Satellite Communications

PRINCIPLE OF SATELLITE COMMUNICATION

Chapter One

Lecture 5

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Elevation angle

- The angle from the horizontal to the point on the center of the main beam of the antenna when the antenna is pointed directly at the satellite

- Coverage angle - the measure of the portion of the earth's surface visible to the satellite

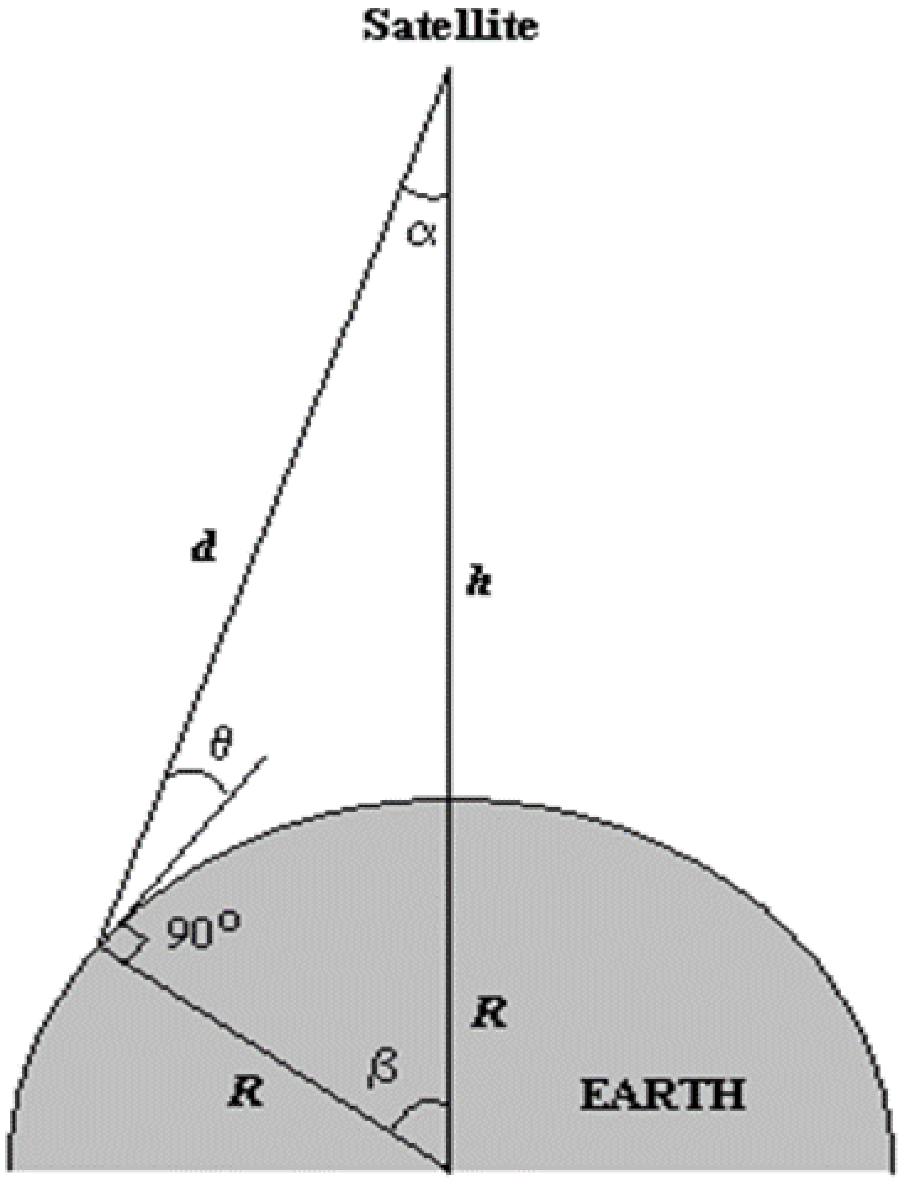
Elevation angle

- Reasons affecting minimum elevation angle of earth station’s antenna $(> 0\ )^{o}$

  - Buildings, trees, and other terrestrial objects block the line of sight.
  - Atmospheric attenuation is greater at low elevation angles.
  - Electrical noise generated by the earth's heat near its surface adversely affects reception.

- $$\frac{\boldsymbol{R}}{\boldsymbol{R}+\boldsymbol{h}} = \frac{\mathbf{cos}(\boldsymbol{\beta}+\boldsymbol{\theta})}{\mathbf{cos}(\boldsymbol{\theta})}$$

- **Orbit Height h**
- **Coverage Angle β**
- **Elevation Angle θ**



H.W

A satellite at a distance of 10000 km from a point on the earths surface , the Coverage Angle $\beta = 45^{\circ}$ draw and find the Elevation Angle θ when R= $6378 * 10^{3}$km

The Forces Acting on Satellite

- When a satellite is launched, it is placed in orbit around the Earth.
- The Earth's gravity holds the satellite on a certain path as it goes around the Earth, and that path is called an "orbit.“

- There are two main forces acting on satellite :

o A centrifugal force due to the kinetic energy of the satellite, which attempts to fling the satellite into a higher orbit.

o A centripetal force due to gravitational attraction of the planet about which satellite is orbiting, which attempts to pull the satellite down forward the planet.

If these two forces are equal, the satellite will remain in stable orbit.

Centrifugal force is

$$Fc = (mv^2/r)$$

Gravitational force between two bodies of mass M and m is

$$Fg = (GMm/r^2)$$

(M) mass of the Earth, (m) mass of the satellite, (G) Newton's Gravitational Constant, (r) orbital radius and (v) speed of satellite.

For the satellite stable in orbit

$$Fc = Fg,$$

$$(mv^2/\mathrm{r}) = (GMm/\mathrm{r}^2)$$

$$v^2/\mathrm{r} = GM/\mathrm{r}^2 \qquad \text{if } v = 2\pi r\ /T$$

$$(4\pi^2\, r/T^2 = GM/\mathrm{r}^2$$

$$\mathrm{r}^3 = (GM\,\mathrm{T}^2)/4\pi^2$$

We know that :

T is one day, since this is the period of the Earth. This is 8.64 x 10^4 seconds.

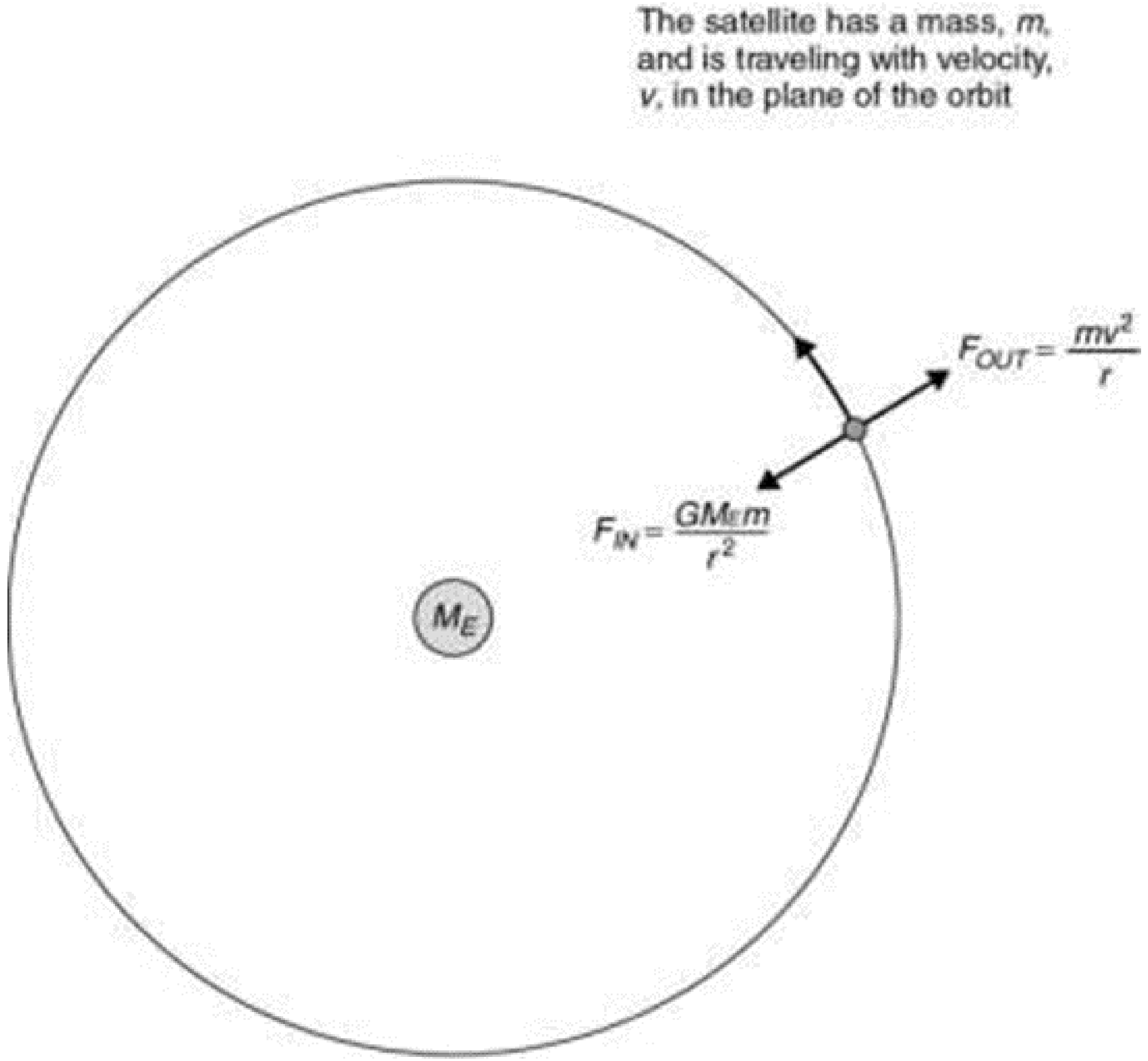
M is the mass of the Earth, which is 6 x 10^{24} kg.

G (Newton's Gravitational Constant) is 6.67 x $10^{-11} m^3/\mathrm{kg}.S^2$, So we can work out r.

r^3 = 7.57 x 10^{22}

So, r = 4.23 x 10^7 = 42,300 km.

- So the orbital radius required for a geostationary is 42,300km.
- When radius of the Earth = 6378 km and height of the geostationary orbit above the Earth's surface = ~36000 km.



- Gravitational force is inversely proportional to the square of the distance between the centres of gravity of the satellite and the planet the satellite is orbiting, in this case the earth.
- The gravitational force inward (FIN, the centripetal force = Fc) is directed toward the centre of gravity of the earth.
- The kinetic energy of the satellite (FOUT, the centrifugal force= Fg) is directed opposite to the gravitational force. Kinetic energy is proportional to the square of the velocity of the satellite. When these inward and outward forces are balanced, the satellite moves around the earth in a “free fall” trajectory: the satellite’s orbit.

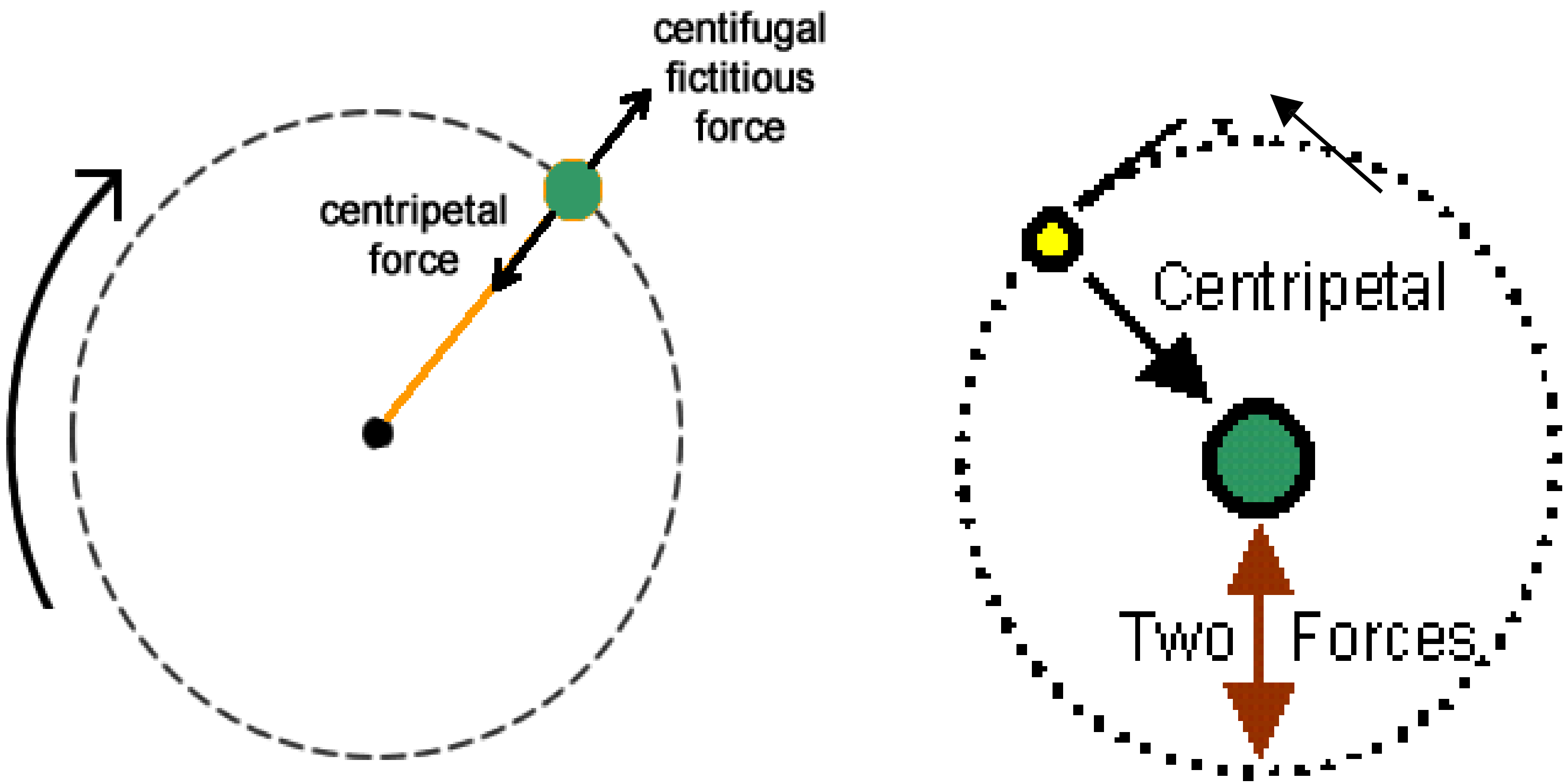


Fig 1.12 The forces acting on satellite