# Geosynchronous Orbit

## Description

A geosynchronous orbit is a high Earth orbit that allows satellites to match Earth's rotation. Located at 22,236 miles (35,786 kilometers) above Earth's equator, this position is a valuable spot for monitoring weather, communications and surveillance. The International Telecommunication Union assigns slots for geosynchronous orbit and settles disputes between countries about slots. Similarly, it is considered good practice to move almost-dead satellites into a "graveyard" orbit above geosynchronous orbit before they run out of fuel, to clear the way for the next generation [1].

A geosynchronous orbit (GEO) is a prograde, low inclination orbit about Earth having a period of 23 hours 56 minutes 4 seconds. A spacecraft in geosynchronous orbit appears to remain above Earth at a constant longitude, although it may seem to wander north and south. The spacecraft returns to the same point in the sky at the same time each day [2].

## Advantages and Disadvantages

A satellite in geosynchronous orbit can see one spot of the planet almost all the time. For Earth observation, this allows the satellite to look at how much a region changes over months or years. The drawback is the satellite is limited to a small parcel of ground; if a natural disaster happens elsewhere, for example, the satellite won't be able to move there due to fuel requirements [1].

# Geostationary Orbit

## Description

To achieve a geostationary orbit, a geosynchronous orbit is chosen with an eccentricity of zero, and an inclination of either zero, right on the equator, or else low enough that the spacecraft can use propulsive means to constrain the spacecraft's apparent position, so it hangs seemingly motionless above a point on Earth. (Any such maneuvering on orbit, or making other adjustments to maintain its orbit, is a process called **station keeping**.) The orbit can then be called geostationary. This orbit is ideal for certain kinds of communication satellites and meteorological satellites. The idea of a geosynchronous orbit for communications spacecraft was first popularized by science fiction author Sir Arthur C. Clarke in 1945, so it is sometimes called the Clarke orbit [2].

# Geosynchronous Transfer Orbit

## Description

To attain geosynchronous (and geostationary) Earth orbits, a spacecraft is first launched into an elliptical orbit with an apoapsis altitude about 37,000 km. This is called a **Geosynchronous Transfer Orbit** (GTO). The spacecraft then circularizes the orbit by turning parallel to the equator at apoapsis and firing its rocket engine. That engine is usually called an **apogee motor**. It is common to compare various [launch vehicles' capabilities](https://solarsystem.nasa.gov/basics/chapter14-1) according to the amount of mass they can lift to GTO [2].

# Polar Orbits

## Description

Polar orbits are 90-degree inclination orbits, useful for spacecraft that carry out mapping or surveillance operations. Since the orbital plane is nominally fixed in inertial space, the planet rotates below a polar orbit, allowing the spacecraft low-altitude access to virtually every point on the surface. To achieve a polar orbit at Earth requires more energy, thus more propellant, than does a direct orbit of low inclination. To achieve the latter, launch is normally accomplished near the equator, where the rotational speed of the surface contributes a significant part of the final speed required for orbit. A polar orbit will not be able to take advantage of the "free ride" provided by Earth's rotation, and thus the launch vehicle must provide all the energy for attaining orbital speed [2].

# Walking Orbits

## Description

Planets are not perfectly spherical, and they do not have evenly distributed surface mass. Also, they do not exist in a gravity "vacuum." Other bodies such as the sun, or natural satellites, contribute their gravitational influences on a spacecraft in orbit about a planet. It is possible to choose the parameters of a spacecraft's orbit to take advantage of some or all these gravitational influences to induce precession, which causes a useful motion of the orbital plane. The result is called a walking orbit or a precessing orbit, since the orbital plane moves slowly with respect to fixed inertial space [2].

# Sun-synchronous Orbits

## Description

A walking orbit whose parameters are chosen such that the orbital plane precesses with nearly the same period as the planet's solar orbit period is called a sun synchronous orbit. In such an orbit, the spacecraft crosses periapsis at about the same local time every orbit. This can be useful if instruments on board depend on a certain angle of solar illumination on the surface. Mars Global Surveyor's orbit is a 2-pm Mars Local Time sun-synchronous orbit, chosen to permit well-placed shadows for best viewing. It may not be possible to rely on use of the gravity field alone to exactly maintain a desired synchronous timing, and occasional propulsive maneuvers may be necessary to adjust the orbit [2].

# Orbital Elements

To completely describe an orbit mathematically, six quantities must be calculated. These quantities are called orbital elements, or Keplerian elements, after Johannes Kepler (1571-1630).

## Semi-major Axis

The value representing one-half of the major axis and the satellites mean distance from the Earth

## Eccentricity

The quantitative value describing deviation of a curve or orbit from circularity (i.e., a value of zero indicates a circle)

## Inclination

The angular distance of the orbital plane from the plane of the planet’s equator (or from the ecliptic plane in heliocentric orbits)

## Argument of Periapsis

The angular distance of the periapsis (shortest distance between satellite and Earth) from the ascending node

## Time of Periapsis Passage

The time in which a satellite moves through its point of periapsis (shortest distance between satellite and Earth)

## Celestial Longitude of Ascending Node

The nodes celestial longitude: celestial longitude is analogous to longitude on Earth and is measured in degrees counter-clockwise from zero with zero longitude being in the direction of the vernal equinox