SE 31000 55000
- UPS-Universal Polar Stereographic like -UTM
- MGRS-Military grid Reference System: 11 U QC 03421 62738
- Maidenhead: FN20FR

Computer Interface-unique to each receiver

Channels

- more is better
 - lock on in less time
 - more accurate
 - maintain lock in heavy foliage

Weight-of concern depending on mode of transportation

Waypoints or Landmarks-coordinates of a location (can be memorized)

Compass-KEEP IT! GPS receiver is dumb until you start moving

Bearing (Azimuth)-compass direction between points

North Settings-There is more than one north and when the receiver reports a bearing, you need to know which north it references. Two most important are true north and magnetic north. True north is referenced to the north pole. Magnetic north is referenced to the magnetic pole on Bathurst Island in northern Canada. Magnetic declination is the difference in degrees or mils, between the north pole and the magnetic pole from your position. You should not buy a receiver which does not provide both modes.

- true north-references the north pole and maps are referenced this way
- magnetic north-references are to magnetic pole-compasses reference magnetic north
- GPS receivers know declinations around the world and convert for you

Data Formats

- metric: kilometer, kilometers/hour
- nautical: nautical mile, knots
- statute: mile, miles/hour
- degrees
- mils

UTMs and Latitude/Longitude

Both are coordinate systems which can be used to uniquely identify points on a map.

Latitudes/longitudes cover the entire surface of the earth while UTM's cover the area between 80 degrees South Latitude and 84 North Latitude. Lat/longs are measured in degrees, minutes, seconds or degrees, minutes and tenths of minutes. UTM's are measured in meters. Both use the equator as the dividing line between north and south. Lat/longs use 0 degrees and 180 degrees for E/W reference and UTM's begin at 180 E/W and divide the world into 6 degree zones and are numbered 1-60. Each zone is split directly in two by a zone meridian from which the easting coordinates are measured and horizontally by the equator from which the northing coordinates are measured.