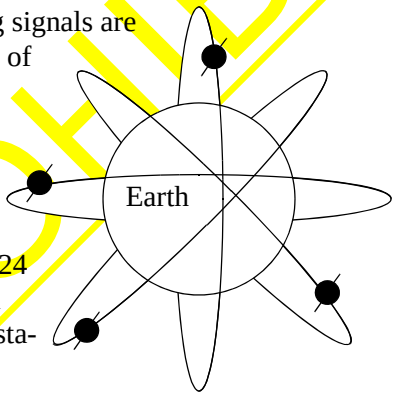
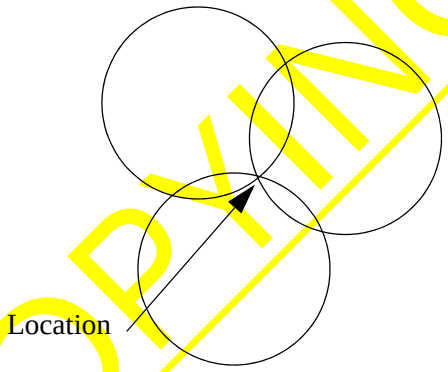
How does GPS work?

GPS, or Global Positioning System, is a program run by the US Air Force where satellites transmit signals to equipment—some fit in your hand—on the ground. These receivers are utilized to find location on earth based on a coordinate system founded on longitude and latitude. Fitted into private automobiles, pleasure boats, and airplanes, GPS receivers passively receive satellite signals, but do not transmit. GPS receivers require an unobstructed view of the sky, so they are used only outdoors and they often do not perform well within forested areas or near tall buildings. GPS operations depend on a very accurate time reference, which is provided by atomic clocks at the U.S. Naval Observatory. Every GPS satellite has atomic clocks on board.

Each GPS satellite transmits data that indicates its location and the current time. All GPS satellites synchronize operations so that these repeating signals are transmitted at the same instant. The signals, moving at the speed of light, arrive at a GPS receiver at slightly different times because some satellites are farther away than others. The distance to the GPS satellites can be determined by estimating the amount of time it takes for their signals to reach the receiver. When the receiver estimates the distance to at least four GPS satellites, it can calculate its position in three dimensions. There are at least 24 operational GPS satellites at all times. The satellites orbit with a period of 12 hours (once around earth every 12 hours). Ground stations are used to precisely track each satellite's orbit.



A GPS receiver "knows" the location of the satellites, because that information is included in satellite transmissions. By estimating how far away a satellite is, the receiver also knows it is located somewhere on the surface of an imaginary sphere centered at the satellite. It then determines the sizes of several spheres, one for each satellite. The receiver is located where these spheres intersect.



In the figure at left, the circles show the actual intersection point. Because the relative size of the spheres is known, there is only one possible point where they can intersect. Three spheres are necessary to find position in two dimensions, four are needed in three dimensions.

The accuracy of a position determined with GPS depends on the type of receiver. Most hand-held GPS units have about 10-20 meter accuracy. Other types of receivers use a method called Differential GPS (DGPS) to obtain much higher accuracy. DGPS requires an additional receiver fixed at a known location nearby. Observations made by the stationary receiver are used to correct positions recorded by the roving units, producing accuracies to less than 1 meter.