Gravitation

$F_g \propto m_1 m_2$

$F_g \propto \frac{1}{r^2}$

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

$\boxed{F_g = G\frac{m_1 m_2}{r^2}(-\hat{r})}$

$\hat{r} = \frac{\vec{r}}{|\vec{r}|}$

$\boxed{F_g = \frac{G m_1 m_2}{r^3}(-\vec{r})}$

$\boxed{\vec{F}_{12} = \frac{G m_1 m_2}{r^3}(\vec{r}_{12})}$

$\boxed{\vec{F}_{21} = \frac{G m_1 m_2}{r^3}(\vec{r}_{21}) = \frac{G m_1 m_2}{r^3}(-\vec{r}_{21})}$

$\boxed{\vec{F}_{12} = -\vec{r}_{21}}$ $\quad$ $\boxed{\vec{F}_{21} + \vec{F}_{12} = 0}$

$\vec{F}_{21} = -\vec{F}_{12}$

* G = universal Gravitational const.

$= 6.67 \times 10^{-11}\ Nm^2/kg^2$ (S.I)

$= 6.67 \times 10^{-8}$ (CGS) **

AIIPMT * Dimension $\Rightarrow \boxed{M^{-1}L^3T^{-2}}$

****** NOTE → * It is only attractive nature force & its direction is always towards mass.

AIR * It is ****** Medium Independent force.

AIR * Gravitational force on a particle inside spherical shell is zero. However (unlike a metallic shell wich shields Electric forces & magnetic forces) the shelldoes not shield other bodies outside it from external gravitational forces onparticle Inside. Gravitational shielding is not possible!! (AIIMS 2015)

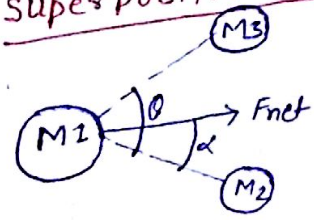
AIR * Gravitational force field is conservative force field. Work done is Independent from path.

AIR * In absence of Gravitational force field net force on system is zero thats why linear Momentum conserved.

AIR * Line of Action of Gravitational force is passed from fixed point & It obey Inverse square law that's why it is called central force.

***!! * Gravitational force b/w two mass remain unchange with presence of another Mass.

superposition of force →



Imp $\boxed{F_{net} = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta} \quad \alpha = \tan^{-1}\left(\frac{F_2\sin\theta}{F_1 + F_2\cos\theta}\right)}$

* Net Gravitational force is vector Addition of Indivisual force.

$\boxed{\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \cdots\cdots \vec{F}_N = \sum_{i=1}^{i=N} \vec{F}_i}$

***** NOTE → * In a Regular polygon If similar mass is placed at the vertex net force at central mass zero.

* If (n−1) similar Mass placed at the vertex of Regular polygon net force on central Mass equal to $\boxed{F}$.

similar Mass 'm' placed along x-axis at $x=0, x=a, x=2a, x=4a$ & up to ∞ calculate net Gravitational force on mass at $x=0$. → $\boxed{F_{net} = \frac{4}{3}\frac{GM^2}{a^2}}$

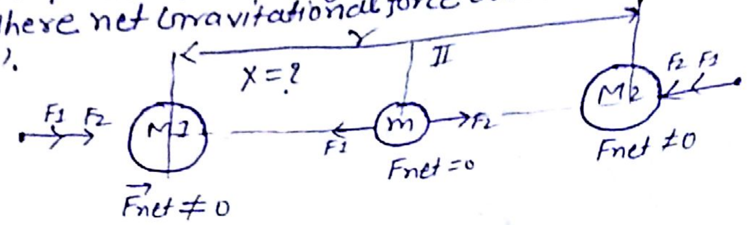
Mass 'M' devide into 2-parts & placed at fixed distance calculate maximum value of force b/w divide mass. If distance b/w mass is x → $\boxed{m = \frac{M}{2}}$ $\boxed{\frac{GM^2}{4x^2}}$

Two sphere of Radius 'R' mass 'm' placed in contact calculate net gravitational force b/w them → $\boxed{0}$

3-sphere of Radius 'R' mass 'm' placed in contact calculate net Gravitational force on one sphere → $\sqrt{3}\frac{Gm^2}{4R^2}$

Two similar Mass 'm' Rotate in a circular path of Radius 'R' due to mutual attractive force. calculate. velocity of each mass. → $\boxed{\sqrt{\frac{GM}{2d}}}$

Mass 'm' placed b/w joining line of M_1 & M_2 calculate distance from mass M_1 where net Gravitational force on mass m is zero distance b/w m_1 & m_2 is 'r'.



$F_1 - F_2 = 0$

$\boxed{F_1 = F_2}$

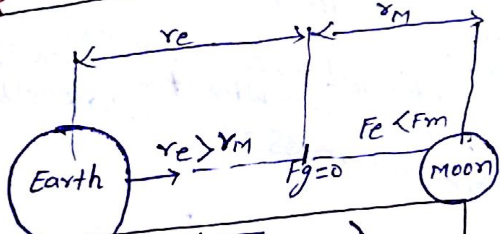
$$\frac{GM_1 m}{x^2} = \frac{GM_2 m}{(r-x)^2}$$

$$\sqrt{\frac{M_1}{x}} = \sqrt{\frac{M_2}{r-x}}$$

* $$\boxed{x = \frac{\sqrt{M_1}\, r}{\sqrt{M_1} + \sqrt{M_2}}}$$

* $$\boxed{r - x = \frac{\sqrt{M_2}\, r}{\sqrt{M_1} + \sqrt{M_2}}}$$

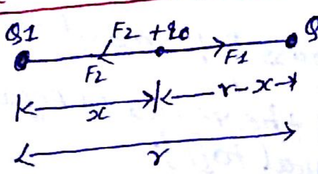
***



* $$\boxed{r_e = \left(\frac{\sqrt{M_e}}{\sqrt{M_e} + \sqrt{M_m}}\right) r_{eM}}$$

* $$\boxed{r_M = \left(\frac{\sqrt{M_m}}{\sqrt{M_e} + \sqrt{M_m}}\right)}$$

CASE-I (When q_1, q_2 are like charge) →



** $$x = \frac{\sqrt{q_1}\, r}{\sqrt{q_2} + \sqrt{q_1}} \rightarrow \text{From } q_1$$

$$r - x = \frac{\sqrt{q_2}\, r}{\sqrt{q_2} + \sqrt{q_1}} \rightarrow \text{From } q_2$$

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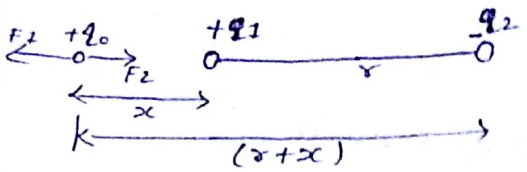
Case-II (When q_1, q_2 are unlike) →



$$x = \frac{\sqrt{q_1}\, r}{\sqrt{q_2} - \sqrt{q_1}} \longrightarrow \text{From } q_1$$

$$r + x = \frac{\sqrt{q_2}\, r}{\sqrt{q_2} - \sqrt{q_1}} \longrightarrow \text{From } q_2$$

** # Rod of Mass 'M' length 'L' placed in a horizontal plane & Mass 'm' is placed at distance 'x' on the axis of Rod calculate Gravitational force on mass m →

$$\boxed{F = \frac{GMm}{x(L+x)}}$$

Gravitational Accln

Accln of particle in presence of Gravitational force field.

$$\boxed{a = \frac{F_g}{m} \qquad g = \frac{GM}{R^2}}$$

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

M = Mass of planet
R = Radius of planet
ρ = Avg. density of planet.

*** **NOTE** → Gravitational Accln of planet independent from mass of particle.
It only depend on mass of planet, radius of planet & density of planet.

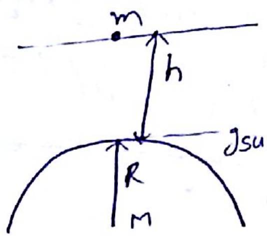
$g_{earth} = g = 9.8\ m/sec^2$
$= 980\ cm/sec^2$
$= 32\ F/sec^2$

$g_m = \frac{g_e}{6}$

$g_{Jupiter} = 1.4 g_e$

Effecting factor of 'g'

[A] Effect of Height →



$$g_{surface} = \frac{GM}{R^2}$$

$$\boxed{g_h = \frac{g_s}{(1+h/R)^2}}$$

* $h << R$ or, 'h' is $\leq$ 5% of R

$h \leq \frac{5}{100} \times 6400$

$\boxed{h \leq 320 Km}$

$g_h = g_s\left(1 + \frac{h}{R}\right)^{-2}$

$h << R = \frac{h}{R} << 1$

$(1+x)^n = 1 + nx \quad (x << 1)$

Exemplar

$$\boxed{g_h = g_s\left(1 - \frac{2h}{R}\right)}$$

** |a| → 'h' is in Range of 'R'

$g_h = g_s/(1+h/R)^2$

|b| → $h \leq 320$ km ($\leq$ 5% of R)

$g_h = g\left(1 - \frac{2h}{R}\right)$

* $h \uparrow \Rightarrow g_h \downarrow$

* 32↑ ⟶ 1% ↓
* 64↓ ⟶ 1% ↑

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* % change in Gravitational Accln at height above from earth surace-

(i) → $h = 32\,km$ → $\boxed{-1\%}$

(ii) → $h = R/2$ → $\boxed{-55.55\%}$

(iii) → $h = 1600\,km$ → $\boxed{-36\%}$

* Height from earth surface where Gravitation Accln Remain

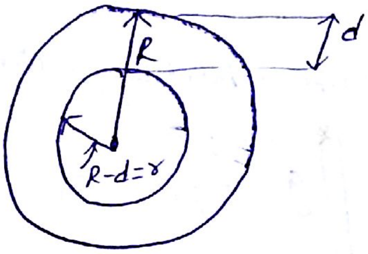
(i) → 19 % of surface → $h = R\left(\frac{10}{\sqrt{10}} - 1\right)$

(ii) → 64 % of surface → $h = \frac{2R}{8} = R/4$

(iii) → 99% of surface → 32 km

[B] → Effect of Depth →

$$\boxed{g_d = g_s\left(1 - \frac{d}{R}\right)}$$



* $d\uparrow \Rightarrow g_d \downarrow$

d = depth from surface.

* d = R (at centre of earth

$$\boxed{g_d = g\left(1 - \frac{R}{R}\right) = 0}$$

* $\boxed{g_d = \frac{4}{3}\pi G \rho (R-d)}$, $\boxed{g = \frac{4}{3}\pi G \rho r}$, r → distance from of centre of earth.

$(R-d)$ → depth from surface.

$$\boxed{g \propto r}$$

Imp * Relation b/w height & depth from earth surface where change in Gravitation Accln Sam (h is << R) → $\boxed{d = 2h}$

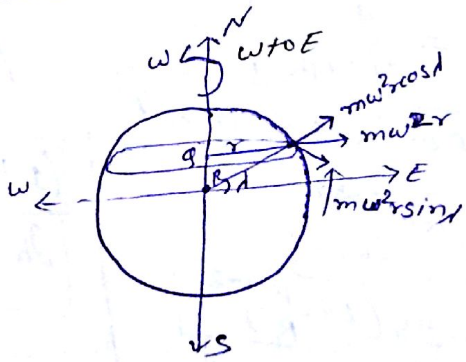
(अगर 1 km down earth surface जाने पे जितना 'g' में कमी होगी उतना earth surface से 2 km upper जाने पे होगा)

से g की value कमी earth surface height & depth for same condn.

* If 'h' in Range of 'R' compair height & depth

$$\boxed{g_h = g} \quad \boxed{\frac{g}{\left(1 + \frac{h}{R}\right)^2} = g\left(1 - \frac{d}{R}\right)}$$

[C] → Effect of Rotation →



$W_{eff} = mg - \omega^2 r\cos\lambda$

$W_{eff} = mg - m\omega^2 R\cos^2\lambda$

$\Downarrow$

mg_{eff}

* $\boxed{g_{eff} = g - \omega^2 R\cos\lambda}$

λ = latitude Angle

R = Radius of earth

ω = Angular speed of earth

* $\omega\uparrow \Rightarrow \cos\lambda\downarrow \Rightarrow g_{eff}\uparrow$

$$\boxed{\omega_{earth} = \frac{2\pi}{T_{earth}} = \frac{2\pi}{24\times60\times60}\ R/S}$$

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#*** UPCPMT

Equator — $g\uparrow$ → pole

Min .... Max

Eg → $w = mg = \text{same}$

$\boxed{m \propto \frac{1}{g}}$

$\boxed{g_{eq} < g_p}$

$\boxed{m_e > m_p}$

UPCPMT (Means 1 kg sugar pole pe कम मिलेगा और equator pe jada)

* $\lambda = 0°$ (at equator)

$g_e = g - \omega^2 R = g_{min}$

* $\lambda = 90°$ (at pole)

$g_p = g = g_{max}$

Gravity free condition → $g' = g - \omega^2 R\cos^2\lambda$

(a) → $\lambda = 0°$ (equator line) ⇒ $g_e = g - \omega^2 R$

(b) → $\lambda = 90°$ (poles) ⇒ $g_p = g \propto \omega^0$

$$\boxed{g_p - g_e = \omega^2 R = 0.03\, m/sec^2}$$

(g_p → Max, g_e → Min)

(c) → Gravity free condn. $g' = 0 = g - \omega^2 R\cos^2\lambda$

$[\omega\uparrow \Rightarrow g'\downarrow]$

$$\boxed{\omega = \frac{1}{\cos\lambda}\sqrt{g/R}} \Rightarrow 1.414(\cos\lambda)\, Hr$$

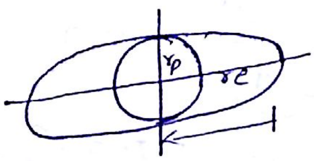
$\boxed{T = 84.6(\cos\lambda) min}$ ⇒ 84.6 mint ⇒ 1.414 hr.

* At equator $\lambda = 0 \Rightarrow \cos 0° = 1 \Rightarrow T$

$\omega = \frac{2\pi}{1} \Rightarrow \boxed{\omega' = 17}$

NOTE → * If angular speed of earth become 17 times of ⊕nt value Gravity free condition is ⊕nt on equator line.
* For Gravity free condition ω_{min} at equator.
! * At pole Gravity free condition is not possible.

[D] → Effect of Shape →



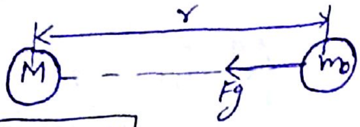
$r_e = r_p + 21\, Km$

$r_e - r_p = 21\, Km$

* $\boxed{\begin{matrix} r_e > r_p \\ g_e < g_p \end{matrix}}$

* $g_e - g_p = 0.02\, m/sec^2$ → Due to Shape
$g_p - g_e = 0.03\, m/sec^2$ → Due to Rotation
* $g_p - g_e = 0.05\, m/sec^2$

Gravitational field Intensity (I_g) → Force per unit in Gravitational field.



$$I_g = \frac{F_g}{m_0} = \frac{\frac{GMm_0}{r^2}}{m_0}$$

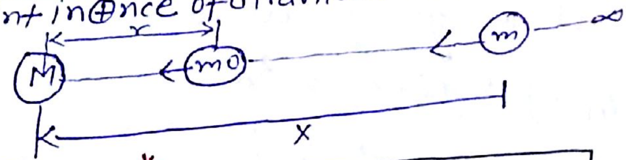
$$\boxed{I_g = \frac{GM}{r^2}}$$ → vector quantity.

$$\boxed{I_g = \frac{GM}{r^2}(-\hat{r}) = -\frac{GM\vec{r}}{r^3}}$$

* Direction in the direction of force.
* unit → $\frac{N}{Kg} = \frac{m}{sec^2}$

NOTE → I_g depend on mass of object & distance from mass it is independend from the mass of testing object.

Gravitational potential (V_g) :→ Workdone to bring a mass from ∞ to specific point in ⊕nce of Gravitational field.



* $$\boxed{(V_g)_P = \frac{W_{\infty P}}{m_0}}$$
* $$\boxed{W_{\infty P} = -\frac{GMm_0}{r}}$$

* $$\boxed{(V_g)_P = \frac{W_{\infty P}}{m_0} = (-)\frac{GM}{r}}$$

(−) → show attractive force field.

NOTE → * V_g is a scalar quantity.
* unit → $\boxed{\frac{J}{Kg}} \neq$ volt

** * Relation b/w I_g & V_g

$$\boxed{I_g = -\frac{\Delta V_g}{\Delta r}}$$

$$\boxed{-\Delta V_g = -\int I_g \Delta r}$$

Similar mass is placed on x-axis at $x=0, x=a, x=2a, x=4a, x=8a$ upto ∞ then

(i) $I_g \rightarrow -\frac{4}{3}\frac{GM}{a^2}\hat{i}$

(ii) $V_g \rightarrow -\frac{2Gm}{a}$

**

$$I_g = -\frac{\Delta V_g}{\Delta r}$$

(a) $V_g = f(r) \Rightarrow I_g = -\frac{d}{dr}[f(r)]$

(b) $I_g = f(r) \Rightarrow \int dV_g = -\int I_g dr$

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*** Gravitational field Intensity & Potential for contineous mass distribution obj.

[A] → Hollow sphere →

|i| → $r > R$ (outside) ⇒ $\boxed{I_g = -\frac{GM}{r^2}}$

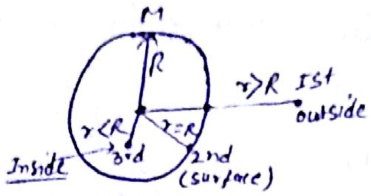
$\boxed{V_g = -\frac{GM}{r}}$

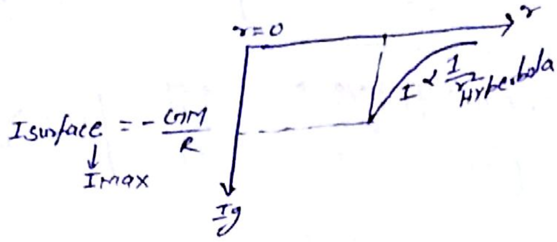
|ii| → $r = r$ (surface) ⇒ $\boxed{I_g = -\frac{GM}{R^2}}$

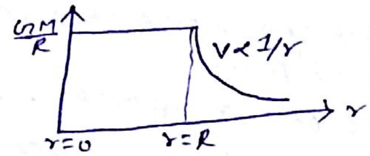
$\boxed{V_g = -\frac{GM}{R}}$

|iii| → $r < R$ (Inside)

$\boxed{I_g = 0}$ $\boxed{V_g = -\frac{GM}{R}}$







[B] → solid sphere →
or planet or, Earth.

|i| → $r > R$ (outside) $\boxed{I_g = -\frac{GM}{r^2}}$

$\boxed{V_g = -\frac{GM}{r}}$

|ii| → $r = R$ (surface) $\boxed{I_g = -\frac{GM}{R^2}}$

$\boxed{V_g = -\frac{GM}{R}}$

|iii| → $r < R$ (Inside) $\boxed{I_g = -\frac{GMr}{R^3}}$

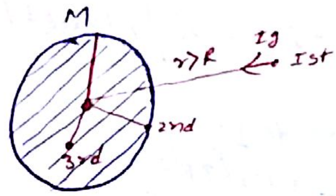
$\boxed{V_g = -\frac{GM(3R^2 - r^2)}{2R^3}}$

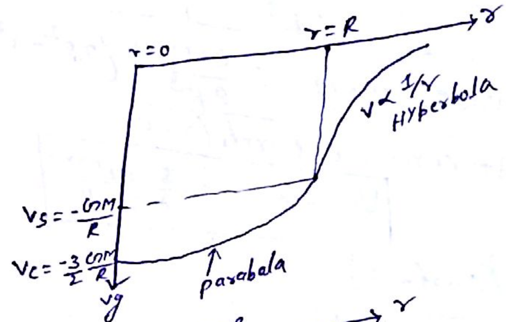
|iv| → At centre ($r = 0$)

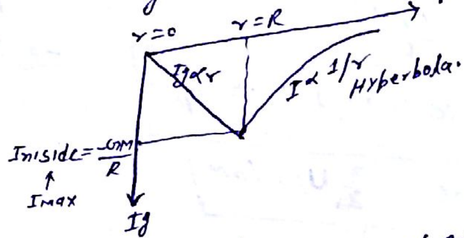
$\boxed{I_g = 0}$

$\boxed{V_{centre} = -\frac{3}{2}\frac{GM}{R}}$

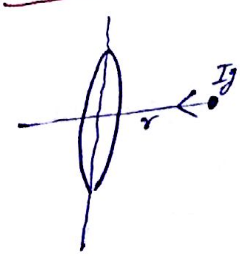
$\boxed{V_{centre} = \frac{3}{2} V_{surface}}$







[C] → Ring →



* $\boxed{I_g = -\frac{GMr}{(R^2 + r^2)^{3/2}}}$

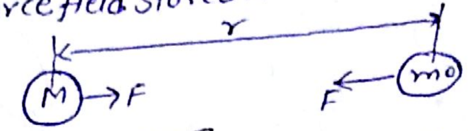
* $\boxed{V_g = -\frac{GM}{(R^2 + r^2)^{1/2}}}$

Imp * At centre of Ring ($r = 0$)

$\boxed{I_g = 0 \quad V_g = -\frac{GM}{R}}$

Gravitational pot. Energy (G.P.E) → In absence of Gravitational force field work done for bringing a mass from ∞ to sp. point.

* Work done against force field stored in system in form of P.E.



$F = -\frac{du}{dr}$

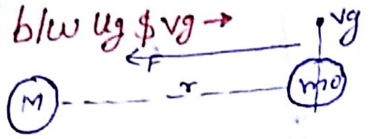
$\int du = -\int F \cdot dr$

$F = -\frac{GMm_o}{r^2}$

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

* At $r = \infty$, $U_\infty = 0$

**
Relation b/w U_g & V_g →



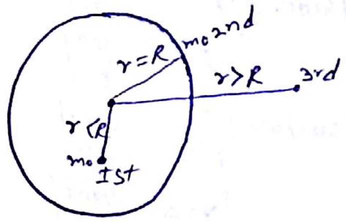
$$\boxed{U = V_g(m_o)}$$

NOTE → (i) → G.P.E of any one mass in 'n' mass system is equal to scalar addition of (n−1) pair.

(ii) → G.P.E of 'n' mass system is scalar addition of $\frac{n(n-1)}{2}$ pair.

(iii) → G.P.E is always (−)ve bcoz it is attractive nature force.

**
G.P.E of Earth/planet/solid sphere :→



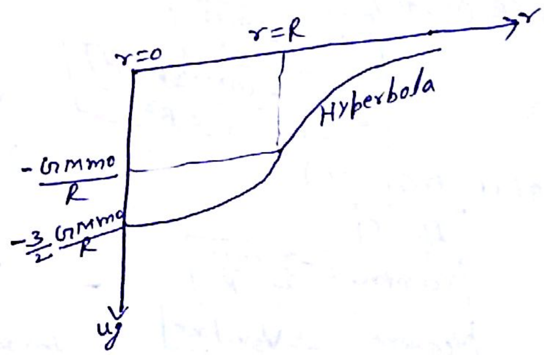
(i) → r < R (Inside)

$$\boxed{V_g = -\frac{GM(3R^2 - r^2)}{2R^3}}$$

* $$\boxed{U_{inside} = m_o V_g = -\frac{GMm}{2R^3}(3R^2 - r^2)}$$

* At centre of Earth (r = 0)

$$\boxed{U_{centre} = -\frac{3}{2}\frac{GMm}{R}}$$



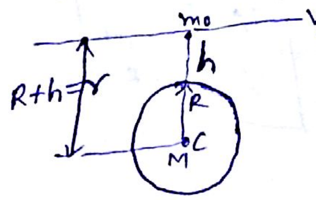
(ii) → R = r (surface)

$$\boxed{V_g = -\frac{GM}{R}}$$

* $$\boxed{U_{surface} = mV_g = -\frac{GMm_o}{R}}$$

$$\boxed{U_{centre} = \frac{3}{2}U_{surface}}$$

(iii) → r > R (outside)



$V_g = -\frac{GM}{r} = -\frac{GM}{R+h}$

* $$\boxed{\begin{aligned} U_g &= m_o V_g = -\frac{GMm}{r} \propto 1/r \\ U_g &= -\frac{GMm_o}{R+h} \end{aligned}}$$

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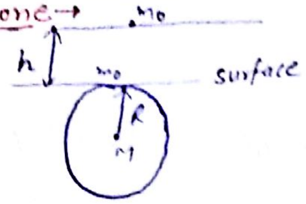
Work done →



$W_{en} + W_{N.C} = \Delta K.E + \Delta U$

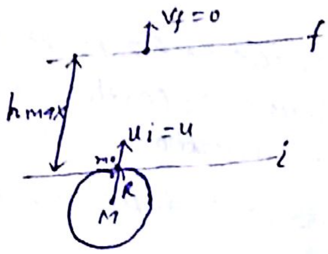
*$\boxed{g_{surface} = \frac{GM}{R^2}}$

*$\boxed{W_{en} = \frac{mgh}{1+\frac{h}{R}}}$

* $h <<< R \Rightarrow \frac{h}{R} <<< 1$ neglect

*$\boxed{W = mgh}$

Max height Attain by particle :→



$W_{N.C} = 0 = W_{en}$

$0 + 0 = \Delta K.E + \Delta U$

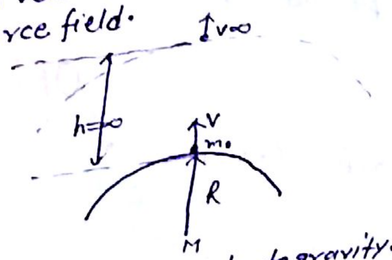
$KE_i + U_i = KE_f + U_f$ *

*$\boxed{V = \sqrt{\frac{2gh}{1+h/R}}}$

$\boxed{h_{max} = \frac{V^2 R}{2Rg - V^2}}$ $(v < v_{escape})$

Escape velocity (V_{escape}) → Min Required velocity of particle to remove from Gravitation force field.

[A] → At surface of planet →



$\boxed{V_{min} = \sqrt{\frac{2GM}{R} + V_\infty^2}}$ (V_∞ zero)

*$\boxed{V_{escape} = \sqrt{\frac{2GM}{R}}}$

$g_{surface} = g = \frac{GM}{R^2}$ → Accl^n due to gravity.

$\boxed{GM = gR^2}$

*$\boxed{(V_{escape})_{surface} = \sqrt{\frac{2GM}{R}} = \sqrt{2Rg} = \sqrt{\frac{8}{3}\pi G R^2 \rho}}$

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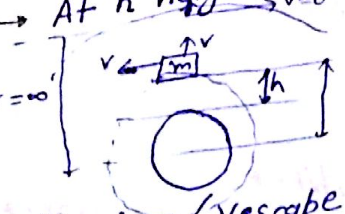
NOTE → |i| → *Escape velocity depend on Mass, Radius & Avg. density of planet but it is independent from mass of particle, protection angle* & protection direction & Rotation of Earth.

|ii| → At 'h' height above from earth surface / plant surface



$\boxed{V_{escape} = \sqrt{\frac{2Gm}{r}} = \sqrt{\frac{2Gm}{R+h}}}$

|a| → $V_{surface} < V_{escape}$

$\boxed{h_{max} = \frac{V^2 R}{2Rg - V^2}}$

velo. at max ht = 0

|b| → $V_{surface} = V_{escape} \Rightarrow \boxed{h_{max} = \infty}$ (particle escape from planet)

$\boxed{V_\infty = 0}$

|c| → $V_{surface} > V_{escape}$

$\boxed{h_{max} = \infty}$

$\boxed{V_\infty = V_{surface}^2 - \frac{2GM}{R}}$

$\boxed{V_\infty = \sqrt{V_s^2 - V_{escape}^2}}$

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* $V_{earth} = 11.2\ km/sec$ / $V_{r.m.s} = \sqrt{\frac{3RT}{M}}$
  $V_{moon} = 3.4\ km/sec$

Max hight attain by particle & its velocity at max hight. If velocity of particle at surface of earth—

(i) $V_s = \sqrt{\frac{GM}{R}} = R$ * at $V = h_{max} = 0$

(ii) $V_s = \sqrt{\frac{3}{2}\frac{GM}{R}} < V_{escape} \Rightarrow V = 3R$

(iii) $V_s = \sqrt{\frac{3GM}{R}} > V_{escape} \Rightarrow h_{max} = \infty$ * $V_\infty = \sqrt{\frac{GM}{R}}$

velocity of particle at R/2 hight above from earth surface is 'f' times of Vescape at surface of Earth. Find out value of 'f'. If particle just escape from gravitational force field of planet → $\boxed{f = \sqrt{2/3}}$

particle of mass 'M' is drop along the dimetric tunnel of earth Find out velo. of particle—

|a| → At centre of Earth → $\boxed{V_C = \sqrt{\frac{GM}{R}} = \frac{V_{escape}}{\sqrt{2}}}$

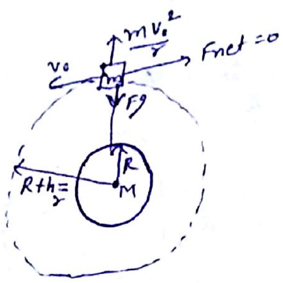
|b| → At opposite end of tunnel = $\boxed{V_B = 0}$

particle of mas 'm' drop along the dimetric tunnel of earth then time period of particle → $\boxed{T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{R}{g}} = 84.6\ mint = 1.414\ hr.}$

ORBITAL MOTION

|1| → orbital velocity →

$$\boxed{V_0 = \sqrt{\frac{GM}{r}} = \sqrt{\frac{GM}{R+h}}}$$



* $h <<< R \Rightarrow \frac{h}{R} <<< 1$ (Near above the earth surface) ← neglet

$$\boxed{V_0 = \sqrt{\frac{GM}{R}} = \frac{V_{escape}}{\sqrt{2}}}$$

* satellite near about earth surface

$V_{orbital} = \frac{V_{escape}}{\sqrt{2}} = 0.0707 \times 11.2\ km/sec$

$$\boxed{V_0 = 7.9\ km/sec = 8\ km/sec.}$$

|2| → Time period : →

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

$$\boxed{T = 2\pi\sqrt{\frac{R}{g}}\left(1+\frac{h}{R}\right)^{3/2}}$$

* Time period of satellite of Earth.

$$\boxed{T = 84.6\left(1+\frac{h}{R}\right)^{3/2}_{min} = 1.414\left(1+\frac{h}{R}\right)^{3/2} hr.}$$

|3| → Energy of sattelite in a stable circular orbit →

[A] → kinetic Energy →

$$\boxed{K.E = \frac{GMm}{2r} = \frac{GMm}{2(R+h)}}$$

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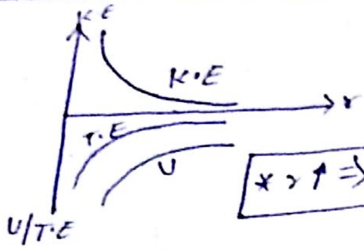
[B] → Potential Energy →

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

[C] → Total Energy / M·Energy →

$$\boxed{T\cdot E = -\frac{GMm}{2r}}$$

$$\boxed{T\cdot E = -K\cdot E = \frac{P\cdot E}{2}}$$



$\boxed{* \; r\uparrow \Rightarrow V_o\downarrow,\ K\cdot E\downarrow,\ T\uparrow,\ U\uparrow,\ T\cdot E\uparrow}$

[D] → Binding Energy (B·E) → Required energy to bound the satellite in a stable orbit or, Require min energy to remove the satellite from stable orbit.

* It is also called Escape Energy.

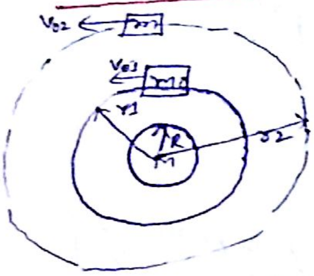
*
$$\boxed{\begin{aligned} K\cdot E_R &= \frac{GMm}{2r} \quad (\text{Require energy to escape the satellite}) \\ B\cdot E &= \frac{GMm}{2r} = \text{Escape energy} = K\cdot E = -T\cdot E \end{aligned}}$$

NOTE → * If K·E of particle in a stable orbit become double or, ↑ 100% satellite escape from planet.

* If T·E of satellite in a stable orbit become zero. It will be escape from Gravitational force field of planet.

* If orbital velocity become $\sqrt{2}$ times or, ↑ 41.4% satelite escape from Gr. Force field of planet.

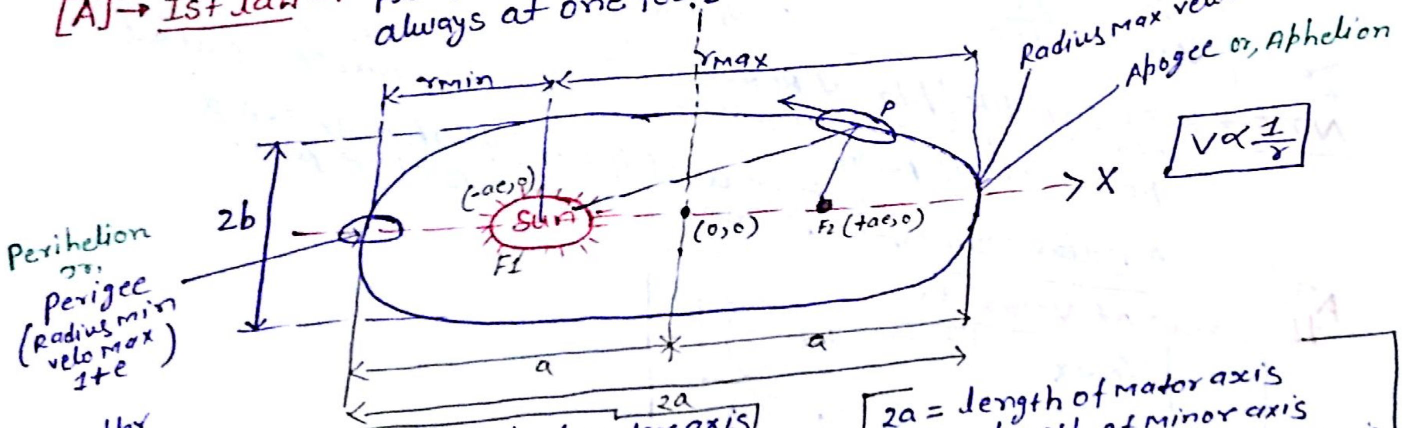
[E] → Work done to change the orbit of Satellite



*
$$\boxed{W = \frac{GMm}{2}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)}$$

'Keppler's Law'

[A] → Ist law → planet rotate around the sun in a elliptical path & sun present always at one focus on eliptical path.



$\boxed{V \propto \frac{1}{r}}$

Exemplar

$\boxed{PF1 + PF1 = \text{const} = \text{length of major axis}}$

$\boxed{r_{min} + r_{max} = 2a}$

$$\boxed{\begin{aligned} r_{min} &= a - ae = a(1-e) \\ r_{max} &= a + ae = a(1+e) \end{aligned}}$$

2a = length of major axis
2b = length of minor axis
a = length of semimajor axis

e = eccentricity of ellipse.

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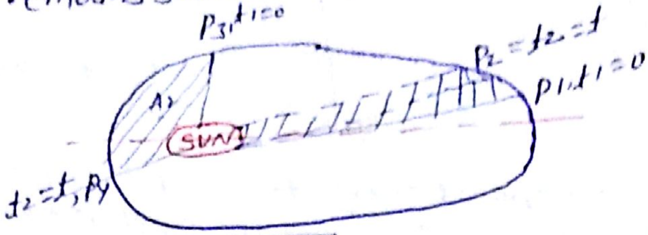
B] → 2nd law: → Joining line of sun & planet swaped equal area in a same time interval. It means areal velocity (Rate of change in Area) remains same at all points of elliptical path.



$\boxed{\frac{dA}{dt} = \text{Areal velo} = \text{same}}$

$\boxed{\frac{dA}{dt} = \frac{vr}{2} = \frac{L}{2m} = \text{same}}$

$\boxed{vr = \text{const}}$

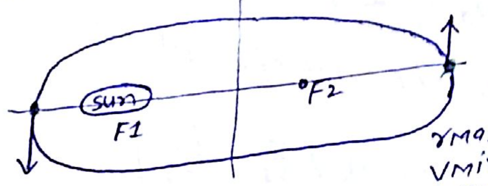
$\boxed{r\uparrow \Rightarrow v\downarrow}$

r = Distance of planet from sun (Focus)

V = velo. of planet.

** Exemplar

$V_{max}\, r_{min} = V_{min}\, r_{max}$



r_{min}
V_{max}
K.E max*
P.E min
T.E = same
(L) Angular Momentum = same

r_{max}
V_{min}
K.E min
*P.E max
T.E = same
L = same

$\boxed{V_{max} = V_{min}\left(\frac{r_{max}}{r_{min}}\right)}$

** AIIMS $\boxed{\frac{V_{max}}{V_{min}} = \frac{1+e}{1-e}}$ → perigee, → apogee

** [V_{max} = velo at perigee point = V_p
V_{min} = velo at apogee " = V_a]

$\boxed{\frac{V_p}{V_a} = \frac{1+e}{1-e} \Rightarrow e = \frac{V_p - V_a}{V_p + V_a}}$

** NOTE → * If satellite/planet Rotate in a circular path then orbital velo., K.E, P.E, T.E, Angular momentum remain same at all point of its path.
But in a elliptical path only T.E & Angular Momentum same at all points of its path.

AIIMS # Value of V_{max} & V_{min}

$$V_{max} = \sqrt{\frac{GM}{a}\left(\frac{1+e}{1-e}\right)}$$

$$V_{min} = \sqrt{\frac{GM}{a}\left(\frac{1-e}{1+e}\right)}$$

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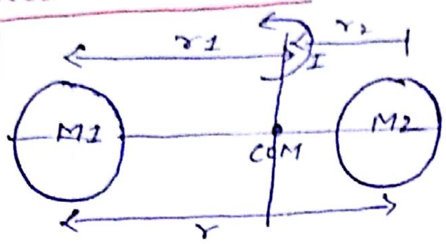
[C] → 3rd Law → Time period of planet around the sun ... path is proportional to $\frac{3}{2}$ power of length of semimator axis.

Imp $\boxed{T \propto (a)^{3/2}}$ $\boxed{T \propto (r_{avg})^{3/2}}$

$$\boxed{T_2 = T_1 \left(\frac{R_2}{R_1}\right)^{3/2}}$$

Reduced mass concept →

$\boxed{M_1 < M_2}$



$$\boxed{I = \left(\frac{M_1 M_2}{M_1 + M_2}\right) r^2 = \mu r^2}$$

** # Max $ Min distance of planet from sun resp. r_1 $ r_2. cal distance b/w planet $ sun when it is ⊥ to the sun → $\boxed{d = \frac{2 r_1 r_2}{r_1 + r_2}}$ H.M.

2005 AIIMS # Mass m_1 $ m_2 initially ⊕nt at ∞. move in ⊕ce of gravitational attractive force cal. relative ~~Ratio~~ of velo. when it is Ist at distance 'R' →

$$\boxed{V_R = \sqrt{\frac{2G}{R}(m_1 + m_2)}}$$

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