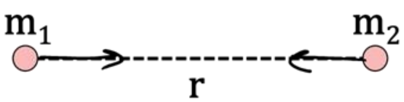
MIND MAP

Gravitation

Universal Law of Gravitation



$$F = \frac{Gm_1m_2}{r^2}$$

$G = 6.67 \times 10^{-11}\ Nm^2/kg^2$

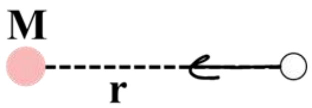
$\downarrow$

Universal Gravitational Constant

Electrostatics Analogy

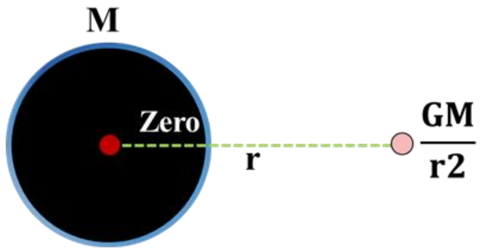
Electrostatics	Gravitation
$\frac{kq_1q_2}{r^2}$	$\frac{G\,m_1m_2}{r^2}$
q	m
$k = \frac{1}{4\pi\varepsilon_0}$	G
λ σ ρ	λ σ ρ
$\vec{E}$	$\vec{G}$

Gravitational Field

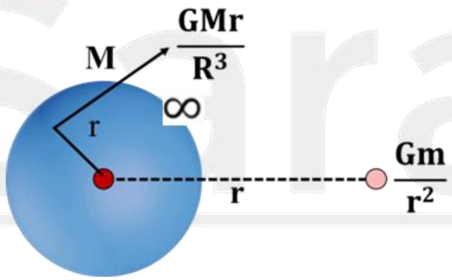


Gravitational Field Intensity $= \frac{GM}{r^2}$

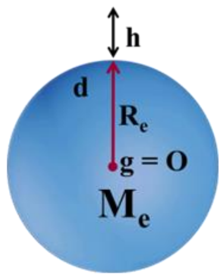
Hollow Sphere



Solid Sphere



Acceleration due to Gravity



At surface

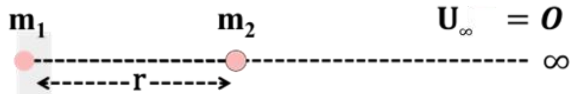
$$GFI = g_o = \frac{Gm_e}{R_e^2} = 9.8\ m/s^2$$

At wight $\quad h << R_e$

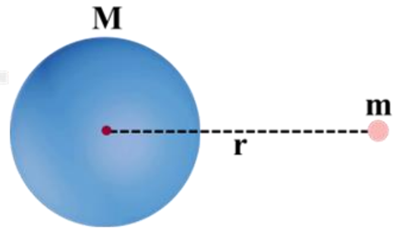
$$g = \frac{g_o}{\left(1+\frac{h}{R_e}\right)^2} \approx g_o\left(1-\frac{2h}{R_e}\right)$$

At depth $\quad g = g_o\left(1-\frac{d}{R_e}\right)$

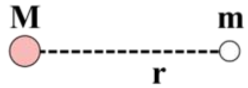
Gravitational Potential Energy



$$U = -\frac{G\,m_1m_2}{r}$$



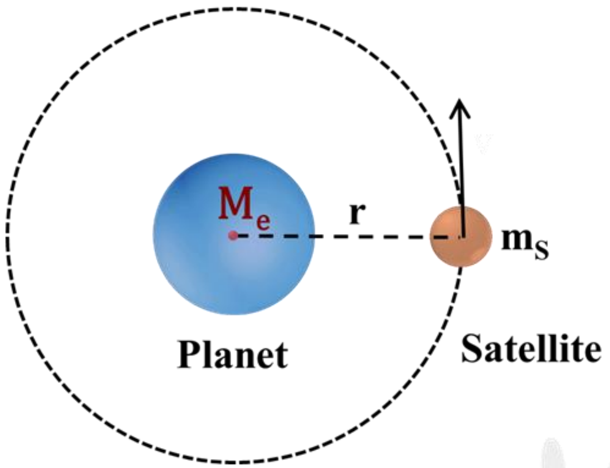
Gravitational Potential



scalar $V = -\frac{GM}{r}$

MIND MAP
Gravitation

Motion of Satellite (Circular Orbit)



$$v = \sqrt{\frac{GM_e}{r}}$$ Orbital Speed

r → Distance b/w center of earth & satellite

$$T = \frac{2\pi r}{v}$$

$$T = 2\pi\sqrt{\frac{r^3}{GM_e}}$$

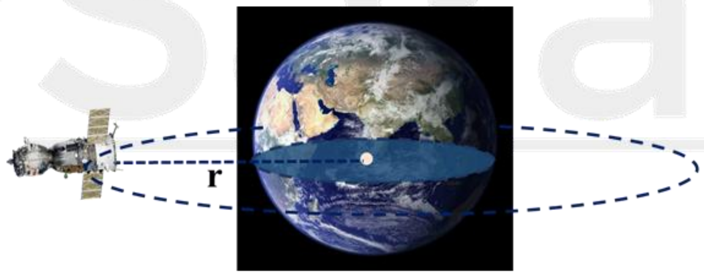
$$T \propto r^{\frac{3}{2}}$$

$$PE = -\frac{G\,m_e m_s}{r}$$

$$KE = \frac{1}{2}m_s v^2 = \frac{G\,m_e m_s}{2r}$$

$$ME = PE + KE = -\frac{Gm_e m_s}{2r}$$

Satellites in a circular orbit around earth in equatorial plane with T=24 hours are called Geostationary Satellite.



It revolves in equatorial plane from west to east in same sense as earth.

Its angular velocity with respect to earth is Zero.

Its orbit is called Parking Orbit.

It is used for telecommunication, weather forecasting, etc.

$$\underset{\uparrow\ 24\text{ hrs}}{T} = 2\pi\sqrt{\frac{r^3}{GM_e}}$$

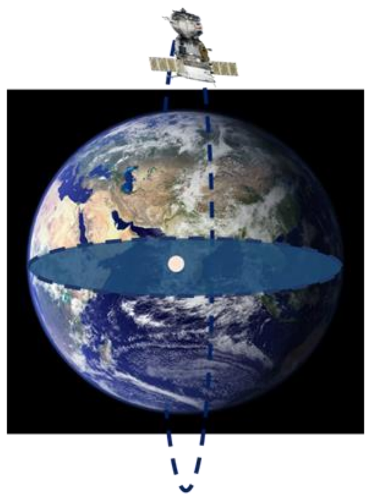
r = 42170 km

From surface = 42170 – 6370
= 35800 km

Orbital Velocity = 3.08 km/sec.

Polar Satellite

It is used for remote sensing, environmental studies.



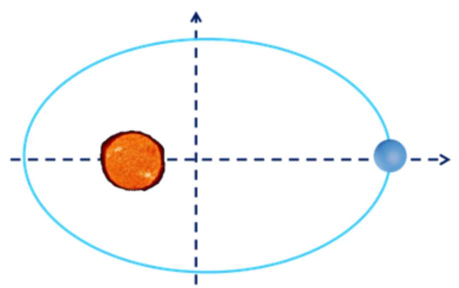
MIND MAP

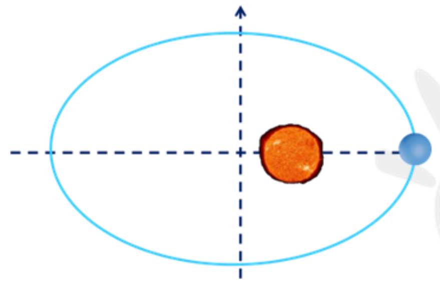
Gravitation

Kepler's Laws

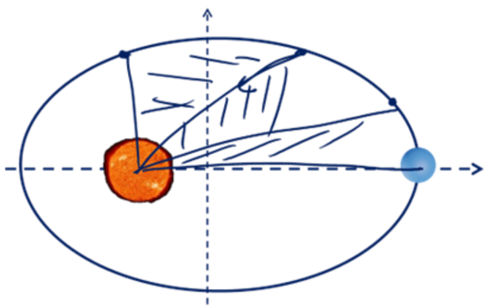
1-Law of Orbits

All planets move in elliptical orbits with the Sun situated at one of the foci.





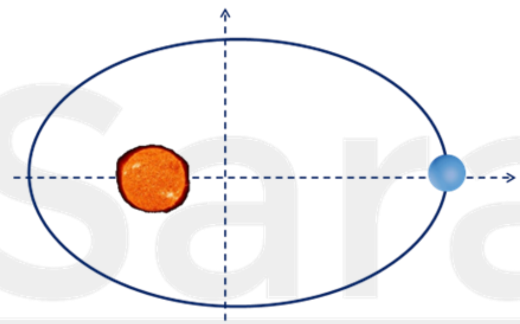
2-Law of Areas



Position vector from Sun to the planet sweeps out equal area in equal time intervals.

Areal velocity of planet around Sun always remains constant.

This law is based on angular momentum conservation.

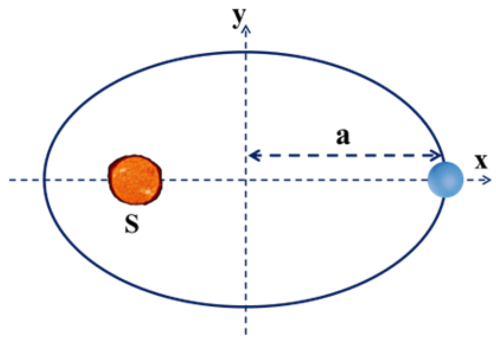


$$A = \frac{LT}{2M_p}$$

Constant

$$\underbrace{\frac{dA}{dt}}_{\text{Areal Velocity}} = \frac{L}{2M_p} \longrightarrow \text{Angular Momentum about Sun}$$

3-Law of Periods



The square of the time period of revolution of a planet is proportional to the cube of the semi-major axis of the ellipse traced out by the planet.

$T^2 \propto a^3$

$\Rightarrow T \propto a^{3/2}$

$$T = 2\pi\sqrt{\frac{a^3}{GM_{sun}}}$$

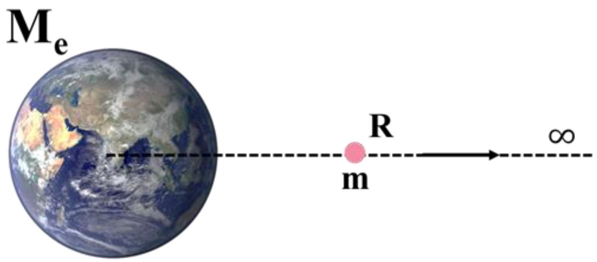
Escape Velocity

$$v_e = \sqrt{\frac{2GM_e}{r}} \qquad \sqrt{\frac{2GM_eR}{R^2}}$$

At Earth's Surface, $v_e = \sqrt{2g_0R}$
$= 11.2$ km/s

MIND MAP

Gravitation



$v = \frac{V_e}{\sqrt{2}}$ Circular

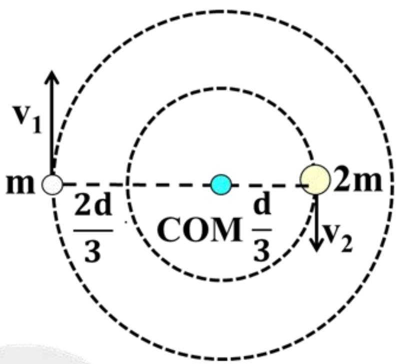
If $v < v_e$ TE < 0 Path: Bounded and Elliptical

If $v = v_e$ TE = 0 Path : Unbounded and Parabolic

If $v > v_e$ TE > 0 Path : Unbounded and Hyperbolic

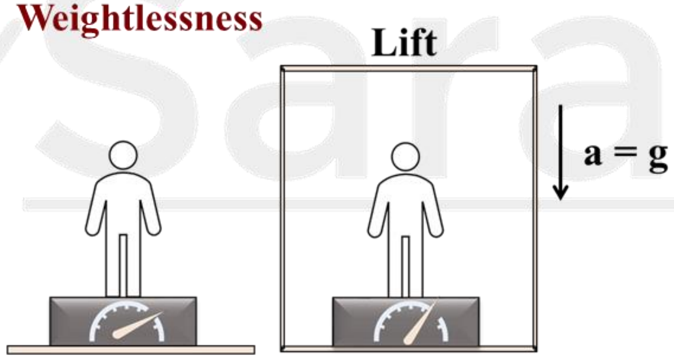
Binary Star System

A pair of stars rotating about their COM (centre of mass).



$\frac{v_1}{v_2} = \frac{2}{1}$ $\frac{T_1}{T_2} = \frac{1}{1}$ $\frac{KE_1}{KE_2} = \frac{2}{1}$ $\frac{L_1}{L_2} = \frac{2}{1}$

Weightlessness



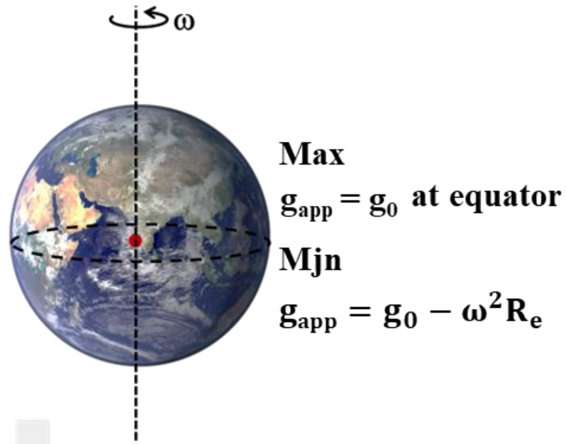
N = mg

N = m (g – a)

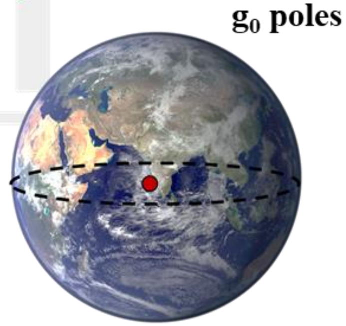
N = O (When a = g)

Motion of an object is referred as free fall , if its acceleration is same as acceleration due to gravity.

Variation of gapp due to Rotation of Earth



Variation of g due to non-spherical Shape of Earth



g_0 equator < g_0 poles

Earth is bulged at equator

g_0 is more at poles than at equator.