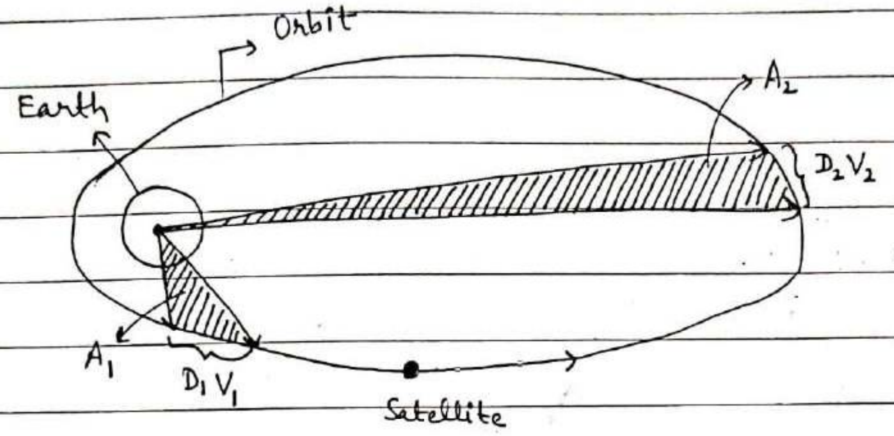
Kepler's Second Law → For equal intervals of time, a Satellite will sweep out equal areas in the orbital plane, focussed at the barycenter



For a satellite traveling distances D_1 and D_2 meters in one sec, areas A_1 and A_2 will be equal. Because of the equal area law, distance D_1 must be greater than distance D_2 and therefore velocity V_1 must be greater than V_2. The velocity will be greatest at the point of closest approach to earth (known as Perigee) and the velocity will be least at the farthest point from earth (known as Apogee).

Kepler's third law → This is known as harmonic law. The square of the periodic time of orbit is proportional to the cube of the mean distance between the primary ~~and~~ body and the satellite. This means distance is equal to the semi major axis thus

$$\alpha = A P^{2/3}$$

where

α = Semi major axis

A = Constant

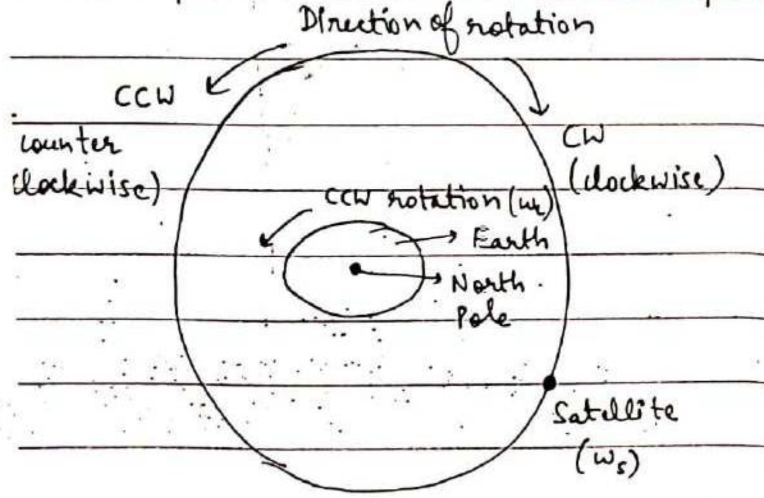
P = Mean Solar earth days

P is the ratio of the time of one side real day (t_s = 23 hours and 56 minutes) to the time of one revolution of earth on its own axis (t_e = 24 hrs)

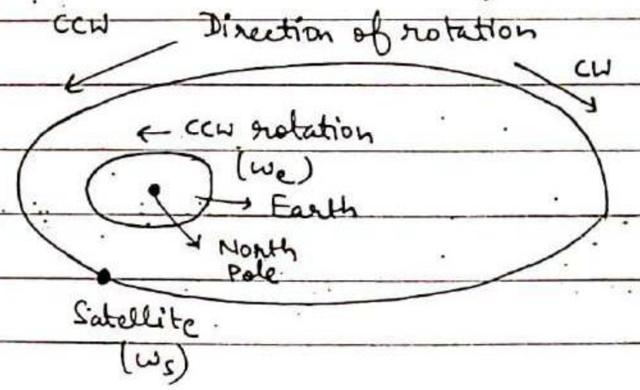
$$P = \frac{t_s}{t_e} = 0.9972$$

Satellite Orbits →

Mostly Satellite Orbits are 'nonsynchronous.
Nonsynchronous satellites rotate around earth in an elliptical or circular pattern



Circular Satellite orbit



Elliptical satellite Orbit

Classification of satellites → According to earth's rotation

1. Prograde or Posigrade Orbit → If a satellite is orbiting in the same direction as earth's rotation (Counter clock wise) and at an angular velocity greater than that of earth ($\omega_s > \omega_e$)

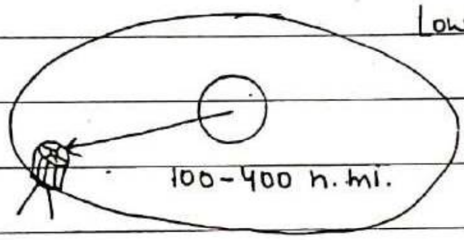
Scanned with CamScanner

2. Retrograde Orbit :- If a satellite is orbiting in the opposite direction as earth's rotation or in the same direction with an angular velocity less than that of earth ($\omega_s < \omega_e$).

According to Satellite elevation :-

1. Low Earth Orbit (LEO) :- LEO satellites operate in 1GHz to 2.5 GHz frequency range. The satellite moves across the sky, and the ground station must actively track the satellite to maintain communications.

Low Earth Orbit
(LEO)

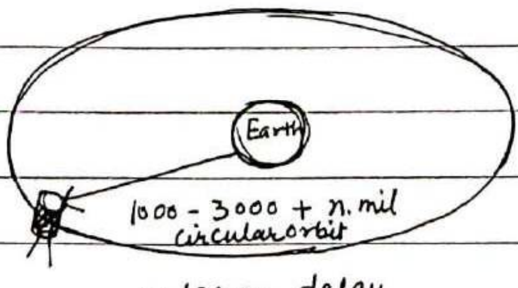


n. mi. → nautical mile
≈ 1852 m.

~10ms delay

2. Medium Earth Orbit (MEO) :- MEO satellites operate in the 1.2 GHz to 1.66 GHz frequency band and orbit between 6,000 miles and 12,000 miles above earth. It is a popular orbit for navigation satellite such as the GPS constilation.

Medium Earth Orbit (MEO)

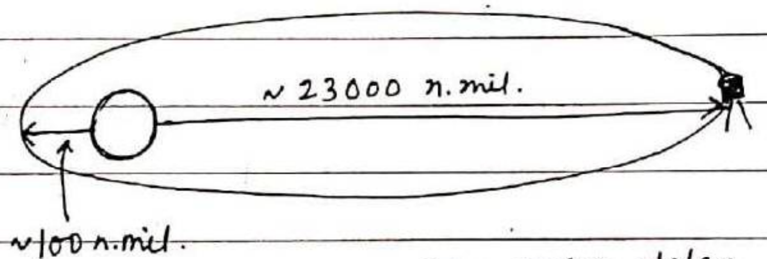


~ 100 ms delay

3. High Earth Orbit (HEO) → It operates with an elliptical orbit, with a maximum altitude (Apogee), similar to geosynchronous orbit (GSO), and a min. altitude (Perigee) similar to LEO. HEO used for special applications where coverage of high latitude locations.

Satellite orbits that are not synchronous, LEO, MEO or HEO are often referred to as non-Geosynchronous orbits (NGSO) Satellites

High Earth Orbit (HEO)



~ 10 to 260 msec. delay

4. Geosynchronous Orbits → (GSO or GEO)

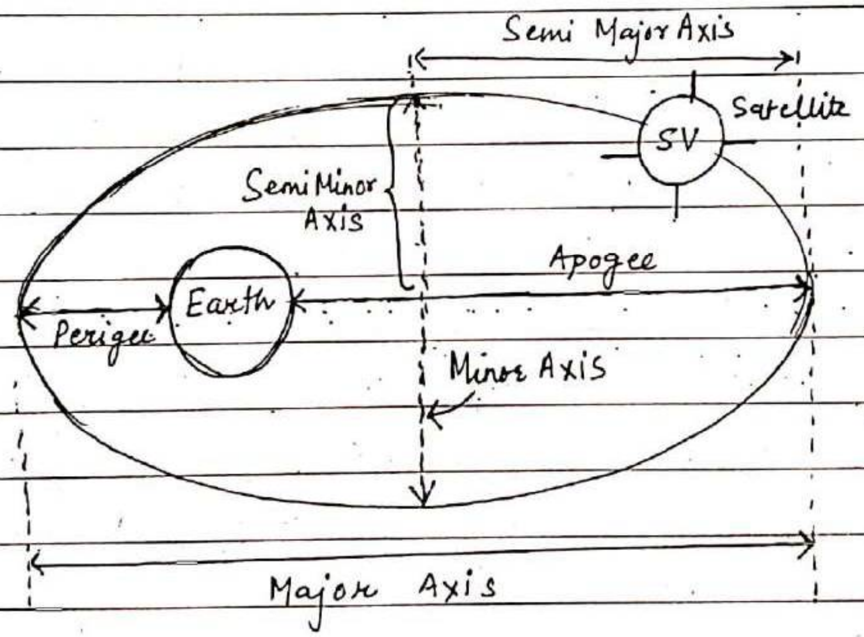
GSO orbits is by far the most popular orbit used for Communication satellite. A GSO satellite is located in a circular orbit in the ~~equi~~ equatorial plane, at a normal distance of 36,000 km at a stable point which maintains the satellite at a fixed location in the sky.

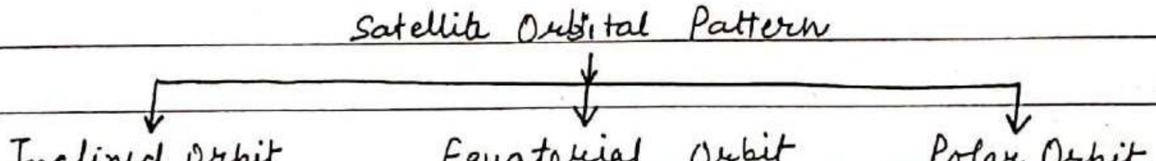
GSO satellites operate in 2 GHz to 18 GHz frequency spectra.

Satellite Orbital Patterns →

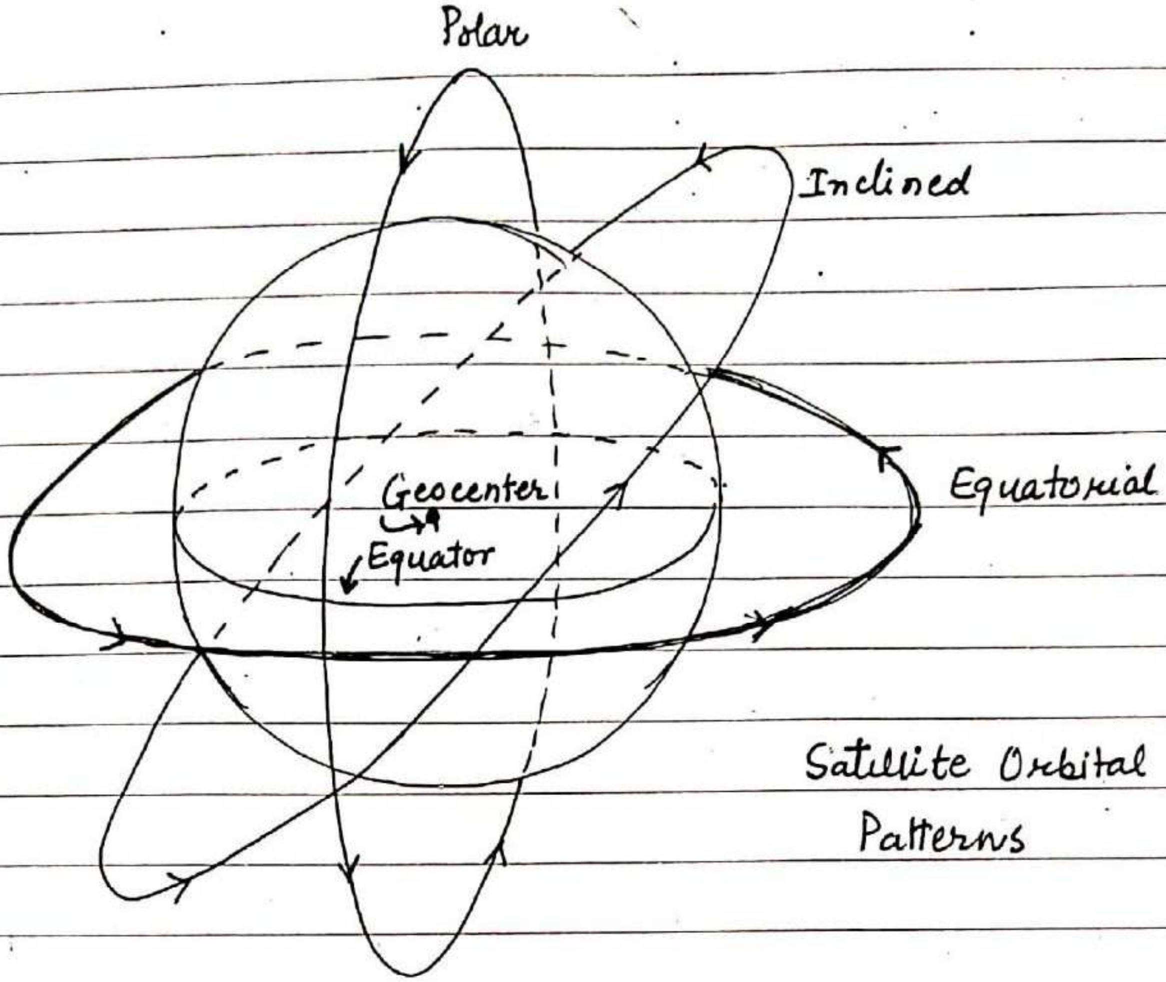
Four important Satellite Orbital parameters are:-

1. Apogee → point in an orbit that is located farthest from earth
2. Perigee → Point in an orbit located closest to earth.
3. Major Axis → The line joining the Perigee and Apogee through the center of earth. It is also called as line of apsides.
4. Minor Axis → Line perpendicular to the major axis and half way between the Perigee and Apogee.





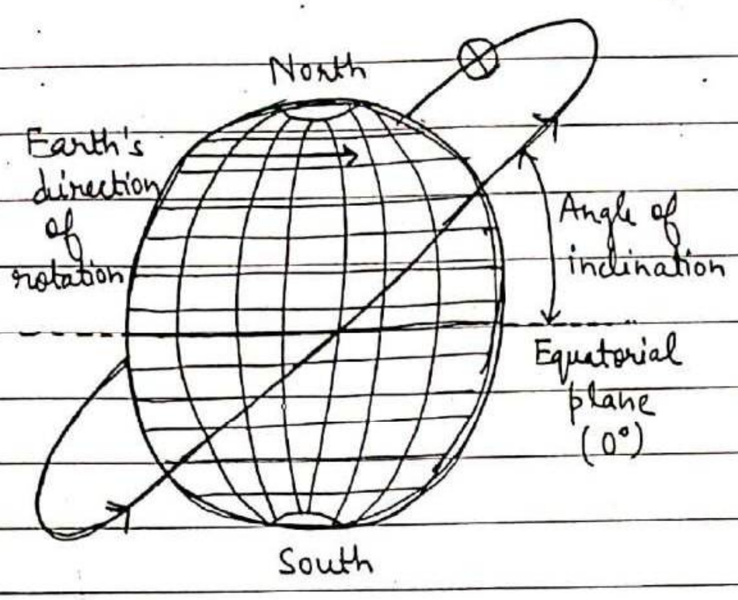
Inclined Orbit → All orbits except those that travel directly above the equator or directly over north and south Poles.

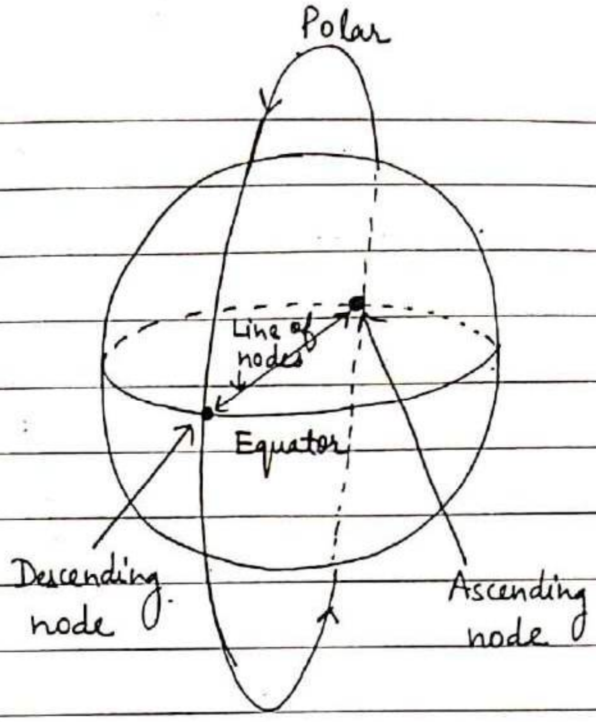


Satellite Orbital Patterns

Angle of Inclination → Angle between earth's equatorial plane and the orbital plane of a satellite measured counter clockwise at the point in the orbit where it crosses the equatorial plane travelling from South to north. This point is called as Ascending node. The point where a polar or inclined orbit crosses the equatorial plane travelling from north to south is called as Descending Node.

Line of Nodes → Line joining the Ascending and descending nodes through the center of earth.





Equatorial orbit → When the satellite rotates in an orbit directly above the equator, usually in a circular path.

Angle of inclination = 0°

No ascending and descending nodes.

Polar orbit → When the satellite rotate in a path that takes it over the North and South Poles in an orbit perpendicular to the equatorial plane.

Angle of inclination = nearly 90°

Geosynchronous Satellite → Geosynchronous Satellites orbit earth above the equator with the same angular velocity as earth. Geosynchronous satellites also known as stationary or geostationary satellites appear to remain in a fixed location above one spot on earth's surface.

The rotation of Geosynchronous Satellite should be in the same direction as that of the direction of orbit of earth.

Their orbits are circular thus the speed of rotation is constant throughout the orbit.

From Kepler's 3rd Law, the orbit radius for Geostationary orbit, r_s, is defined as

$$r_s = \left[\frac{\mu}{4\pi^2}\right]^{1/3} T^{2/3}$$

where

μ = Geocentric gravitational constant
$= 3.986 \times 10^5 \ km^3/s^2$

T = time taken for the earth to complete one rotation about its axis wrt fixed star
= 1 mean sidereal day
= 86164.09 s

$\Rightarrow r_s = 42164.17$ km