Introduction to Satellite Orbits

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Basics of Satellite Orbits

- The speed of a satellite is
  - Determined by the satellite's orbit
  - Closely tied to the satellite's altitude.
- A satellite's orbit does not depend on its mass
  - All objects with the same velocity (speed and direction) at a given point in space follow the same orbit.
- Satellites close to the Earth move faster than those at higher altitudes
  - ISS moves faster than a GPS satellite when viewed from earth
  - Satellites in low earth orbits (hundreds of kilometers above the Earth) move rapidly relative to the Earth, completing an orbit in 1.5 to 2 hours.

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Basics of Satellite Orbits

- Satellites in higher orbits move at slower speeds than those in lower orbits
  - Distance they travel in one orbit is longer.
  - The time required for a satellite to orbit (the orbital period) increases with altitude.
  - Only one altitude (36,000 km)permits satellites to orbit at the same rate at which the Earth rotates, such satellites are called geosynchronous.
- Once in orbit, a satellite does not need constant powering to remain in flight, as airplanes do. Satellites use small onboard rocket engines to maneuver in space.
- A satellite's orbit always lies in a plane that passes through the center of the Earth.
  - The angle between that plane and the plane of the equator is called the orbit's inclination.

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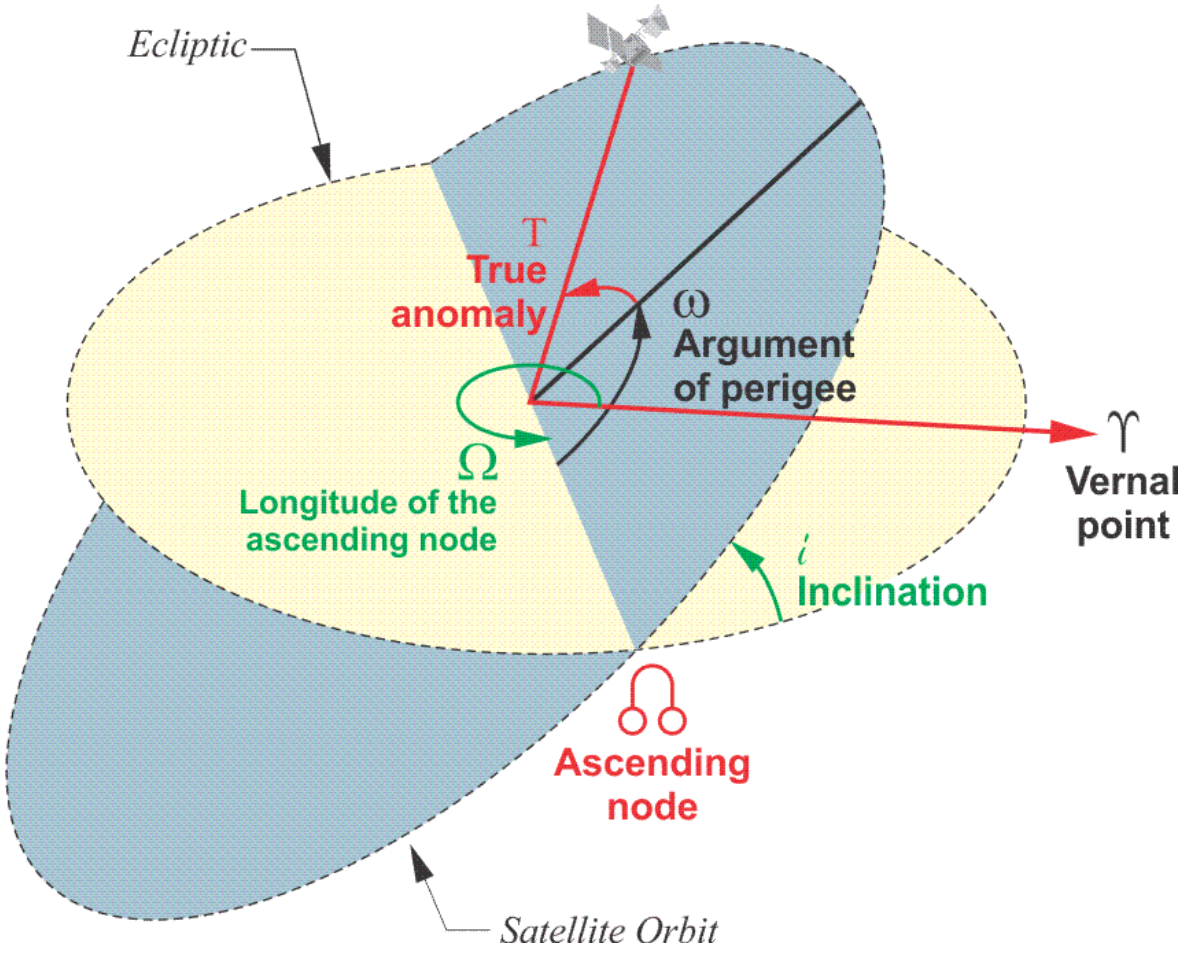
Basics of Satellite Orbits

- Ground Track: The part of the earth that lies beneath the satellite orbit
- A satellite in an orbit with inclination angle “theta” cannot pass directly over any location on Earth with latitude greater than “theta”.
- A satellite launched from a site at latitude “theta” follows an orbit with inclination greater than or equal to “theta”.
- From a launch site at latitude “theta” it is not possible to launch a satellite into an orbit with inclination less than “theta”.
- A launch site that is not on the equator cannot place a satellite directly into an equatorial orbit.



Altitude vs. Orbital Speed vs Orbital Period

Altitude (km)	Orbital Speed (km/s)	Orbital Period (min)
200	7.8	88.3
500	7.6	94.4
1,000	7.4	104.9
5,000	5.9	201.1
10,000	4.9	347.4
20,200 (semi-synchronous)	3.9	718.3
35,800 (Geo-synchronous)	3.1	1436.2 (24 hours)

Speed needed to keep an object on orbit does not depend on its mass. Any object small or large with the same velocity will travel on the same orbit.

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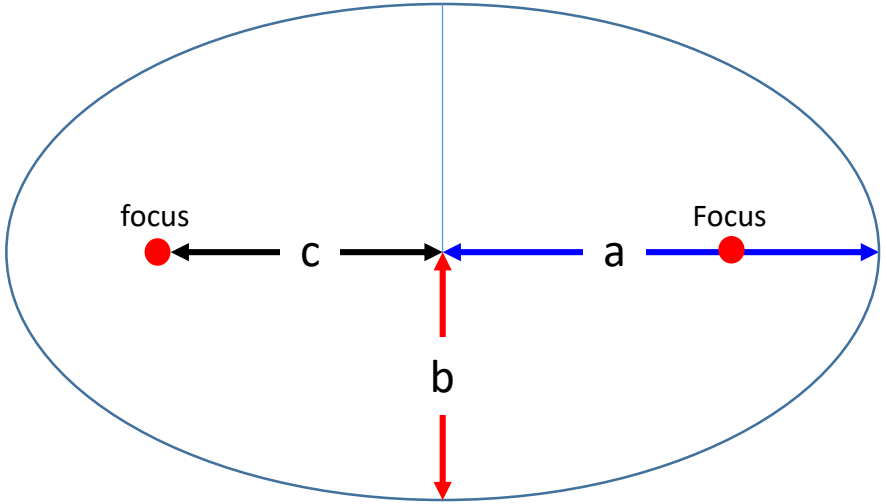
Basics of Satellite Orbits : Elliptical Orbits

$$a^2 = b^2 + c^2$$

where:
Major Axis = 2a, Line that contains two foci
Minor Axis = 2b, Line perpendicular to Major Axis
Distance between the two foci = 2c



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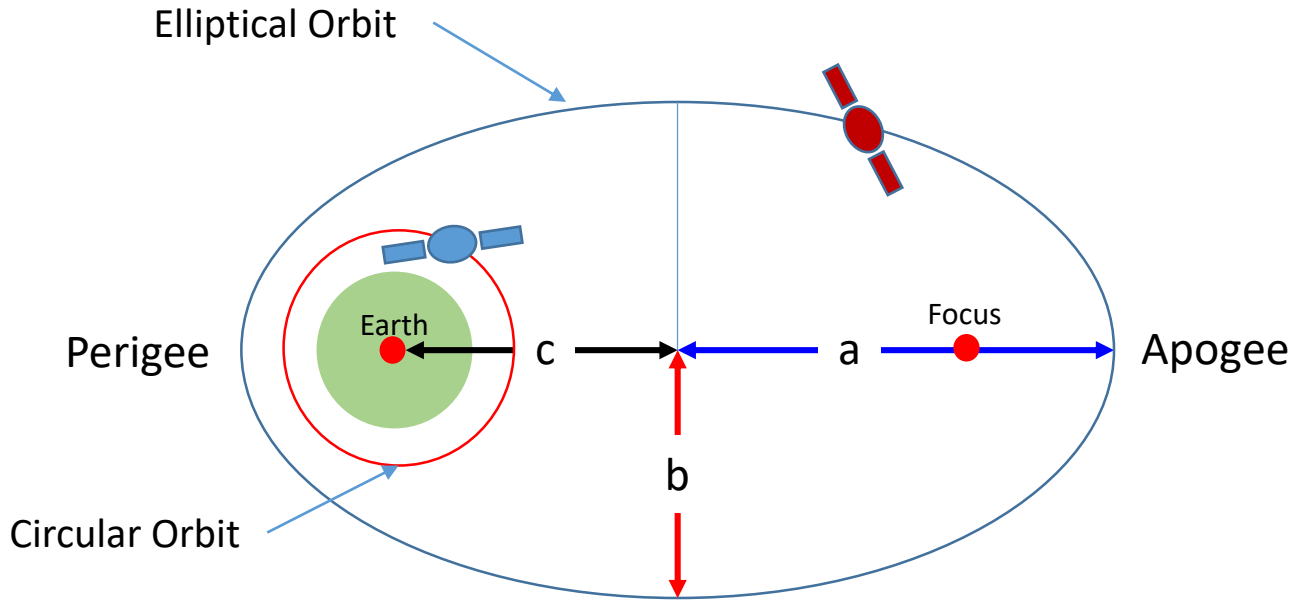

Perigee: the point on an elliptical orbit when the satellite is the closest to the earth
Apogee: the point on an elliptical orbit when the satellite is the farthest to the earth

A satellite when near to the perigee moves faster
A satellite when near to apogee moves slower
The speed of a satellite depends not only on Altitude but also the shape of the orbit (length of major-axis)