Gravitation

Satellite

Heavenly object that revolves around a planet

Geostationary satellite
Height from surface of earth = 36000km Radius of orbit = 42,400km
Time periods = 24 hours
Orbital velocity = 3.1km/s

Polar satellite
Height from earth's surface = 880km
Time period = 84min
Orbital velocity = 7.92km/s

Escape speed $v_{esc} = \sqrt{2GM/R}$
$= \sqrt{2gR}$

Earth 's $v_{esc} = 11.2\text{km/s}$

Orbitals speed $v_{orb} = \sqrt{gR} = \frac{v_e}{\sqrt{2}}$

Total Energy of a satellite

E = K.E + P.E

$$= \left(\frac{GMm}{2r}\right) + \left(\frac{-GMm}{r}\right) = -\frac{1}{2}G\frac{Mm}{r}$$

Weightlessness
During free fall under gravity inside a spacecraft or satellite a body is weightless i.e., effective weight becomes zero.

Gravitational field and potential

· Gravitational field Intensity

$$I = \frac{Gm}{r^2}$$

· Gravitational potential

$$V_g = \frac{\text{work done}}{\text{mass}} = \frac{-Gm}{r}$$

· Gravitational Potential Energy

$$U = \frac{-GMm}{r}$$

Kepler's Law-of planetary motion

(i) Law of Orbit: Every planet revolves around the Sun in an elliptical orbit and Sun is at its one focus.

(ii) Law of Area: The radius vector drawn from the Sun to a planet sweeps out equal areas in equal intervals of time.

$$\frac{dA}{dt} = \frac{L}{2m} = \text{Constant}$$

(iii) Law of Periods: $T^2 \propto a^3$
where, a = length of semi-major axis

Acceleration due to gravity (g)

Acceleration possessed by an object during free fall due to earth's gravitational pull,

$$g = \frac{GM_e}{R_e^2}$$

Variation in acceleration due to gravity (g)

(i) with height $g' = g\left(1 - \frac{2h}{R_E}\right)$,
i.e. g decreases with height

(ii) with depth $g' = g\left(1 - \frac{d}{R_E}\right)$,
i.e. g decreases with depth

(iii) with rotation of earth about its own axis
$g' = g - R\omega^2\cos^2\lambda$,
At poles, $\lambda = 90^0$, g maximum
At equator, $\lambda = 0^0$, g minimum

Newton's universal low of Gravitation

When two mass bodies are separted by a distance, they experience an attractive force which is directly proportional to the product of their masses and inversaly proportional to the square of their separation.

$$F = \frac{Gm_1m_2}{r^2}, \quad G = 6.67 \times 10^{-11} Nm^2 kg^{-2}$$

Characteristics of gravitational force
(i) Weakest force in Nature.
(ii) Central as well as conservative.
(iii) Always attractive in nature.
(iv) Applicable for all bodies irrespective of their shape, size and position.