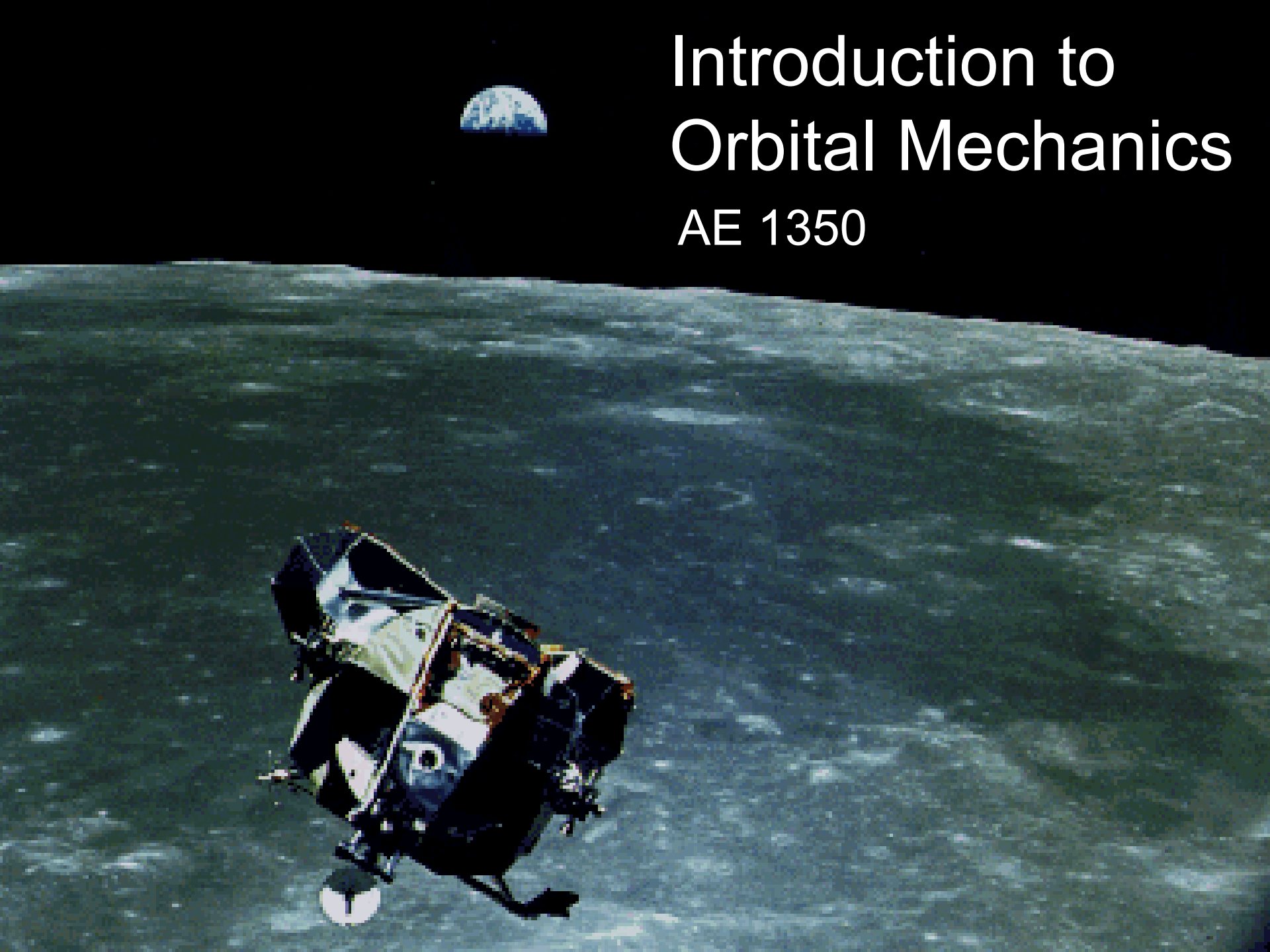
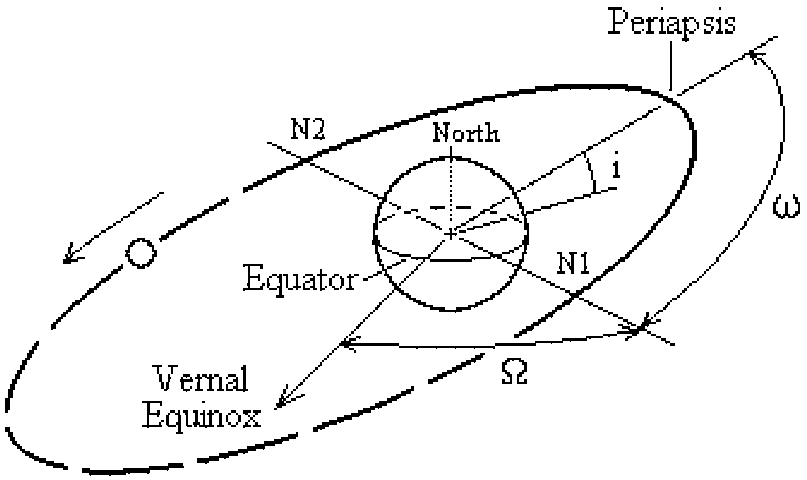
# Introduction to Orbital Mechanics

AE 1350



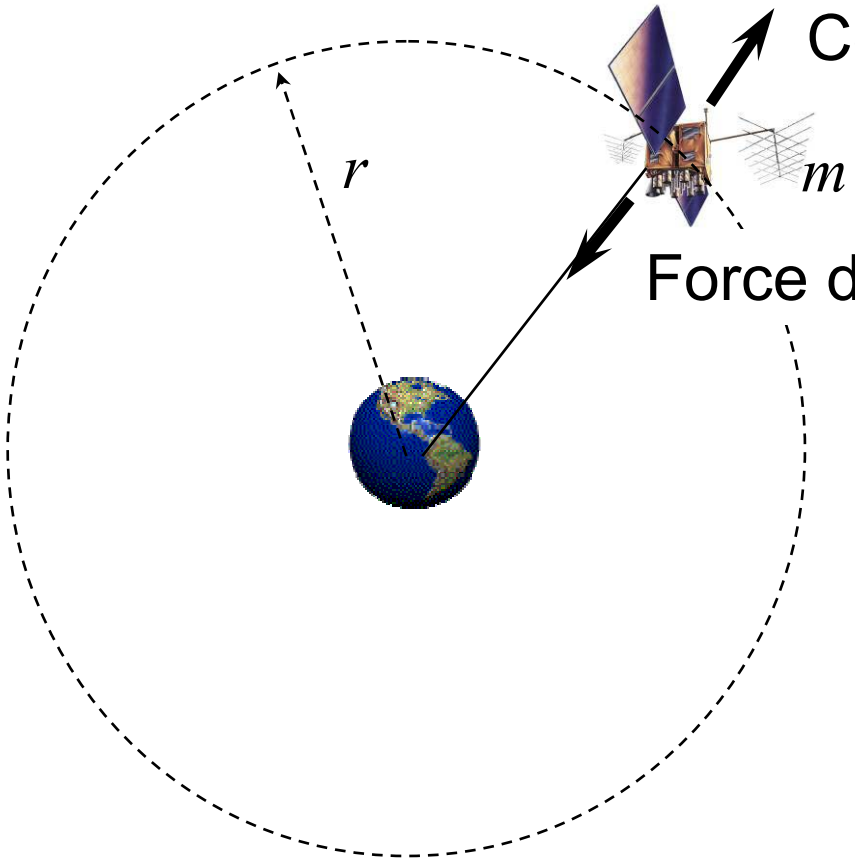
# Orbits!

- Low Earth Orbits
- Geosynchronous Orbits
- Transfer Orbits
- Gravitational Slingshot
- Lagrangian Points




i = Inclination
ω = Argument of Periapsis
Ω = Longitude of Ascending Node
N1 = Ascending Node
N2 = Descending Node

# Satellites in Circular Orbit




Centrifugal force $= mV^2/r$

Force due to gravity $= GMm/r^2$

$$GMm/r^2 = mV^2/r$$
$$GM/r = V^2$$

Here,

$G$ = Universal constant

$M$ = Mass of the earth

$V$ = Velocity of the satellite

$r$ = Radius of the orbit

# Low Earth Orbit (LEO)

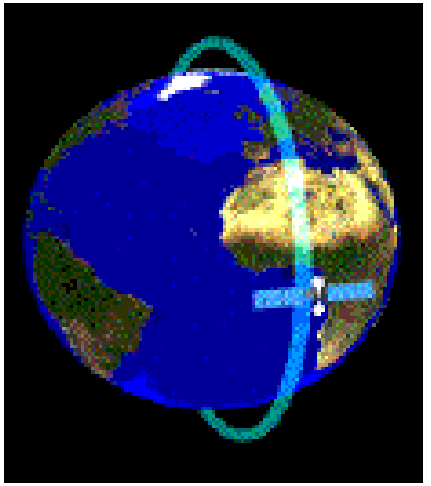
- Defined as all orbits below geostationary
- Lowest energy required to achieve
- Almost all LEO missions between
  - The atmosphere ~400,000 ft
    (so the orbit will last a while…)
  - The Van-Allen Belts ~400 nm
    (radiation trapped in the magnetic field of the Earth, a dangerous place to be)

# Low inclination LEO

- *Inclination of orbit* = *launch latitude* is the minimum required-energy orbit
- So inclination of most US manned missions has been approximately the latitude of Kennedy Space Center (KSC), about 28 degrees, with launches almost due East
- The lower the latitude, the lower the required energy due to the spin of the Earth
  - Cheaper to launch from Florida than North Carolina…

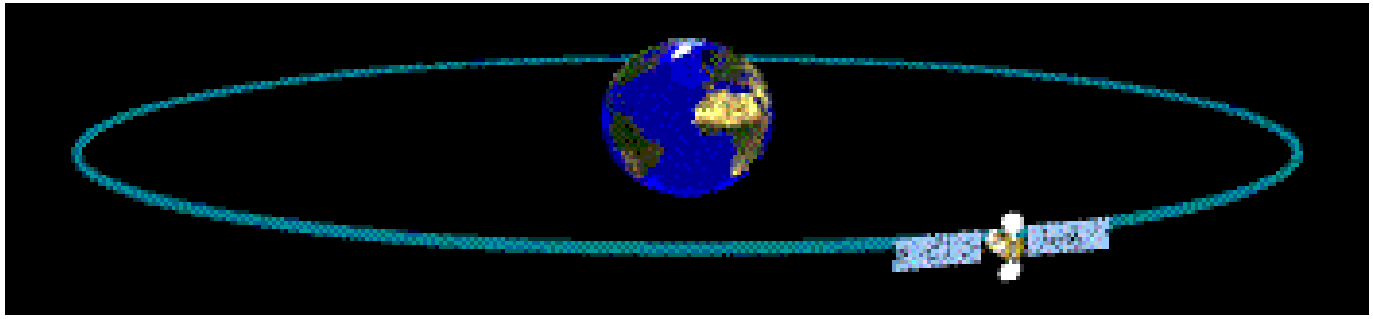
# Polar LEO

- Polar orbits have an inclination near 90 degrees
- Have the advantage that they pass over the entire planet at regular intervals
  - Which has many uses…
- Takes more energy to get there than for low inclination orbits

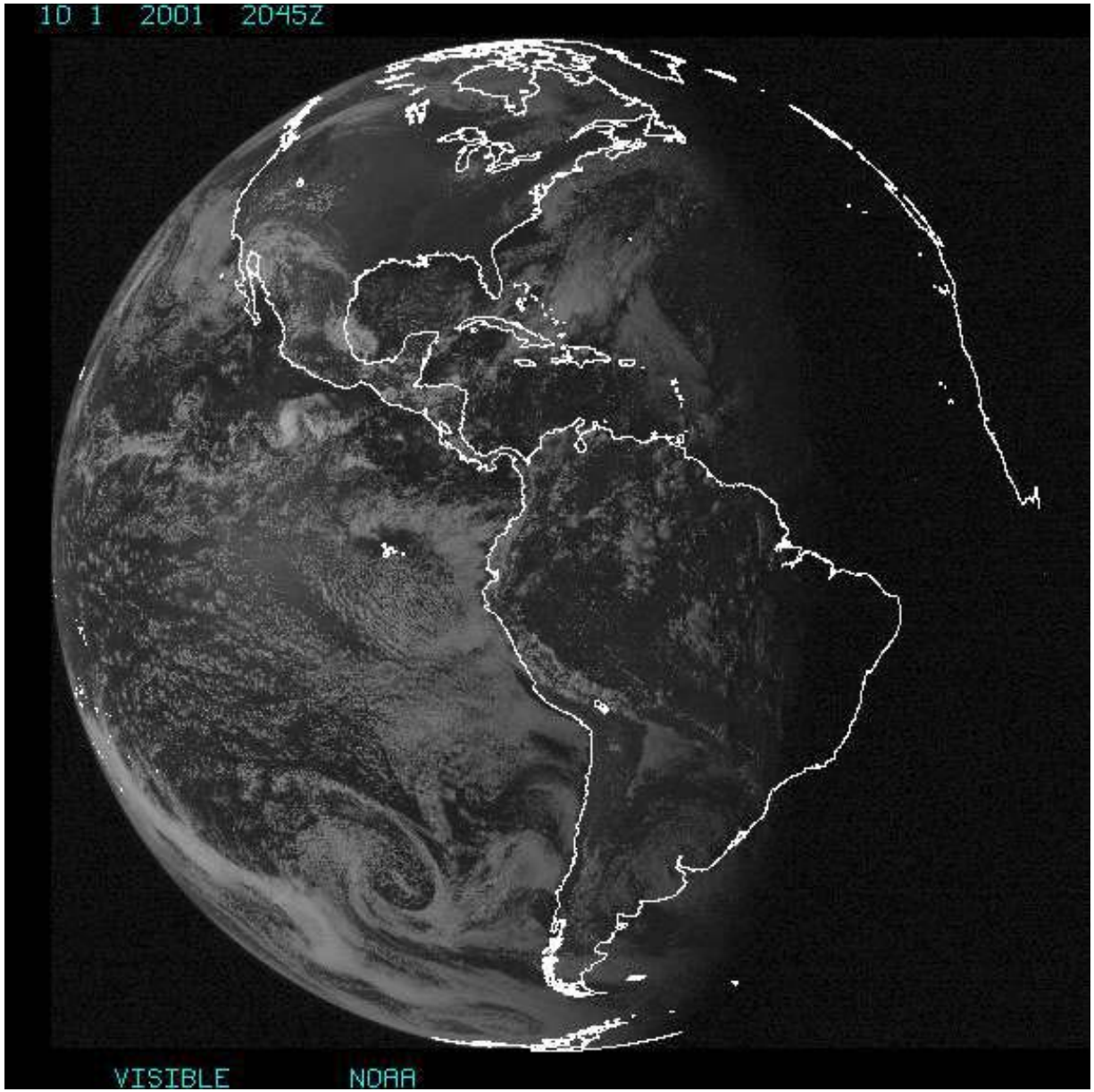


# Geostationary Orbit (GEO)

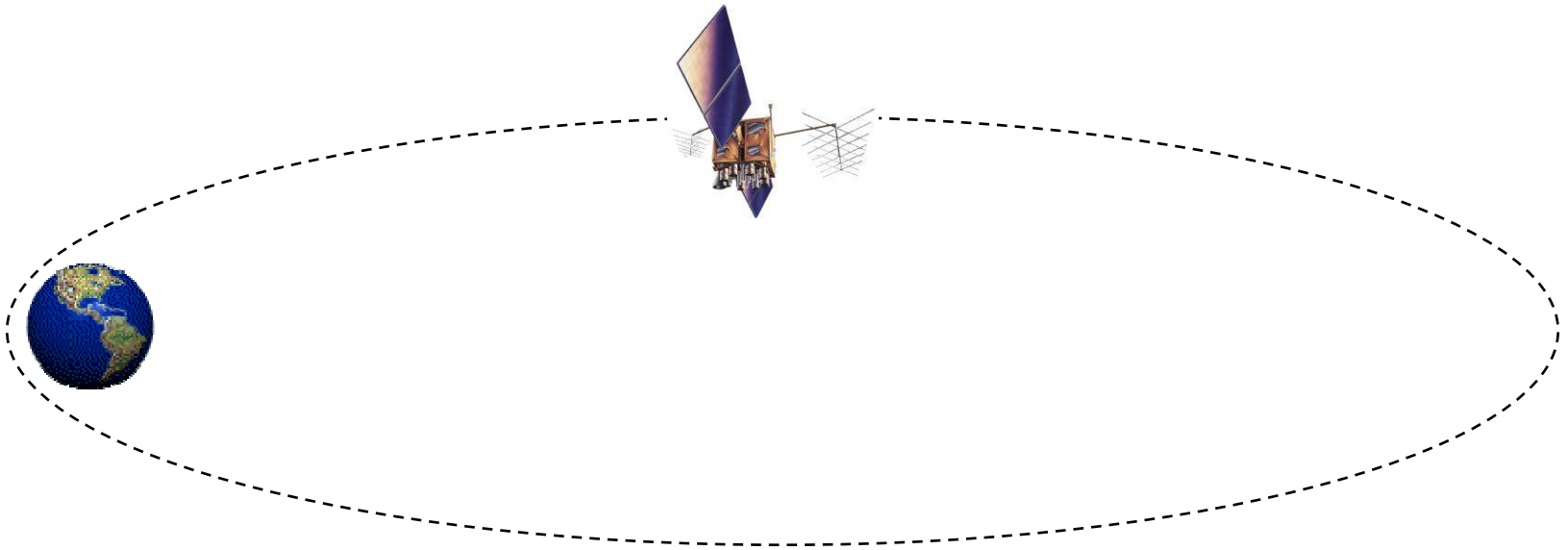
- Circular
- Equatorial (inclination is zero)
- Radius is such that angular rate of orbit is the same as the angular rate of the Earth
- Radius is about 23,000 nm, period 23.934 hours
- Because it's only one radius, and one inclination – it's getting very crowded up there!



# GOES-8 Typical Image



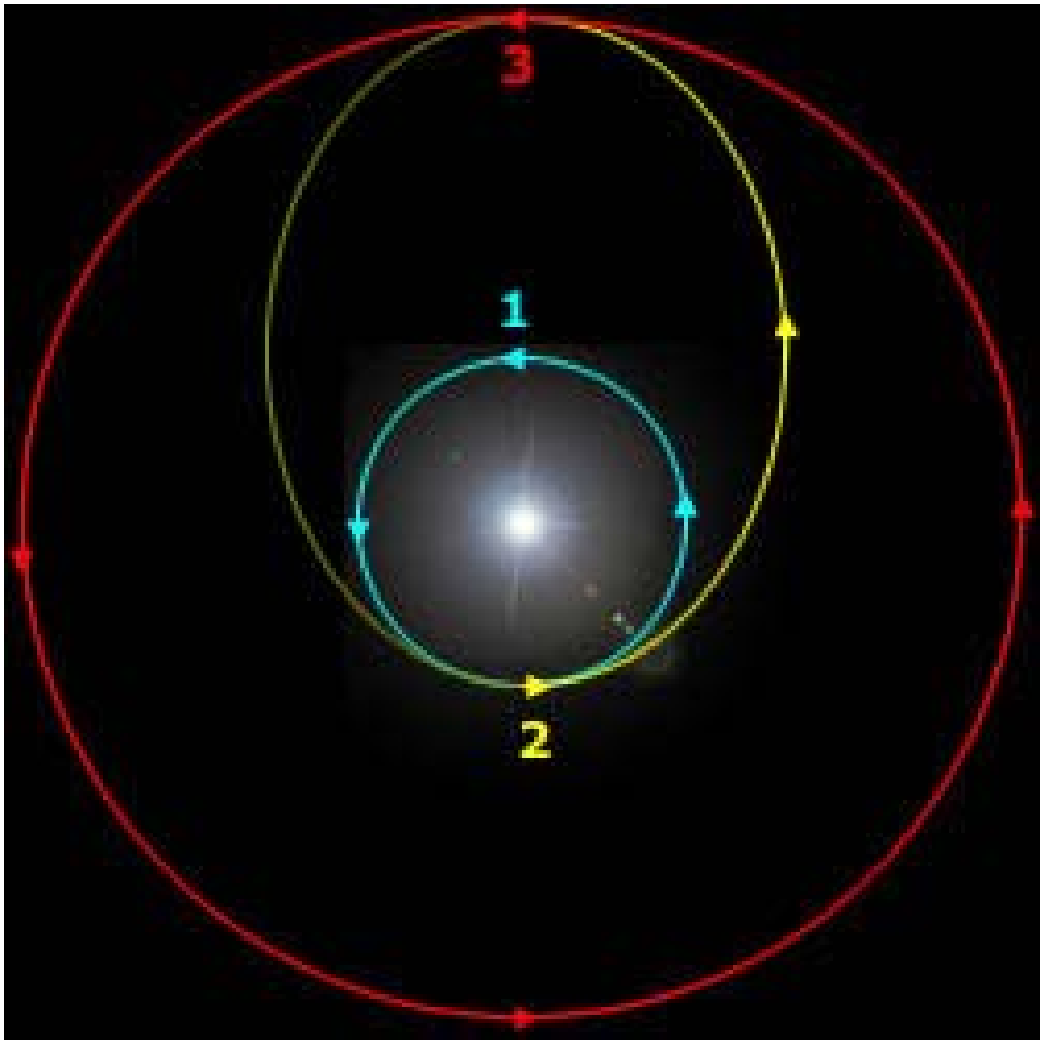
# Elliptical Orbits



Elliptical Orbits are also possible
In such orbits, the object will be at one of the focal points of the ellipse

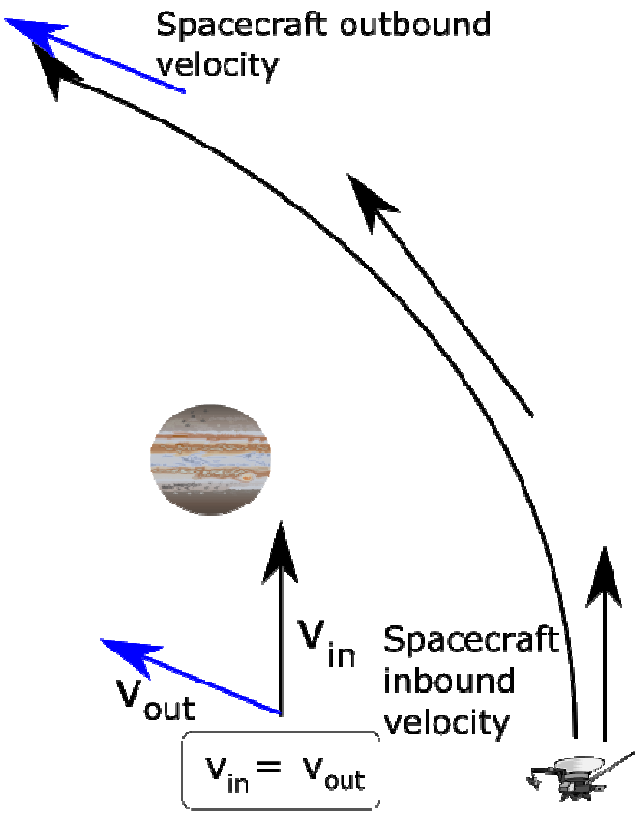
# Orbital Transfers

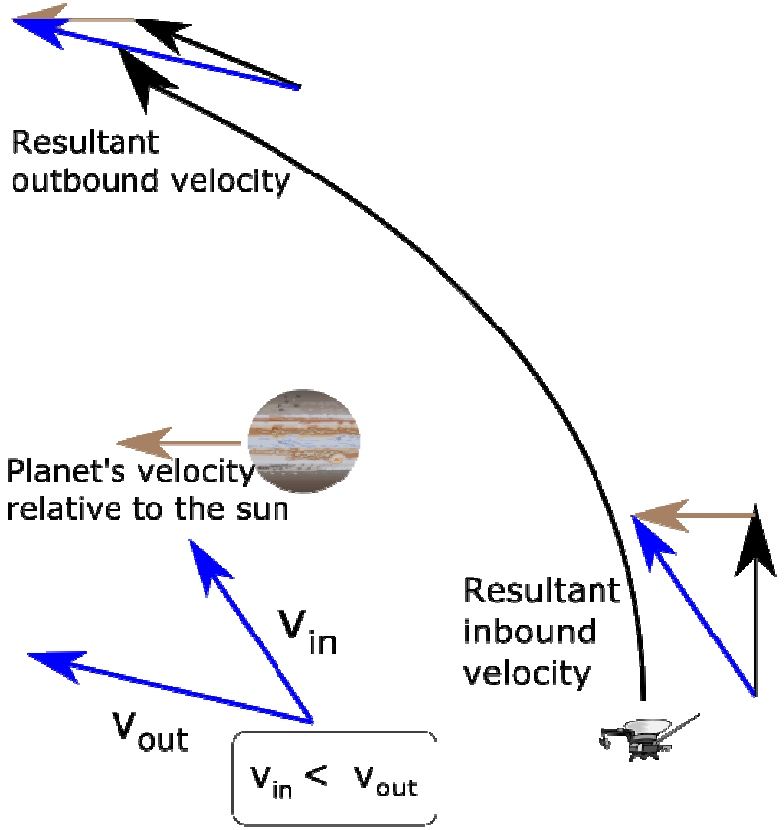
- Hohmann transfer requires minimum delta-V



# Gravitational Slingshot

- Use of gravity of an object to alter the path and/or speed of a spacecraft (hyperbolic orbit)




(wikipedia)

# Lagrangian Points

- For the restricted three-body problem
  - Planar motion of a spacecraft relative to two other masses (which orbit each other)
    e.g., motion of spacecraft with respect to the Earth/Sun or Earth/Moon
- 5 equilibrium points for the spacecraft exist

# Lagrangian Points