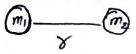
① Newton's law of Gravitation



$$\boxed{F = \frac{G m_1 m_2}{r^2}}$$

$G \Rightarrow Nm^2/kg^2$

$[M^{-1}L^3T^{-2}]$

- force is independent of medium

	$x\%\uparrow$	Constant	Increasing
M	mass	R radius	$g\uparrow$ by $x\%$
D	density	R radius	$g\uparrow$ by $x\%$
R	radius	D density	$g\uparrow$ by $x\%$
R	radius	M Mass	$g\uparrow$ by $2x\%$

Acceleration due to gravity (g)

$$\boxed{g = \frac{GM}{r^2}}$$

At surface $r = R_e$

$$\boxed{g = \frac{GM}{R_e^2}}$$

$g = \frac{G \rho V}{R^2}$

$$\boxed{g = \frac{4}{3}\pi R \rho G}$$

$G = 6.67\times10^{-11}\ Nm^2/kg^2$

$M_e = 6\times10^{24}\ kg$

$R_e = 6400\ km$

$$\boxed{g \approx 10\ m/s^2}$$

Time period of satellite :

$$\boxed{T = \frac{2\pi r^{3/2}}{\sqrt{GM}}}$$

$\boxed{T^2 \propto r^3} \rightarrow$ Kepler Third law.

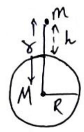
when satellite is close to earth surface $(r \rightarrow R)$

$\boxed{T = 2\pi\sqrt{\frac{R}{g}}} \approx 84.6\ min \Rightarrow 1.4\ hr$

$V < V_o$	spiral	$K.E < P.E$	$T.E \rightarrow -ve$	e ~~e(x)~~
$V = V_o$	circular	$K.E < P.E$	$-ve$	0
$V_o < V < V_e$	Elliptical	$K.E < P.E$	$-ve$	<1
$V = V_e$	Parabolic	$K.E = P.E$	0	1
$V > V_e$	Hyperbolic	$K.E > P.E$	$+ve$	>1

Variation in g

① Above Earth's surface



$$\boxed{g' = \frac{g}{\left[1 + \left(\frac{h}{R_e}\right)\right]^2}}$$

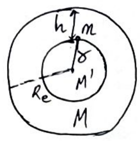
if $h << R_e$ then

$$g' = g\left[1 + \left(\frac{h}{R_e}\right)\right]^{-2}$$

$$\boxed{g' = g\left[1 - \frac{2h}{R_e}\right]}$$

∴ Thus g decrease with increase in altitude

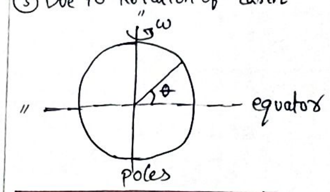
② Below Earth's



$$\boxed{g' = g\left(1 - \frac{h}{R_e}\right)}$$

$$\boxed{g' = \frac{GMr}{R_e^3}}$$

③ Due to Rotation of Earth



$$\boxed{g'_{eff} = g - R\omega^2\cos^2\theta}$$

At equator $\theta = 0°$

$\boxed{g_{eff} = g - R\omega^2}$ → minimum

At poles $\theta = 90°$

$\boxed{g_{eff} = g}$ → maximum.

Escape Velocity

$$\boxed{V_e = \sqrt{\frac{2GM}{R}}}$$

$$\boxed{V_e = \sqrt{2gR}}$$

$g = \frac{4}{3}\rho G\pi R$

$$\boxed{V_e = R\sqrt{\frac{8}{3}\pi G\rho}}$$

$$\boxed{V_e = 11.2\ km/s}$$

At certain height $r = R + h$

$$\boxed{V_e = \sqrt{\frac{2GM}{R+h}}}$$

$$\boxed{V_e = \sqrt{2g(R+h)}}$$

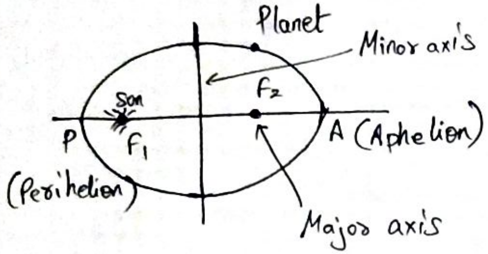
$$\boxed{V_o = \sqrt{\frac{GM}{r}}}$$

$\boxed{V_o = \sqrt{gR}}$ if 'm' is very close to earth $[r \rightarrow R]$

$$\boxed{V_e = \sqrt{2}\, V_o}$$

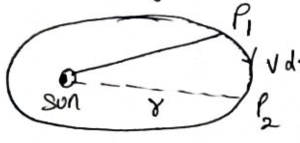
Kepler's law :

① 1^{st} law



② 2^{nd} law : (In accordance with conservation of $\vec{L}$)

Areal velocity = constant



$$\frac{dA}{dt} = \frac{1}{2}\frac{(\vec{r} \times \vec{v}\,dt)}{dt}$$

$$= \frac{1}{2}\vec{r} \times \vec{v} = \frac{1}{2}\frac{(\vec{r} \times \vec{p})}{m}$$

$$= \frac{\vec{L}}{2m} = \text{Constant}$$

③ 3^{rd} law :

$$T^2 \propto r^3$$

$r \rightarrow$ semi-major axis

Energy of satellite :

Case I :
Rest

i) $K.E = 0$

$$P.E = -\frac{GMm}{R}$$

$$T.E = -\frac{GMm}{R}$$

$$B.E = +\frac{GMm}{R}$$

Case II : In orbit.

$$K.E = \frac{1}{2}mv_0^2 = \frac{1}{2}m\frac{GM}{r} = \frac{1}{2}\frac{GMm}{r}$$

$$P.E = -\frac{GMm}{r}$$

$$T.E = -\frac{1}{2}\frac{GMm}{r}$$

$$B.E = +\frac{1}{2}\frac{GMm}{r}$$

$$B.E = K.E = \ominus T.E = \ominus\frac{P.E}{2}$$

Energy required to raise the satellite to height 'h'?

$$E = -\frac{GMm}{R+h} - \left(-\frac{GMm}{R}\right) = GMm\left[\frac{1}{R} - \frac{1}{R+h}\right] = \frac{GMmh}{R(R+h)}$$

Energy required to launch a satellite of mass 'm' from surface of earth of Mass 'M' & radius R at an altitude 'h'.

$$E = T.E_f - T.E_i = -\frac{GMm}{2(R+h)} - \left(-\frac{GMm}{R}\right) =$$

Gravitational potential

$\boxed{V_p = -\frac{GM}{R}}$ on the surface of earth $\boxed{V = -\frac{GM}{(R+h)}}$ at height h

$V_p \rightarrow$ scalar quantity

$M \rightarrow$ should be point Mass