PBL PROJECT
PHYSICS - 15B11PH111

BY- NITIN CHAUDHARY ; ENROLMENT: NBTG13715; BATCH: F8

QUANTUM MECHANICS

GPS:

The **Global Positioning System** (**GPS**), originally **Navstar GPS**, is a satellite-based radionavigation system owned by the United States government and operated by the United States Space Force. It is one of the global navigation satellite systems (GNSS) that provides geolocation and time information to a GPS receiver anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.[] Obstacles such as mountains and buildings can block the relatively weak GPS signals.

The GPS does not require the user to transmit any data, and it operates independently of any telephonic or Internet reception, though these technologies can enhance the usefulness of the GPS positioning information. The GPS provides critical positioning capabilities to military, civil, and commercial users around the world. The United States government created the system, maintains, and controls it, and makes it freely accessible to anyone with a GPS receiver.

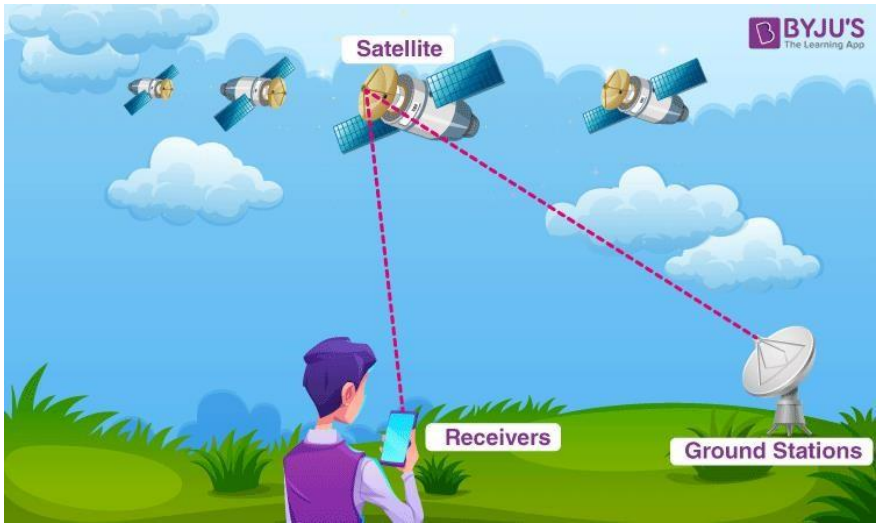
HISTORY:

The GPS project was launched in the United States in 1973 to overcome the limitations of previous navigation systems, combining ideas from several predecessors, including classified engineering design studies from the 1960s. The U.S. Department of Defense developed the system, which originally used 24 satellites, for use by the United States military, and became fully operational in 1995. Civilian use was allowed from the 1980s. Roger L. Easton of the Naval Research Laboratory, Ivan A. Getting of The Aerospace Corporation, and Bradford Parkinson of the Applied Physics Laboratory are credited with inventing it. The work of Gladys West is credited as instrumental in the development of computational techniques for detecting satellite positions with the precision needed for GPS.

The design of GPS is based partly on similar ground-based radio-navigation systems, such as LORAN and the Decca Navigator, developed in the early 1940s.

Components of a GPS system

GPS is a system and it is made up of three parts: ***satellites, ground stations,*** and ***receivers***.



SRC: https://cdn1.byjus.com/wp-content/uploads/2021/06/How-GPS-Works-1.png

Following are the functionalities of each of these parts:

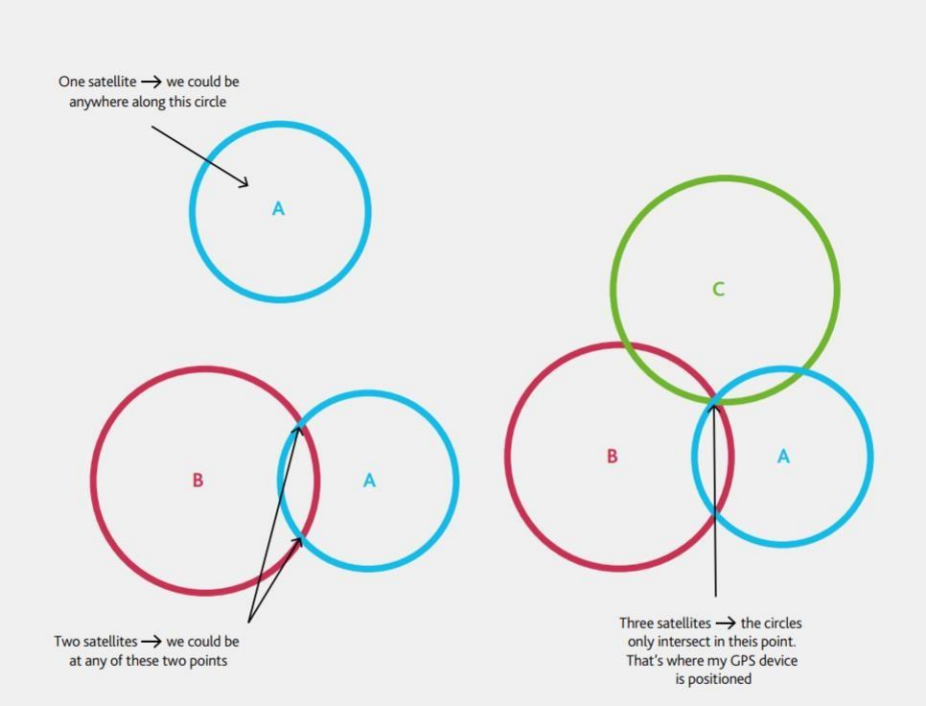
- *Satellites* act like the stars in constellations, and we know where they are because they invariably send out signals.
- The *ground stations* make use of the radar to make sure the satellites are actually where we think they are.
- A *receiver* is a device that you might find in your phone or in your car and it constantly seeks for the signals from the satellites. The receiver figures out how far away they are from some of them. Once the receiver calculates its distance from four or more satellites, it knows exactly where you are.

How GPS Works?

There are at least 4 GPS satellites in the line of sight of a receiver on the earth. The transmitter GPS sends information about the position and time to the receiver GPS at fixed intervals. The signals that are sent to the receiver devices are radio waves. By finding the difference in time between the signal sent from the GPS satellite to the time the GPS receives, the distance between the GPS receiver and the satellite can be calculated. Using the trilateration process, the receiver locates its position as the signals are obtained from at least three satellites.

For a GPS to calculate a 2-D position, which includes the latitude and longitude, a minimum of 3 satellites are required. For a 3-D position that provides latitude, longitude, and altitude, a minimum of 4 satellites are needed.

Physics behind GPS



Src:
https://www.stem.org.uk/system/files/elibraryresources/2018/08/Quantum%20Tech_Teacher%20guide_GPS%20and%20Trilaterati on.pdf

There are many Global Positioning System (GPS) satellites orbiting the Earth. These are used to locate your position on the planet. GPS positioning works on fairly simple principles, but the installation and application of such a system requires incredible precision.

Two main mathematical ideas underpin the GPS positioning network. Trilateration is the first concept and it is based on finding the position of a GPS device from three distances. The second idea is the relationship between the speed of the signal (speed of light, c = 299,792,458ms-1), the time taken for the signal to travel and the distance travelled. All that is needed for this second concept is the equation:

Distance travelled (m) = Speed (ms^{-1}) x Time (s)

Trilateration works by finding your position on Earth once the location of GPS satellites orbiting the Earth and their distance from your location are known. Since we cannot physically measure the distance of these satellites directly, we need to use the known speed of the signal sent by the GPS satellites and the time the signals were sent. This is quite easy, because satellites send out electromagnetic signals constantly. If our GPS receiver detected the signal from only one satellite, all we could tell is that we could be anywhere on the surface of a sphere of radius equal to the calculated distance from the satellite. If we only received signals from two satellites (satellite A and B, for example), we could tell that we are somewhere along the circle drawn by the intersections of the spheres described by the two signals. But with a third satellite signal we can tell the exact location of our device, because the three spheres will intersect in one point

only. We can simplify this concept in 2D, using circles rather than spheres (this is what your activity will model).

References:

1. https://byjus.com/
2. https://www.wikipedia.org/
3. https://www.stem.org.uk/

THANK YOU