
Satellite Basics

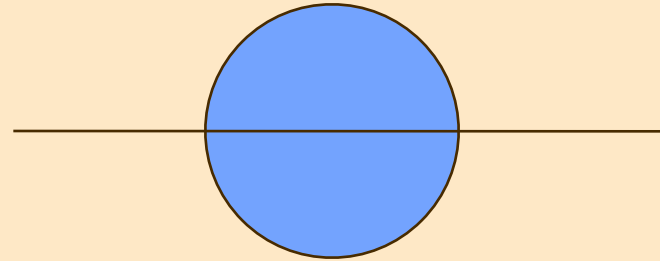
ITS 437

Satellite Components

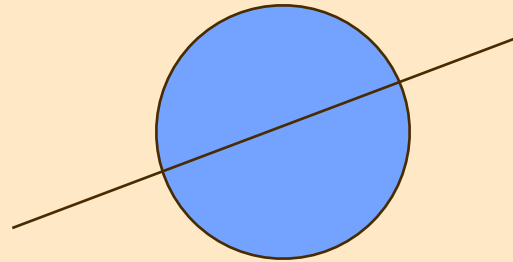
- Satellite Subsystems
 - Telemetry, Tracking, and Control
 - Electrical Power and Thermal Control
 - Attitude Control
 - Communications Subsystem

Satellite Orbits

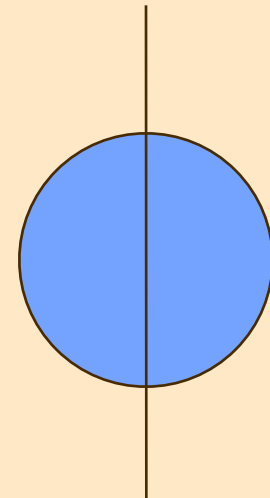
- Equatorial



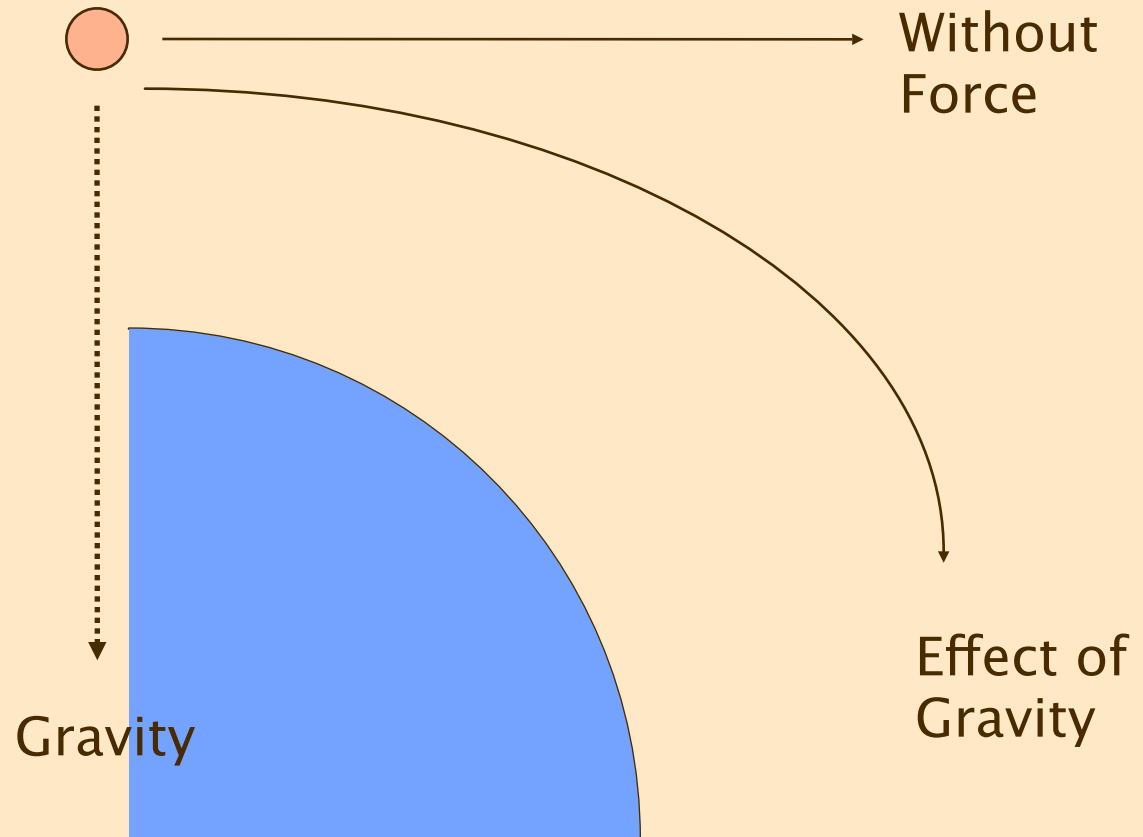
- Inclined



- Polar



Orbital Mechanics



Here's the Math...

- Gravity depends on the mass of the earth, the mass of the satellite, and the distance between the center of the earth and the satellite
- For a satellite traveling in a circle, the speed of the satellite and the radius of the circle determine the force (of gravity) needed to maintain the orbit

But...

- The radius of the orbit is also the distance from the center of the earth.
- For each orbit the amount of gravity available is therefore fixed
- That in turn means that the speed at which the satellite travels is determined by the orbit

Let's look in a Physics Book...

- From what we have deduced so far, there has to be an equation that relates the orbit and the speed of the satellite:

$$T = 2\pi \sqrt{\frac{r^3}{4 \times 10^{14}}}$$

T is the time for one full revolution around the orbit, in seconds

r is the radius of the orbit, in meters, including the radius of the earth ($6.38 \times 10^6 \text{m}$).

The Most Common Example

- “Height” of the orbit = 22,300 mile
- That is 36,000km = $3.6 \times 10^7 \text{m}$
- The radius of the orbit is
 $3.6 \times 10^7 \text{m} + 6.38 \times 10^6 \text{m} = 4.2 \times 10^7 \text{m}$
- Put that into the formula and ...

The Geosynchronous Orbit

- The answer is $T = 86,000$ sec (rounded)
- $86,000$ sec = $1,433$ min = 24hours (rounded)
- The satellite needs 1 day to complete an orbit
- Since the earth turns once per day, the satellite moves with the surface of the earth.

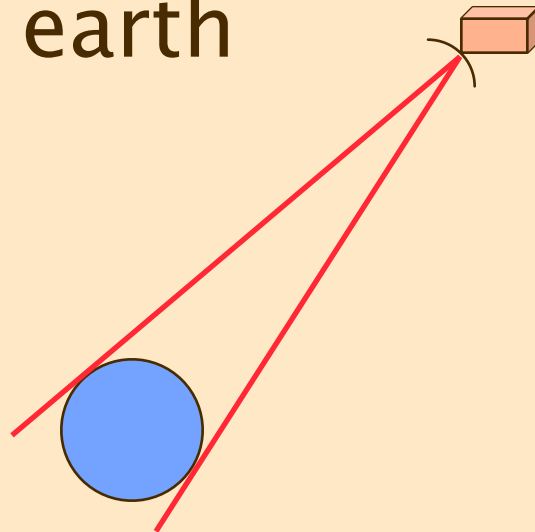
Try it...

- How long does a Low Earth Orbit Satellite need for one orbit at a height of 200miles = 322km = 3.22×10^5 m
- Do this:
 - Add the radius of the earth, 6.38×10^6 m
 - Compute T from the formula
 - Change T to minutes or hours

$$T = 2\pi \sqrt{\frac{r^3}{4 \times 10^{14}}}$$

GEO Coverage

- Altitude is about 6 times the earth's radius
- Three satellite can cover the surface of the earth

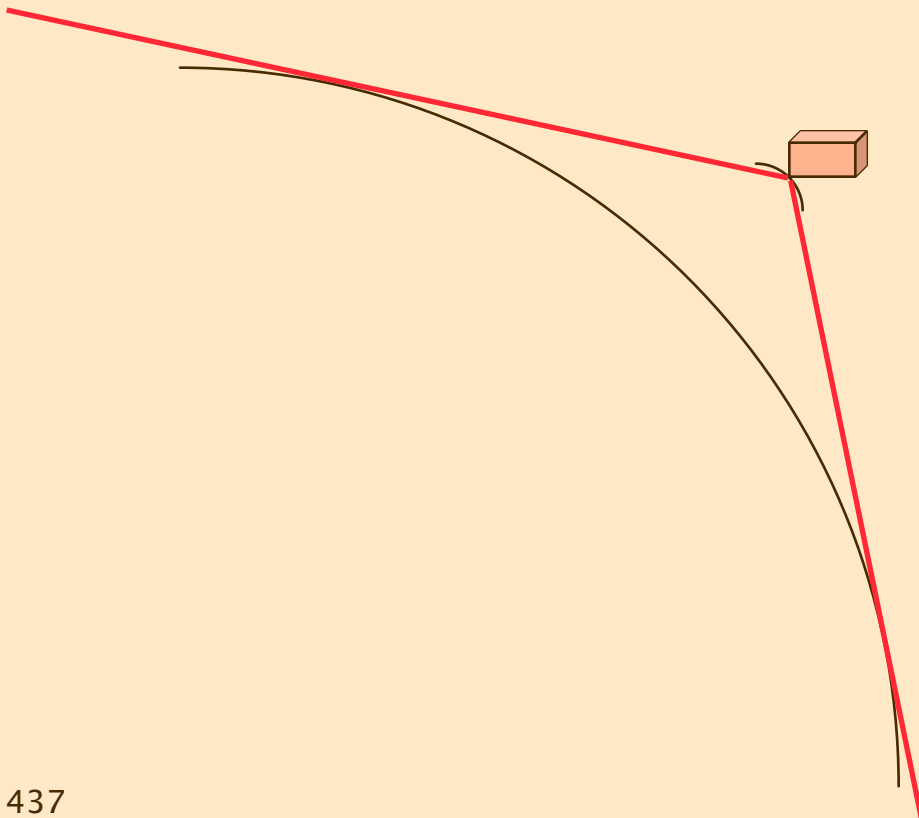


Orbit Examples

- Geostationary
 - Equatorial and Geosynchronous
- Inclined Geosynchronous
 - Satellite moves north/south relative to the earth station
- Polar LEO
 - Satellite group covers the entire earth

LEOS Coverage

- Altitude is $1/6$ of the earth's radius



Communication Frequencies

- Uplink (Earth to Satellite)
 - C Band: around 6 GHz
 - K_u Band: around 14 GHz
 - K_a Band: around 30 GHz
- Downlink (Satellite to Earth)
 - C Band: around 4 GHz
 - K_u Band: around 12 GHz
 - K_a Band: around 20 GHz