An essay about orbits communications essay

The word orbit we hear it very often, whenever the space shuttle launched or it meets up ISS (International Space Station) or when a rocket launches a payload, we always come across the word ‘ orbit’. But what actually the orbit is?

An orbit is a specific path on which an artificial satellite revolves/travels around another body or planet . This path is regular and repeating . Satellite can be natural and artificial, like Moon . Moon itself acts like a satellite which travels around the Earth in a particular path.

In the solar system , nine planets including Earth , revolves around the sun in an orbit . Satellite that travels around the Earth are not in a constant distance from Earth, it varies . Sometimes its closer and sometimes far away. The closest orbit of satellite around the Earth is called “ perigee” and farthest orbit called “ apogee”. The time required for a satellite to complete full orbit is called a “ period”.

According to Isaac Newton’s first law of motion, a moving object will remain in motion unless something pulls it or push it, and that is gravity. Without Earth’s gravity, satellite would go off in the space along a straight path . With Earth’s gravity it keep on pulled satellite back to Earth.

To maintain the orbit, the gravitational force and the momentum of moving object have to be balanced. Another factor is Escape velocity. It is the speed of an object (satellite) to break free from the gravity of the planet and enters into a certain orbit. It depends on the mass of the planet and varies from planets to planets and the distance from the centre of the planet to the

object (satellite) is also important. The escape velocity of Earth is approx. 11. 3 km (7 miles)/hr.

Orbital Velocity:

Orbital velocity is the required speed needed for an object (satellite) to stay in an orbit. It is about and altitude of 242 km, approx 17, 000 miles /hr.[4]

SATELLITE ORBITS

There are three different types of orbits High Earth orbit (Geostationary orbit), Medium Earth orbit (MEO), and Low Earth orbit (LEO). The orbit selected for satellite is depend on its usage and application. Direct Broadcast Programmes and weather communication satellites use Geostationary Orbit, as they are far away from the Earth and they travel in the Earth's direction therefore looks stationary . Satellite navigation systems (NAVSTAR or GPS [global positioning system]), designed to navigate a particular region or area and satellite phones are in MEO(Medium Earth Orbit). NASA's Earth Observing System and other scientific satellites uses LEO (Lower Earth Orbit).[5][6]

Earth orbits.[7]

ORBITAL DISTANCES[8],[9]

Orbits	Orbit Initials	Miles	Km	1-way Delay	Orbit altitude (KM above earth's surface)
Low Earth Orbit	(LEO)	100-500	160 – 1,	50ms	200 –

		400		1200
Medium Earth Orbit	(MEO)	6, 000 – 12, 000 000	10-15, 000 s	100m 1200 – 35790
Geostationary Earth Orbit	(GEO)	~22, 300	36, 000	250 ms 35790

Circular and Elliptical Paths

There are two types of orbit paths, in which satellite travels around the Earth, circular and elliptical. In circular orbits, the distance between the earth and satellite remains same all the time.

When a satellite orbit around the Earth, it creates a plane, which goes across the geo -centre or centre of gravity of Earth. If the satellite orbit with Earth's rotation, it is called " posigrade" and if it is in opposite direction, it is " retrograde".

The path of satellite around Earth is also defined. If the satellite travels directly overhead the Earth, it makes a circle which had the centre of gravity of Earth known as " Ground Track" and it consists of single point on Earth's Equator.[10]

Satellite orbit paths.[11]

HEIGHT OF ORBIT

The distance between satellite and earth or the height of orbit decides how fast the satellite is going to travels around the Earth. The satellite motion is always controlled by the gravity of the Earth. The more nearer the satellite is, gravity gets stronger and it travels more faster. For instance, NASA's Aqua satellite completes the period in 99 minutes around Earth at approx 750kms up, on the other hand a weather satellite takes 23 hrs, 56 min's, and 4 sec's to complete a period at 42, 164km away from Earth. If we look at Moon's one complete period around Earth, it takes 28days at 384, 403 km's from the centre of Earth.

By changing the height of satellite, it effects on its orbital speed as well. For changing the speed of the satellite's orbit, the satellite operator fire thrusters which helps the satellite to accelerate more. It would boost the orbit, in terms of increasing the altitude but it will slow the orbital velocity. Instead of that, the satellite operator should fire the thrusters in opposite direction of the satellite , By doing this , it will push the satellite into the lower orbit , which causes increment in orbital velocity.

ECCENTRICITY OF AN ORBIT

It directs to the pattern, shape of the orbit path. With a low eccentricity the satellite will move close to the Earth in circle (Lower earth orbit). The Eccentricity of an orbit refers to the diversion of orbit from an ideal circle path. With eccentricity of (e) = 0 the orbit forms a circular path, the value of eccentricity lies between 0 ~1. With high (e) = 0. 9 the orbits forms an elliptical orbit, the nearest distance from Earth is called perigee and furthest distance is called apogee.

In any elliptical orbit, it focused on two focal points, and one of them is geo-centre of Earth,

Picture taken from[link], (NASA illustration by Robert Simmon

Another crucial factor is plane of satellite orbital path. An orbital inclination is the angle between the plane of the orbit with the equator of the earth. If the orbit is directly overhead the equator of Earth, it will have an inclination of 0° or 180° and generally it is called equatorial orbits . And if the orbit is passing over the north and south poles of the Earth , it will make and inclination of 90°and known as polar orbits.

Angle of Inclination[link1],[link2].

Another feature is the angle of elevation, above the earth's plane with a given location of earth and time. It plays an important role when a contact between satellite and earth station is required. Angle of elevation means, when the satellite appears on the horizontal axis of earth. Signals from Earth station may be interrupted if the angle is too small or if the earth station's antenna is not located on high altitude. Minimum of 5° angle of elevation is acceptable for satisfactory results.[link]

All together, the satellite height, inclination and eccentricity helps to observe the satellite path and what vision it will have on the Earth.

TYPES OF ORBITS

HIGH EARTH ORBIT [GEO (Geostationary /Geosynchronous orbit)]

When a satellite approaches 42, 164 km's away from the centre of the Earth (approx 36, 000km's from the surface of Earth) it enters into a special plane

of orbit where its period starts matching the earth’s rotation and it orbits the same velocity as Earth’s. So, the satellite starts behaving as stationary over the Earth’s equator surface. This High Earth Orbit is known as Geosynchronous.

A satellite moving in circular orbit directly overhead the Earth’s surface with eccentricity and angle of inclination at 0°forms a geosynchronous also known as geostationary orbit. As it follows the Earth , so it completes its 1 period in 24 hours.

GEO orbit is an ideal orbit for monitoring weather forecast events , because in GEO orbit , the satellite can provide a constant image of same surface range as it follows the Earth. GEO stationary satellites like, GOES (Geostationary Operational Environmental Satellite) sends data after every few minutes about wind , regular inspection of cloud impressions and water vapours. Launched and built by NASA, operated by NOAA (National Oceanic & Atmospheric Administration) . GOES satellite also helps to locate the ships and aeroplanes in distress situation.

Earth images at different intervals of time.[link]

As geostationary satellite is always on fixed single position, they can be useful for satellite phones, direct satellite broadcast, radio etc.

Just beyond the bounds of High Earth Orbit, there are Lagrange Points. At these points the earth’s gravity pull cancels the Sun’s gravity pull . Any satellite placed on these points will get proportional pull towards the Sun and the Earth and it will start moving with the Earth around the Sun.

There are 5 Lagrange points, L1 & L2 are located opposite sides of the Earth i. e., night and day sides. L3 is located on the other side of the Sun, adverse side of the earth. Only are stable points , located at 60° above and behind the Earth in same orbit.

On L1, L2 & L3 any slight agitation will drop out the satellite out of Lagrange point. At these critical points, they need constant and regular adjustments to stay balanced within the orbit. But on L4 and L5

even if they get disturbed they return back to their initial point.

Lagrange Points

MEDIUM EARTH ORBIT

Satellites which orbits in medium earth orbit they move more quickly as compared to GEO because they are closer to Earth. There are two types of medium earth orbits,

1. Semi Synchronous orbit and
2. Molniya Orbit.

1) Semi Synchronous orbit:

This orbit is a near to circular orbit with a very low eccentricity, with a distance of 26, 560 km’s away from the centre of Earth approximately 20, 200 km’s from the Earth’s surface. At this distance, the satellite takes 12 hours to complete its 1 period/orbit. As satellite orbits, the Earth revolves under it and in 24 hours of time, the satellite come across the same 2 points everyday on the equator. This orbit is persistent and much more predictable. This orbit is used by GPS satellites (Global Positioning System).

2) Molniya Orbit:

This is the second orbit in MEO, the Molniya orbit. Made by Russians, it works satisfactory for determining high latitudes. With the high eccentricity of 0. 722 and inclination of 63. 4° it forms a huge ellipse orbital path with the Earth, and it is very close with the Earth on one edge. Due to this, it gets accelerated by the earth’s gravity. As it orbits more faster when it is near to Earth and it slows down, when it moves far away . Due to the high eccentricity, it spends more time at the top of ellipse orbit. Similar to Semi Synchronous orbit, it takes 12 hours to complete its 1 period/orbit and in 24 hours of time, the satellite come across the same 2 points everyday . Molniya orbit is useful for communication in far hemispheres.

This orbit is used by Russian communications satellites and the Sirius radio satellites.

LOW EARTH ORBIT

With a 160-1, 240 miles altitude, it forms a low earth orbit in a circular path above the Earth’s surface. The satellites moving in this orbit complete one period/orbit in roughly 90 minutes. It means they can faster in LEO at approximately 17, 000 mph.[link].

Mostly weather communication satellites and scientific satellites are in Low earth orbit . the satellites in LEO got different angle of inclination . the inclination angle depends on the purpose of what to monitor. For example, TRMM (Tropical Rainfall Measuring Mission) satellite tasked to monitor the rainfalls in the tropic regions. So that it has a low inclination of 35° and it is closer to the equator.

NASA’s Earth observing system satellites are in LEO and in polar orbits. As they orbits around the north to south poles, they are highly inclined and they takes 99 minutes to complete 1 period/orbit.

In half of the period (e. g. north to south pole), they captured the daytime of Earth’s surface, and in second half period they capture the opposite night time side of the Earth. In 24 hours, the satellites in polar orbits capture the Earth twice, once in daytime and second in night time.

The polar -orbiting satellites have one special spot on the equator which lets them to stay in 1 time. This orbit is a Sun Synchronous orbit which indicates that no matter whenever the satellite comes across the equator, the local solar time will be same on the ground as well.

For example, Terra satellite, when it crosses the Brazil on equator the time is always about 10: 30 am. After completing its one orbit in 99 minutes, when it next overpasses the Earth equator, it comes across the Ecuador or Colombia at about 10: 30.

The path of Sun-synchronous obit is very narrow. To maintain the sun - synchronous orbit, it is necessary for a satellite to achieve a height of 100 km’s with an orbital inclination of 96°.

Accomplishing & Maintain the Orbit:

To launch a satellite into a particular orbit, an enormous amount of energy is required, and this energy is depends upon the height of the orbit, location of launch site and orbital inclination.

For High Earth Orbits, requires huge energy boost just to reach their destination. Polar orbit satellites take more energy as compared to the satellites which are overhead the Earth’s equator as they didn’t gets boost from earth’s momentum . The ISS (International Space Station) orbits at orbital inclination of 51. 6397° and it helps other space shuttles to reach to it .

Maintaining the Orbit:

perturbation

There are many factors which effects the orbital inclination of satellites. As in the solar system there are many other gravity pulls as well, such as from the Sun , Moon , and Jupiter , the biggest planet in the solar system NASA’S LEO satellites , requires maintenance every year to maintain the inclination of sun-synchronous orbit.

1. Satellites in LEO are also dragged out from their orbit because of the atmosphere. Satellites in lower earth orbit moves through the thinnest layers of the atmosphere where air friction is quite strong and it is more than enough to pull them out from the orbit or pull them closer to Earth. If the satellite comes closer to Earth, Earth’s gravity accelerates them to boost up, it will either burn up or fall down to earth.
2. Air always rises and expands if heated. The air in the atmosphere rises and expands due to the Sun’s extra enormous amount of energy. The thinner sheet of atmosphere rises and thicker layer under it takes it place. Now, the satellite orbits in thicker layer instead of thinner layer. It creates more friction between the medium and the satellite.

3. As there is a lot of space junk, orbital debris in orbital paths.