The Global Positioning System

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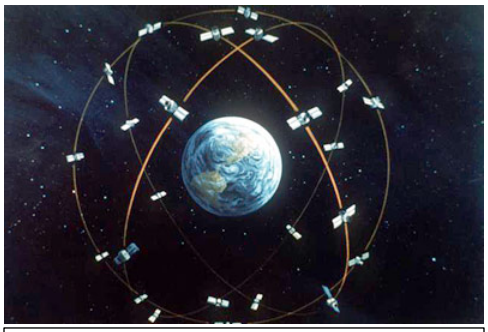
The **Global Positioning System** (**GPS**) is a network of Earth-orbiting satellites. They broadcast information about time and location that GPS receivers can use to determine your position on the surface of the Earth.



The Global Positioning System

The initial GPS network consisted of twenty-four satellites, orbiting the Earth every twelve hours. Anywhere from four to twelve of them are potentially observable at one time. Signals from at least three satellites are required to establish your position, and the more one can see, the more accurate the measurement. Mountains, buildings, and even trees can block the signals, so the clearer your view of the sky, the better.

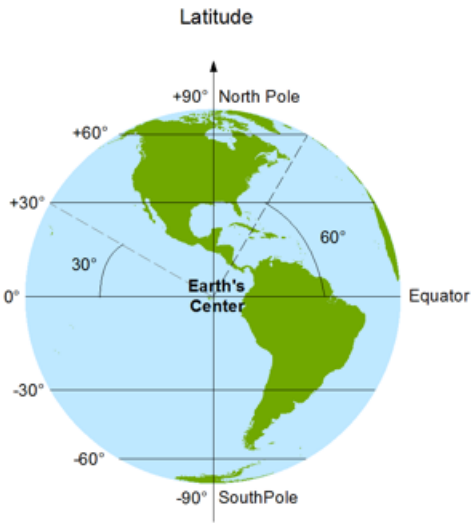
The original accuracy of GPS can be measured in tens of meters. However, the newer WAAS satellites use differential correction from ground stations to substantially improve accuracy, sometimes down to 3 meters! Most current GPS receivers can take advantage of these supplementary signals. Very recent models are also more sensitive and provide sophisticated signal analysis to ensure more uniform accuracy — enough by which a car can be driven!

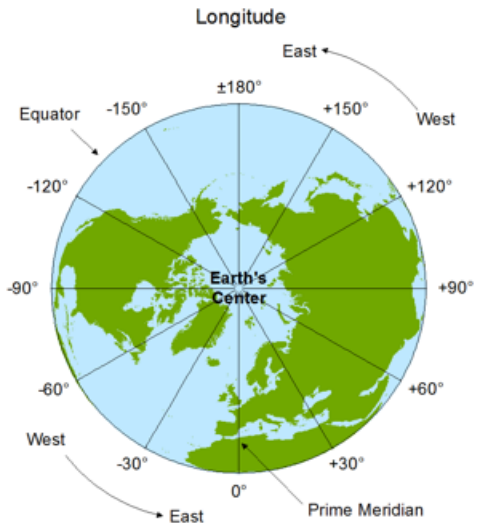
For more information about GPS, visit the Garmin GPS web site
https://www.garmin.com/en-US/aboutgps/

Your Position on Earth: Latitude and Longitude

The basic information provided by GPS is your latitude and longitude, two values that describe your position on the surface of the Earth.

Latitude is your north-south position and varies between –90° (the South Pole) and +90° (the North Pole).





Longitude is your east-west position, and varies between –180° (the Pacific Ocean) to +180°, which is the same as –180°, since the Equator is a circle. The half-circles between the poles are called **meridians**, and the one at 0°, called the **Prime Meridian**, is generally chosen to pass through Greenwich, England.

What is the approximate position of Amherst?

One degree of latitude measures 111 Km; 1 meter is therefore 0.000 009°. A degree of longitude varies.

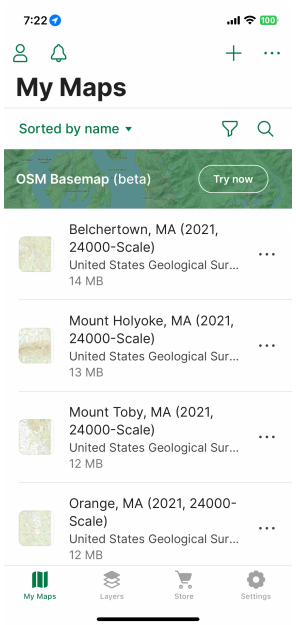
Degrees are divided into 60 **minutes of arc**, signified by the prime ' character, and the latter into 60 **seconds of arc**, signified by the double-prime ". One second of latitude is about 31 meters.

Your Smartphone as a GPS Device

Your smartphone has built-in GPS! That's how it knows where to place you on Google Maps. (It also uses cell tower signals to quickly triangulate your initial position, as it can take a while to lock in the GPS signals.) To really make use of GPS, however, we need a dedicated app on your phone. There are a number to choose from, but we'll use Avenza Maps, https://store.avenza.com , which works on both iPhones and Android phones.

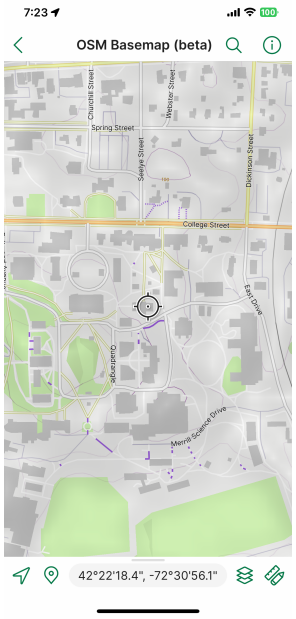
> *In your smartphone's app store, find Avenza Maps, download it, install it, and open it.*

Your initial view will be an empty list of possible maps called **My Maps**. Each of these references a background map, which is called a **basemap**. But you must first choose one. We'll start with the one provided by OpenStreetMap.



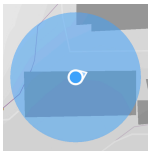
> *To the right of **OSM Basemap (beta)**, tap the button **Try now**.*

The map that appears will have a ⊙ circle in the middle, which marks *the center* of the map, and its location is listed at the bottom of the screen (using degrees-minutes-seconds notation), e.g. 42°22'18.4", -72°20'56.1" :



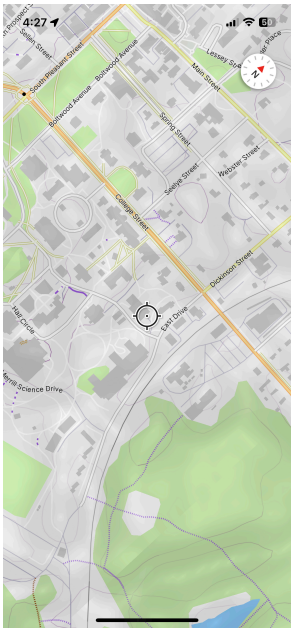
> *If you don't see the Amherst campus initially, tap the ➤ arrow button at the bottom of the screen to center your current location.*

Your location on the map will be indicated by a small blue circle with an arrow sticking out, which indicates your direction of movement (your **bearing**).



You may also see a larger transparent blue circle surrounding it, which indicates the estimated error of your location; it will become smaller when three or more visible satellites are in view (or if you zoom out).

> *Experiment with positioning the map:*
>
> - *With one finger:*
>   - *Tap the map to make the controls at top and bottom disappear; tap it again to make them reappear.*
>   - *Drag the map around and see how the displayed position changes.*
> - *With two fingers:*
>   - *Spread them apart to zoom in;*
>   - *Bring them together to zoom out;*
>   - *Move them in a circle to rotate the map.*

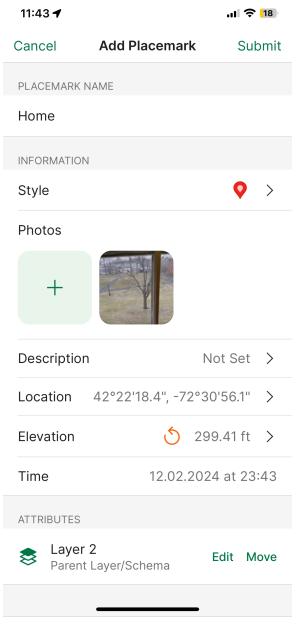


Once you've rotated the map, "north" will no longer be in its standard position at the top of the map; the north arrow will appear to indicate its direction relative to the features on the map:

> *Tap the north arrow to reset north at the top.*

Placemarking

Let's practice creating a **placemark** (aka a **waypoint**) at our current location, so we're ready when we come to an interesting location we want to record.



Placemarks are recorded for the ⊙ center of the screen, so to create one:

At the bottom of the screen, tap the ➤ arrow button to center your current location.

Tap the button **Add Placemark**.

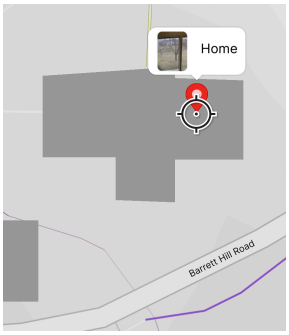
In the dialog **Add Placemark**, *provide a* ***PLACEMARK NAME****, e.g. "Home".*

Tap the + *button and add a photo from your camera or photo library.*

If you want, add a **Description** *or change the marker* **Style**.

Finally, tap the button **Submit**.

Information about your placemark location such as its name, description, and photo is called **metadata**.



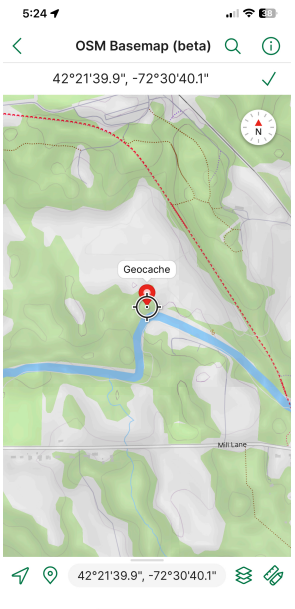
To view and edit a placemark's metadata:

Tap on a placemark, and a popup with its name (and photo, if any) will appear.

Tap on a placemark's popup, and the dialog **Edit Placemark** *will open, where you can make other changes.*

Geocaching

Next, we're going to find a **geocache**, a dropbox of goodies at some distant, specified location.



Let's find this specified location and add a placemark for it:

At the bottom of the screen, tap the button **Edit**.

In the menu that appears, tap **Find by Coordinates**.

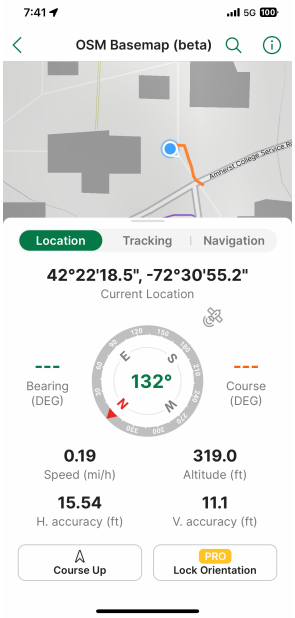
In the field **Search**, *tap the* × *to delete the centered location and type in the following location, with spaces instead of the symbols ° ' " :*

42 21 39.9, -72 30 40.1

Tap the button **Search**. *The map will center on this location.*

Add a placemarker called "Geocache" for this location, as described above.

We have our destination! By what route might we get there?



Location

Time to go outside! With multiple satellites in view, you'll have a much better location estimate.

When you are looking at a map, you can open the panel at the bottom that has ° ,° and a short gray bar above.

Drag up the bottom panel to open it.

Tap the tab **Location**, *if it's not already selected.*

Drag down on the panel to hide it.

The **Location** panel provides detailed information about your location and altitude. Altitude is not typically well-defined by GPS, requiring at least four visible satellites.

Note the compass! It's not magnetic, instead it uses GPS, but you need to move for it to be accurate.

The panel also tells you about your bearing and speed. Bearing is measured in degrees of **azimuth**, where north is 0°, east is 90°, south is 180°, and west is 270°. The compass shows the direction toward the top of your smartphone, which is normally straight ahead of you (in this case 132° — southeast).

Tracking

Let's create a **track** to mark our journey.

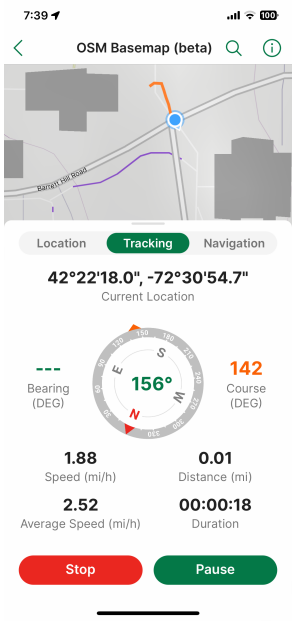
Drag up the bottom panel to open it, if necessary.

Tap the tab **Tracking**, *if it's not already selected.*

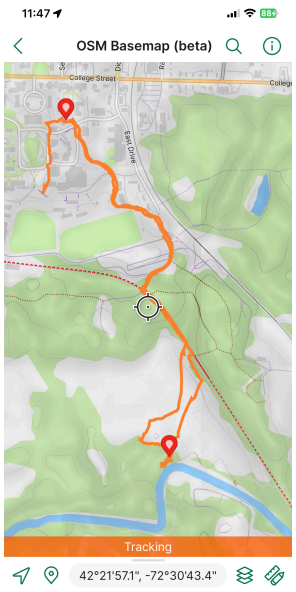
Tap the button **Start Tracking**.

Once you've started, you can **Pause** *for a break and* **Resume** when ready, *or* **Stop** *when finished.*

Drag down on the panel to hide it, and an orange bar **Tracking** *will be displayed until you stop your track.*



Note that, in addition to your current speed, the duration of your track and average speed are also displayed.



As you move, an orange line will appear on the map, tracking your footsteps.

To view and edit your track's metadata:

Tap on the track, and a popup with its name (and photo, if any) will appear.

Tap on the track's popup, and the dialog **Edit Track** *will open, where you can make changes to its metadata.*

In the text field **TRACK NAME**, *type in a name for the track, e.g. "Geocache Hunt".*

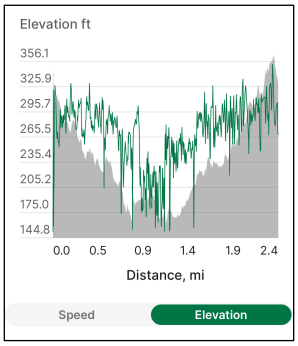
Tap the + *button and add a photo from your camera or photo library.*

If you want, add a **Description** *or change the line* **Style**.

To see an elevation profile of your track, tap **Show Graph** *and then tap the tab* **Elevation** *(the instantaneous speed is superimposed as the green line).*

Tap the button **Back** *to return to the dialog* **Edit Track**.

Finally, tap the button **Close**.

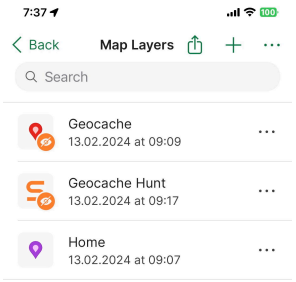


Layers

The particular basemap you're using is now overlaid with two or more placemarks and a track. These items are collected together in a **layer**.

To view your layers:

At the bottom of the screen tap the button **Map Layers**.



Initially, you'll see one layer, "Layer 1", containing some number of **features** (placemarks, tracks, and areas).

To view and edit the features in your layer:

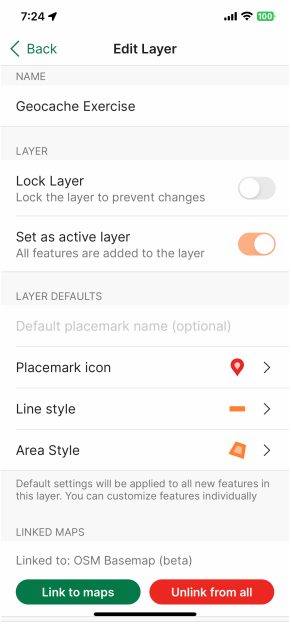
Tap the layer description. A list of features in the layer will appear.

To edit the metadata of any particular feature, tap the menu⋯ and then tap the menu item **Edit**.

To delete a particular feature, tap the menu⋯ and then tap the menu item **Delete**.

To move a feature from one layer to another, tap the menu⋯ and then tap the menu item **Move**.

To exit the dialog, tap the link **< Back**.



To edit a layer:

To the right of the layer description, tap the menu⋯ and then tap the menu item **Edit**.

In the dialog **Edit Layer**, *in the text field* **NAME**, *change the layer name to "Geocache Exercise".*

If you want to, change the default style of new features added to this layer.

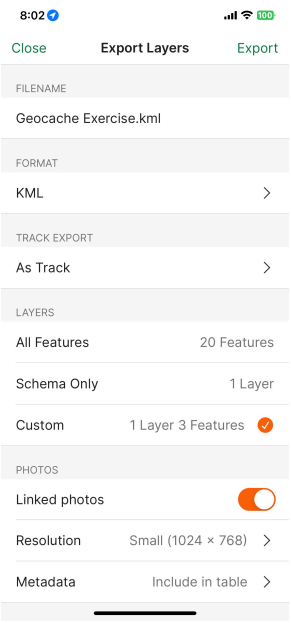
Note that you can also change the current basemap, aka its ***Linked Map***.

To exit the dialog, tap the link **< Back**.

Important: one layer is the **active layer**, and all new features are added to that layer. You can turn that off and on here, as well as in the menu⋯ if you have more than one layer.

If you don't want to see the features from other layers, you can hide those layers in their menu ⋯ .

Exporting Your Data



You can export an individual feature from its menu in its layer's feature list, and you can also export the entire layer from the layer list.

To export all of the features in a layer:

To the right of the layer description, tap the menu⋯ and then tap the menu item **Export**.

In the dialog **Export Layers**, *in the text field* **FORMAT**, *change the format to* **KML** *(if necessary). This is a standard format recognized by many mapping programs, in particular Google Earth and ArcGIS.*

Tap the button **Export**.

The standard sharing dialog for your smartphone should open. You can e-mail it to yourself, save to Dropbox if you have that installed, or save to Files (which may be your iCloud Drive on a Mac).

To exit the dialog, tap the link **Close**.