[Chapter-3]

Gravitation

$A \propto B$

$C \propto \frac{1}{D}$

$\rightarrow B \propto A$

$m_1 \longleftarrow r \longrightarrow m_2$

$F \propto m_1 m_2$

$\Rightarrow F \propto \frac{1}{r^2}$ (Inverse square law)

combining them we get,

$$\Rightarrow F \propto \frac{m_1 m_2}{r^2}$$

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

where, G = Universal gravitational constant.

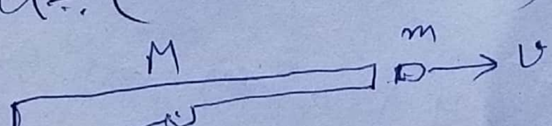
$G = 6.67 \times 10^{-11}\ Nm^2 kg^{-2}$ (Newton meter square per kilogram square)

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

$$= \frac{[MLT^{-2}][L^2]}{[M][M]}$$

$$\therefore G = [M^{-1} L^3 T^{-2}]$$ ✓

✓ g = Acc^n (acceleration) due to gravity.



$\leftarrow V$ $(-MV) + (+mv) = 0$

$\Rightarrow \boxed{MV = mv}$

V = Recoil velocity of gun.

Acceleration due to gravity (g)

$g = 9.8\ m/s^2$ $[LT^{-2}]$

$\boxed{F = mg}$

or $\boxed{W = mg}$ $\Rightarrow$ $\boxed{g = \frac{W}{m}}$

W = weight of the body

m = Mass of the body.

g = Accl^n due to gravity.

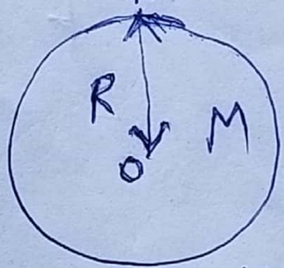
Relation between g & G

M = Mass of the earth

R = Radius of the earth

O = centre of the earth

m = point mass kept on the surface of the earth



$$F = \frac{GMm}{R^2} \quad \text{--- (1)}$$

Also, $F = mg$ --- (2)

Equating eq^ns (1) & (2)

$$\Rightarrow mg = \frac{GMm}{R^2}$$

$$\Rightarrow \boxed{g = \frac{GM}{R^2}} \quad \text{--- (3)}$$

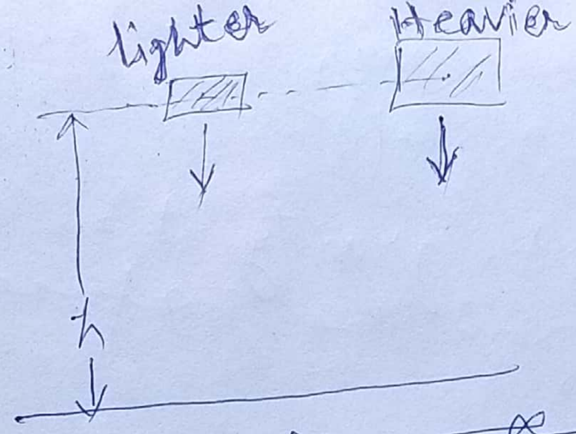
This is relation between g & G.

$R = 6.4 \times 10^6\ m$ or 6400 km

$\boxed{g_m = \frac{1}{6} g_e}$

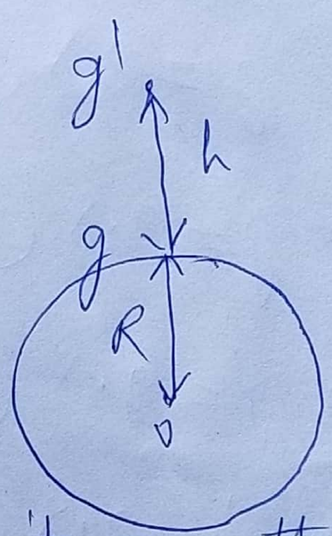
$\Rightarrow g_m = \frac{9.8}{6}$

$\Rightarrow g_m = 1.63\ m/s^2$



$$g = \frac{GM}{R^2}$$

Variation of g with altitude



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

Here, $\boxed{g' < g}$

where,

g = Acceln due to gravity on the surface of the earth.

g' = Acceln due to gravity at an altitude of 'h' from the surface of earth.

R = Radius of earth = 6.4×10^6 m

Q:- What is the value of g at an altitude of 10 km from the surface of earth.

Soln = $h = 10$ km $= 10 \times 10^3$ m $= 10^4$ m.

We know that, $R = 6.4 \times 10^6$ m.

g = Accl^n due to gravity on the surface of earth = $9.8\,m/s^2$.

g' = Accl^n due to gravity at an altitude of 10 Km from the surface of earth = ?

then,

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

$$\Rightarrow g' = 9.8\left(1 - \frac{2\times10^4}{6.4\times10^6}\right)$$

$$\Rightarrow g' = 9.8\left(1 - \frac{1}{3.2\times10^2}\right)$$

$$\Rightarrow g' = 9.8\left(1 - \frac{1}{320}\right)$$

$$\Rightarrow g' = 9.8\left(\frac{319}{320}\right)$$

$$\Rightarrow g' = \text{-----}\ m/s^2$$

x

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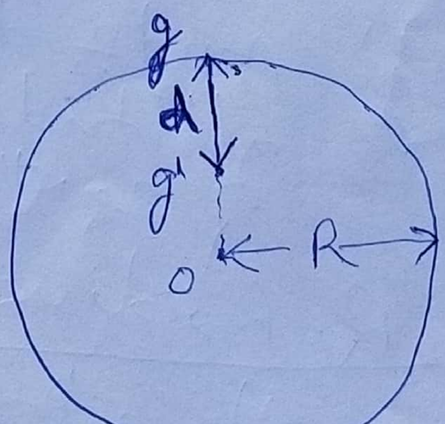
d = Depth from the surface of earth.



g' = Accl^n due to gravity at depth d from the surface of earth.

g = Accl^n due to gravity on the surface of earth

$$\Rightarrow \boxed{g' = g\left(1 - \frac{d}{R}\right)}$$

$$g' = g\left(1 - \frac{d}{R}\right)$$

~~when~~ At the centre of the earth

Then, $d = R$

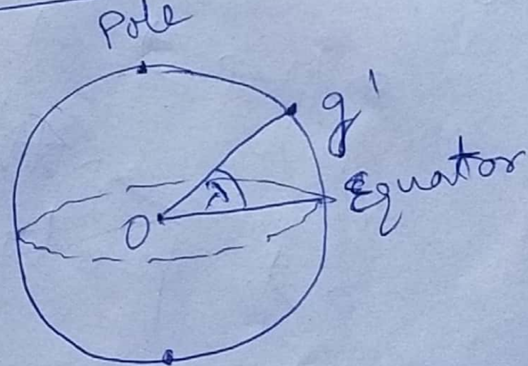
Then, $g' = g\left(1 - \frac{R}{R}\right)$

$\Rightarrow g' = g(1-1)$

$\Rightarrow \boxed{g' = 0}$ This shows that the value of accel^n due to gravity becomes zero at the centre of the earth.

Variation of g due to latitude or rotation of the earth

λ = Latitude or latitude (angle).



$$\boxed{g' = g - R\omega^2\cos^2\lambda}$$

ω = Angular velocity of rotation of earth.

$\boxed{\omega = \frac{2\pi}{T}}$ rad./s.

for earth
$T = 24$ hrs
$= (24 \times 60 \times 60)$ second

special cases.

Case I :- At the equator of earth

$\lambda = 0^\circ$

$\cos^2\lambda = 1$

So, $\boxed{g' = g - R\omega^2}$

Case II :- At the pole of the earth.

$\lambda = 90^\circ$

$\cos^2\lambda = 0$

So, $\boxed{g' = g}$

This proves that there is no effect of lattitude or rotation of the earth on accel. due to gravity at pole of the earth.