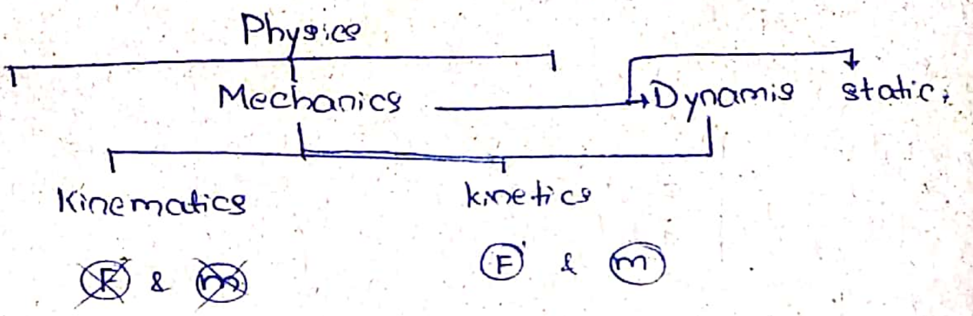
→ $\boxed{\text{KINEMATICS}}$:

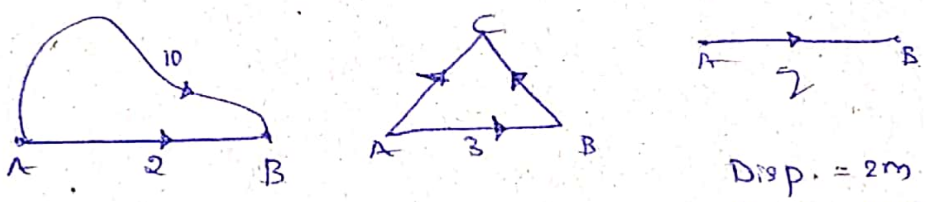
It is the sub. which deals with the motion of the bodies without regarding the force and mass.



→ Displacement : The change in position of a particle is called displacement & it is a vector. with only 1 direction

→ Distance : The length of the path covered by the body is called distance. It is scalar.

1. When a body reaches to the starting position, its displacement will be zero.
2. It is possible for a body to have distance without displacement.
3. It is not possible to have displacement without distance

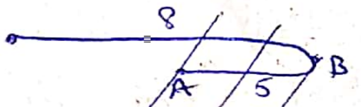


Disp = 2m
Dist = 10m

Disp = 0m
Dist = 9m

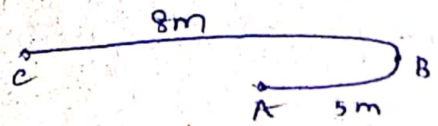
Disp. = 2m
Dist = 2m

Disp. $\leq$ Distance ; $\frac{\text{Disp.}}{\text{Dist.}} = \leq 1$

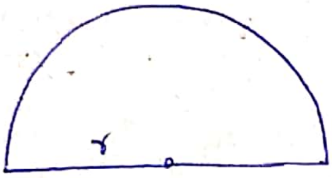


Disp. = 5-8=-3m

→ Disp. may be −ve but
Dist. always be +ve.

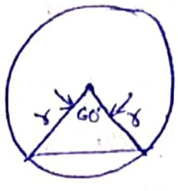


Disp. = −3m
Dist = 13m



Disp. = $2r$
Dist = πr

$\theta = 180° = \pi$ rad

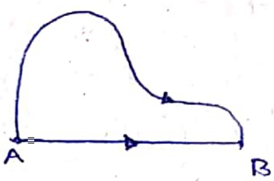


Disp. = r
Dist. = $\pi r/3$

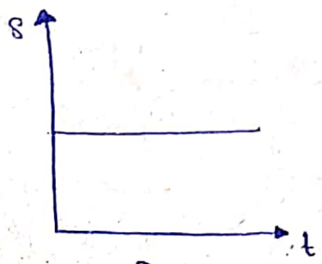
Disp. : Dist = $3 : \pi$

$\theta = 60° = \frac{\pi}{3}$ rad

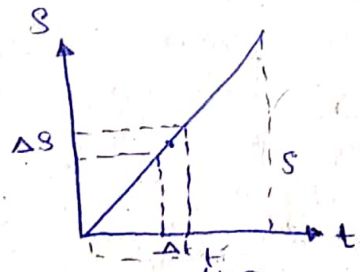
$$\left\{ \begin{array}{l} \text{Disp. in a circle} = 2 \times r \times \sin\frac{\theta}{2} \\ \text{Dist. " " "} = r \times \theta \end{array} \right\}$$



Velocity = Disp. / time
Speed = Dist. / time



Rest



motion

Graphical Representation

→ Velocity is defined as rate of change of disp. [vector qty]
→ Speed " " " " " " " dist. [scalar qty]

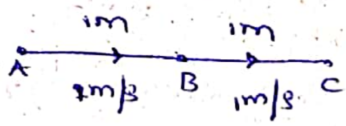
→ angle of slope, $\tan\theta = \frac{s}{t} = V$

Instantaneous velocity

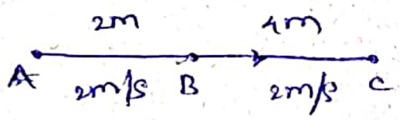
$$V = Lt \frac{\Delta s}{\Delta t} = \frac{ds}{dt}$$

$$\boxed{V = \frac{ds}{dt}}$$

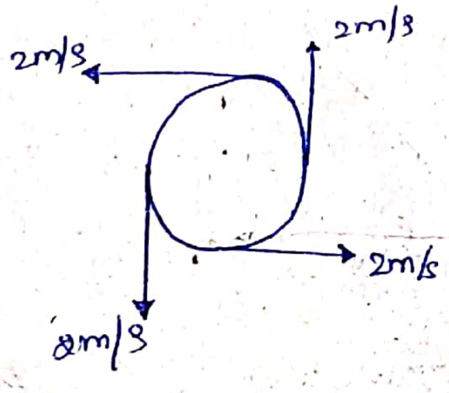
→ Uniform velocity:
When magnitude & direction of velocity does not changes it is uniform velocity



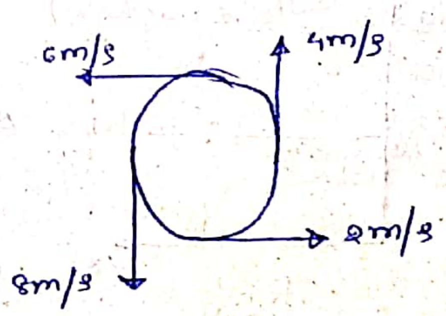
→ Non uniform velocity: When magnitude of velocity changes or direction changes or both changes, then it is non-uniform velocity.



→ When a body has uniform velocity it must have uniform speed
→ When a body " " speed " is not necessary to have uniform velocity



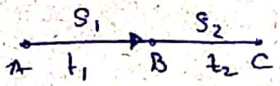
Uniform speed
Non - " velocity



Non - uniform velocity
" " speed

AVERAGE VELOCITY

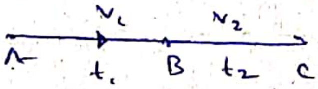
Case 1: s, t given



$$A.V = \frac{\text{total dist}}{\text{total time taken}}$$

$$= \frac{s_1 + s_2}{t_1 + t_2}$$

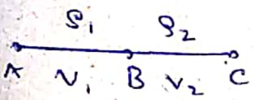
Case 2: v_1, t_1 given



$$A.V = \frac{s}{t} \Rightarrow s = vt$$

$$= \frac{v_1t_1 + v_2t_2}{t_1 + t_2}.$$

Case 3: s, v given

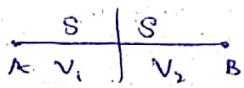


$$v = \frac{s}{t} \Rightarrow t = \frac{s}{v}$$

$$AV = \frac{s_1 + s_2}{\frac{s_1}{v_1} + \frac{s_2}{v_2}}$$

$$\frac{v_1v_2(s_1 + s_2)}{s_1v_2 + s_2v_1}$$

Case 4: When the first half with v_1 & next " with v_2 velocities

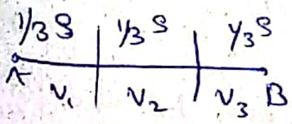


$$S_1 = S_2 = S$$

$$AV = \frac{v_1v_2(s + s)}{s(v_1 + v_2)}$$

$$= \frac{2v_1v_2}{v_1 + v_2}$$

Case 5: When three eq parts with v_1, v_2, v_3 velocities

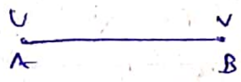


$$S_1 = S_2 = S_3 = S$$

$$AV = \frac{s + s + s}{\frac{s}{v_1} + \frac{s}{v_2} + \frac{s}{v_3}}$$

$$= \frac{3v_1v_2v_3}{v_2v_3 + v_1v_3 + v_1v_2}$$

Case 6: When u, v given

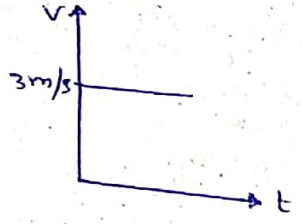


$$A.V = \frac{u + v}{2}$$

→ Acceleration: The rate of change of velocity

$$a = \frac{\Delta v}{t} \quad m/s^2$$

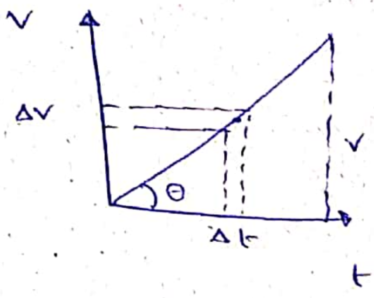
→ Graphical representation



uniform velocity

$a = \frac{\Delta v}{t}$

$a = \frac{0}{t} = 0$



acceleration = ~~tan~~

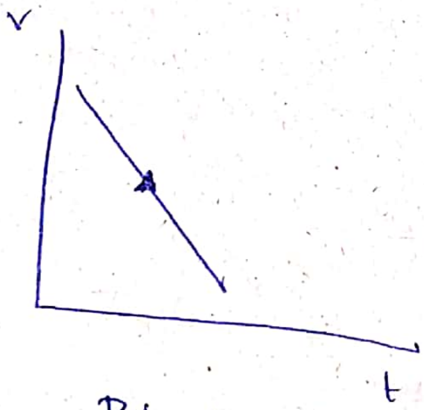
angle of slope

$\tan\theta = \frac{v}{t} = a$

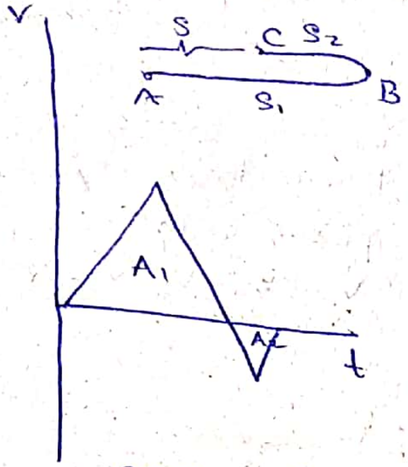
Instantaneous accln

$a = \lim \frac{\Delta v}{\Delta t} = \frac{dv}{dt}$

$$\boxed{a = \frac{dv}{dt}}$$



Retardation

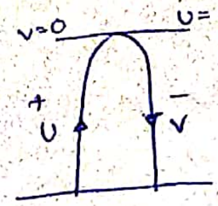


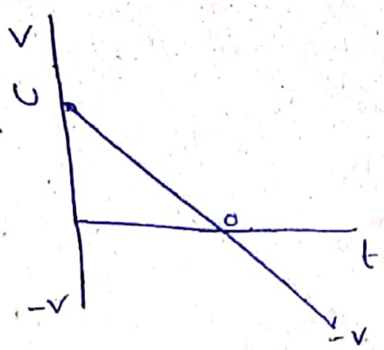
area of the curve gives displacement

$S = A_1 - A_2$

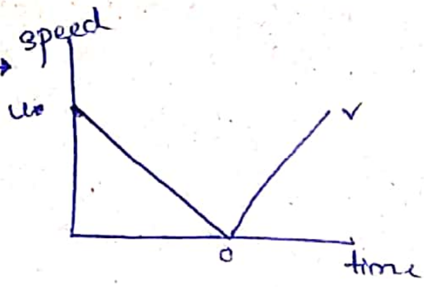
$S = [A_1^2 - A_2^2]$

Projected body

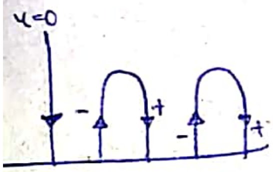


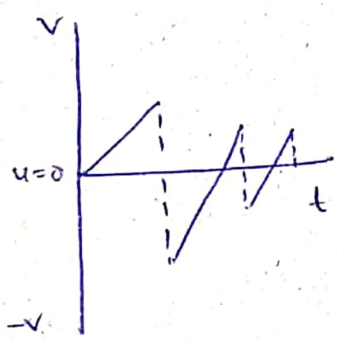


in terms of speed

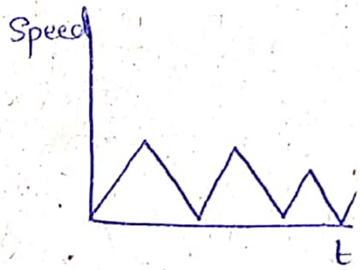


For a freely falling body

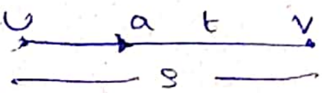




in terms speed/time



Eqn of motion:



1. $v = u + at$

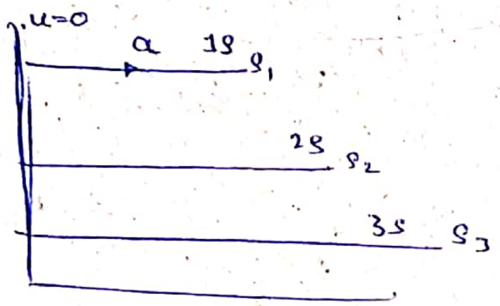
if $u = 0$, $a = \text{const.}$

$v \propto t$

2. $S = ut + \frac{1}{2}at^2$

if $u = 0$; $a = \text{const}.$

$S \propto t^2$



$S_1 : S_2 : S_3 = 1 : 4 : 9$

$v = u + at$

$u = v - at$

$S = ut + \frac{1}{2}at^2$

$S = (v - at)t + \frac{1}{2}at^2$

$S = vt - at^2 + \frac{1}{2}at^2$

$$\boxed{S = vt - \frac{1}{2}at^2}$$

3. $v^2 - u^2 = 2as$

if $v = 0$; $a = \text{const}.$

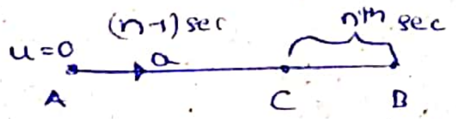
$0 - u^2 = -2as$

$S \propto u^2$

→ Disp. = Avg. velocity × time

$S = \left(\frac{u+v}{2}\right) \times t$

4. Disp. in the nth second



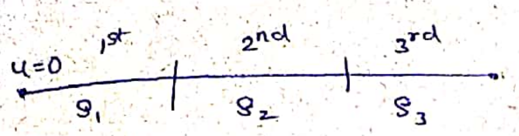
$S_n = u + a\left(n - \frac{1}{2}\right)$

$= u + \frac{1}{2}a(2n - 1)$

if $u = 0$; $a = \text{const}.$

$$\boxed{S_n \propto 2n - 1}$$

Disp. in successive seconds

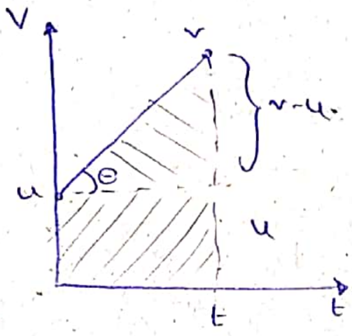


$$s_1 : s_2 : s_3 = 1:3:5$$

$$s_2 = \frac{s_1 + s_3}{2}$$

$$s_n = s - s_{(n-1)}$$

From graph



$$\tan\theta = \frac{v-u}{t} = a$$

$$v - u = at$$

$$\boxed{v = u + at}$$

Area of curve [disp.]

$$s = ut + \frac{1}{2}(v-u)t$$

$$= ut + \frac{1}{2}(at)t$$

$$\boxed{s = ut + \frac{1}{2}at^2}$$

By differentiation

$$a = \frac{dv}{dt}$$

$$\int_u^v dv = a\int_0^t dt$$

$$[v]_u^v = a[t]_0^t$$

$$v - u = at$$

$$\boxed{v = u + at}$$

$$v = \frac{ds}{dt}$$

$$ds = v \times dt$$

$$\int_u^v ds = a\int_0^t$$

$$ds = (u + at)dt$$

$$ds = udt + atdt$$

$$\int_0^s ds = u\int_0^t dt + a\int_0^t t.dt$$

$$s = ut + \frac{at^2}{2}$$

$$\boxed{s = ut + \frac{1}{2}at^2}$$

$$a = \frac{dv}{dt}$$

$$= \frac{dv}{ds} \cdot \frac{ds}{dt}$$

$$a = \frac{dv}{ds} \cdot v$$

$$a\,ds = v\,dv$$

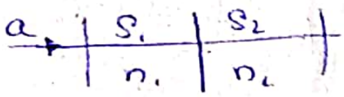
$$a\int_0^s ds = \int_u^v v\,dv$$

$$as = \left[\frac{v^2}{2}\right]_u^v$$

$$as = \frac{v^2 - u^2}{2}$$

$$\boxed{v^2 - u^2 = 2as}$$

→ When a body s_1 disp. in n_1^{th} sec & s_2 disp. in n_2^{th} sec then its accl^n is ______



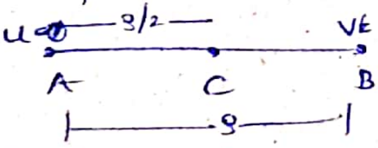
$$S_n = u + a\left(n - \tfrac{1}{2}\right)$$
$$s_1 = \cancel{u} + a\left(n_1 - \tfrac{1}{2}\right)$$
$$s_2 = \cancel{u} + a\left(n_2 - \tfrac{1}{2}\right)$$

$$s_2 - s_1 = a(n_2 - n_1)$$

$$\boxed{a = \frac{s_2 - s_1}{n_2 - n_1}}$$

When a body crosses two points A & B with velocities of u & v then the velocity a) midpoint of A & B b) half the time

a) mid point of A & B



$$v^2 - u^2 = 2as$$

$$a = \frac{v^2 - u^2}{2s} \quad \text{—} ①$$

$$a = \frac{v_0^2 - u^2}{s} \quad \text{—} ②$$

$$a = \frac{v_0^2 - u^2}{s} = \frac{v^2 - u^2}{2s}$$

$$= 2v_0^2 - 2u^2 = v^2 - u^2$$

$$v_0^2 = \frac{v^2 + u^2}{2}$$

$$v = \sqrt{\frac{v^2 + u^2}{2}}$$

b) at mid time

$v = u + at$

$a = \frac{v-u}{t}$

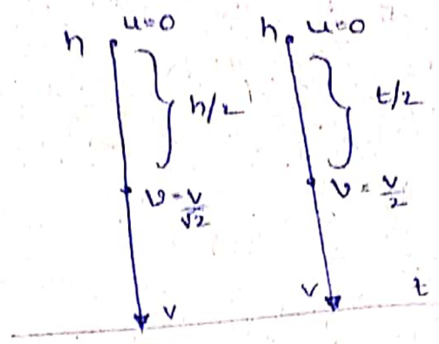
$a = \frac{v-u}{t/2}$

$a = \frac{v-u}{t} = \frac{v-u}{t/2}$

$\Rightarrow 2v - 2u = 2(v-u)$

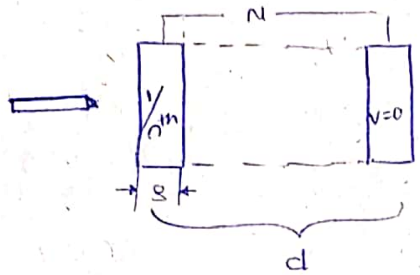
$\Rightarrow \boxed{v \Rightarrow \frac{v+u}{2}}$

For a freely falling body



$v = \sqrt{\frac{v^2}{2}}$ $\qquad$ $v = \frac{v}{2}$

When a bullet loses $\frac{1}{n^{th}}$ velocity when it passes through a plank of thickness s



1. The min. no. of planks required to stop the bullet, $N = \frac{n^2}{2n-1}$
2. The further dist. travelled ~~by~~ before it comes to rest

$d = \left[\left(\frac{n^2}{2n-1}\right) \times s\right] - s$

$[N-1] \times s$

Ex:- $\frac{1}{n^{th}} - \frac{1}{5}$

$N = \frac{n^2}{2n-1} = \frac{5^2}{2 \times 5 - 1} \Rightarrow \frac{25}{9}$

$= 2.7$

$=$ 3 planks

$d - (2.7 - 1) \times 10$ $\qquad$ $[(N-1) \times s]$

$=$ 17cm

Disp. $s = (t^2 - 8t + 4)m$, the time taken to comes to rest

$V = \frac{ds}{dt}$

$v' = 2t - 8$ $[v = 0]$

$2t - 8 = 0$

$t = 8/2$

$= 4$

Disp. of a particle changes with time as $t = \sqrt{x} + 3$
then it disp. when it is comes rest

$t = \sqrt{x} + 3$

$x = (t-3)^2$

$= t^2 - 6t + 9$

$v = \frac{dx}{dt}$

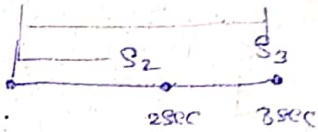
$= 2t - 6$ [at $v = 0$]

$t = 3s$

$x = 0$

$s = t^2 + 2t + 2m$ disp. during 3rd sec

$s = t^2 + 2t + 2m$



$S_3 = 3^2 + 6 + 2$

$= 17m$

$S_2 = 2^2 + 2^2 + 2$

$= 10$

$S_3 - S_2 = 7m$

$s = t^2 + 2t + 2$

$v = \frac{ds}{dt} = 2t + 2$

$v = 2t + 2$

at initial velocity 'u' , $t = 0$

$v = 2 m/s$

$a = \frac{dv}{dt} = 2 m/s^2$

$S_n = u + a(n - \frac{1}{2})$

$= 2 + 2[3 - \frac{1}{2}]$

$= 2 + (\cancel{2} \times \frac{5}{\cancel{2}})$

$= 7m$

Scanned by CamScanner

Velocity of a particle changes with disp. as $v = \sqrt{25 - 6s}$, $a = ?$

$a = \frac{dv}{dt} = \frac{d}{ds}\sqrt{25 - 6x^2}$

$\cancel{\frac{1}{-2\sqrt{25-6x}} \times -6}$

$= \frac{-3}{\sqrt{25 - 6s}}$

$a = \frac{dv}{dt} = \frac{dv}{dx} \times \frac{dx}{t}$

$\Rightarrow \frac{-6}{2\sqrt{25-6x}} \times \frac{dx}{t}$

$a = \frac{-6}{2 \times (dx/dt)} \times \frac{dx}{dt}$

$a = -3$

$v^2 - u^2 = 2as$

$v^2 - 5^2 = 2(-3)s$

$a = -3\ m/s^2$

Displacement of particle is $s = t^3 - 12t^2 + 5t + 2m$, the time taken to attain the max. velocity is

$s = t^3 - 12t^2 + 5t + 2$

$\frac{ds}{dt} = 3t^2 - 24t + 5$

$\frac{d^2s}{dt^2} = 6t - 24$

$a = 6t - 24$ $[a = 0]$

$6t = 24$

$t = 4\ sec$

s_1	s_2
5 km	10 km
10 min	0.25 h

Avg. velocity $= \frac{s_1 + s_2}{t_1 + t_2} = \frac{5 + 10}{1.66 + 0.25}$

$\frac{1}{6}$

$6)10(1.6$
6
40
36

$= \frac{15}{1.91} \Rightarrow \frac{1500}{191}$

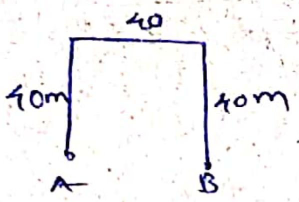
$\frac{km}{h} = \frac{5000}{3600} = \frac{5}{18}\ m/s$

$= 15$

$= \frac{15}{\frac{1}{6} + \frac{1}{4}}$

$= \frac{\cancel{24}^{12} \times \cancel{15}^{3}}{\cancel{10}_{5}} = 36\ km/h$

$= 10\ m/s$



$V = 12\,m/s$

$Av = \frac{\cancel{s}\ 40}{40/12 \times 3}$

$t = \frac{d}{s}$ $\quad Av = \frac{s}{t}$

$= \frac{s}{(d/s) \times \text{total dist.}}$

$= \frac{40m}{(40/12) \times 3}$

$t = 4\text{seconds}$

A car travels first 1/2 of the disp. with 40 km/hr & next 1/2 60km/hr

$AV = \frac{\cancel{s}\ 2V_1V_2}{V_1 + V_2}$

$= \frac{S_1 + S_2}{\left(\frac{S_1}{V_1}\right) + \left(\frac{S_2}{V_2}\right)}$

$= \frac{2 \times 40 \times 60}{40 + 60}$

$= \frac{4800}{100} = 48km/hr$

→ A body from rest its velocity is 3m/s after 6sec. Its velocity after 8sec ________

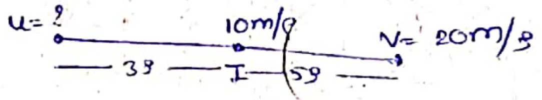
$V = u + at$

$V \propto t$

$\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{3}{\cancel{6}} = \frac{V_2}{8}$

$V_2 = 4m/s$

→ The velocity of a body at an instant is 10m/s, after 5sec it becomes 20m/s, it velocity 3sec before the instant



$v = u + at$

$20 = 10 + a \times 5$

$a = 2m/s^2$

$v = u + at$

$10 = u + (2 \times 3)$

$u = 4m/s$

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→ A particle is started from rest its displacement is s_1 in first two seconds, and s_2 in next two seconds, then s_1, s_2

→ $s_1 = 3s_2$

$\frac{s_1}{s_2} = 3$

$\boxed{s_2 : s_1 = 1:3}$

$s_1 : s_2 : s_3 : s_4 = \underbrace{1:3}\,:\underbrace{5:7}$

$s_1 : s_2 = 4:12$

$\frac{s_1}{s_2} = \frac{\cancel{4}}{\cancel{12}_3}$

$s_1 = \frac{1}{3}s_2$

$\Rightarrow \boxed{s_2 = 3s_1}$

$s = \cancel{ut}^{0} + \frac{1}{2}\cancel{a}t^2$

$s \propto t^2$

$\frac{s_1}{s_1 + s_2} = \frac{t_1^2}{s_2}$

$\frac{s_1}{s_1+s_2} = \left(\frac{2}{4}\right)^2$

$= \frac{1}{4}$

$4s_1 = s_1 + s_2$

$\Rightarrow \boxed{s_2 = 3s_1}$

→ A train is started from rest and moves with an accl^n of $1 m/s^2$ and man who is 48 m behind the train running uniformly with 10m/s the min. time to catch the train is ______

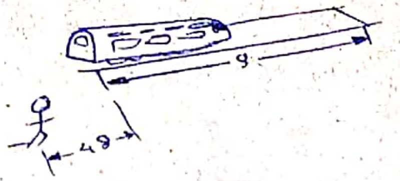
$s = ut + \frac{1}{2}at^2$

For train

$s = \frac{1}{2}at^2$ —— ①

For man

$(s+48) = v \times t$ —— ②



from ① & ②

~~s + 48~~

$\left[\frac{1}{2}at^2 + 48 = vt\right] \times 2$

$\frac{1}{2}t^2 + 48 = 20t$

$t^2 + 96 = 20t$

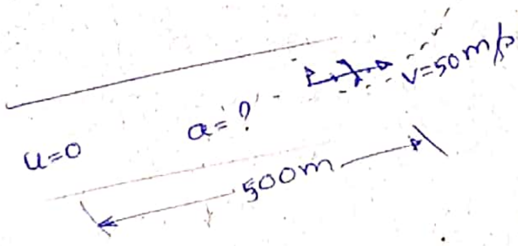
$t^2 - 20t + 96$

$t = 8s$, $t = 12s$

$t = 8s$ min. time or time taken by man

$t = 12s$ time " " train

→ When an aeroplan requires 15m/s inorder to takeoff the leng of runway is 500m $a = ?$



$a = \frac{v}{t}$

$= 15$

$t = \frac{d}{v}$

$v^2 - u^2 = 2as$

$50^2 = 2 \times a \times 500$

$\frac{2500}{1000} = 2.5 m/s^2$

$= \frac{5}{2} m/s^2$

A body crosses points A & B with a velocities of 4 & 8 m/s its velocity at midpoint of A & B

$\Rightarrow v = \sqrt{\frac{v^2+u^2}{2}}$

$= \sqrt{\frac{16+64}{2}}$ $\sqrt{\frac{80}{2}}$

$\frac{\cancel{2}\sqrt{40}}{\cancel{2}}$

$= \sqrt{40}$ m/s

$S_n = u + \frac{1}{2}a(n - \frac{1}{2})$

$5 = u + a(3 - \frac{1}{2})$

$u = 5 - (6-1)$

$= 0$

$v = u + at$

$= 0 + 2 \times 7$

$= 14$ m/s

A body has velocity at a point after a disp. 'S', the velocity becomes 2×V its velocity after another S disp.

V   2V   ?
A   B   C

$2V = \sqrt{\frac{v^2+u^2}{2}}$

$(2V)^2 = \frac{x^2+u^2}{2}$

$x^2 = 8V^2 - u^2$

$x = \sqrt{7V}$

→ A bullet of velocity 100m/s comes to rest within 10 cm in a wooden block, the time taken is ______

$u = 100$ m/s
$v = 0$
$S = 10$ cm

$S = \left(\frac{u+v}{2}\right) \times t$

$10 = \left(\frac{100+0}{2}\right) \times t$

$\cancel{t = \frac{1}{50}\text{ sec}}$

$0.1 = \left(\frac{100+0}{2}\right) \times t$

$2(0.1 = 50t)$

$\cancel{t = \frac{0.1}{50}}$

$0.2 = 100t$

$t = 0.002$ sec

→ A body is moving const. accl^n its disp. 5m in 3rd sec & 9m in 5th sec its velocity after 7 sec

A) u — S_1 — S_2 — S_2
a
3rd   5th
n_1 n_2

$a = \frac{S_2 - S_1}{n_2 - n_1}$

$= \frac{9-5}{5-3} \Rightarrow \frac{4}{2} = 2$ m/s^2

→ A bullet loses 1/20th velocity when is passes through a plank then the min. no of planks required

$N = \frac{n^2}{2n-1}$

$= \frac{40\cancel{0}}{3\cancel{9}}$

~~13.3~~

$= 10.2$

$= 11$

A bullet loses half of the velocity when it passes 60cm in a wooden block the further distance travelled before it comes to ________

$d = N \times s$

$= \left(\frac{n^2}{n-1}\right) \times s - s$

$= (N-1) \times s$

$= \left(\frac{4}{3} - 1\right) \times 0.6$

$= \frac{1}{3} \times 0.2$

$= \frac{2}{10}\, m$

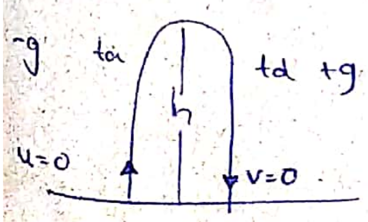
Accl^n due to gravity

accl^n of a freely falling body due to gravit^n accl^n force is called " due to gravity [g]

- g is independent of mass of the body, but it changes from place to place
- For a freely falling body g is +ve
- " " projected " g is -ve

CGS	MKS	FPS
9800 cm/s	9.8 m/s	32 ft/s

Motion of a body under gravity



1. Time of ascent

$V = u + at$

$0 = u - gt_a$

$t_a = u/g$

2. Time of descent

$V = u + gt$

$V = gt_d$

$t_d = V/g$

3. Initial velocity

$V^2 - u^2 = 2as$

$0 - u^2 = -2gh$

$u = \sqrt{2gh}$

4. Final velocity

$V^2 = 2gh$

$V = \sqrt{2gh}$

→ When air resistance is neglected then

$V = u$, $t_d = t_a$

→ When the air resistance is considered then

$V < U$; $t_d > t_a$

5. Time of flight

$T = t_a + t_d$

$= \frac{u}{g} + \frac{v}{g}$ $[U = V]$

$= \frac{2u}{g}$

6. Max. height

$u^2 = 2gh$

$h = \frac{u^2}{2g}$

$\boxed{h \propto U^2}$

7. Heigh of Fall

$S = ut^2 + \frac{1}{2}at^2$

$h = 0 + \frac{1}{2}gt^2$

$h = \frac{1}{2}gt^2$

$\boxed{h \propto t^2}$

→ For a freely falling body the disp. in successive seconds increase by g

$$h = g$$
$$h_2 = h + g$$
$$h_n = h_{n-1} + g$$

→ For a freely falling body the disp. in n^{th} sec is h, then the next second disp. is $h+g$ & previous disp. is $h-g$

$u = 0$

1st	$s = \frac{1}{2}gt^2$ $s_1 = 4.9$	$h = g$
2nd	$s_2 = \frac{1}{2} \times 9.8 \times 4$ $= 14.7$ $s_2 = s_1 + g$ $= 4.9 + g$	$h_2 = h_1 + g$
3rd	$s_3 = \frac{1}{2} \times 9.8 \times 3^2$ $= 24.5$ $= s_2 + g$	$h_3 = h_2 + g$

$$h_1 : h_2 : h_3 = 1 : 3 : 5$$

When a projected body has same velocities after x and y sec then the initial velocity is.

$$\Rightarrow T_f = T_a + T_g$$
$$T = x + y$$
$$x + y = \frac{2u}{g}$$
$$u = \frac{g(x+y)}{2}$$

For a freely falling body

1. Velocity $v = u + gt$

$= 0 + 9.8 \times 1$

$= 9.8\, m/s$

$V \propto t = 1:2:3:4:5$

After 1 second $V_1 = 9.8\, m/s$

$V_2 = 19.6\, m/s$

$V_3 = 29.4\, m/s$ ....

2. Displacement at $S = ut + \frac{1}{2}gt^2$

$S \propto t^2 \Rightarrow 1:4:9:16:25$

$S_1 = 0 + \frac{1}{2} \times 9.8 \times 1^2$

$= 4.9\, m/s$

After 1 second $S_1 = 4.9\, m$

$S_2 = 19.6\, m$

$S_3 = 44.1\, m$

$S_4 = 78.4\, m$..

$S_5 = 122.5\, m$

3. Disp. in successive seconds

$S_n = u + \frac{1}{2}g(2n-1)$

$S_n \propto 2n-1$

$S_1 = 0 + \frac{1}{2} \times 9.8(1)$

$= 4.9\, m$

$S_n \propto 2n-1 = 1:3:5:7:9$

In the 1st second $S_1 = 4.9\, m$

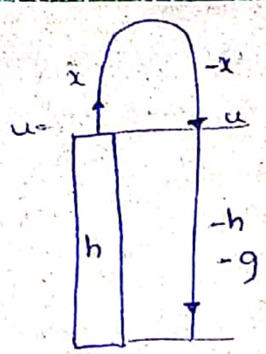
$S_2 = 14.7\, m$

$S_3 = 24.5\, m$

$S_4 = 34.3\, m$

Displacement in successive seconds		Displacement in seconds	
1st sec	4.9	4.9	1 sec
2nd sec	14.7	19.6	2 sec
3rd sec	24.5	44.1	3 sec
4th sec	34.3	78.4 m	4 sec

When a body is projected up from the top of the tower which reaches the ground in the time 't' with a velocity 'v' then the height of tower.

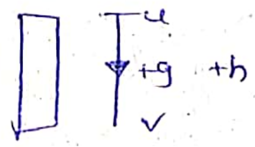


$\Rightarrow s = (\cancel{x} - \cancel{x} - h)$

$= ut + \frac{1}{2}(-g)t^2$

$-h = ut - \frac{1}{2}gt^2$

$$\boxed{h = \frac{1}{2}gt^2 - ut}$$



→ Heigh of tower

$v^2 - u^2 = 2gs$

$v^2 - u^2 = 2gh$

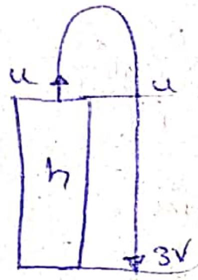
$$\boxed{h = \frac{v^2 - u^2}{2g}}$$

→ $h = \frac{v^2 - u^2}{2g}$

$= \frac{9v^2 - v^2}{2g}$ $[u = v]$

$v = 3v$

$$\boxed{h = \frac{4v^2}{g}}$$

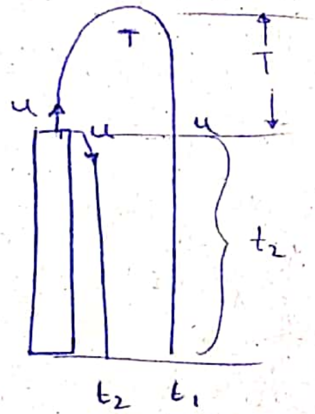


→ Special concept

$t_1 - t_2 = T$

$t_1 - t_2 = \frac{2u}{g}$

$$\boxed{u = \frac{g(t_1 - t_2)}{2u}}$$



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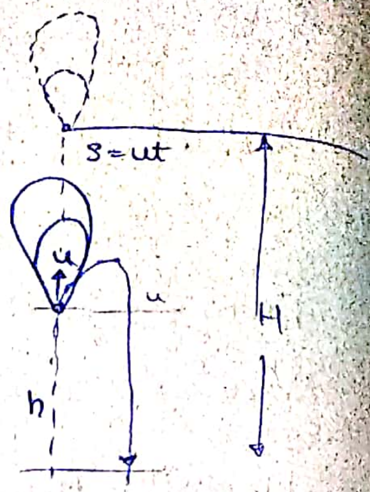
→ The height of the balloon when the stone is dropped

$$\boxed{h = \frac{1}{2}gt^2 - ut}$$



→ The height of the balloon when the stone touches the ground

$H = h + s$

$= \left[\frac{1}{2}gt^2 - \cancel{ut}\right] + \left[\cancel{ut}\right]$

$$\boxed{H = \frac{1}{2}gt^2}$$

→ When a stone is dropped from the top of a tower & another stone is projected up from the ground, then the time taken by them to meet is ________

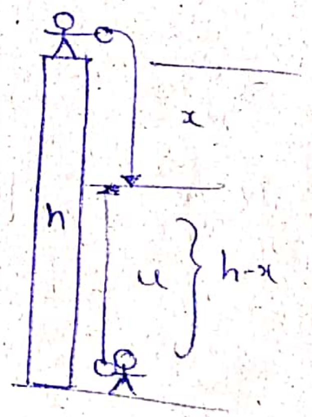
$S = ut + \frac{1}{2}at^2$

I stone $\cancel{x} = \frac{1}{2}gt^2$

II stone $h - \cancel{x} = ut - \cancel{\frac{1}{2}gt^2}$

$h = ut$

$$\boxed{t = h/u}$$



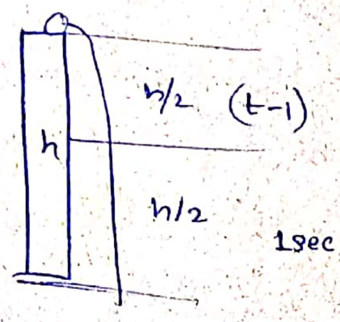
→

$S = ut + \frac{1}{2}at^2$

→ $\cancel{h} = \frac{1}{2}gt^2$

→ $\frac{\cancel{h}}{2} = \frac{1}{\cancel{2}}g(t-1)^2$

$h = g(t-1)^2$



$\frac{1}{2}gt^2 = g(t^2+1-2t)$

$t^2 = 2t^2+2-4t$

$t^2-4t+2=0$

$t = \frac{4 \pm \sqrt{16-8}}{2}$

$t = \frac{\cancel{2}(2 \pm \sqrt{2})}{\cancel{2}}$

$t = (2+\sqrt{2})$ sec

$h = \frac{1}{2}\times(2+\sqrt{2})^2 \times 9.8$

$h = 57.111$ m

4.9
3.41
1600
2700
12
55.36

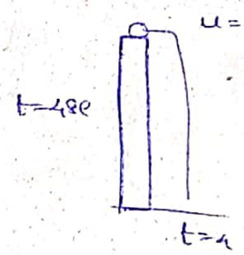
→ A stone is dropped from a top of the tower, the height

$h = \frac{1}{2}gt^2$

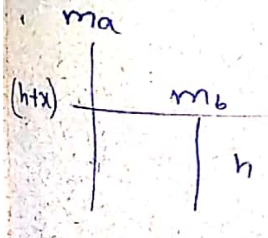
$= 4.9\times 16$ $\quad \frac{1}{2}\times 9.8 \times \cancel{16}$ 8

~~= 43.84~~

$= 78.4$ m



→ Two bodies of mass of m_a, m_b are dropped from the heights of A, & b the ratio of time taken to reach the ground



$S = ut + \frac{1}{2}gt^2$

$S \propto t^2$

$\sqrt{\frac{S_1}{S_2}} = \frac{t_1}{t_2}$

$t_a : t_b = \sqrt{A:B}$

49
16
4384

→ A stone is dropped from a height, it reaches the ground in 5 sec, after 3 sec it is stopped and allowed to fall again, $T_2 = ?$

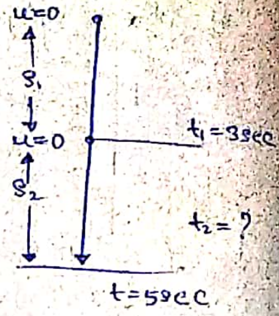
$$S = S_1 + S_2$$

$$\cancel{\tfrac{1}{2}g}t^2 = \tfrac{1}{2}gt_1^2 + \tfrac{1}{2}gt_2^2$$

$$t_2 = \sqrt{t^2 - t_1^2}$$

$$= \sqrt{5^2 - 9}$$

$$= 4 \text{ sec}$$

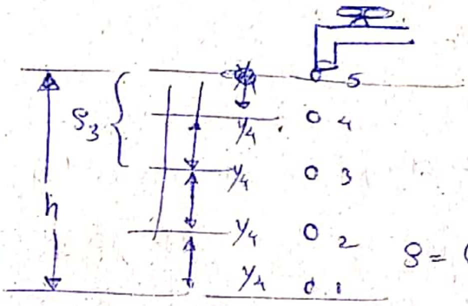


→ Water drops are falling from a cap at an interval of 1/4 sec, the first drop ~~doesn~~ touches the ground the 5th drop is abt. to fall

Soln.

Total time, $T = \frac{1}{4} \times 4$

$= 1$ sec



$S = (N-1) \times S$

$N - \frac{n^2}{2n-1}$

$S = \frac{1}{2} \times g \times t^2$

$= 4.9 \times 1$

$= 4.9$

~~$S_n = u + \frac{1}{2}g(2n-1)$~~ ~~Time~~

~~4.9(3)~~ Time taken for 3rd drop

$t = 2 \times \frac{1}{4}$

$= 1/2$ sec

distance dropped, $S_3 = \frac{1}{2} \times 4.9 \times (1/2)^2$

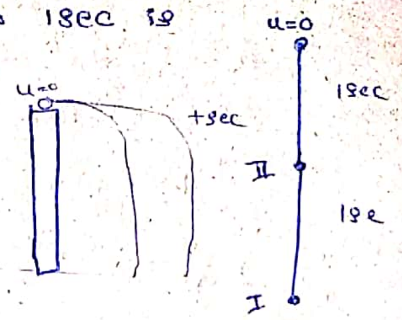
$= 1.225$ m

Dist. remaining, $h_3 = 4.9 - 1.225$

$= 3.675$ m

→ A stone is dropped from a height after 1sec another stone is dropped, the dist. b/w them after another 1sec is

$s = \frac{1}{2}gt^2$



$s_1 = \frac{1}{2}g(1)^2$ $\quad$ $s_2 = \frac{1}{2} \times g \times (2)^2$

$= 4.9m$ $\quad$ $= 9.8 \times 2$

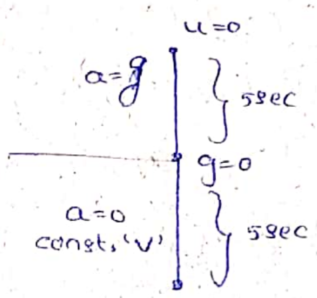
$= 19.6$

$\quad 4.9$

$\quad 14.7$

$s_2 - s_1 = 14.7m$

→ A stone is dropped from a height after 5sec the gravity is dissappear, it displacement in next 5sec



$\therefore v = u + gt$

$= 0 + 9.8 \times 5$

$= 49 \, m/s$

$s = v \times t$

$= 49 \times 5$

~~= 245 m/~~

$= 245 \, m$

→ A stone is dropped from the top of a tower, after 1sec another stone is dropped from balcony which is 20m below the top. both reaches the ground at ones, the heigh

$s_1 = s_2$

$(20 + h) = h$

$h_1 = h_2 - 20$

$s_1 = \frac{1}{2}gt^2$

$(s_2 - 20) = \frac{1}{2}g(t-1)^2$

~~$s_2 = \frac{1}{2}gt^2$~~

$\frac{1}{2}gt^2 - 20 = \frac{1}{2}g(t-1)^2$

$t^2 - 20 = t^2 + 1 - 2t$

~~$1 - 2t + 20$~~

$2t - 20 = 1$

$2t = 19/2$

$= 9.8$

$\frac{1}{2}\left[gt^2 + g - 2tg - gt^2\right] + 20 = 0$

$g - 2tg = -10$

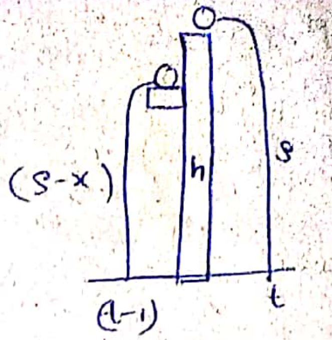
$g(1 - 2 \times t) = -10$

$t = \frac{-1-1}{-2}$

=

$s - x = s$

$\frac{1}{2}g(t-1)^2 = \frac{1}{2}gt^2$



$-20 = \frac{1}{2} \times 10 - 10t$

$t = 2.5 sec$

$h = \frac{1}{2}gt^2$

$= \frac{1}{2}$

$= 31.25 m$

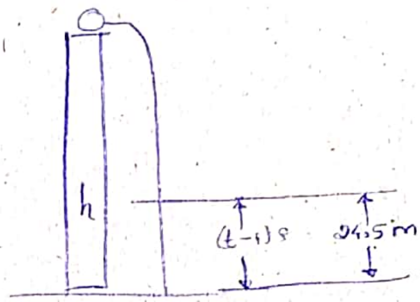
→ A stone from the top of the tower, it travels 24.5 m in the last second, the heigh of tower is.

$24.5 = u + \frac{1}{2}a(2n-1)$

$\frac{\cancel{24.5}^{5}}{\cancel{4.9}} = \cancel{}\ 4.9(2n-1)$

$2n - 1 = 5$

$\cancel{2}\ n = 3 sec$



$\frac{24.5}{2}$
4.9×9
$\cancel{44.7}$
8
44.1

$h = \frac{1}{2}gt^2$

$= \frac{1}{2} \times 9.8 \times 3^2$

$= 44.1 m$

→ A ball is projected up which ~~is the g~~ reaches the ground ~~the~~ after 6 sec. the find the height of tower after 4 sec

$v = u + gt$

$= 9.8 \times 2$

$= 19.6$

$T_f = \frac{t_a + t_d}{2} = \frac{2u}{g}$

$3\cancel{6} = \frac{\cancel{2}}{g} \times u$

$u = 30 m/s \Rightarrow S = ut - \frac{1}{2}gt^2$

$= 30 \times 4 - \frac{1}{2} \times \cancel{9}1.0 \times 16$

$= 40 m$

In the above promblem the max. height of the ball and it velocity after 4sec.

$$\begin{array}{r} 35 \\ \times 35 \\ \hline 900 \\ 300 \\ 25 \\ \hline 1225 \end{array}$$

$$H_{max} = \frac{u^2}{2g}$$
$$= 45m$$

$\frac{90}{2} = 45$

$$V = u - gt$$
$$= 30 - 9.8 \times 4$$
$$= -10 m/s$$

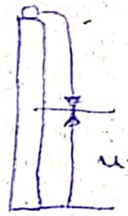
→ A ballon rising uniformly with 9.8 m/s a stone is dropped from it which reaches the ground is 10 sec

~~h=0~~

$$h = \frac{1}{2}gt^2 - ut$$
$$= \frac{1}{2} \times 9.8 \times 10^2$$
$$= 4.9 \times 100 - 98$$
$$= 490 - 98$$
$$h = 490 - 98$$
$$= 392m$$

→ When a stone is dropped from the top the tower & another " " projected up " " ground with 39.2 m/s

$$h = ut$$
$$= 39.2 \times 2$$
$$= 78.4 m$$



→ HORIZONTAL MOTION

- When a body is projected horizontally from the top of a tower, then it reaches the ground in parabolic path
- The horizontal velocity remains const.
- When a stone is dropped from the top of a tower & another stone is projected horizontally then both reaches the ground at the same time but with diff. velocities.

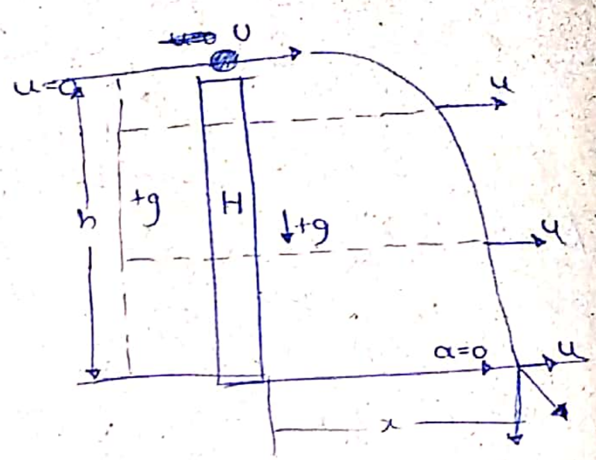
For a dropped (velocity) body, $v = \sqrt{2gh} = gt$

" " projected " " , $v = \sqrt{V_x^2 + V_y^2}$
$$= \sqrt{u^2 + 2gh}$$

$$\tan \alpha = \frac{V_y}{V_x}$$
$$\alpha = \tan^{-1}(V_y / V_x)$$

→ When a bomb is dropped from aeroplane it seems to be falling in a parabolic path for the person the ground for the

- The bomb seems to be falling vertical. down for the person in the aeroplane



$s = ut + \frac{1}{2}at^2$

heigh of tower

$h = \frac{1}{2}gt^2$ — ①

Range

$x = ut$

Time of descent

$t = \frac{x}{u}$ — ②

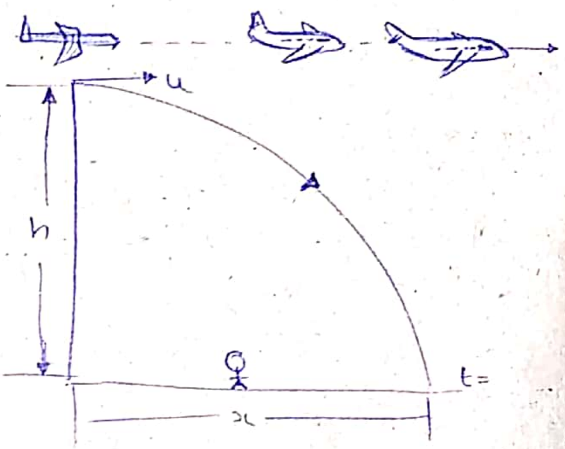
from ① & ②

$\boxed{h = \frac{1}{2}g\frac{x^2}{u^2}}$

$V_x = u$

$V_y = \sqrt{2gh}$

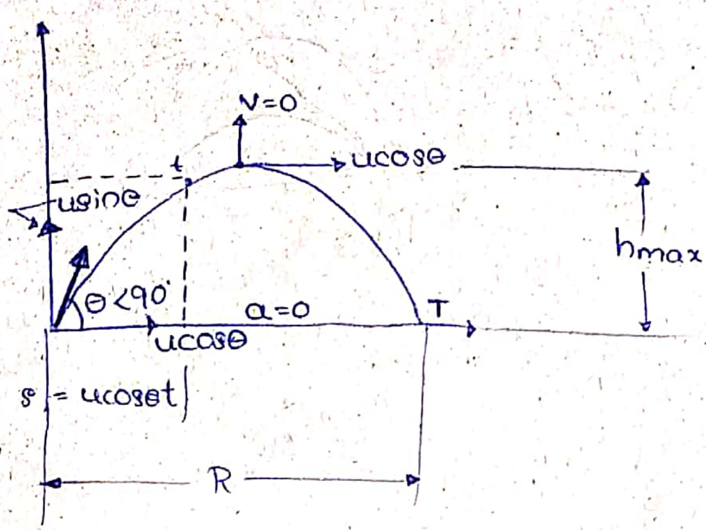
$V = \sqrt{u^2 + 2gh}$



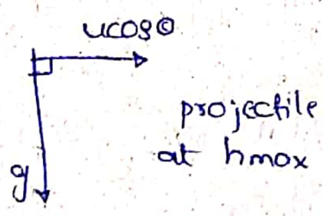
→ OBLIQUE PROJECTION

→ When a body is projected with some initial velocity at a certain angle ~~with~~ $(\theta < 90^\circ)$ and allowed the body to move under gravity that projection is called oblique projection

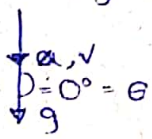
- The path of the projectile is parabola
- The " " " " " a straight line when it is observed from another projectile.
- The horizontal velocity $(u\cos\theta)$ remains constant but vertically $(u\sin\theta)$ changes due to ~~gravity~~ gravitational force.
- The projectile has min. velocity at max. height $(u\cos\theta)$

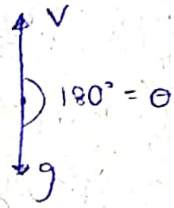


θ = 90°



Freefalling body





Range, $R = u\cos\theta \times T$

$H_{max} = \frac{u^2\sin^2\theta}{2g}$

Time of flight, $T = \frac{2u\sin\theta}{g}$

$R = u\cos\theta \times \frac{2u\sin\theta}{g}$

$\boxed{R = \frac{\sin 2\theta\, u^2}{g}}$ (or) $R = \frac{u^2 2\tan\theta}{g \times (1+\tan^2\theta)}$

→ For max.

Range, $R = \sin 2\theta = 1$; $\theta = 45°$ $= \frac{u^2}{g}$

Height, $h = \sin^2\theta = 1$; $\theta = 90°$ $= \cancel{2u/g}$ $u^2/2g$

Flight, $T = \sin\theta = 1$; $\theta = 90°$ $= 2u/g$

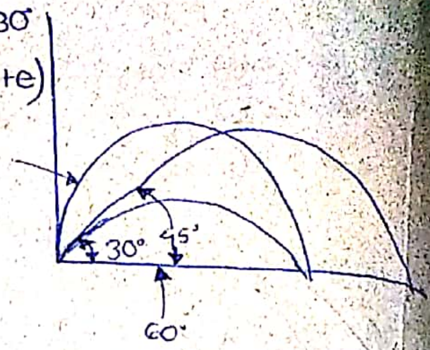
→ $s = ut + \frac{1}{2}at^2$

Horizontal disp. $x = u\cos\theta\, t$

Vertical " , $y = u\sin\theta t - \frac{1}{2}gt^2$

• Range is same for the angle of θ & $90-30$

• " " " " " " (45-θ) " (45+θ)



Relat^n b/w 'R' & 'h'

$$h = \frac{u^2 \sin^2\theta}{2g}$$

$$R = \frac{u^2\, 2\sin\theta\cos\theta}{g}$$

$$\frac{h}{R} = \frac{\cancel{u^2}\sin^{\cancel{2}}\theta}{2g} \times \frac{\cancel{g}}{\cancel{u^2}\, 2\cancel{\sin\theta}\cos\theta}$$

$$\frac{h}{R} = \frac{\tan\theta}{4}$$

$$\boxed{R \cdot \tan\theta = 4h}$$

$$\boxed{R = 4h \;;\; h = R/4} \quad \{\theta = 45°\}$$

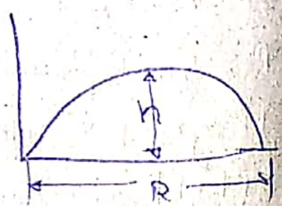
→ When the range of projectile is double to h_{max}, then the Range is

$$R = 2H$$

$$R\tan\theta = 4h$$

$$2\tan\theta = \frac{4h}{2h}$$

$$\tan\theta = 2$$



$$R = \frac{u^2\, 2\tan\theta}{g(1+\tan^2\theta)}$$

$$= \frac{u^2\, 2 \times 2}{g(1+2^2)}$$

$$= \frac{4u^2}{5g}$$

Relatⁿ b/w h & T

$h = \frac{u^2\sin^2\theta}{2g}$ $\left(T = \frac{2u\sin\theta}{g}\right)^2$

$\frac{h}{T^2} = \frac{u^2\sin^2\theta / 2g}{4u^2\sin^2\theta / g^2}$

$\frac{h}{T^2} = \frac{g}{8}$

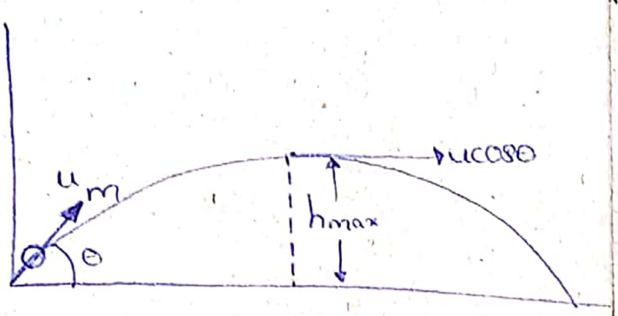
$gT^2 = 8h$

$\boxed{h \propto T^2}$

→ Relatⁿ b/w R & T

$R = u\cos\theta \cdot T$

→ Energy of a projectile



At the ground

$K.E = \frac{1}{2}mu^2$

$P.E = 0$

$\boxed{T.E = \frac{1}{2}mu^2}$

At H_{max}

1. $K.E = \frac{1}{2}mv^2$

But $v = u\cos\theta$

$= \frac{1}{2}mu^2\cos^2\theta$

2. Potential energy

$P.E = mgh$

but $h = \frac{u^2\sin^2\theta}{2g}$

$P.E = \frac{m\cancel{g}\cdot u^2\sin^2\theta}{2\cancel{g}}$

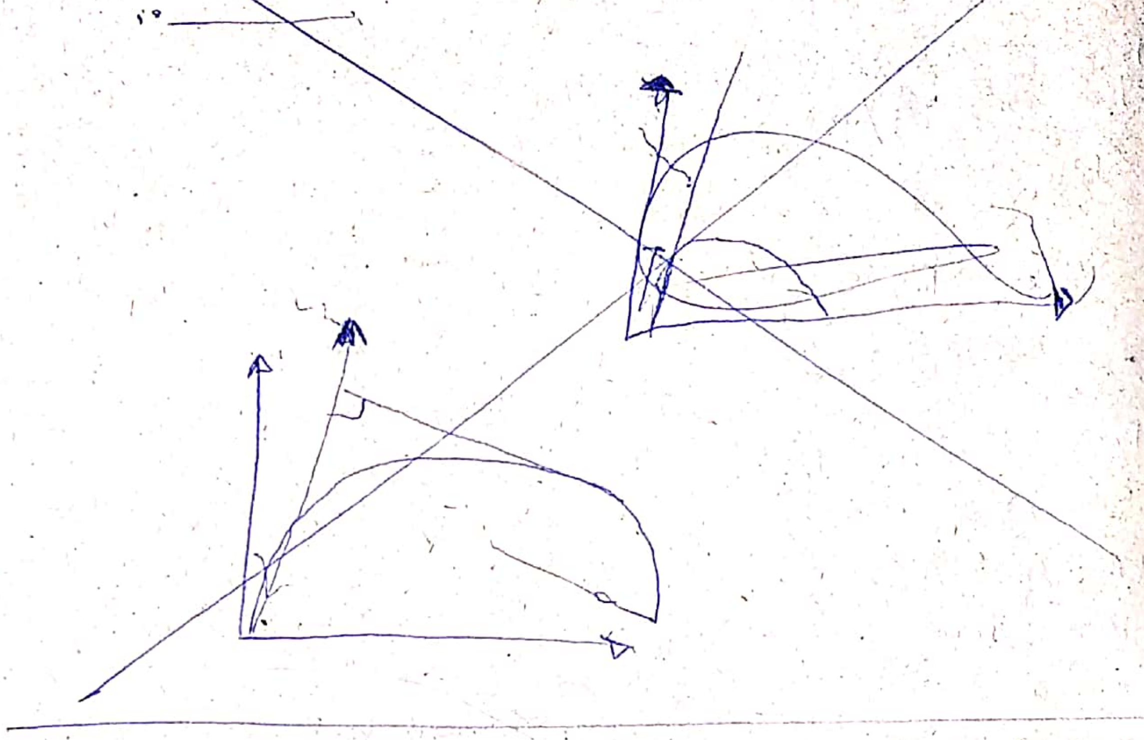
$\boxed{P.E = \frac{1}{2}mu^2\sin^2\theta}$

→ If $\theta = 45°$

$K.E = P.E = \frac{1}{2}\cdot\frac{1}{2}mu^2$

$= \frac{1}{2}T.E$

→ When a body is projected with a velocity u and at angle θ, the time taken by it to keep perpendicular to initial direction

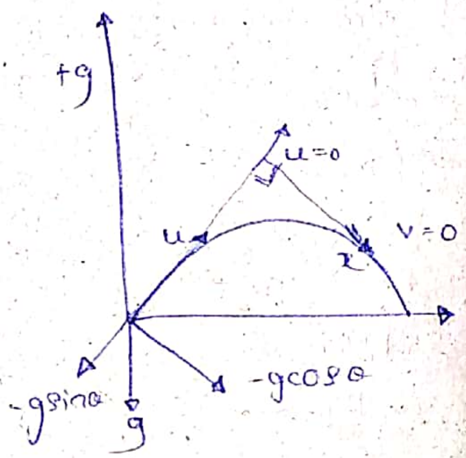


1. Time taken

$v = u + at$

$0 = u - g\sin\theta t$

$t = \frac{u}{g\sin\theta}$



2. Velocity

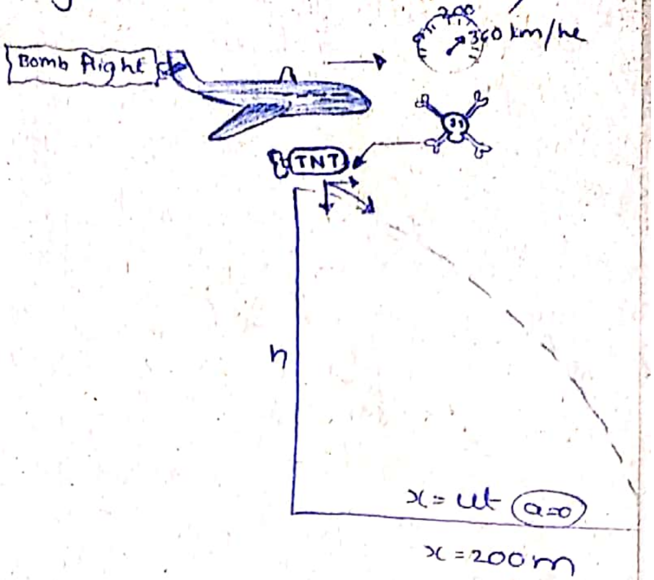
$v = u + at$

$v = 0 - g\cos\theta \cdot \frac{u}{g\sin\theta}$

$v = -\cot\theta\, u$

$v = -u\cot\theta$

An aeroplane is flying horizontally with 360km/hr releases a bomb on to a target which is 200m away



→ $h = \frac{1}{2} \times g \times \frac{x^2}{u^2}$

$= \frac{1}{2} \times 9.8 \times \frac{200^2}{100\,m/s \times 100\,m/s}$

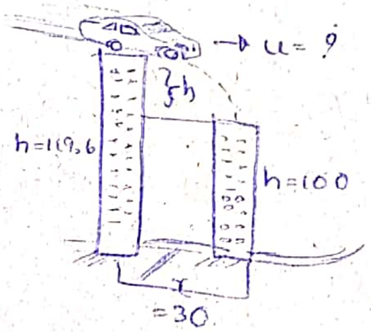
$= 19.6m$

$t = x/u$

$= 200/100$

$= 2$ sec

→ A car jumps from the top of tower at height of 119.6m on to another tower height of 100m which are 30m apart,



$h = \frac{1}{2} \times g \frac{x^2}{u}$

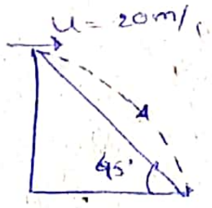
$19.6 = \frac{1}{2} \times 9.8 \times \frac{900}{u^2}$

$u^2 = \frac{9.8 \times 900}{2 \times 19.6}$

$= \sqrt{225}$

$= 15\,m/s$

→ A stone is projected horizontal with 20m/s from the top of a tower, it hits the ground with a point which is joined makes 45°, then height.



$h = \frac{1}{2} \times g \times \frac{x^2}{u^2}$

$\tan 45 = \frac{h}{x}$

$x = h$

$\cancel{h} = \frac{1}{2} \times g \times \frac{h^{\cancel{2}}}{u^2}$

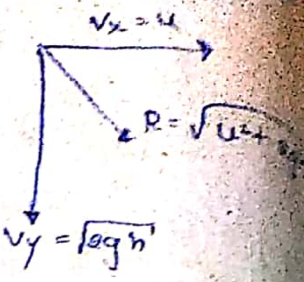
$\frac{400 \times 2}{10}$

$h = 80m$

cos 45

$\frac{1}{\sqrt{2}} = \frac{20}{?}$

→ In the above promblem the velocity at ground is



$V = \sqrt{u^2 + 2gh}$ $\quad$ 160

$= \sqrt{20^2 + 40^2}$

$\cancel{V = 60}$

$\sqrt{400 + 1600}$

$\cancel{400}$ $\quad 20\sqrt{1 + 4\cancel{00}}$

$20\sqrt{5}$

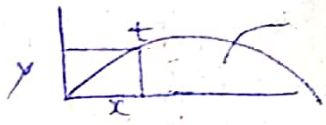
$\sqrt{7} = 2.6457513$

$\sqrt{5} = 2.2360678$

→ The horizontal & vertical disp. of projectile .

$x = 6t$ $\quad$ then $u = ?$

$y = 8t - 5t^2$



$x = u\cos\theta \times t$

$\Rightarrow u\cos\theta = 6$

$y = u\sin\theta\, t - \frac{1}{2}gt^2$

$= u\sin\theta = 8$

$x^2 + y^2 \Rightarrow$

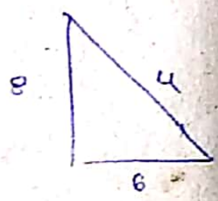
$u^2\cos^2\theta + u^2\sin^2\theta = 6^2 + 8^2$

$u^2(1) = 100$

$u = 10$

$\cos\theta = 6/u$

$\sin\theta = 8/u$



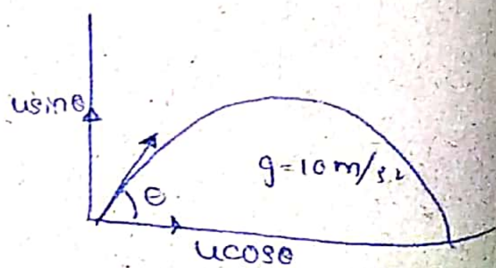
$\Rightarrow u = \sqrt{8^2 + 6^2}$

$= \sqrt{100}$

$= 10$

→ $\bar{u} = 3i + 4j$ m/s $\quad T = \frac{2u}{g}$

$= u\cos\theta\, i + u\sin\theta\, j$



$u\cos\theta = 3$

$u\sin\theta = 4$

$T = \frac{2u\sin\theta}{g} = \frac{2 \times 4}{10} = 0.88$

$h = \frac{u^2 \sin^2\theta}{2g}$

$= \frac{16}{20} \Rightarrow 0.8m$

$R = u\cos\theta \, T$

$= 8 \times 0.8$

$= 6.4m$

→ The min velocity of a projectile eq/ to the half of the initial velocity, the angle of projection is ____

$\cancel{u}\cos\theta = \frac{1}{2}\cancel{u}$

$\theta = 60°$

→ The min velocity of a projectile is 8m/s. It is in air for 6 seconds. it range is ____

$u\cos\theta = 8$

$R = u\cos\theta \times t$

$= 8 \times 6$

$= 48m$

→ The range ~~are~~ 'R' is same for the angle of θ & $90-\theta$ the ratio of Times of flight

$\cancel{R} = u\cos\theta \times T_1$

$\cancel{R} = u\sin\theta \times T_2$

$\frac{T_1}{T_2} = \frac{\cancel{u}\sin\theta}{\cancel{u}\cos\theta}$

$\frac{T_1}{T_2} = \tan\theta$

$T_1 = \frac{2u^2\sin^2\theta}{\cancel{g}}$

$T_2 = \frac{2u^2 \cancel{\sin}(90-\theta)}{g}$

$\frac{T_1}{T_2} = \tan\theta$

→ In the above the ratio of H_{max} is

$H_{max_1} = \frac{u^2\sin^2\theta}{2g}$

$H_{max_2} = \frac{u^2\sin^2(90-\theta)}{2g}$

$H_1 : H_2 = \tan^2\theta$

→ " " " " ~~the~~ relatn among R, h_1, h_2

$R = \frac{4h}{\tan\theta}$

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$R\tan\theta = 4h_1$ —— ①

$R\tan(90-\theta) = 4h_2$

$R\cancel{\tan}\frac{1}{\tan\theta} = 4h_2$ —— ②

① × ②

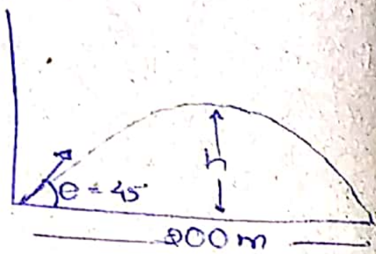
$R^2 = 16h_1h_2$

$R = 4\sqrt{h_1h_2}$

→ The range of projectile is 200m when it is projected with 45

$\cancel{\frac{u^2}{g}}\ R\tan\theta = 4h$

$h = 50m$



→ The range of projectile is 1.5km (1500m) when the angle of projection is 15°, the angle is made 45°, the range —

$\cancel{1500\tan 15° = 4h}$

$\cancel{1500\tan 45 = 4h}$

$\cancel{1500(\tan 15° - \tan 45) = 0}$

$R_1 = 1500m$ $\alpha_1 = 15°$

$R_2 = x$ $\alpha_2 = 45°$

$R = \cancel{\frac{u^2\sin 2\theta}{g}}$ $R \propto \sin 2\theta$

R $\frac{1500}{x} = \frac{\sin 30°}{\sin 90°}\ \frac{1/2}{1}$

$x\frac{1}{2} = 1500$

$x = 3000$

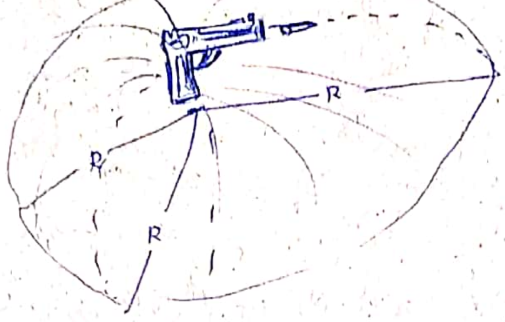
$= 30km$

$= 3km$

→ A m/c gun fires the bullets in all directions with a velocity 'u', the max. Area covered on the ground by the bullets ______

$R = \cancel{u\cos\theta}$ $R_{max} = \frac{u^2}{g}$

~~Area = $\pi u^2 \cos^2\theta$~~



$$Area = \pi\left[\frac{v^2}{g}\right]^2$$

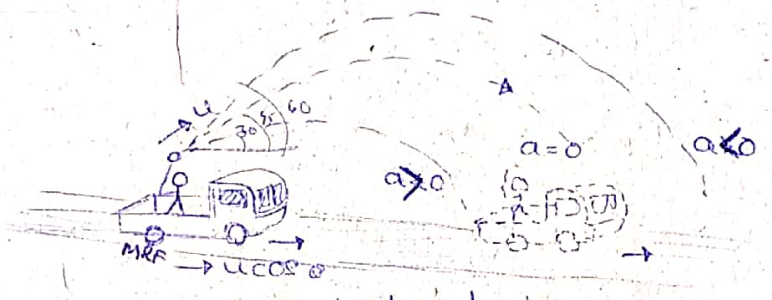
$$= \frac{\pi v^4}{g^2}$$

→ A ball is projected with [20 m/s] at angle of 60°, the velocity of boy who run to catch the ball when it is falls on the ground is ______

$u = 20\,m/s$

$u\cos\theta = 10\,m/s$

NOTE :



→ A ball is thrown from one player to another player its max. height is ______ . Time = 2sec

$$T_f = \frac{2u\sin\theta}{g} = 2 \qquad H_{max} = \frac{u^2\sin^2\theta}{2g}$$

$$u\sin\theta = g$$

$$h_{max} \Rightarrow \frac{u^2\sin^2\theta}{2g} \Rightarrow \frac{g}{2}$$

$$= 4.9\,m$$

$$gT^2 = 8h$$

$$g \times 4 = 8h$$

$$h = g/2$$

$$= 4.9$$

→ The max. Range of a projectile is numerically eq to initial velocity.

$$R_{max} \Rightarrow \frac{u^2 \sin 2\theta}{g} = u$$

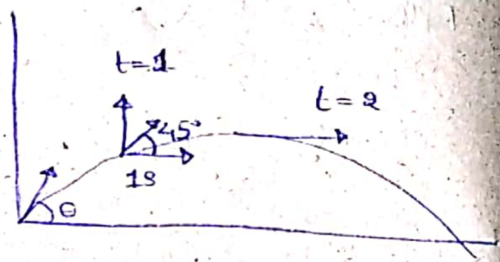
$$\Rightarrow \frac{u^2}{g} = u$$

$$\Rightarrow u = g$$

$$u = 9.8 \, m/s$$

→ A body is projected with an initial velocity u at an angle θ after one second, it is at an angle of 45° after 2 seconds it is horizontal

$T_f = 2 + 2 = 4 sec$

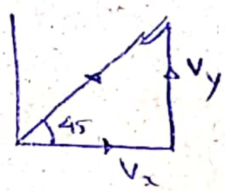


$$T = \frac{2u\sin\theta}{g}$$

$$4 = \frac{2u\sin\theta}{10}$$

$$u\sin\theta = 20$$

$$\tan 45° = \frac{V_y}{V_x}$$



$$1 = \frac{V_y}{V_x}$$

$$V_y = V_x$$

$$V_y = u\cos\theta$$

$$V_y = u\sin\theta - gt \quad [u - gt]$$

$$V_y = u\sin\theta - (10 \times 1)$$

$$V_y = 20 - 10$$

$$V_y = u\cos\theta = 10 = V_x$$

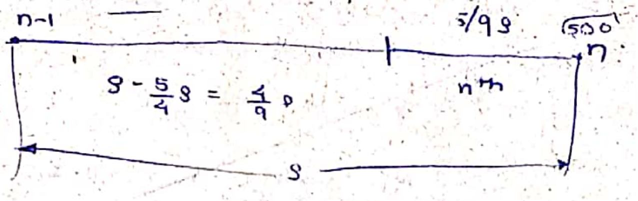
$$u\sin\theta = 20$$

$$u\cos\theta = 10$$

$$u = 10\sqrt{5}$$

$s = \frac{1}{2} a n^2$

$\frac{4}{9} s = \frac{1}{2} a (n-1)^2$



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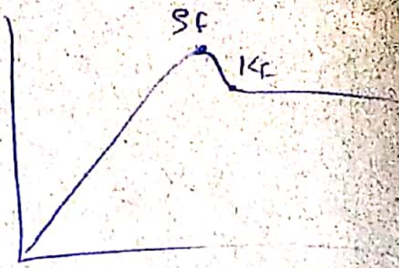
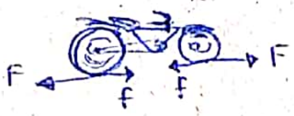
Friction:

~~Friction is an external force which acts b/w two surfaces & which opposes the motion b/w~~
~~When a man is walking ground, the fr. acts in the direction of motion of the man~~



- Friction is an external force which acts b/w two surfaces and which opposes the motion of body.
- When a man is walking on ground, the friction acts in direction of motion of man.
- For a cycle
  In forward direction for the back wheel & backward direction for front wheel



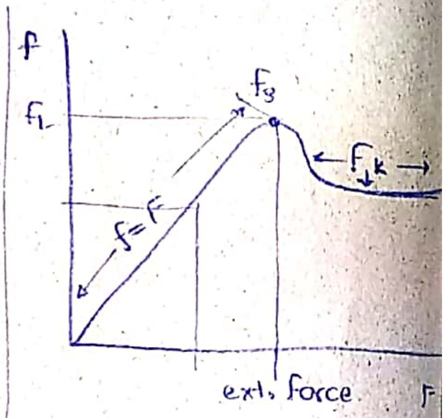
- When the pedalling is stopped the friction acts in the backward direction for both the wheel

→ Friction is 3 types :

1. Static friction 2. kinetic friction 3. Rolling friction

→ 1. Static friction is a self adjusting force

- The max. static friction is called limiting friction [limiting eq^{bm} state (or) ~~ready to~~ ready to start].
- The min. ext. force require to start the body is limiting friction



→ Advantages of friction

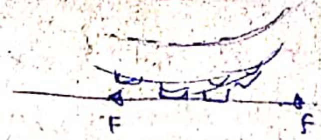
1. Without friction we can't hold the things
2. " " m/c can't be run

→ Disadvantages

1. η of engine ↓
2. Wear & tear takes place in the m/c

→ Methods to reduce friction

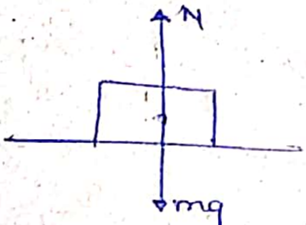
1. Polishing
2. Using lubricating oils
3. ball bearings
4. Using anti-friction mtl [steel]
5. Streamlining shape of a vehicle [aerodynamic shape]



→ When the surface is moderately polished

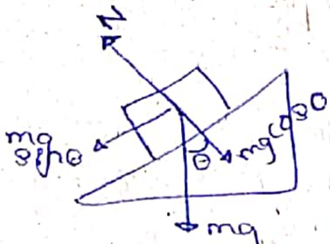
→ When the surface is heavily polished the friction increases due to adhesive forces

→ Normal react^n: The force applied by the surface on the body in $\perp^{lr}$ to the surface is called Normal react^n



N = mg

Horizontal



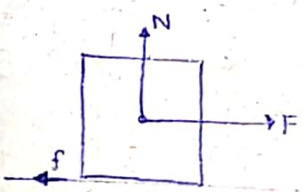
N = mg cosθ

& Inclined surface

→ $f \propto N$

→ f ~~is~~ independent of area of contact except Rolling friction

→



μ = coefficient of friction

$f \propto N$

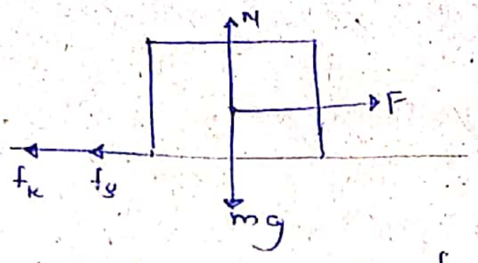
$f = \mu N$

$\mu = \frac{f}{N}$

μ_s >	μ_k >	μ_R
$F_s = \mu_s N$	$F_k = \mu_k N$	$F_R = \mu_R N$

If the Normal react^n doubles, the friction becomes double but coefficient of friction remains same (depends on nature of the surface).

→ Motion of a body on a horizontal surface



At rest $F = f_s$ [Self adjusting force]

The min. ext. force required to start the body

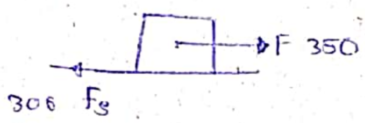
$F = f_L = f_s = \mu_s N = \mu_s mg = 400N$

The min. force required to move the body uniformly

$F = f_k = \mu_k N = \mu_k mg = 300N$

If $F > f_k$ then the body moves with acclⁿ

Static



Net force

$F = f_s$

$F - f_s = ma$

$$\boxed{a = \frac{F - f_s}{m}}$$

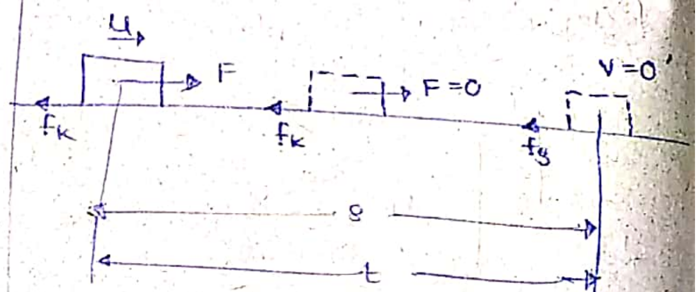
(acclⁿ)

$F = 350$, $f_s = 300$

$m = 10$

then $a = 5 m/s^2$

Kinetic



Net force

$0 - f_k = ma$

$-\mu_k \cancel{m} g = \cancel{m} a$

$$\boxed{a = -\mu_k g}$$ (Retardation)

For stopping dist.

$v^2 - u^2 = 2as$

$-u^2 = 2(-\mu_k g)s$

$$\boxed{S = \frac{u^2}{2\mu_k g}}$$

Time taken, $v = u + at$

$\Rightarrow u - \mu_k g t = 0$

$$\boxed{t = \frac{u}{\mu_k g}}$$

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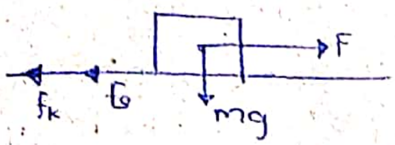
→ When a body is started with a force & the same force is continued, then the accl^n of the body is



$$F = f_s = \mu_s mg = f_L$$

$$f_k = \mu_k mg$$

Net force

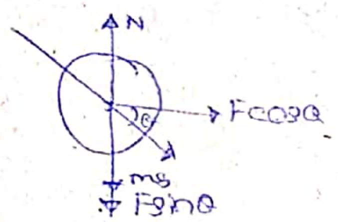
$$F - f_k = ma$$

$$\mu_s \cancel{m}g - \mu_k \cancel{m}g = \cancel{m}a$$

$$\boxed{a = g(\mu_s - \mu_k)}$$

→ It is easy to pull a roller than pushing it. bcoz while pulling net W ↓ ∝ f_s
" pushing " " ↑ ∝ f_s

• Pushing

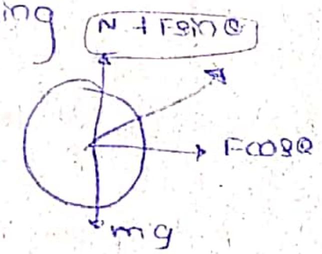


$$N = mg + \sin\theta$$

$$f_r = \mu_r N$$

$$f_r = \mu_s[mg + F\sin\theta]$$

• Pulling



$$N + F\sin\theta = mg$$

$$N = mg - F\sin\theta$$

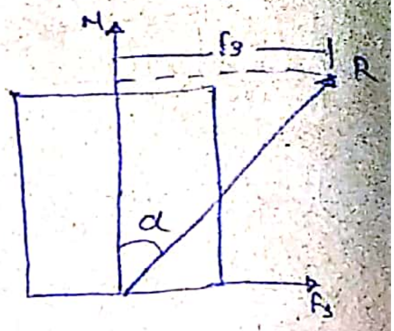
$$f_R = \mu_R[mg - F\sin\theta]$$

- Angle of friction :

The angle b/w contact force & normal reactⁿ is called [Resultant of N & f_s]

angle of friction or limiting angle

R = contact Force



$$\tan \alpha = \frac{f_s}{N}$$

but $\frac{f_s}{N} = \mu_s$

$$\boxed{\tan \alpha = \mu_s}$$

Contact force

$$R = \sqrt{N^2 + f_s^2}$$

$$\boxed{R = N\sqrt{1 + \mu_s^2}}$$

→ A block of 10kg is placed on a horizontal surface (μ_s = 0 the min. force is required to start the block.

$$F = \mu_s \times m \times g$$

$$= 0.5 \times 10 \times 9.81 \quad kg \times$$

$$= 49 \text{ kN}$$

→ A block of mass is 20kg is dragged on a horizontal surface $\mu_k = 0.2$ with a force of 59.2N If a = 0

$$\cancel{a = g(\mu_s - \mu_k)}$$

$$\cancel{= 9.8[}$$

$$\mu_s = \frac{F}{m \times g}$$

$$= \frac{59.2}{20 \times 9.81}$$

$$F - \mu_k mg = ma$$

$$a = \left(\frac{F - \mu_k mg}{m}\right)$$

$$= \frac{[59.2 - (0.2 \times 20 \times 9.81)]}{20}$$

$$= 1 \text{ m/s}^2$$

39.24

→ A block of mass 10kg is dragged on a horizontal surface of $\mu = 0.2$ with a $v = 2m/s$. the work done in 5 seconds is (1)

A) $W = F \times s$

$= \mu_k mg \times v \times t$

$= 0.2 \times 10 \times 9.8 \times 2 \times 5$

$= 0.2 \times 9.8 \times 100$

$= 9.8 \times 50$

$= 196 J$

→ A block of mass = 20kg is placed on a horizontal surface of $\mu_s = 0.5$, A force of 20N is applied on the body the static friction is

$m = 20kg \quad \mu_s = 0.5 \quad F = 20N$

$f_s = f_L = \mu_s mg$

$= 0.5 \times 20 \times 9.8$

$= 9.8 \times 10$

$= 98N$

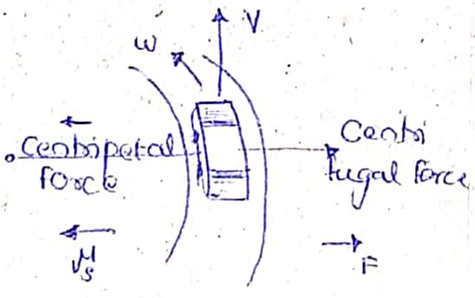
$F < F_L$ [Rest]

$F = f = 20 N$

→ A car is moving O's path of radius 100m & $\mu_s = 0.2$, the V_{max} to move safely and angular velocity.

$r = 100m$

$\mu_s = 0.2$



C.F = friction

$\frac{\cancel{m}v^2}{r} = \mu_s \cancel{m}g$

$\boxed{v = \sqrt{\mu_s r g}}$

Linear velocity

but $v = r\omega$

$r\omega = \sqrt{\mu_s r g}$

$\boxed{\omega = \sqrt{\frac{\mu_s g}{r}}}$

Angl^r velocity

$V = \sqrt{0.2 \times 100 \times 9.8}$

$= \sqrt{196}$

$= 14\ m/s$

$\omega = \sqrt{\frac{0.2 \times 9.8}{100}}$

$= \sqrt{\frac{196}{10^4}}$

$\omega = \frac{14}{100} = 0.14\ m/s^2$

→ A ball is moving with 9.8 m/s on a horizontal surface of $\mu_k = 0.2$, It comes to rest after a distance of ____

$u = 9.8\ m/s$

$\mu_k = 0.2$

$\Rightarrow s = \frac{u^2}{2\mu_k g}$

$= \frac{\overset{49}{\cancel{9.8}} \times \cancel{9.8}}{2 \times 0.2 \times \cancel{9.8}}$

$= 24.5\ m$

$\Rightarrow t = \frac{u}{\mu_k g}$

$= \frac{\cancel{9.8}}{0.2\cancel{9.8}}$

$= 5s$

→ On a horizontal surface $\mu_s = 0.5$, $\mu_k = 0.3$. A block is started with a force and same force continued, then its a = ____

$\mu_s = 0.5$

$\mu_k = 0.3$

$F = f_s = f_L = mg \times \mu_s$

$f_k = \mu_k mg$

Net force

$F - f_k = ma$

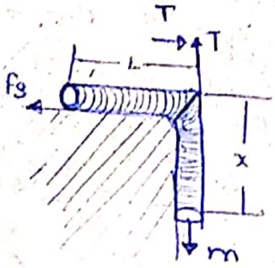
$\mu_s \cancel{m}g - \mu_k \cancel{m}g = \cancel{m}a$

$a = (0.5 - 0.3) \times 9.8$

$= 0.2 \times 9.8$

$= 1.96\ m/s^2$

A rope of length 'L' is placed on a horizontal table, μ_s — the max. length of the rope can be hanged over the edge without slipping is



$f_s = \mu_s N$

$f_s = \mu_s m(L-x)g$

$mxg = T = f_s = \mu_s (L-x) mg$

$x = \mu_s (L-x)$

$\frac{x}{L-x} = \mu_s$

$x = \mu_s L - \mu_s x$

$x[1+\mu] = \mu_s L$

$x = \frac{\mu_s}{1+\mu} \times L$

A body of mass m is dragged uniformly by a force F, the force is made 3F, then its a=?

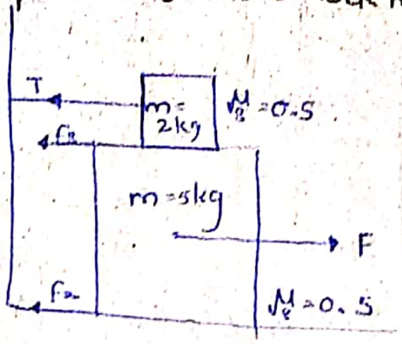
$F = f_s$

$3F - f_k = ma$

$3F - F = ma$

$a = \frac{2F}{m}$

Force required to move block m



$F = f_1 + f_2$

$f_1 = \mu_s mg = 0.5 \times (5+2) 9.8$

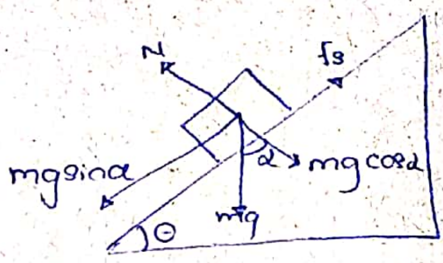
$f_2 = \mu_s mg = 0.5 \times (2) \times 9.8$

$F = 0.5 \times 9.8 (7+2)$

$= 16 \times 0.5 \times 9.8$

$= 44.1N$

Angle of repose: The min. angle of inclination required by a body to be at limiting eq^{bm} is called angle of repose.



$\Rightarrow$ $mg\sin\alpha = f_s$

$mg\cos\alpha = N$

① % ②

$\tan\alpha = f_s / N$

$\boxed{\tan\alpha = \mu_s}$ eq^{bm}

$\boxed{\tan\alpha = \mu_k}$ sliding uniformly

$\rightarrow$ Angle of repose = angle of friction

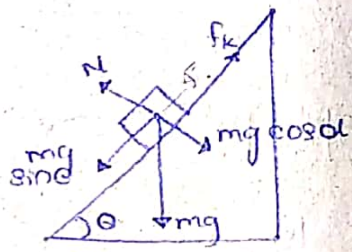
$\theta < \alpha \rightarrow$ the body will be at rest, $f_s = mg\sin\theta$ [self adjusting]

$\theta = \alpha \rightarrow$ The " " " " limiting eq^{bm} or slides uniform

$\theta > \alpha \rightarrow$ " " " slides with $accl^n$

Motion of a body on an inclined rough surface:

1. Downward



$\theta > \alpha$

Net force

$mg\sin\theta - f_k = ma$

but $f_k = \mu_k mg\cos\theta$

$mg\sin\theta - \mu_k mg\cos\theta = ma$

$Accl^n$; $\boxed{a = g[\sin\theta - \mu_k\cos\theta]}$

$\boxed{a = g\sin\theta}$ – on smooth surface $\mu_k = 0$

$\boxed{a = 0}$ if $\theta = 0°$

$\boxed{a = g}$ if $\theta = 90°$

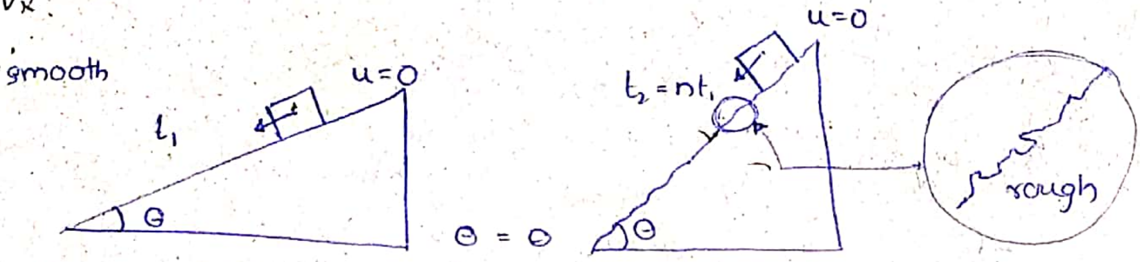
Time of descent

$s = \cancel{ut} + \frac{1}{2}at^2$

$t = \sqrt{\frac{2s}{g}}$

$$t = \sqrt{\frac{2s}{g(\sin\theta - \mu_k\cos\theta)}} \qquad t = \sqrt{\frac{2s}{g\sin\theta}} \quad \{\mu_k = 0\}$$

When a body takes n times ~~the~~ greater time to slide down on a inclined rough surface and on smooth surface, then μ_k —



$$t_1 = \sqrt{\frac{2s}{g\sin\theta}} \quad -① \qquad t_2 = nt_1 = \sqrt{\frac{2s}{g(\sin\theta - \mu_k\cos\theta)}} \quad -②$$

① ÷ ②

$$\left[\frac{t_1}{nt_1}\right]^2 = \frac{\sin\theta - \mu_k\cos\theta}{\sin\theta}$$

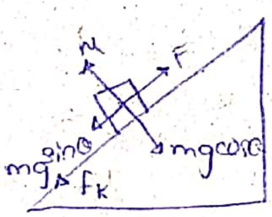
$$\frac{1}{n^2} = 1 - \mu_k\frac{\cos\theta}{\sin\theta}$$

$$\boxed{\mu_k = \left(1 - \frac{1}{n^2}\right) \times \tan\theta}$$

$$\boxed{\mu_k = 1 - \frac{1}{n^2}} \qquad \text{if } ~~\tan\theta~~ \theta = 45°$$

2. Upward

Max. force required to move up the body uniformly



$$F = mg\sin\theta + \mu_k mg\cos\theta$$

$$\boxed{F = mg(\sin\theta + \mu_k\cos\theta)}$$

If $F > mg\sin\theta + \mu_k$

then body moves with accl^n

→ When body moved up & released $[F=0]$

Net force

$$0 - mg\sin\theta + \mu_k = ma$$

$$\boxed{a = -g(\sin\theta + \mu_k\cos\theta}$$

On smooth surface , $\mu_k = 0$

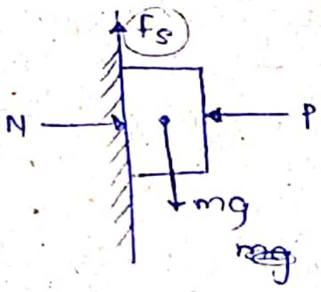
$\boxed{a = -g\sin\theta}$

$a = 0$ if $\theta = 0°$

$a = -g$ if $\theta = 90°$

When a block is pressed against a wall

1. At eq.bm.



$f_s = mg$

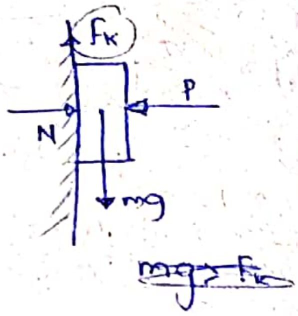
$\mu_s N = mg$

$\mu_s P = mg$ [N=P]

$\boxed{g = \frac{\mu_s P}{m}}$

$\boxed{P = \frac{mg}{\mu_s}}$

2. When slides down



$mg - f_k = ma$

$\boxed{a = \frac{mg - \mu_k P}{m}}$

A block is sliding on an inclined smooth surface of 30° accln is ______

$a = g\sin\theta$

$= 9.8 \times \sin 30$

$= 4.9$

A block is started from rest on a smooth inclined plane it travels 12.25m in 3rd sec , the angle of inclination is______

$S_n = u + a(n - \frac{1}{2})$

$a = g\sin\theta$

$\rightarrow t = \sqrt{\frac{2s}{g(\sin\theta - \mu_k \cos\theta)}}$ $\rightarrow t = \sqrt{\frac{2s}{g\sin\theta}}$ on smooth surface, $\mu_k = 0$

$12.25 = 9.8\sin\theta\left(3 - \frac{1}{2}\right)$

$\cancel{12.25} \times \cancel{5}$, $\cancel{9.8}$, 4.9

$12.25 = 4.9 \times 5\sin\theta$

$12.25 = 24.5\sin\theta$

$\sin\theta = 1/2$

$\theta = 30°$

A block is started from an inclined smooth surface, it takes 4 seconds to reach the ground, the time taken to cover 1st 1/4 dist. is ______

$\cancel{t = \sqrt{\frac{2s}{g\sin\theta}}}$

$S = \cancel{ut} + \cancel{\frac{1}{2}a}t^2$

$S \propto t^2$

$\frac{S_1}{S_1/4} = \frac{t_1^2}{t_2^2}$

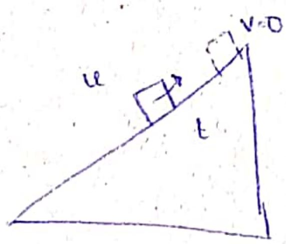
$t_2 = \sqrt{4^2/4}$

$t_2 = 2$ seconds

A block is pushed up an ~~inclinete~~ inclined smooth surface of 30° with a velocity of 20m/s, it time of ascent is ______

$v = u + at$

$v = u - g\sin\theta t$ $[a = -g\sin\theta]$



$t = \frac{v - u}{-g\sin\theta}$

$t = \frac{u}{g\sin\theta}$

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A block is sliding down uniformly on an inclined surface of 30 the angle is made 60 then the accl? is

$\cancel{\tan}\ \alpha = 30^\circ$ $\theta = 60^\circ$

$\tan 30^\circ = \mu_k$

$\frac{1}{\sqrt{3}} = \mu_k$

$\Rightarrow a = g(\sin\theta - \mu_k \cos\theta)$

$= 9.8\left(\frac{\sqrt{3}}{2} - \frac{1}{\sqrt{3}} \times \frac{1}{2}\right]$

$\frac{9.8}{2}\left[\frac{\sqrt{3}}{2} - \frac{\sqrt{3}}{2\times 3}\right]$

$4.9\left(\sqrt{3} - \frac{\sqrt{3}}{3}\right)$

$4.9 \times \frac{2\sqrt{3}}{3}$

$= \frac{9.8\ \sqrt{3}\times\sqrt{3}}{3\sqrt{3}}$

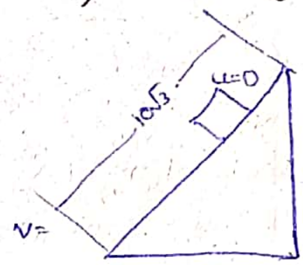
$= \frac{9.8}{\sqrt{3}}\ m/s^2$

In the above promblem, the length of inclination is $10\sqrt{3}$ m the block is started from rest, its velocity at the ground is

$V = \sqrt{2\times\frac{9.8}{\sqrt{3}}\times 10\sqrt{3}}$

$= \sqrt{196}$

$= 14\ m/s$

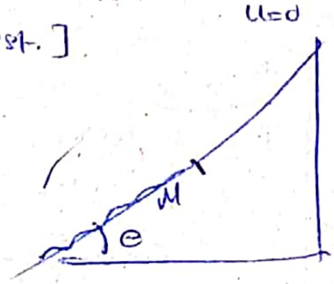


A body is started from rest on an inclined surface of an angle θ. the lower half is rough, the body reaches the ground and stops, then μ_k = ——

$V^2 - u^2 = 2as$ [for first half dist.]

u=0

$V^2 = 2g\sin\theta \times S$



For second half dist.

$V^2 = u^2$

$V^2 - u^2 = 2as$

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$v = 0$

$-u^2 = 2as$

$-\cancel{2}\cancel{g}\sin\theta\cancel{s} = \cancel{2}\cancel{g}(\sin\theta - \mu_k\cos\theta) \times \cancel{s}$

$-\sin\theta = \sin\theta - \mu_k\cos\theta$

$\mu_k \cancel{\cos\theta} = \dfrac{\sin\theta + \sin\theta}{\cos\theta}$

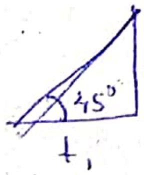
$= \dfrac{2\sin\theta}{\cos\theta}$

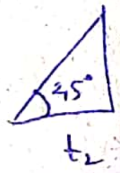
$\mu_k = 2\tan\theta$

A body ~~gains~~ takes double the time to slide down on an inclined rough surface of $45°$, then on smooth surface of same angle, then μ_k is ______

$t_1 = t_2$

$t_1 = 2t_1$





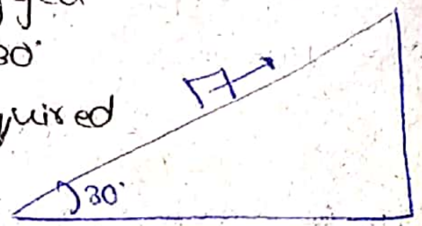
$\mu_k = \tan\theta\left(1 - \dfrac{1}{n^2}\right)$

$\tan\theta\left(1 - \dfrac{1}{4}\right)$

$= \dfrac{3}{4}\tan\theta$

$\mu_k = \dfrac{3}{4} = 0.75$

A block of mass 10kg is dragged up on an incline surface of $30°$ & $\mu_k = \dfrac{1}{\sqrt{3}}$, the min. force is required



~~$f_s =$~~

~~$F = mg\sin\theta + f_s$~~

~~$+ mg\sin$~~ $\mu_k\cos\theta$

$=$ ~~mg~~

$F = mg\sin\theta + f_s$

$= mg\sin\theta + \mu_k \underline{mg\cos\theta}$ N

$= mg(\sin\theta + \mu_k\cos 3\theta)$

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$10 \times 9.8 \times \left[\frac{1}{2} + \frac{1}{\sqrt{3}} \times \frac{\sqrt{3}}{2}\right]$

$F = 98\,N$

n the above promblem the force required to move up the body with an accl^n of $2m/s^2$ is ______

nat $F = mg[\sin\theta + \mu_k \cos\theta]$

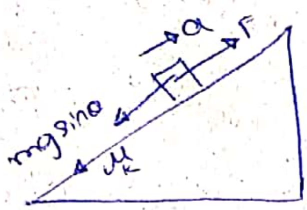
$F = mg(\sin\theta) + mg\mu_k\cos\theta + ma$

$= m[g(\sin\theta + \mu_k\cos\theta) + a]$

$= \cancel{\frac{98}{20} + (10\times2)}$ $98 + 20$

$\boxed{\cancel{F = 118N} \quad F = 78N}$

$118N$

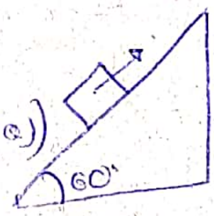


The force required to move up a body on an inclined surface of 60° is double to the force required prevent the body from sliding down then μ_k –

$F = 2F$

upward = static

$\cancel{mg}(\sin\theta + \mu_k\cos\theta) = 2(-\cancel{mg}(\sin\theta + \mu_k\cos\theta))$



$\frac{\sqrt{3}}{2} + \mu_k \frac{1}{2} = -2 \times \left[\frac{\sqrt{3}}{2} + \mu_k \frac{1}{2}\right]$

$\frac{\sqrt{3}}{2} + \mu_k \frac{1}{2} - \frac{\cancel{2}\sqrt{3}}{\cancel{2}} + \mu_k = 0$

$\frac{\mu_k}{2} + \mu_k = \sqrt{3} - \frac{\sqrt{3}}{2}$

$\frac{3\mu_k}{\cancel{2}} = \frac{\sqrt{3}}{\cancel{2}}$

$\therefore \mu_k = \frac{1}{\sqrt{3}}$

he time of descent on inclined surface of 60° is double to the time of ascent, then $\mu_k = ?$

$t_d = 2t_a$

$\cancel{t_d = \frac{2s}{g}}$

$t_d = 2t_a$

$\sqrt{\frac{2s}{g(\sin\theta - \mu_k\cos\theta)}} = 2\sqrt{\frac{2s}{g(\sin\theta + \mu_k\cos\theta)}}$

$$\frac{1}{4} \times \frac{\cancel{2s}}{\cancel{g}(\sin\theta - \mu_k\cos\theta)} \times \frac{1}{\cancel{2}} \times \frac{\cancel{g}(\sin\theta + \mu_k\cos\theta)}{\cancel{2s}} = 0$$

$$\frac{\sin\theta + \mu_k\cos\theta}{\sin\theta - \mu_k\cos\theta} = 0$$

$$\boxed{\mu_k = -\tan\theta}$$

$$s = \cancel{ut} - \frac{1}{2}at^2$$

$$= -\frac{1}{2}(g\sin\theta - \mu_k\cos\theta)$$

$$s = \frac{1}{2}(g\sin\theta + \mu_k\cos\theta)t$$

$$t = \sqrt{\frac{2s}{g(\sin\theta + \mu_k\cos\theta)}}$$

$$\sin\theta + \mu_k\cos\theta = 4(\sin\theta - \mu_k\cos\theta)$$

$$\mu_k = \frac{3\sin\theta}{5\cos\theta}$$

$$= \frac{3}{5}\tan\theta$$

$$= \frac{3}{5} \cdot \frac{\sqrt{3}}{3} \times \frac{\sqrt{3}}{\sqrt{3}}$$

$$= \frac{3\sqrt{3}}{5}$$

A block of 2kg is pressed against a wall of $\mu_s = 0.5$ the min force required for eq^{bm}. and static friction

1. $f_s = mg$

$= 2 \times 9.8$

$= (1.96 \times 10)$ N

$= 19.6$ N

2. $P = ?$

$P = mg/\mu_s$

$= 19.6/0.5$

$= 39.2$

$P = 39.2$ N

Work, Power & Energy

Force is a physical quantity which can changes (or) try to change the state of body.

Force units

Inertia units (F=ma)

Inertia units (F=ma)	Gravitational units (W=mg)
CGS – gm.cm/s² – dynes	grav. wt = 980 dynes
MKS – kg. m/s² – newtons	kg wt – 9.8 N
FPS – lb. ft/s² – Poundals	lb wt = 32 poundal

Libra = pound

$1N = 10^5$ dynes

1 poundal = 13,800 dynes

Newtons law of Motion:

1st law: Every body continues in state of rest (or) uniform motion in a straight line unless a external force applied on it.

- Every body ~~continues~~ continues in a ~~state~~ same state due to inertia.
- Inertia is the property of body which opposes the change in the state.

Inertia are three types

Inertia of rest — Inertia of motion — Inertia of direct

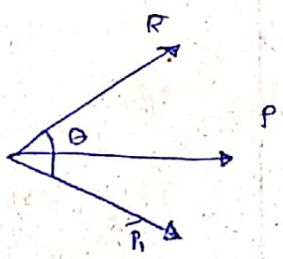
- Mass is the measurement of inertia.
- Newton's first law also called as law of inertia

Momentum: The product of mass and ~~vel~~ velocity ~~projection~~ is called momentum.

units = kg m/s

$\bar{P} = m\bar{v}$

$\bar{P}$ is a vector



$$P = \sqrt{P^2 + P^2 + 2P_1P_2\cos\theta}$$

change in motion

~~Δ ...~~

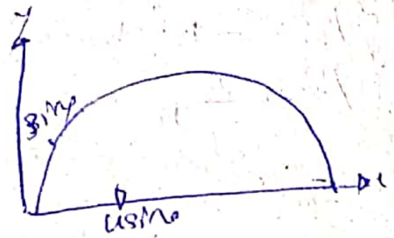
$$\Delta\bar{p} = \bar{p} = \bar{P_2} - \bar{P_1}$$

~~$dp = P_1 + P_2 + \cos\theta$~~

$$dp = \sqrt{P_1^2 + P_2^2 + 2P_1\theta\cos\theta}$$

If $\theta = 0^\circ$

$\vec{P_1} - \vec{P_2}$



$\Delta p = dp = P_2 - P_1$

if $\theta = 180^\circ$

$\Delta p = P_2 + P_1$

~~$\Delta p = 2musin$~~

$\Delta p = 2mu\sin\theta$

Seconlaw:

$\xrightarrow{F} \bigcirc \longrightarrow$ $\bar{P_1} = mu$

$\bigcirc \rightarrow P_2 = mv$

$F \propto \frac{\bar{P_2} - \bar{P_1}}{t}$

$F \propto \frac{dp}{dt}$

$F = k\frac{dp}{dt}$

$\boxed{k = 1}$

$F = dp/dt$

but $p = mv$

$F = \frac{d}{dt}(mv)$

$= \frac{dmv}{dt} + m\frac{dv}{dt}$

~~If m in cos~~ $h = 4$

① If m is const. ($dm = 0$) $\cos \sqrt{\frac{3}{4}}$

$F = m\frac{dv}{dt}$ $\frac{\sqrt{3}}{2}$

but $\frac{dv}{dt} = a$

$$\boxed{F = ma}$$

② If V is const. ($dv = 0$)

$F = \frac{dm}{dt} v$

Second law: The rate of change in momentum is $\propto$ applied force & also follows the direction of the future.

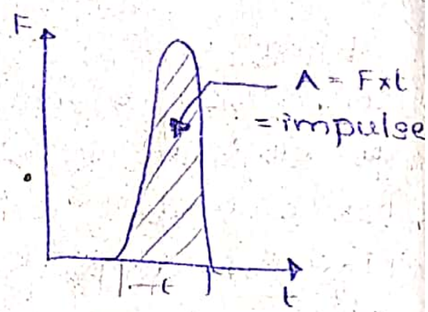
Impulse: When a large amount of force in very short interval of time, The change in momentum is called impulse

$F = \frac{dp}{dt}$

$F = \frac{mv - mu}{t}$

$I = F \times t$
$= mv - mu$

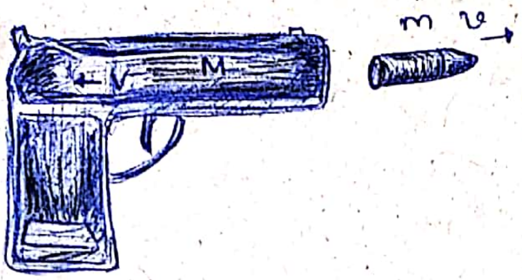
units ; N.s (or) kgm/s



Third law: For reactⁿ there is opp. & eq reactⁿ.
Rocket & Jet engines works on third law of motion (or) law of $\underbrace{\text{conservation}}_{\text{const.}}$ of linea momentum

law of momentum
Unless the ext. force applied on the sys. the total momentum of the sys. remains const.

Recoil of gun:



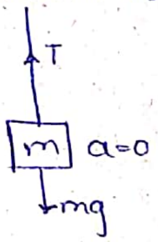
$$\underbrace{m_1u_1 + M_1V_1}_{\text{initial}} = \underbrace{m_2u_2 + M_2V_2}_{\text{final}}$$

$$0 = m_2u_2 + M_2V_2$$

$$\boxed{V_2 = \frac{-m_2u_2}{M}}$$

Tension Concepts:

Rest or uniform velocity

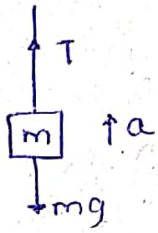


Net force

$T - mg = \cancel{ma}^{\,0}$

$\boxed{T = mg}$

Upwards



Net force

$T - mg = ma$

$\boxed{T = mg + ma}$

Downwards

Net force

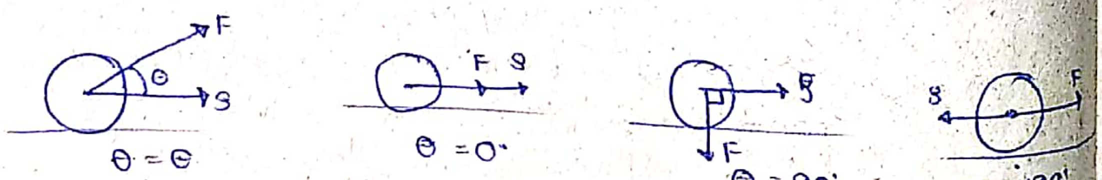
$mg - T = ma$

$\boxed{T = mg - ma}$

Work:

When a force is applied on a body to move through a certain ~~displ~~ disp. ~~through~~ in a direction of force, the work is said to be done.

- Work is dot product of force & disp.
- " " a scalar



$\theta = \theta$ — $\boxed{W = FS\cos\theta}$

$\theta = 0°$ — $\boxed{W = F.S}$

$\theta = 90°$ — $\boxed{W = 0}$

$\theta = 180°$ — $\boxed{W = -FS}$

when $\left.\begin{array}{l} F = 0 \\ S = 0 \\ \theta = 90° \end{array}\right\} \rightarrow W.D = 0$

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units $W = F.S$

CGS	MKS	FPS
1. dyne	newton	Poundal ft
2. erg	Joule	ft-poundal

$1 \text{ Joule} = 10^7 \text{ erg}$

$1 \text{ ft poundal} = 4.2 \times 10^5 \text{ erg}$

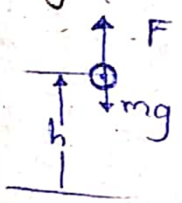
When a man is carrying a load on his head and moves on a level road, then W.D by the gravitational force is '0'.

When an electron is rotating around a nucleus, then the W.D by the electrostatic force is '0'.

When a pendulum is oscillating, then the workdone by tension is zero.

Types of work

Work done by lifting a body

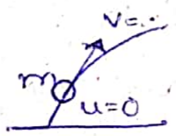


$W = FS$

$\boxed{W = mgh}$

W.D by gravity

$\boxed{WD = -mgh}$

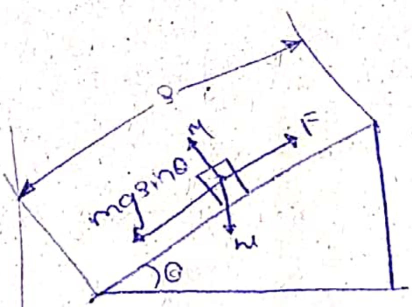


$W = FS$

$= ma\,S$

$= m\left(\frac{v^2 - 0}{2S}\right) \times S$

$\boxed{W = \frac{1}{2} m v^2}$



$W = FS$

$\boxed{W = mg\sin\theta . S}$

→ if f_s adds

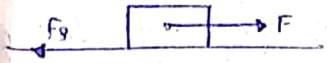
$\boxed{W = mg(\sin\theta + \mu_k \cos\theta) \times S}$

Work done on a moving body

$$W.D = F.S$$
$$= maS$$
$$= m\left(\frac{v^2 - u^2}{2S}\right)S$$
$$= \frac{mv^2}{2} - \frac{mu^2}{2}$$

W.D = change in K.E

W.D against friction



$W = FS$

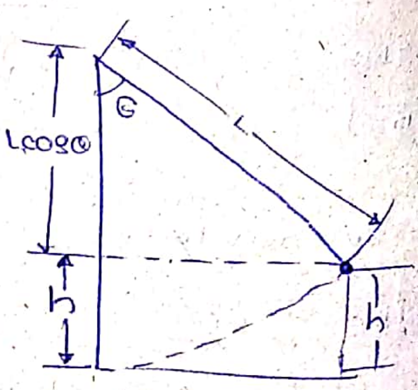
~~but~~ W.D = FS

but $F = f_s = \mu_s mg$

$f_k = \mu_k mg$

$$\boxed{W.D = \mu_k mgS}$$

W.D to pull a pendulum aside



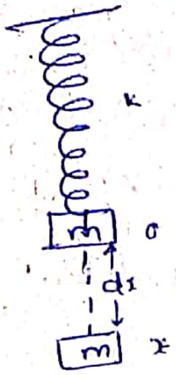
$W = mgh$

but $h = L - L\cos\theta$

$W = mgl(1 - \cos\theta)$

W.D to compress (or) to stretch a spring

Force const. of the spring



$$k = \frac{F}{x}$$

$$F = kx$$

$$S = dx$$

$$\boxed{W = \int F S}$$

$$= \int_0^x kx \, dx$$

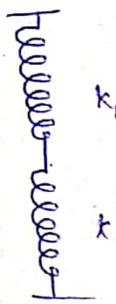
$$= k\left[\frac{x^2}{2}\right]$$

$$\boxed{W = \frac{1}{2}kx^2}$$

$$\rightarrow \quad W = \int_{x_1}^{x_2} kx\,dx$$

$$= \frac{1}{2}k\left[\frac{x_2^2 - x_1^2}{2}\right].$$

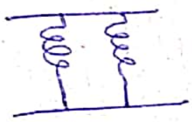
Spring in series



$$\frac{1}{k} = \frac{1}{k_1} + \frac{1}{k_2}$$

$$k = \frac{k_1 \times k_2}{k_1 + k_2}$$

Parallel series



$$k = k_1 + k_2$$

Spring in cut into parts

$$k_a = \frac{k(a+b)}{a}$$

$$k_b = \frac{k(a+b)}{b}$$

For two eq. parts

$$k' = 2k$$

For n eq. part

$$\boxed{k' = nk}$$

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Series

$K \propto \frac{1}{l}$

$\rightarrow l \propto \frac{1}{K}$

$l = l_1 + l_2$

$\rightarrow \frac{1}{K} = \frac{1}{K_1} + \frac{1}{K_2}$

Parallel

$K \propto \frac{1}{l} \Rightarrow Kl = const.$

$Kl = k_1 l = k_2 l$

$\rightarrow K = K_1 + K_2$

Cut into parts

$Kl = const.$

$K(a+b) = K_a a = K_b b$

$K_a = \frac{K(a+b)}{a}$

$K_b = \frac{K(a+b)}{b}$

Power: The rate of work done is called power and it is a scalar.

Units $P = W/t$

CGS	MKS	FPS	
erg/s	Joules/s (watt)	ft-panda	HP

1 watt = 10^7 joules/s

1 H.P = 736 watts (metric)

746 watts

= 550 × 32 ft pandal/s

1 metric Hp = 735.5 watts

→ Power of a m/c gun:

$$\boxed{P = \frac{W}{t} = \frac{1}{2} n . mv^2 / t}$$

n = no. of bullets fired

m = mass of "

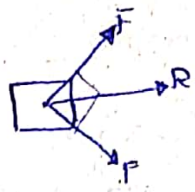
efficiency $\boxed{\eta = \frac{P_c}{P_r}}$

A force F is applied on a body, it moves with a accl^n 'a'. Two forces of F each acts in ⊥^{le}, then accl^n of a body is

$F = ma$

$R = \sqrt{F_1^2 + F_2^2}$

$= \sqrt{2} F$



$F \alpha a$

$\frac{F_1}{F_2} = \frac{a_1}{a_2}$

$\frac{\cancel{F}}{\sqrt{2}\cancel{F}} = \frac{a}{a_2}$

$a_2 = \sqrt{2} a$

A body of mass 'm' kilogram is acted by a force, it moves through a disp. x ; $t = \sqrt{x} - 3$ the force applied in ~~2se~~ 2second is ______ W.D ______

$t = \sqrt{x} - 3$

$\sqrt{x} = t + 3$

$x = t^2 + 9 + 6t$

velocity. $\frac{dx}{dt} = 2t + 6$ m/s

accl^n. $\frac{dv}{dt} = 2$ m/s^2

$F = m.a$

$= 1.2$

$= 2N$

W.D = F. S

$= 2N \times (4 + 9 + 12)$

$= 50$Nm

$= 50$J

$W.D = \frac{1}{2} m v^2$

$= \frac{1}{2} \times 1 \times (4+6)^2$

$= \frac{100}{2} = 50$J

2. Second law: The rate of change in momentum ∝ applied force

Momentum of a particle is
$P = t^2 + 2t + 5 \, (kg\,m/s)$

$F = \frac{dp}{dt}$

$= 2t + 2 \qquad (t=2)$

$F = 2\times2 + 2$

$= 6N$

Mass of rocket is 5000kg is fixed vertically, the mass of the fuel to be burned per second to overcome the gravitational force to move with a velocity of 1000m/s²

$F = \frac{dP}{dt}$

$= \frac{d}{dt}(mv)$

$= \frac{dm}{dt}v + m\cancel{\frac{dv}{dt}}^{0}$

$F = Mg$

$Mg = \frac{dm}{dt}v$

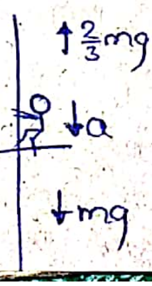
$5000\times9.8 = \frac{dm}{dt}\times1000$

$\frac{dm}{dt} = 49 m/s$

A man is slidding down along a rope whose breaking strength is $\frac{2}{3}$ of its weight. The min. accl^n of man to slide down safely is ____

Net force

$mg - \frac{2}{3}mg = ma$



$\frac{\cancel{m}g}{3} = \cancel{m}a$

$\boxed{a = \frac{1}{3}g}$

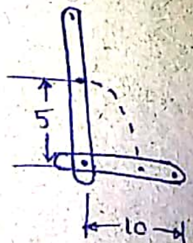
An uniform rod of mass 8kg and length 10m is lying on the ground, the W.D to make it vertical

$W.D = mgh$

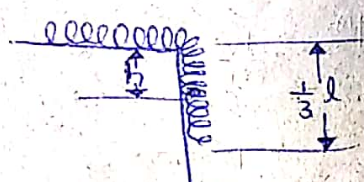
$= 8kg\times9.8\times5$

$= ~~40~~\ 9.8\times40$

$= 392 J$



An uniform change of mass 'm' length 'l' is placed on a table with $\frac{1}{3}$ length hanging over the edge, the W.D to pull the hanging part to back on to the table is ____



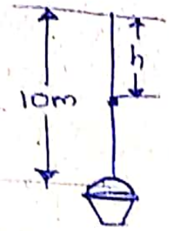
$W = mgh$

~~= 8×9.8×~~

$= \frac{m}{3}\times9.8\times\frac{l}{6}$

$W = \frac{mgl}{18}$

A water bucket has mass 2kg tighted to a rope ~~area~~ of 1kg and length 10m is lifted, then the W.D to be lifted the bucket with load



$W = W_1 + W_2$

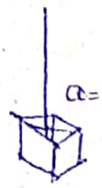
$= m_1gh_1 + m_2gh_2$

$= 2\times9.8\times10 + 1\times9.8\times5$

$= 196+49$

$W = 245\,J$

A block of mass 10kg is lifted from rest with an accl^n of $1.2\,m/s^2$, the W.D in 1st sec is ______



$S = \frac{1}{2}at^2$

$F = mg + ma$

$= m(g+a)$

$W.D = m(g+a)\cdot\frac{1}{2}at^2$

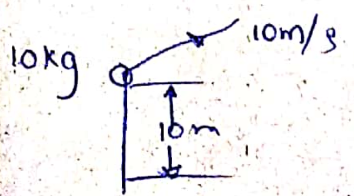
$= 10(9.8+1.2) + \frac{1}{2}1.2\times\frac{2}{4}$

$= 10\times11 + 2.4$

$= \cancel{114.4\,J}$

$= 264\,J$

A body of mass 10kg is lifted through 10m and projected with 10m/s the W.D is ______



$W.D = mgh + \frac{1}{2}mv^2$

$= m(9.8\times10) + \frac{1}{2}\cancel{100}\,50$

$= 10(98+50)$

$= 148\times10$

$= 1480\,J$

A force acts on a body at an angle of 60° with horizontal, the W.D is 500J to move the body through 10m

$\frac{500}{10}$

co. 50

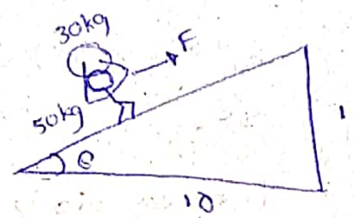
$W = FS\cos\theta$

$500 = F\times10\times\cos60°$

$500 = F\times5$

$F = 100\,N$

A man of mass 50kg carry a load of 30kg on his head and moves up on an incline surface raising 1 in 10, the W.D to move 10m is ______



$\sin\theta = \frac{1}{10}$

$W = F\times S$

$= mg\sin\theta\, S$

$= 80\times9.8\times\frac{1}{\cancel{10}}\times\cancel{10}$

$= \cancel{980}$

$= 784\,J$

9.8

80   80×0.2

4

80×10

800

16

784

A block of mass 10kg is dragged on a horizontal surface of $\mu_k = 0.2$ with a velocity of 2m/s the workdone in 5sec

~~W = F×S~~

$F = \mu_k N$ | $S = v \times t$

$= \mu_k mg$ | $= 2 \times 5$

$= 10$

$= 0.2 \times 10 \times 9.8$

$= 98 \times 0.2$

$= 19.6N$

$W.D = \bar{F}.\bar{S}$

$= 19.6 \times 10$

$= 196$

A body of mass 2kg is moving with 4m/s, it velocity is doubled by applying a force, the W.D by force is ____

$m = 2kg$; $u = 4m/s$; $W = ?$

$v = 8m/s$

$\Delta K.E = W.D = \frac{1}{2}m(v^2 - u^2)$

$= \frac{1}{\cancel{2}} \times \cancel{2}(64 - 16)$

$= 48J$

A pendulum of mass 2kg and length 2m is pulled aside through and angle of 60°

W.D -

$= mgl(1 - \cos\theta)$

$W.D = 2 \times 9.8 \times \cancel{2}\left(1 - \frac{1}{\cancel{2}}\right)$

$W.D = 19.6 J$

A spring of $k = 400N/m$ is stretched through 20cm (0.2)m the W.D is ____

" " to strecth another 20cm is ____

$W = \frac{1}{2}kx^2$

$= \frac{1}{\cancel{2}} \times 400 \times 0.0\cancel{4}^2$

$= 8Nm$

~~200~~

W.D

$x_1 = 20cm$

$x_2 = 20 + 20$

$= 40cm$

$= \frac{1}{2}k(x_2^2 - x_1^2)$

$= \frac{1}{2} \times 400\left(\frac{16}{\cancel{10^2}} - \frac{4}{\cancel{10^2}}\right)$

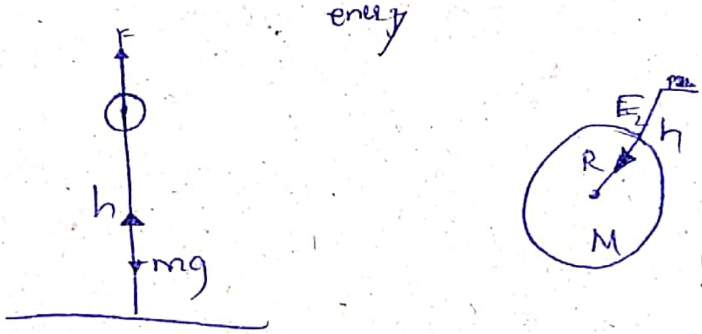
$= 2\cancel{00} \times 12$

$= 24\cancel{00} J$

$\boxed{W_2 = 3W_1}$ for extra same disp.

→ Potential energy:

Potential energy : The energy possed by a body by virtue of position is called potential energy



$$\boxed{GP = \frac{-GMm}{R}}$$

P = mgh

Flying object possesses both P.E & K.E.

$$E_1 = \frac{-GMm}{R} \qquad E_2 = \frac{-GMm}{R+h}$$

$$\Delta E = E_2 - E_1$$

$$= \frac{-GMm + GMm}{R+h + R}$$

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

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

$$\Delta E = mgR\left(\frac{1}{r+h}\right)$$

$$\Delta E = mgR\left(\frac{1}{1+r/h}\right)$$

$$\Delta E = \frac{mgh}{1+\frac{r}{h}}$$

If $h = r$

$\Delta E = \frac{1}{2} MGR$

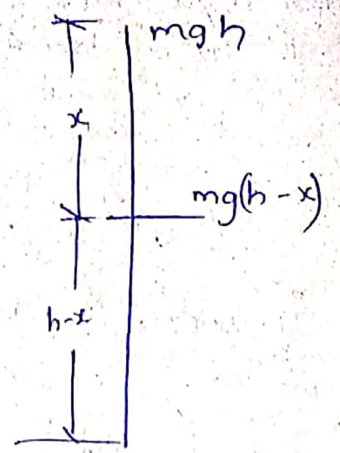
G = Gravitational const.

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

M = mass of the earth

R = Radius of the earth

R = 6400 km



→ For a freely falling body, the loss P.E converts into K.E

$$K.E = mgh - mg(h-x)$$

$$= mgx$$

- When two protons brought closer, the P.E of the sys. ↑ (Work is done on the sys.)
- When a proton and the electron brough closer, then P.E of the sys. ↓ (work is done by the sys.)

→ Sources of energy

1. Source of energy which cannot be renewed, is called conventional source of energy Ex:- Wood (Rahul), coal petroleum etc
2. Source of energy which can " " " " nonconventional " " " Ex: solar, hydra, wind energy etc.

- Solar energy will be produced by the sun due to nuclear fusion reactⁿ.
- Fusion reaction requires high temperatures to overcome the coloumb ~~reverBible~~ repellisble forces.

Positrat

$$4H^1 = {}_2He^4 + 2e^+ + 26.7\ He$$

helium

• In hydrogen bomb, the nuclear fusion is the main react
• In atom bomb, nuclear fission is the main reactⁿ.
• " " " uncontrolled chain reactⁿ takes place

$$U^{235}_{92} + n^1_0 \rightarrow Kr^{92}_{36} + Ba^{144}_{36} + 3n^1_0 + 200 \text{ MeV}$$

In power reactor, the controlled chain reactⁿ takes place.

→ A body of mass 2kg is moving with a velocity of $v = \bar{v}$; $3i + 4j$ m/s, then K.E =

$\bar{v} = 3i + 4j$

$v = 5$

$v^2 = 25$

$K.E = \frac{1}{2} \times 2 \times 25$

$= 25 J$

→ The K.E of a body is 2J, its mass & velocity are double the K.E

$2J = \frac{1}{2} \times m \times v^2$

$K.E = \frac{1}{2} \times 2m \times 4v^2$

$= 4mv^2$

$\frac{2}{E} = \frac{mv^2}{2m \times 4v^2}$

$E = 16 J$

→ The K.E of a body is double to K.E of a man whose mass is double to mass of body. The ratio of velocity of man & body

~~$K.E_2 = 2K.E_1$~~

$K.E = \frac{1}{2} mv^2$

$\frac{E_1}{m_1} = \frac{E_2}{m_2}$

$\frac{2E}{m_1} = \frac{E_2}{2m}$

$\frac{V_1}{V_2} = \sqrt{\frac{4}{1}}$

$= 2:1$

$V_2 : V_1 = 1:2$

(Upper) A river is flowing with a velocity of 2m/s, the K.E of water of $1m^3$ is ______

$\rho = \frac{m}{v}$; $m = \rho \times v$

$= 1000 \times 1$

$= 10^3$ kg

$K.E = \frac{1}{2} m v^2$

$= \frac{1}{2} \times 10^3 \times \cancel{2^2}$

$= 2 \times 10^3$ J

→ Two metal spheres of same metals and radii 1:2 are moving with velocities of 2:1 The ratio of K.E

$K.E_1 : K.E_2$

$\frac{1}{2} m v^2 : \frac{1}{2} m v^2$

$\cancel{\frac{1}{2}} \times \cancel{\frac{4}{3}} \cancel{\pi} r^3 \times \cancel{\rho} \times v^2 : \cancel{\frac{1}{2}} \cancel{\frac{4}{3}} \cancel{\pi} r^3 \times \cancel{\rho} \times v^2$

$r^3 . v^2 : r^3 . v^2$

$1^3 . 2^2 : (2)^3 . 1^2$

$4 : 8$

$1 : 2$

→ A shell of mass 5kg which is at rest explodes into two parts in which 1 part of 3kg moves with 20 m/s

Law of momentum

$\underbrace{m_1 u_1 + m_2 u_2}_{} = m_1 V_1 + m_2 V_2$

$u = 0$ $= 3 \times 20 + 2V$

$-60 = 2V$

$V_2 = -30$ m/s

$K.E = \frac{1}{2} m v^2$

$= \frac{1}{\cancel{2}} \times \cancel{2} \times 900$

$= 900$ J

K.E $\propto \frac{1}{m}$

$\frac{E_1}{E_2} = \frac{m_2}{m_1}$

$\frac{\cancel{1/2} \times 3 \times \cancel{20}^{10} \times \cancel{20}^{10}}{E_2} = \frac{\cancel{2}}{3}$

$E_2 = 900$ J

Scanned by CamScanner

→ A projected up with a K.E then at heigh 'h' the K.E & P.E are eq., the hmax

$h = \frac{\cancel{v^2}}{2g}$

$P.E = K.E$

$\cancel{m}gh = \frac{1}{2}\cancel{m}v^2$

$v^2 = 2gh$

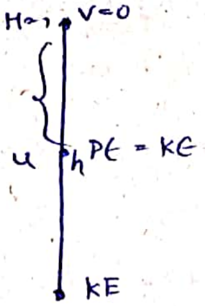
$2as = v^2 - u^2$

$\cancel{2g}s = \cancel{2g}h$

$S = h$

$\Rightarrow H = h + h$

$= 2h$



→ A stone is projected which reaches hmax of 100m, the height at which the K.E becomes $\frac{3}{4}$ of initial value is ______

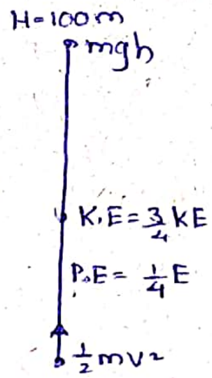
$K.E = \frac{3}{4} K.E$

$P.E = \frac{1}{4} E$

$\cancel{mg}h = \frac{1}{4} \times \cancel{mg}H$

$h = \frac{1}{4} \times 100$

$= 25m$



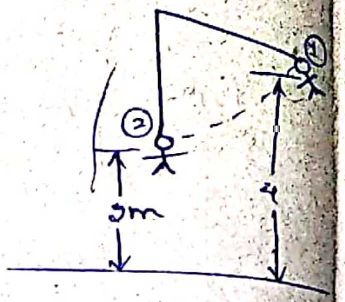
→ A ball is dropped from a height of 20m it rebounces to height of 15m, the % of loss of energy is ______

% of loss of energy

$= \frac{\cancel{mg}h_1 - \cancel{mg}h_2}{\cancel{mg}h_1} \times 100$

$= \frac{20-15}{20} \times 100 = 25\%$

→ A boy in a swing has Hmax 4m & min heigh 2m above the ground, the max. velocity the swing is ______



$\Delta KE = \Delta PE$

$\frac{1}{2}\cancel{m}v^2 = \cancel{m}gh_1 - \cancel{m}gh_2$

$\frac{v^2}{2} = 2$

$v^2 = 4 \times g \Rightarrow v = 2\ m/s\ \sqrt{9.8}$

$= 2\sqrt{9.81}$

→ A body is moving with a velocity of 1m/sec at a height of 3m, its velocity at a height of 2m is ______

$\frac{1}{2}\cancel{m}v^2 + \cancel{m}gh = \frac{1}{2}\cancel{m}v^2 + \cancel{m}gh$

$\frac{1}{2} + 9.81 \times 3 = \frac{1}{2}v^2 + 9.81 \times 2$

$\frac{1}{2}(v^2 - 1^2) = 9.81(3-2)$

$= 9.81 \times 2$

$= 19.6 + 1$

$v = \sqrt{20.6}$

→ A bullet of mass 10g moving with 100 m/s embeded into a suspened wooden block of 990g, the sys. raise to a height of ______

$$\cancel{\frac{1}{2}mv^2 = mgh}$$

$$\underbrace{m_2u_2}_{0} + m_1u_1 = M_1V_1 + M_2V_2$$

$$10 \times 100 = (M_1+M_2)V_2$$

$$V_2 = \frac{1000}{1000}$$

$$= 1$$

then $K.E = P.E$

$$\frac{1}{2}\cancel{m}v^2 = \cancel{m}gh$$

$$\frac{1}{2} \times (1)^2 = 9.81\,h$$

$$h = \frac{1}{20}$$

$$h = 0.05\,m$$

$$= 5cm$$

~~The motion of particle~~

Simple Harmonic potion (SHM)

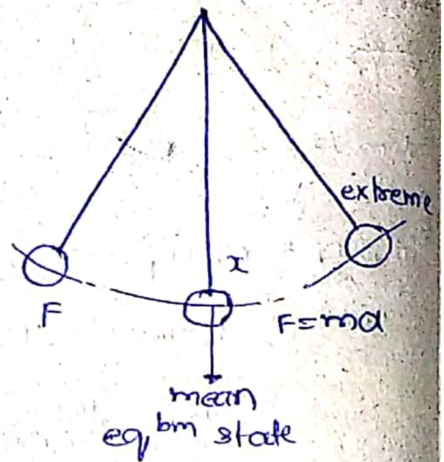
The motion of a particle in a straight line above to the mean position is called SHM

- This is a periodic motion
- In this motion accl^n $\propto$ disp. but opp. in direction

$$\rightarrow a \propto -x \qquad v = \frac{dx}{dt}$$

$$\rightarrow a = -kx \qquad a = \frac{dv}{dt}$$

$$\frac{d^2x}{dt^2} + kx = 0 \qquad a = \frac{d^2x}{dt^2}$$

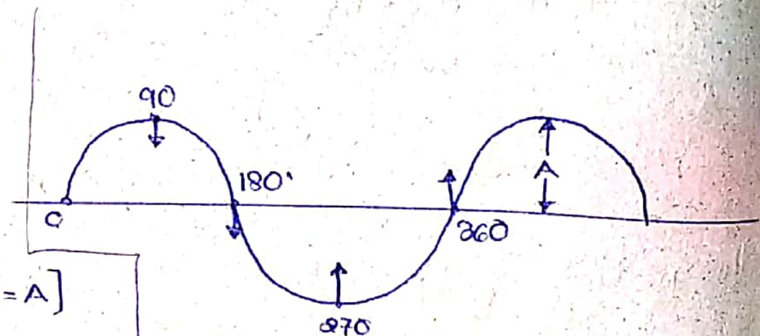


→ The force acting ona particle is alway directed towards the mean position

→ Phase: The angle subtended by the particle in SHM is called phase

- It denotes ~~the~~ angle & position & direction ~~by pov~~ of vibration of the particle.

- The initial phase is called epoch
- The disp max of a particle in S.H.M is called amplitude [R = A]



- The time for one vibration is called time period
- No. of vibrations in 1 seconds is called frequency

$$n = \frac{1}{T}$$

Amplitude (A)

Time period (T)

Frequency (n) $= \frac{1}{T}$

- The rate of phase is called angular velocity [ang. frequency]

$$\boxed{\omega = \frac{\theta}{t} = \frac{2\pi}{T} = 2\pi n}$$

Disp. of a particle in SHM

on x-axis

$\cos\theta = \frac{x}{A}$

$x = A\cos\theta$

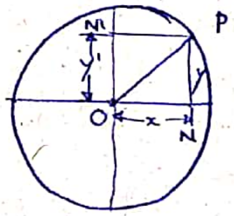
$x = A\cos\omega t$

on y-axis

$\sin\theta = \frac{y}{A}$

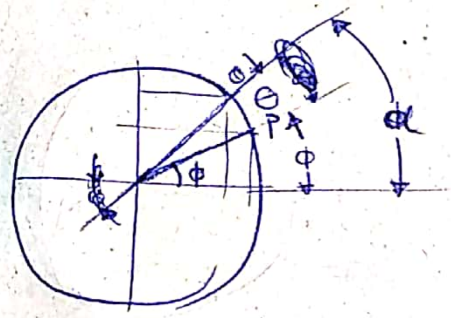
$y = A\sin\theta$

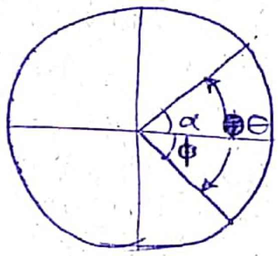
$y = A\sin\omega t$



$\boxed{\omega = \theta / t}$

$$\boxed{\begin{array}{l} x = A\cos\omega t \\ y = A\sin\omega t \end{array}}$$





$\alpha = \theta + \phi$

$\alpha = \theta - \phi$

$y = A\sin\alpha$

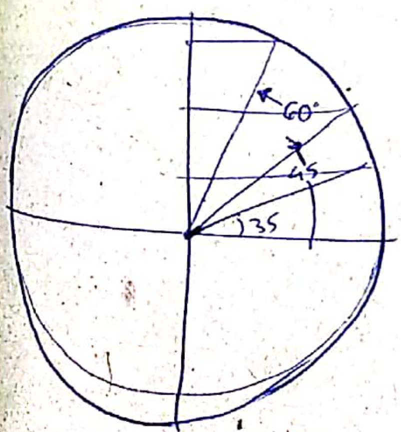
but $\alpha = \theta \pm \phi$

$y = A\sin(\theta \pm \phi)$

but $\theta = \omega t$

$y = A\sin(\omega t \pm \phi)$ —— Transverse wave

$x = A\cos(\omega t \pm \phi)$ —— longitudinal wave



$\theta = 0°$ $\quad y = A\sin\theta = 0$

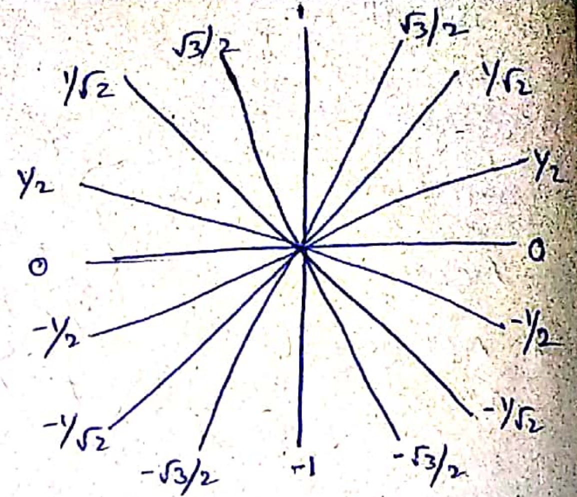
$\theta = 30° \quad = \frac{1}{2}A$

$45° \quad = \frac{1}{\sqrt{2}}A$

$60° \quad = \sqrt{3}/2\,A$

$90° \quad = A$

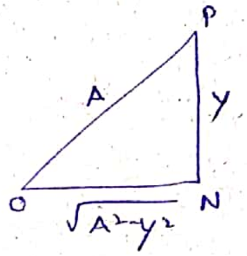
Sine values

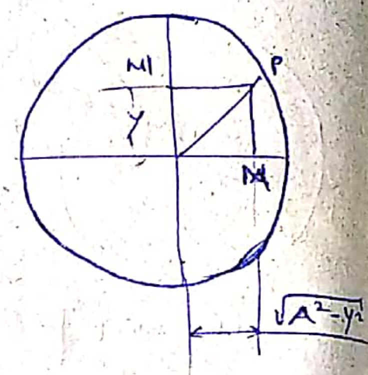


→ Velocity of a particle in SHM

Disp.

$y = A\sin\omega t$





velocity, $v = \frac{dy}{dt}$

$= \frac{d(A\sin\omega t)}{dt}$

$= \omega A\cos\omega t$

$= A\omega \underbrace{\cos\omega t}\left[\frac{\sqrt{A^2-y^2}}{A}\right]$

$v = \cancel{A}\omega \cdot \frac{\sqrt{A^2-y^2}}{\cancel{A}}$

$v = \sqrt{A^2-y^2}\cdot\omega$

$\boxed{v = \omega A}$ —— when $y=0$ — at mean position

$\boxed{v = 0}$ —— when $y = A$ — at extreme position

→ Accn of a particle in SHM

Velocity, $v = A\omega \cos\omega t$

$a = \frac{dv}{dt} = \frac{d(A\cos\omega t \cdot \omega)}{dt}$

$= -A\omega^2\sin\omega t$

$= -\omega^2 \underbrace{A\sin\omega t}$

$a = -\omega^2 y$

$\boxed{a = -\omega^2 y}$

$a = 0$ ——— $y = 0$ — at mean position

$a = -\omega^2 A$ ——— $y = A$ — at extremene "

→ Time period

$a = \omega^2 y$

$\omega^2 = a/y$

$\omega = \sqrt{a/y}$

$\omega = \frac{2\pi}{T}$

$\frac{2\pi}{T} = \sqrt{a/y}$

$T = \frac{2\pi}{\sqrt{a/y}} = \frac{2\pi\sqrt{y}}{\sqrt{a}}$

→ Force acting on a partide

$F = ma$ $\{a = -\omega^2 y\}$

$\boxed{F = -m\omega^2 y}$

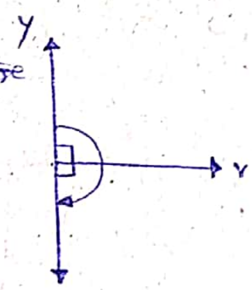
$F \propto -y$

$\frac{F_1}{F_2} = \frac{y_1}{y_2}$

→ The phase diff b/w velocity-disp. is 90° ~~dise~~

" " " " " " -accl" " "

" " " " " disp - " " 180°



$y = A\sin\omega t$

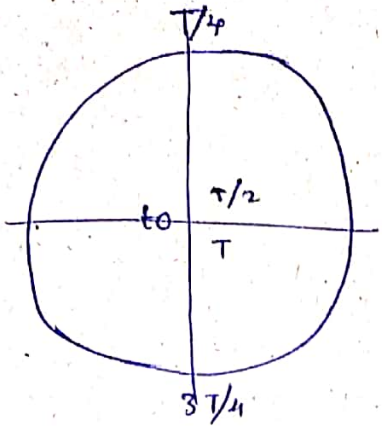
$V = A\omega\cos\omega t$

$V = A\omega\sin(90 + \omega t)$

$\delta = 90 + \omega t - \omega t$

$= 90°$

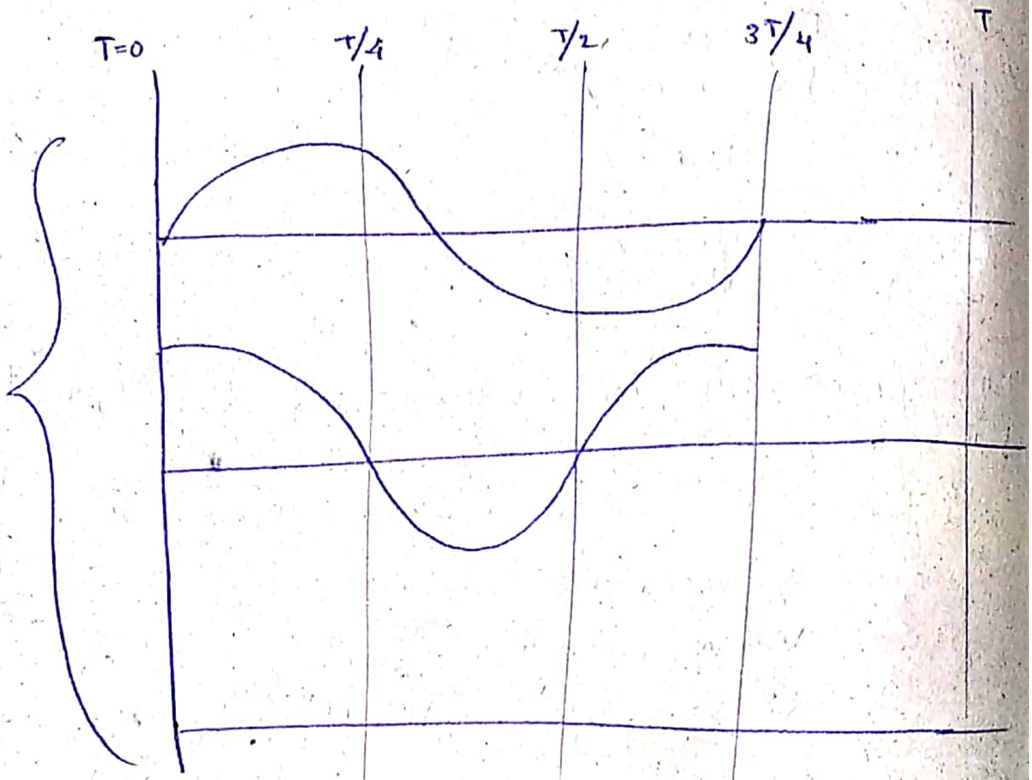
Graphical representation



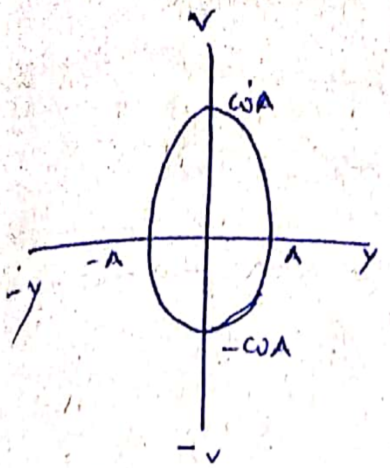
time	y	v	a	θ
0	0	ωA	0	0°
t/4	A	0	$-\omega^2 A$	90°
t/2	0	$-\omega A$	0	180°
3t/4	−A	0	$\omega^2 A$	270°
T	0	ωA	0	360°

→ Graphs

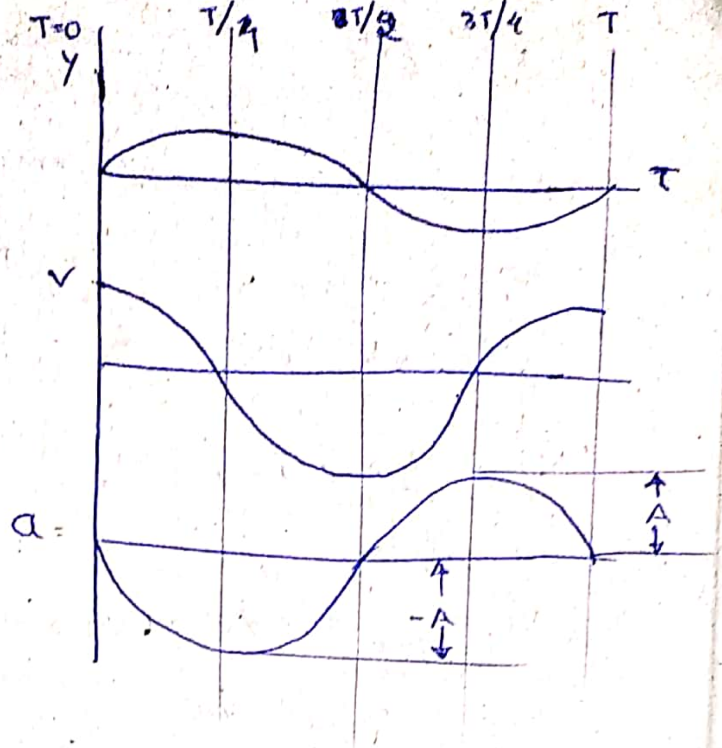
Wrong



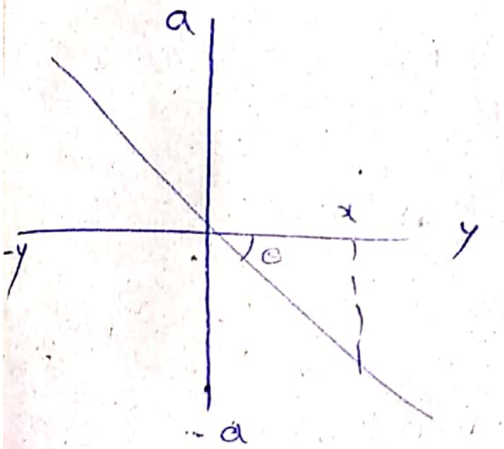
Elliptical circle



V-y graph



a-y graph



Straight line with -ve slope

→ Angle of slope

$$\tan \alpha = \frac{-a}{y} = \frac{-(-\omega^2 y)}{y}$$

$$\tan \alpha = \omega^2$$

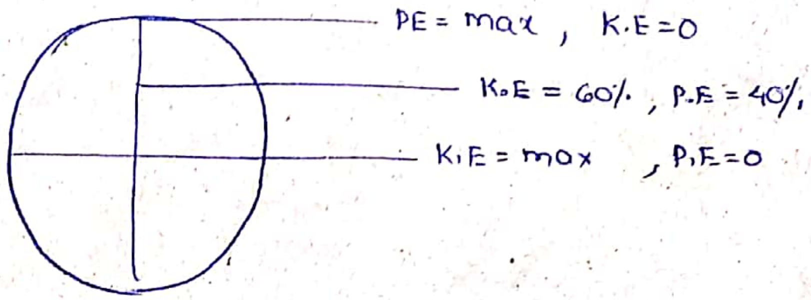
$$\omega = \sqrt{\tan \alpha}$$

$$\frac{2\pi}{T} = \sqrt{\tan \alpha}$$

$$T = \frac{2\pi}{\sqrt{\tan \alpha}}$$

$$T = 2\pi \quad [\alpha = 45^\circ]$$

→ Energy of a particle in SHM



→ K.E

→ P.E

At a displacement

$K.E = \frac{1}{2} m v^2$

$\Rightarrow v = \omega\sqrt{A^2 - y^2}$

$\boxed{K.E = \frac{1}{2} m \omega^2 (A^2 - y^2)}$

$P.E = T.E - K.E$

$= \frac{1}{2} m\omega^2 A^2 - \frac{1}{2} m\omega^2 (A^2 - y^2)$

$\boxed{P.E = \frac{1}{2} m \omega^2 y^2}$

At mean

$(y = 0)$

$T.E = K.E = \frac{1}{2} m\omega^2 A^2$

$(y = 0)$

$P.E = 0$

At extreme

$(y = A)$

$\boxed{K.E = 0}$

$(y = A)$

$T.E = P.E = \frac{1}{2} m\omega^2 A^2$

$\boxed{TE \propto A^2}$

→ When frequency of vibration is 'n', then the frequency of change in K.E (or) P.E is '2n'

Scanned by CamScanner

→ Time period of a particle is 12 seconds, the time taken for the disp. = A/2 from mean is ______

$T = 12\,sec$

$y = A\sin\omega t$

$\frac{\cancel{A}}{2} = \cancel{A}\sin\omega t$

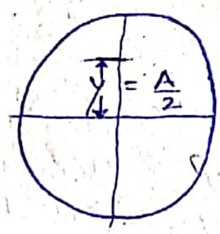
$\omega t = 45°$

$\left(\frac{2\pi}{T}\right) t = \frac{\pi}{6} \times \frac{1}{2\pi}$

$\left(\frac{2\pi}{T}\right) \times$

$\frac{2\pi}{12} \times t = \frac{\pi}{6}$

$t = 1\,second.$



$t = \frac{\pi}{4} \times \frac{12}{2\pi}$

$t = 3$

$y = A \quad , \quad A/\sqrt{2}$

$t = 3 \quad , \quad 1.5$

→ Time period of a particle is 3.14 seconds and amplitude is 5cm, its velocity at a disp. of 3cm is ______

$V = \omega\sqrt{A^2 - y^2}$

$= \frac{2\pi}{T}\left[\sqrt{5^2 - 3^2}\right]$

$= \frac{8\pi}{3.14}$

$= 8\,cm/s$

$V_{max} = \omega \times A$

$= \frac{2\pi}{3.14} \times 5$

$25 - 9 = 16$

$= 10\,cm/s$

The V_{max} is V, its velocity at a disp. of half of the Amplitude is ______

~~$V_{max} = \omega y$~~

$V = \omega A$

$v = \omega\sqrt{A^2 - y^2}$

$= \omega\sqrt{A^2 - \frac{A^2}{4}}$

$= \underbrace{\omega A}\frac{\sqrt{3}}{4}$

$\boxed{v = V\frac{\sqrt{3}}{4}}$

→ Amplitude of a particle is 5cm the ratio of velocities and the disp.s of 3cm and 4cm is ______

$A = 5cm$, $V_1 : V_2 = ?$ $y_1 = 3$

$y_2 = 4$

$\cancel{\frac{V}{y} = \frac{\omega A}{\sin \omega t}}$

$V = \omega\sqrt{A^2 - y^2}$

$\frac{V_1}{V_2} = \frac{\cancel{\omega}}{\cancel{\omega}}\sqrt{\frac{5^2 - 3^2}{5^2 - 4^2}}$

$\frac{V_1}{V_2} = \frac{4}{3}$

→ Time period of a particle is 3.14 second, it acclⁿ at a disp. of 3cm is ______

$a = -\omega^2 y$

$= -\omega^2 \, 3$

$\omega = \frac{2\pi}{T}$

$\cancel{\omega^2 = \frac{2\pi^2}{T^2}}$

$= \frac{2\pi}{\omega} \times 3$

$\frac{4\pi^2}{3.14^2} \times 3$

~~$a = -6cm/s^2$~~

$-12s$

→ The accⁿ of a particle is $25 cm/s^2$ at a disp of 4cm, $T = ?$

$25 = -\frac{4\pi^2}{T^2} \times 4$

$T^2 = \frac{-16\pi^2}{25}$

$T = \frac{-4\pi}{5}$

$= \frac{4\pi}{5}$

→ The a_{max} and V_{max} are numerically eq, $T = ?$

$\omega^2 A = \omega A$

$\omega = 1$

$\frac{2\pi}{T} = 1$

$T = 2\pi$

→ A particle of mass 2kg is in S.H.M with an Amplitude of 5m and time period is 3.14 second, it K.E at a disp. of 3m

$= \frac{1}{2} m \omega^2 (A^2 - y^2)$

$= \frac{1}{\cancel{2}} \times \cancel{2} \times \frac{4\pi^2}{3.14^2}(5^2 - 9)$

$= 4(16)$

$K.E = 64 KJ$

$P.E = \frac{1}{2} m\omega^2 y$

$= 36 J$

$T.E = K.E + P.E$

$= 100 J$

→ ~~If~~ $T = 8s$, $y =$ $K.E = P.E$ is ______

$\frac{1}{2} \cancel{m\omega^2}(A^2 - y^2) = \frac{1}{2}\cancel{m\omega^2} y^2$

$A^2 = 2y^2$

$y = \frac{A}{\sqrt{2}}$

$\frac{A}{\sqrt{2}} = A \sin \omega t$

$\frac{1}{\sqrt{2}} = \sin \omega t$

$\frac{\pi}{4} = \frac{2\pi}{8} \times t$

$t = 1 sec$

→ The % of K.E in the total energy at a disp. of $\frac{A}{2}$

$\cancel{\frac{\Delta KE}{K.E}} \cancel{\times T.E}$

$\frac{K.E}{T.E}$

$\frac{\frac{1}{2} m \omega^2 (A^2 - y^2)}{\frac{1}{2} m \omega^2 A^2} \times 100$

$\left(1 - \frac{y^2}{A^2}\right) \times 100$

$\frac{y}{A} = \frac{A}{2A} = 1$

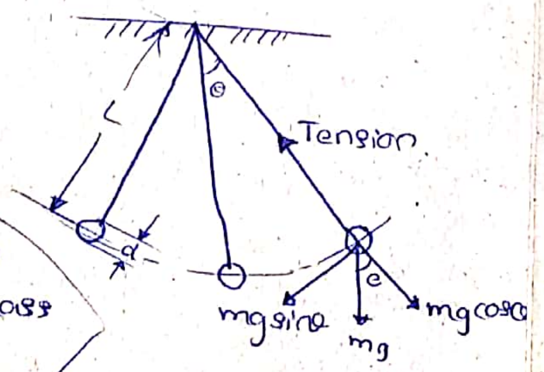
$= 1 - \frac{A^2}{4A^2}$

$= 1 - \frac{1}{4}$ $\times 100$

$= 3/4 \times 100$

$= 75\%$

→ Time period of a simple pendulum :



$T = 2\pi \sqrt{\frac{L}{g}}$

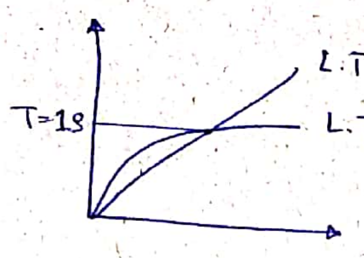
$T \propto \sqrt{L}$

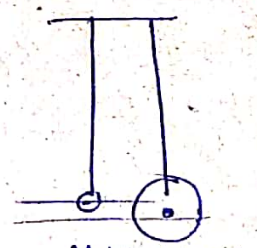
$T \propto \frac{1}{\sqrt{g}}$

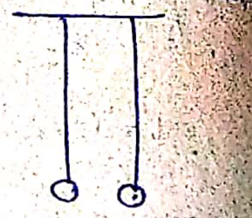
Time period is independ of mass

L = length of the pendulum

g = accln due to gravity.



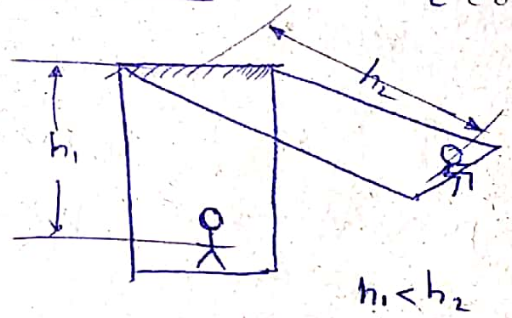




- The simple pendulum doesnot oscillates in the spring but oscillates in the vaccum
- LT^2 & LT graph intersects at $T = 1s$.
- The pendulum which has time period 2seconds is called seconds pendulum.
- When an iron pendulum and a wooden pendulum of same mass are oscillates, the time period of wooden pendulum is more
- When they have same sides, then the time period will be same

→ When a body who is standing in a swing suddenly sits then the time period of the swing

Increases, length increases $[T \propto \sqrt{L}]$



→ Time period for considerable length

$$T = 2\pi \sqrt{\frac{1}{g\left(\frac{1}{L} + \frac{1}{R}\right)}}$$

R = radius of earth

= 6400km

If $L = \infty$

$$T = 2\pi\sqrt{\frac{R}{g}}$$

$$T = 2\pi\sqrt{\frac{6400 \times 1000}{9.8}}$$

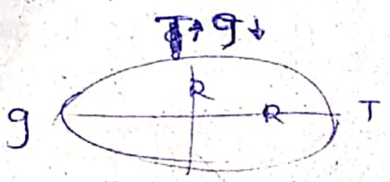
$$\boxed{T = 84\text{min}}$$

(2) If $L = R$

$$T = 2\pi\sqrt{\frac{R}{2g}}$$

$$\boxed{T = 59\text{min}}$$

• When a pendulum is carried from equators to poles its time period decreas $g\uparrow$ $T\downarrow$



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

$$g \propto \frac{1}{R^2}$$

$$g\uparrow \quad R\downarrow$$

$$g\downarrow \quad T\uparrow$$

$$T \propto \frac{1}{\sqrt{g}}$$

$$\frac{T_m}{T_e} = \sqrt{\frac{g_e}{g_m}}$$

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

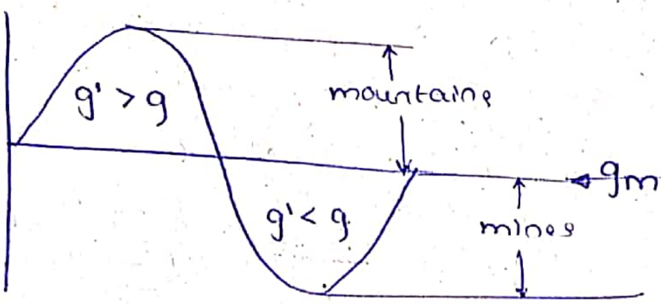
$$\boxed{T_m = \sqrt{6}\,T_e}$$

~~When a~~ pe

When a pendulum is carried from earth to moon, its time period increases

$$g' = \frac{GM}{(R+h)^2} \quad , \quad g = \frac{GM}{R^2}$$

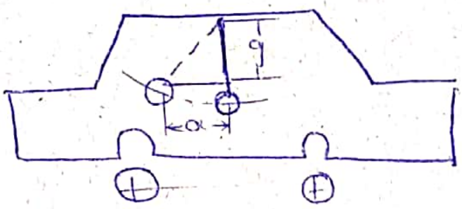
→ When a hydrogen balloon is released on the moon, th its falls down with accl^n with $\frac{1}{6}$ gravity on earth

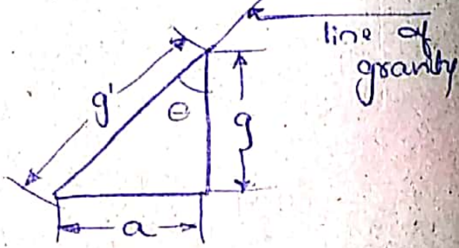


$$g' = g\left(\frac{R}{R+h}\right)^2$$

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

When a pendulum is suspended in a vechicle with some accl^n. then the time of period of the pendulum decreases





$$g' = \sqrt{g^2 + a^2}$$

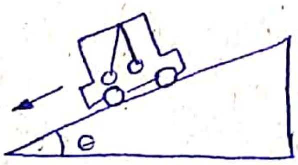
$g' \uparrow \quad T \downarrow$

Angle of pendulum

$$\tan\theta = \frac{a}{g}$$

$$\theta = \tan^{-1}(a/g)$$

When a pendulum is sliding down on a incline surface then the time period of pendulum increases



$$g' = g\cos\theta$$

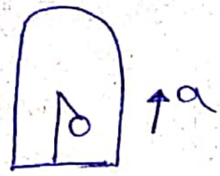
$$g \downarrow = T \uparrow$$

$$T = 2\pi\sqrt{\frac{L}{g\cos\theta}}$$

Time period of the pendulum decrease when it is placed in a lift which is moving up ~~ae~~ with some accl^n.

$g' = g + a$

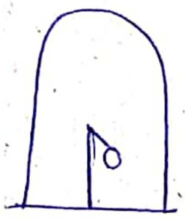
$g \uparrow T \downarrow$



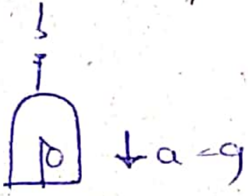
Time period of the pendulum increases when the lift moves down with some accl^n.

$g \downarrow T \uparrow$

$g' = g - a$

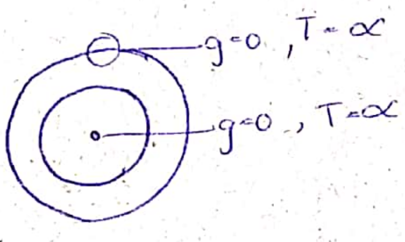


In a freely falling lift at the centre of earth and in a orbitati[ng] satellite, the time period of pendulum is infinity.

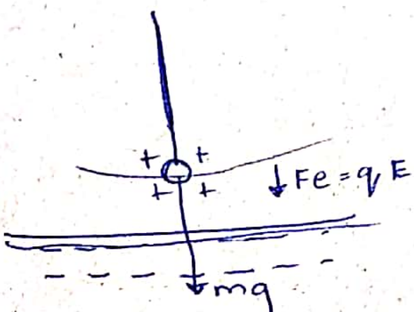


$g' = g - a$
$= 0$

$g = 0 \quad T = \infty$

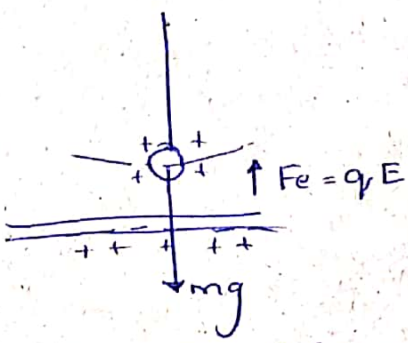


1. When a ~~pos~~ +vely charged pendulum is allowed to oscillate on a -vely charged plate, Then time period decrease.
2. When a +vely charged pendulum is allowed to oscillate on a +vely charged plate, Then time period increases.



$g' = g + \frac{qE}{m}$

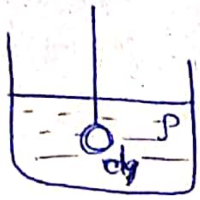
$g \uparrow T \downarrow$



$g' = g - \frac{qE}{m}$

$g \downarrow T \uparrow$

When a pendulum is allowed to oscillate in water, then its time period increases



Spe. gravity or relative density

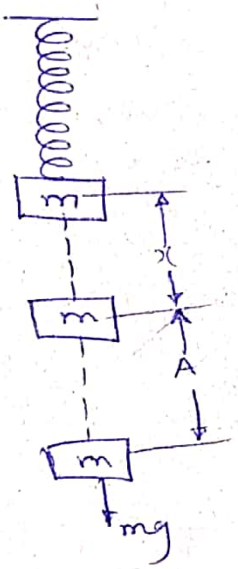
$$\frac{\cancel{m}g}{\cancel{m}(g-g')} = \frac{d}{\rho}$$

$$\rho g = dg - dg'$$

$$g' = \frac{g(d-\rho)}{d}$$

$g \downarrow T \uparrow$

Time period of a loaded spring



Force const. $k = \frac{F}{x}$

P.E = W.D

$$\frac{1}{2} m\omega^2 y^2 = \frac{1}{2} k y^2$$

$$\boxed{k = m\omega^2}$$

$$\boxed{\omega = \sqrt{k/m}}$$

→ when $\omega = \frac{2\pi}{T}$

$$\frac{2\pi}{T} = \sqrt{\frac{k}{m}}$$

$$\boxed{T = 2\pi\sqrt{\frac{m}{k}}}$$

→ for suspended load

$$T = 2\pi\sqrt{\frac{m}{k}}$$

but $K = \frac{F}{x} = \frac{mg}{x}$

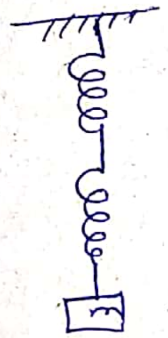
$$T = 2\pi\sqrt{\frac{m}{mg/x}}$$

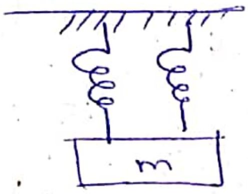
$$\boxed{T = 2\pi\sqrt{x/g}}$$

Series

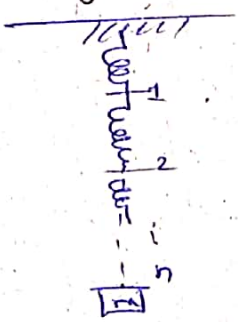
Parallel

Spring cut into 'n' parts





$K = k_1 + k_2$



$\frac{1}{k} = \frac{1}{k_1} + \frac{1}{k_2}$

$k = \frac{k_1 k_2}{k_1 + k_2}$

$K = nk$

$T \propto \frac{1}{\sqrt{K}}$

$\frac{T_1}{T_2} = \sqrt{\frac{K_2}{K_1}}$

$\frac{T_1}{T_2} = \sqrt{\frac{nk}{k}} = \sqrt{n}$

$\boxed{T_2 = T_1/\sqrt{n}}$

Time period of a pendulum of length 9.8 m is ______

$T = 2\pi\sqrt{\frac{L}{g}}$ $L = 9.8$

$= 2\pi$

length of seconds pendulum $T = 2\pi\sqrt{\frac{L}{g}}$

$L = 1m$

length " " " on moon is

$T = 2\pi\sqrt{\frac{L}{g}}$

$L \propto g$

$$\frac{L_m}{L_e} = \frac{g_m}{g_e}$$

$$\frac{L_m}{1} = \frac{1/6\, \cancel{g_e}}{\cancel{g_e}}$$

$$L_m = \frac{1}{6} m$$

decrease in length

$$\Delta l = L_m - L_e$$

$$= 1 - \frac{1}{6}$$

$$= 5/6\, m$$

length of a second pendulum is doubled, then time period is ______

$$T = 2\pi \sqrt{\frac{L}{g}}$$

$$T \propto \sqrt{L}$$

$$\frac{T_1}{T_2} = \sqrt{\frac{L_1}{L_2}}$$

$$\frac{T_1^2}{T_2} = \frac{\cancel{L_1}}{2\cancel{L_0}}$$

$$\frac{2}{T_2} = \sqrt{\frac{\cancel{L_1}}{2\cancel{L_1}}}$$

$$\frac{T_1}{T_2} = \frac{1}{4}$$

$$\boxed{T_2 = 4T_1}$$

$$T_2 = 2\sqrt{2}\, s$$

length of a pendulum is increased by 21%. then, Time period is increases by ______ %.

$$T \propto \sqrt{L}$$

$L_1 = 100\%$

$L_2 = 121\%$

$$\left(\frac{T_2 - T_1}{T_1}\right) \times 100 = ?$$

$$\left(\frac{T_2}{T_1} - 1\right) \times 100 = ?$$

$$\frac{T_2}{T_1} = \sqrt{\frac{121}{100}}$$

$$= \frac{11}{10}$$

$$\% \left(\frac{11}{10} - 1\right) \times 100$$

$$= \frac{1}{\cancel{10}} \times 10\cancel{0}$$

$$= 10$$

The length of pendulum is increased by 1%. Then the time is increased by ______

$$T \propto \sqrt{L}$$

$$\log T = \frac{1}{2} \log L$$

$$\frac{1}{T} \cdot \frac{dT}{dL} = \frac{1}{2} \times \frac{1}{L}$$

$$\frac{dT}{T} = \frac{1}{2} \times \frac{dL}{L}$$

$$\frac{dT}{T} \times 100 = \frac{1}{2} \frac{dL}{L} \times 100$$

$$100 \times \frac{dT}{T} = \frac{1}{2} \times [1 \times 100]$$

$$\frac{dT}{T} = \frac{1}{2}$$

$$= 0.5$$

A seconds pendulum is a placed on a planet of double the radius of earth, then Time period becomes ______ [same mass]

$$g = \frac{GM}{R^2} \text{ — } k$$

$$g \propto \frac{1}{R^2}$$

$$\frac{g_1}{g_2} = \left(\frac{R_2}{R_1}\right)^2$$

$$\frac{g_1}{g_2} = \left(\frac{2R_1}{R_1}\right)^2$$

$g_1 = 4g_2$

$T_1 \propto \frac{1}{\sqrt{g}}$

$\frac{T_1}{T_2} = \sqrt{\frac{g_2}{g_1}}$

$\frac{2}{T_2} = \sqrt{\frac{\cancel{g_2}}{4\cancel{g_2}}}$

$T_2 = 4$ seconds

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

Time on earth = 6s

Time on moon = ?

$T_m = \sqrt{6}\, T_e$

$= 6\sqrt{6}$

A seconds pendulum is placed in a lift which is moving up with an accl^n of $3g$, Time period becomes ______

$T_1 = 2sec$ $g_1 = g$

$T_2 = ?$ $g_2 = g + a$

$= g + 3g$

$= 4g$

$T \propto \frac{1}{\sqrt{g}}$

$\frac{T_1}{T_2} = \sqrt{\frac{g_2}{g_1}}$

$\frac{2}{T_2} = \sqrt{\frac{4\cancel{g}}{\cancel{g}}}$

$T_2 = 1$ second

A pendulum is suspended in a vehicle which is moving with accl^n of $g/\sqrt{3}$, the angle made by pendulum is ______

$\theta = \tan^{-1}(a/g)$

$= \frac{1\cancel{g}}{\sqrt{3}\cancel{g}}$

$\Rightarrow 30° \Leftarrow$

$g' = \sqrt{g^2 + a^2}$

$= \sqrt{g^2 + \frac{g^2}{3}}$

$= \frac{4g^2}{3}$

$g' = \frac{2g}{\sqrt{3}}$

A pendulum of sp. gravity '4' has a length ~~l~~ 9.8m, it is oscillated in a water, Time period ______

$S_g = 4$

$L = 9.8m$

$Sp.\ gravity = 4 = \frac{d}{\rho}$

$\frac{\rho}{d} = \frac{1}{4}$

$g' = g\left[1 - \frac{\rho}{d}\right]$

$= g\left[1 - \frac{1}{4}\right]$

$= \frac{3}{4}g$

$T = 2\pi\sqrt{\frac{L}{g}}$

$= 2\pi\sqrt{\frac{9.8}{3/4\, g}} = \frac{4\pi}{\sqrt{3}}$ seconds

A spring of $k = 100\,N/m$ is loaded with a mass of 4kg. Time period is ______

$$T = 2\pi\sqrt{\frac{m}{k}}$$

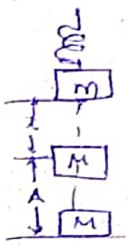
$$= 2\pi \times \sqrt{\frac{4}{100}}$$

$$= 2\pi \times \frac{2}{10}$$

$$= \frac{4\pi}{10}$$

$$= \frac{2\pi}{5}$$

A spring is loaded with a mass which it stretches by 20cm. It is further pulled to 5cm and released, T = ?



$$T = 2\pi\sqrt{\frac{x}{g}}$$

$$= 2\pi \times \sqrt{\frac{20}{9.8 \times 10^2}}$$

$$\cancel{\frac{4\sqrt{5}\,\pi}{3.14}}$$

$$2\pi \times \sqrt{\frac{2\cancel{0}}{98\cancel{0}}}$$

$$= \cancel{\frac{2\sqrt{2}\,\pi}{3.14}}$$

$$= \cancel{2\sqrt{2}} = \frac{2\pi}{7}$$

In above problem mass suspended is 2kg. Energy of vibration is ______ $A = 5\,cm$

$$E = \frac{1}{2} m \omega^2 A^2$$

$$= \frac{1}{\cancel{2}} \times \cancel{2} \times \frac{2\pi}{T} \times (5 \times 10^{-2})^2$$

$$= 7^2 \times 25 \times 10^{-4}$$

$$= 49 \times 25 \times 10^{-4}\ J$$

$$\begin{array}{r} 49 \\ \times 25 \\ \hline 800 \\ 800 \\ 1800 \\ 45 \\ \hline 28.45 \end{array}$$

Time period of spring increases from 3s to 4s, the mass suspended increased by 1kg. The initial mass is ______

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$T_1 = 3 \qquad m_1 = 1$

$T_2 = 4 \qquad m_2 = m + 1$

$$\frac{T_1}{T_2} = \sqrt{\frac{m_1}{m_2}}$$

$$\frac{3}{4} = \sqrt{\frac{m}{m+1}}$$

$$\frac{9}{16} = \frac{m}{m+1}$$

$$9m + 9 = 16m$$

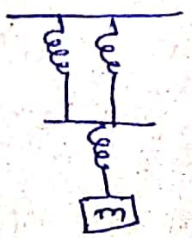
$$7m = 9$$

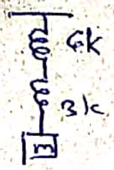
$$m = 9/7\ kg$$

Time period of a spring is 2 sec, it cut into 3 eq. parts then two parts are kept in parallel and 1 in series, T = ?

$T_1 = 2\,sec \qquad k_1 = k_3$

$T_2 = ? \qquad k_2 = ?$





$k = 3k + 3k$
$= 6k$

$\frac{1}{k_1 + k_2} = \left(\frac{6k + 3k}{18k^2}\right)^{-1}$

$k_2 = \frac{18k^2}{9k}$

$k_2 = 2k$

$\frac{T_1}{T_2} = \frac{k_2}{k_1}$

$\frac{2}{T_2} = \sqrt{\frac{2\cancel{k}}{\cancel{k}}}$

$T_2 = \frac{2}{\sqrt{2}}$

$= \sqrt{2}$ seconds

In the above promblem the spring is cut into 4 eq parts then Time period of one part is ______

$T_1 = 2$ $\quad k_1 = k$
$T_2 =$ $\quad k_2 = 4k$

$\frac{T_2}{T_1} = \sqrt{\frac{k_1}{k_2}}$

$\frac{T_2}{2} = \sqrt{\frac{1}{4}}$

$T_2 = 1$ seconds ______

Sound (Acoustics)

It is a form of energy which will be produced when an body vibrated in an elastic medium. The range b/w 20 Hz — 20kHz is called audible range

$V = n\lambda$

$\lambda = \frac{v}{n}$

At room temp. V = 340m/s
" 0° " " = 332m/s
min V = 330 m/s
In Vaccum = 0

Infrasonic
$< 20Hz$.

ultrasonic
$> 20kHz$

$\lambda = \frac{340}{20}$

$= 17m$

$\lambda = \frac{340}{20k}$

$= 0.017m$

The range below 20Hertz is infrasonics, which is herd insects, rats, snakes,

The range above 20 Hertz is ultrasonic, " " herd by dog (50kHz), bats (100kHz)

- Ultrasonics are used to purify the liq. like milks, in scanning, in solar [sound navigation and ranging] & to find the velocity of moving objects
- The ratio b/w the Velocity of obj. Vo & Velocity of Sound Vs is called mach number

→ Mach. no. = $\frac{V_o}{V_s}$

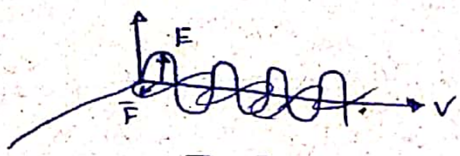
$V_o < V_s$ – subsonic

$V_o = V_s$ – sonic

$V_o > V_s$ – supersonic

1 mach = 340m/s

Wave motion: The disturbance created in a elastic medium travells from particle to particle is called wave motion



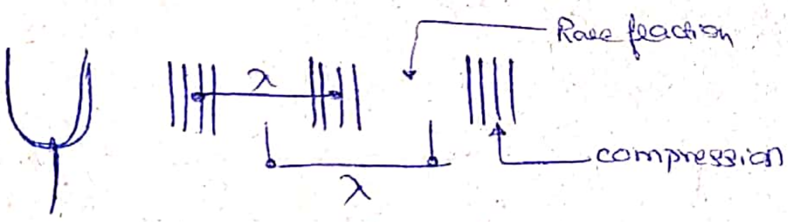
$\bar{V} = \bar{F} \times E$

Wave

- Mechanical (sound)
  - longitudinal
  - Transverse
- electromagnetic (light)

Longitudinal wave: The wave in which, the direction of vibration of particle, the direction of propogation of wave are parallel to each other is called ~~longitudin~~ longitudinal wave

- This wave contains compression and rarefraction
- The dist. b/w two successive compression or rarefraction ~~is call~~ is eq to wave length (λ) and phase difference is 2π radians
- Sound travels in gases only in the form of longit-udinal mechanical wave.
- Longitudinal wave cannot be polarised



longitudinal wave

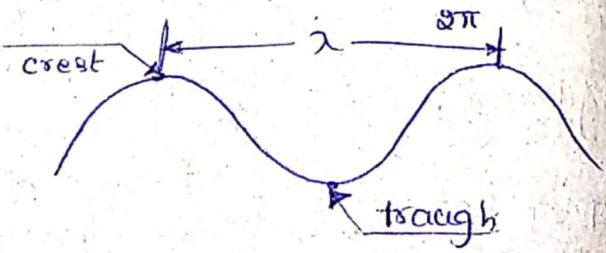
$x = A \cos(\omega t \pm \phi)$

Transverse wave·

- The wave in which the direction of vibration of particle & the direction of propogation wave are $\perp^{le}$ to each other is called transverse wave
- This wave contains crest and traugh.
- The dist. b/w two successive crests or traughs = wavelength & phase difference is 2π radians
- Sound travells in solids, liqs, in the form of longitudinal as well as transverse waves
- Transvers waves can be polarised

Transverse wave

$$\boxed{y = A\sin(\omega t \pm \phi)}$$



Velocity of sounds:

$V = \sqrt{\frac{E}{S}}$ [~~Newton's law~~ Newton's law]

$\{V = n\lambda$
$V \propto \lambda\}$

E - elastic modulus

d : density of elastic medium

$V_s > V_l > V_g$

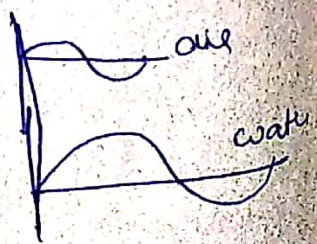
V in solids > V in liq ~~> in gases~~ > V in gases.

5000m/s 1500m/s 340m/s

When sound passed from ~~rare~~ rare to denser medium, V ↑, its sounds passes from one medium to an other medium, Its frequency remains consti

→ When sound passed from rare to denser medium, its Velocity ↑

→ When ·



Velocity

1. In solids

$V = \sqrt{\frac{Y}{d}}$

Y = young's modulus

2. In liq.

$V = \sqrt{\frac{K}{d}}$

K = bulk's modulus

3. In gases

$V = \sqrt{\frac{\gamma P}{d}}$

γP = Adiabatic modulus

For isothermal, $K = P$

For Adiabatic, $K = \gamma P$

In Gases:

Effect on temp

$V = \sqrt{\frac{\gamma P}{d}}$

$V = \sqrt{\frac{\gamma R T}{m}}$

$PV = RT$

$P \times \left(\frac{m}{d}\right) = RT$ $\left\{ d = \frac{m}{V} \right\}$

$\boxed{V \propto \sqrt{T}}$

At 819°C the Velocity of sound is double to the velocity at 0°C

$\frac{V_1}{V_2} = \sqrt{\frac{t_1}{t_2}}$

2. Effect on pressure

At const. temp.

Gas follows Boyle's law

$PV = \text{const.}$

$\frac{Pm}{d} = \text{const.}$

$\frac{P}{d} = \frac{\text{const.}}{m}$

$V = \sqrt{\frac{\gamma\, \text{const.}}{m}}$

$V = \text{const.}$

$\therefore V$ is const.

Velocity of sound in gases is independent of pressure at const. temp.

3. Effect on density

$V = \sqrt{\frac{\gamma P}{d}}$ at const. temp.

γ, P - are const.

$\boxed{V \propto \frac{1}{\sqrt{d}}}$

$\boxed{\text{density} \propto \text{mol. wt}}$

Echo:

When a sound is produced, which is heard after a time gap, due to reflection of sound, then the reflected wave is called echo wave, the first " " " progressive wave.

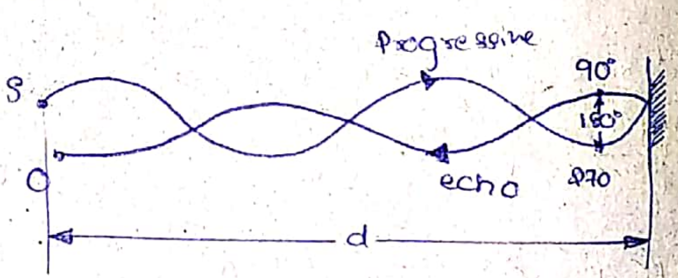
- The intensity of echo wave is alway < than the " " progressive wave
- The min. time required to recognise two sound waves seperately is $\frac{1}{10}$ seconds.
- The min. dist. required to absorb the echo is 16.5m

$V = \frac{2d}{t}$

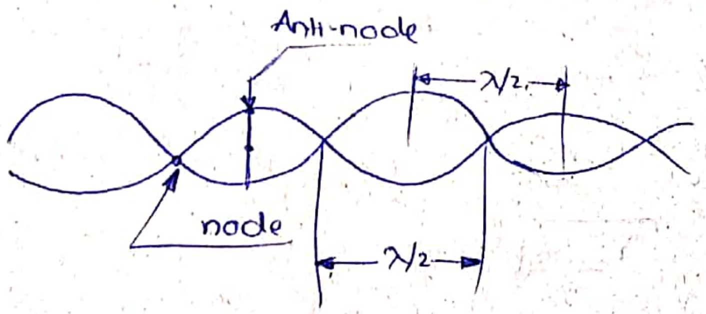
$d = Vt/2$

$= \frac{330 \times}{2} \frac{1}{10}$

$= 16.5m$



- The phase difference b/w progressive wave and echo wave ~~the~~ at the reflecting surface is 180°
- At the reflecting surface always node takes place

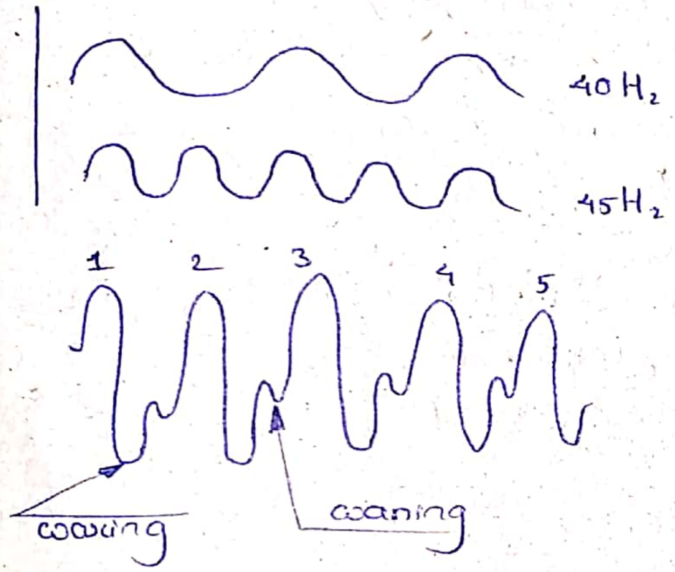


Beats:

When two sounds waves are slightly different frequencies propogated together, then they combine and causes the variation in the intensity [effect of waxing and waning] called beats.

1. Constructive interference causes waxing effect
2. Distructive " " waning "

- The no. of beats heard in 1second is called Beat frequency
- The max. no. of beats " " " is 10



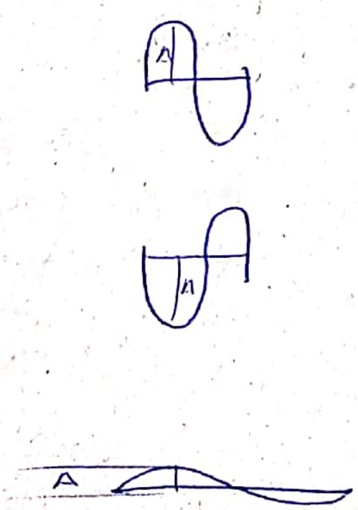
~~Constructive interference~~

Constructive interference

$A = A_1 + A_2$

Waxing

Destructive interference



$A = A_1 - A_2$

Waving

Beat frequency

$\boxed{N = n_1 \sim n_2}$ $(n_2 - n_1)$

Time period.

$T = \frac{1}{n}$

Max → Max } (T)

Min → Min

Max → Min (T/2)

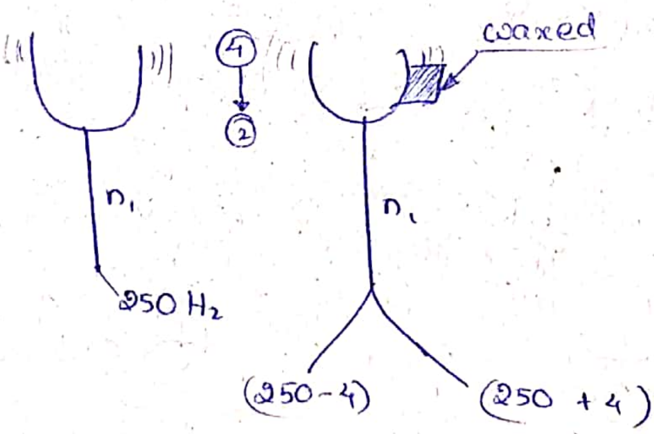
• When the frequency ratio is 1:1, they are set to be in unison

• " " " " " 1:2 " " " " " " octave

• When a tuning fork is waxed, its frequency ↓ (individual)

• " " " " " filed, " " ↑ (")

→ When a tuning fork is sounded with another fork and beats are heard, when the second force is waxed then beats are decreased. The frequency of second force is ______



N = 4 ← 246
= 5 245
= 6 244
= 7 243

254 → N = 4
253 = 3
$\boxed{252 = 2}$ ✓
251

(or)

$N = n_2 - n_1$

$4 = n_2 - 250$

$\boxed{n_2 = 254\ Hz}$

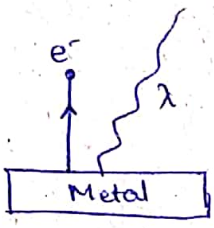
Fork	Beats are decreased	Beats are increased
Waxed	$N = n_2 - n_1$	$N = n_1 - n_2$
filed	$N = n_1 - n_2$	$N = n_2 - n_1$

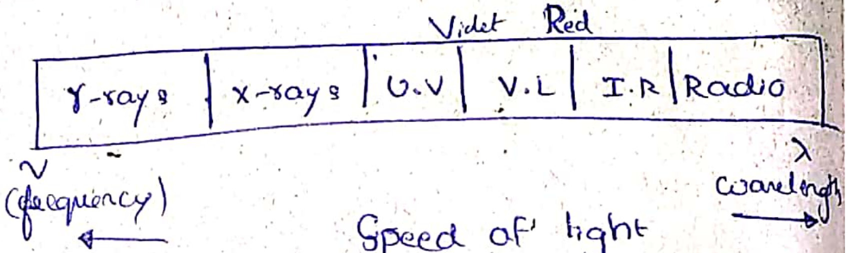
- Beats cannot be heard due to echo, when the source and observer at rest
- Beats can be heard due to echo, when the source and observer has relative motion.

Modern Physics

Photoelectric effect: When a metal surface is exposed to electromagnetic radiation of suitable wave length (λ). Then electrons will be emitted from the surface of the metal. This effect is called photoelectric effect.

- Photo electric " was discovered by Hertz and developed by Einstein
- The electrons emitted are called photo electrons.





Speed of light

$C = 3 \times 10^{18}$ m/s

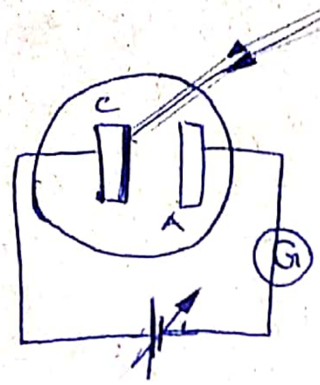
$= \dfrac{1}{\sqrt{\mu_0 \varepsilon_0}}$

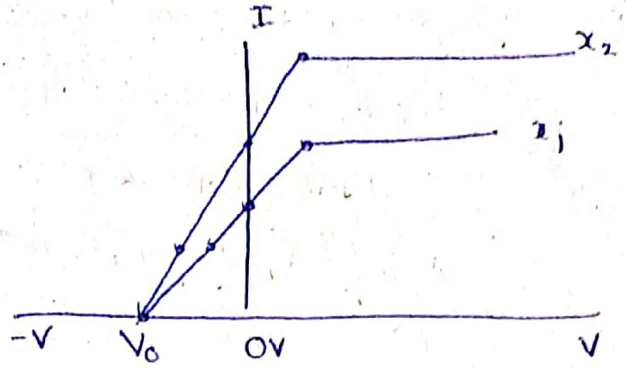
Scattering power, $S \propto \dfrac{1}{\lambda^4}$

- Visible light ranges from 4000 Å − 7200 Å angstrong

- Photoelectric effect is a instantaneous process.
- The rate of emission of photoelectrons depends intensity of incident light & independent of frequency
- The Kinetic energy of photoelectron depends on the frequency of incident light photon and independent of intensity
- The min. frequency of incident light photon required by the substance to emit photoelectron is called threshold frequency (ν_0)

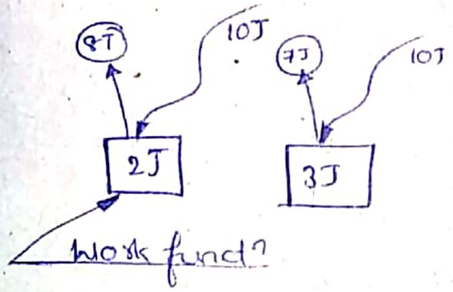
Relation b/w V & I





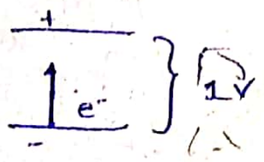
$\left\{ V_0 = \text{Cut off potential} \right.$
stopping potential }

• $\boxed{eV_0 = \frac{1}{2}mv^2}$



- All the photoelectron will not have the same K.E
- Free electrons doesnot causes photoelectric effect.
- The min. -ve potential required at which no photo-electric current, doesnot passes in the circuit. is called cut-off potential or stopping potential [V_0]
- At cut-off potential the max. K.E of photoelectron becomes eq to electrical energy $\boxed{eV_0 = \frac{1}{2}mv^2}$
- Cutoff potential depends on the frequency of incident light photon and workfunct^n of the substance
- Cut-off potential is independent of intensity of incident light.

→ Electron volt [eV]

Energy = charge × potential 

- The energy attained by an electron when it passes through one volt potential is called electron volt

$$1\,e_v = 1.6 \times 10^{-19}\,C \times 1\,V$$

$$\boxed{1\,e_v = 1.6 \times 10^{-19}\,J}$$

$$1\,Me_v = 1.6 \times 10^{-19} \times 10^{6}\,J$$

$$\boxed{1\,Me_v = 1.6 \times 10^{-13}\,J}$$

Energy of photon

$$\boxed{E = h\nu}$$

h = plank's consta

$= 6.625 \times 10^{-34}\,J.s$

ν = frequency of incident photon

but $C = \nu A$

C = velocity of light

$= 3 \times 10^{8}\,m/s$

$$\nu = \frac{c}{A}$$

$$\boxed{E = \frac{hc}{\lambda}}$$

$$E \propto \frac{1}{\lambda}$$

- 1 Angstron unit $(A^\circ) = 10^{-10}\,m$.
- $1\,nm = 10^{-9}\,m$

$$\boxed{310\,nm = 3100\,A^\circ}$$

*** ** $$\boxed{E \text{ in } e_v = \frac{12400}{\lambda \text{ in } A^\circ}}$$

Work function

The min. energy of incident light photon required by substance just to emit the photoelectron is called work function

$$W = E_0 = h\nu_0$$

ν_0 = Threshold frequency

But $C = \nu_0 \lambda_0$

λ_0 = cut off wave length

$$\boxed{\nu_0 = \frac{C}{\lambda_0}}$$

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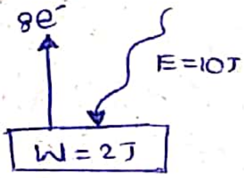
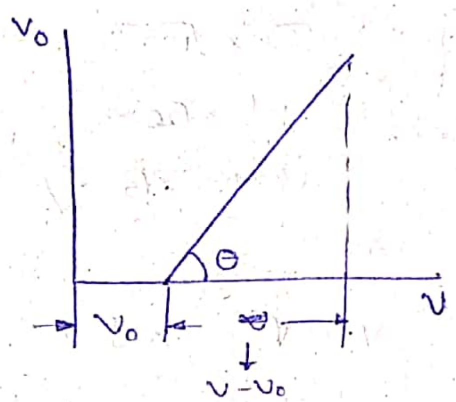
$$\boxed{W = \frac{h.c}{\lambda_0}}$$

$$\boxed{W_{\text{in eV}} = \frac{12400}{\lambda_0 \text{ in } A^o}}$$

Einstein's Photoelectric function

The max. K.E of photoelectron is = diff. b/w the energy of incident light photon & the work function of the substance.





$$\boxed{K.E = E - W}$$

$$\frac{1}{2}mv^2 = h\nu - h\nu_0$$

$$\boxed{\frac{1}{2}mv^2 = h(\nu - \nu_0)}$$

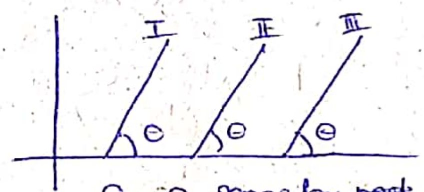
$\cancel{eV_0}$.

$$eV_0 = h(\nu - \nu_0)$$

$$\frac{V_0}{\nu - \nu_0} = \frac{h}{e} = \text{const.}$$

$$\tan\theta = \frac{V_0}{\nu - \nu_0} = \frac{h}{e}$$

$$= \text{const.}$$



θ is same for ~~each~~ all metal

→ Photoelectric is a device which converts the light energy into electrical energy

- Photoelectric cells are used in calculators & satellites
- In fire alarms & burgular alarms
- In automatic opening & closing of doors
- In street lights as the timer.
- In cinematography to reproduce the sound track printed on the films.

Cutoff potential of electron is 9.1 volt? It velocity is ____

$m = 9.1 \times 10^{-31}$ kg

$\frac{1}{2}mv^2 = eV_0$

$v^2 \times \frac{1}{2} \times 9.1 \times 10^{-31} = 9.1 \times 1.6 \times 10^{-19}$

$V = \sqrt{\frac{\cancel{9.1}}{\cancel{9.1}} \times \frac{2}{10^{-31}}}$

$= \sqrt{2 \times 10^{31}}$

$= \sqrt{20} \times \sqrt{10^{30}}$

$= 10^{15} \times \sqrt{20}$ m/s

$= 2 \times 10^{15} \times \sqrt{5}$ m/s

$V = \sqrt{3.2} \times 10^{6}$ m/s

Wavelength of a photon is 400nm its energy is ____

$\lambda = 400$ nm

$= 4000\ A^0$

$E = \frac{\overset{31}{\cancel{12400}}}{\cancel{4000}A^0}$

$= 31/10$

$E = 3.1$ ev

Workfunction of a metal is 3.3ev, the threshold frequency is ____

$W = h\nu_0$

$3.3\ ev = 6.6 \times 10^{-34} \times \nu_0$

$ev = J/e$

$3.3 \times 1.6 \times 10^{-19} J = 6.6 \times 10^{-34} \times \nu_0$

$\nu_0 = \frac{\cancel{3.3} \times 1.6 \times 10^{\overset{15}{\cancel{34}}}}{\underset{2}{\cancel{6.6}} \times \cancel{10^{19}}}$

$= 0.8 \times 10^{15}$ Hertz

$C = \lambda_0 \nu_0$

$3 \times 10^8 = \lambda_0 \times 8 \times 10^{14}$

$\lambda_0 = \frac{3 \times 10^8}{8 \times 10^{14}}$

$= 0.375 \times 10^{-6}$ m

$\lambda_0 = 375 \times 10^{-9}$ m

$\lambda_0 = 375$ nm

Work function of a metal is 1.5ev wavelength of incident photon is 310nm the K.E of photo electron & cutoff potential are

$K.E = E - W$

$= \frac{12400}{3100 A^0} - 1.5ev$

$= 4 - 1.5$

$= 2.5 ev_0$

$eV_0 = \underbrace{\frac{1}{2}mv^2}_{K.E}$

$1.6 \times 10^{-19} \times V_0 = 2.5 \times 1.6 \times 10^{-19}$

$eV_0 = 2.5 eV_0$

$V_0 = 2.5$ volt

$\boxed{K.E \text{ in ev} = V_0 \text{ in volt}}$

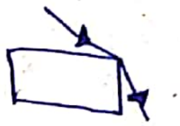
. Light is a form of energy which cause a sense of vision.

~~Lig~~

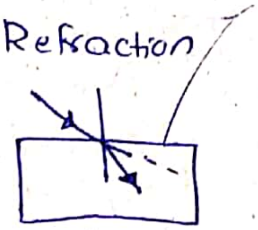
Light has properties of 5types

1. Reflection

2. Diffraction



3. Refraction



4. Interference

5. Refraction

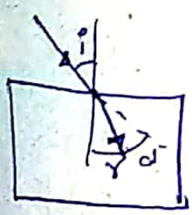
. Refraction:

. When a light passes from one medium to another medium due to change in the density of the medium called refraction

. When the light passes from raser to denser medium it beats towards the normal

. The Ratio of sine of the angle of incident and sine of ~~the~~ refraction is called refractive index.

Refraction



$${}^{1}\mu_{2} = \frac{\sin i}{\sin r} \quad \text{[Snell's law]}$$

Angle of deviation

$$\boxed{d = i - r}$$

$${}^{a}\mu_{air} = 1$$

$${}^{air}\mu_{water} = \frac{4}{3} = 1.33$$

$${}^{a}\mu_{glass} = \frac{3}{2} = 1.5$$

$${}^{a}\mu_{diamond} = 2.4$$

(1) $\mu \propto \frac{1}{v}$

v = velocity of light

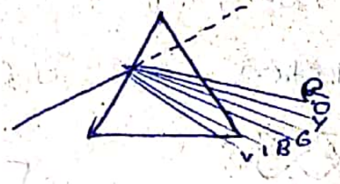
$$\frac{^{m}\mu}{^{}\mu_a} = \frac{V_a}{V_m}$$

(1)

$$\boxed{\mu_m = \frac{V_a}{V_m}}$$

(2) $\mu \propto \frac{1}{\lambda}$

λ = wavelength

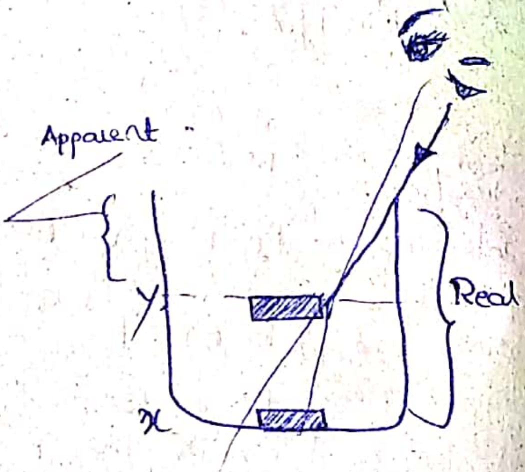


$$\boxed{\begin{array}{l} v \propto \lambda \\ \mu \propto \frac{1}{\lambda} \end{array}}$$

→ Refractive index of liq.

$$\mu = \frac{\text{Real depth}}{\text{Apparent depth}}$$

$$\mu = \frac{x-z}{y-z}$$



Relative refractive index

$$^{w}\mu_g = \frac{^{a}\mu_g}{^{a}\mu_w} = \frac{3/2}{4/3} = \frac{9}{8}$$

$$= 1.125$$

• When the light passes from denser to rarer medium then its bends away from the normaly

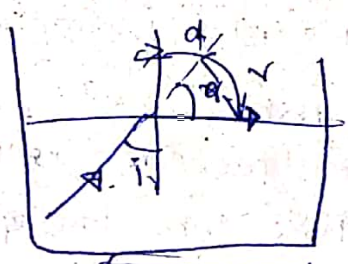
• Critical angle:

$${}^1\mu_2 = \frac{\sin i}{\sin r}$$

$${}^2\mu_1 = \frac{\sin r}{\sin i}$$

$$= \frac{\sin 90}{\sin i}$$

$$\mu = \frac{1}{\sin i}$$



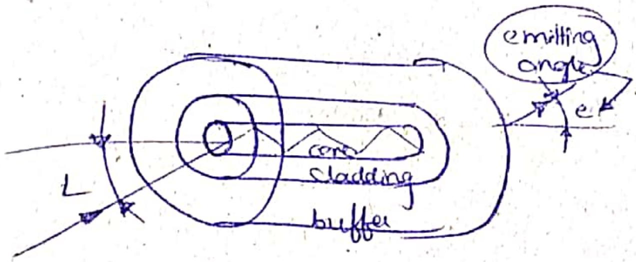
$\boxed{d = r - i}$

When a light passes from denser to rarer medium ~~φ~~ with the angle of incid of which the angle of ~~friction~~ refraction become ~~(angle)~~ 90 - called become ~~[illegible]~~. 90° is ~~called~~ called critical angle

Total internal reflection (TIR):

when the light ray trd from decrease

- Optical Fibre is a narrow tube of dia. 2μ to 150μ [μ=micron]
- It is made with high quality glass or silicon.
- Optical fibre works on the ~~propera~~ principle of TIR
- The Fibre tube through which the light pulses passes is called core [$1.7 = \mu_1$]
- The core is coated with less-density material called cladding [$\mu_2 = 1.6$]
- To protect the cladding, a plastic coating is given called buffer
- The angle of incidence at which the light enters the core called launching angle.



Launching angle

$$L = \sin^{-1}\sqrt{\mu_1^2 - \mu_2^2}$$

$$\sqrt{\mu_1^2 - \mu_2^2} = NA$$

NA = Numerical aperture

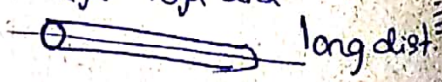
Optical fibre is two types:

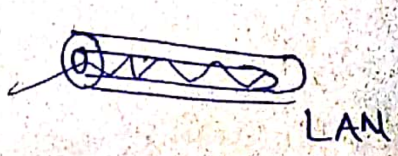
1. Step index fibre in which the refractive index of core and cladding has step profile

   It is of two types

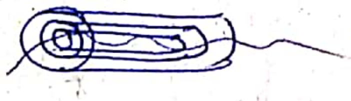
   (1) Single mode ______ $2\mu - 10\mu$ dia

   (2) Multi mode ______ $10\mu - 50\mu$





Graded index fibre: in which multiple core sys. is present. It is normally multimode.



USES

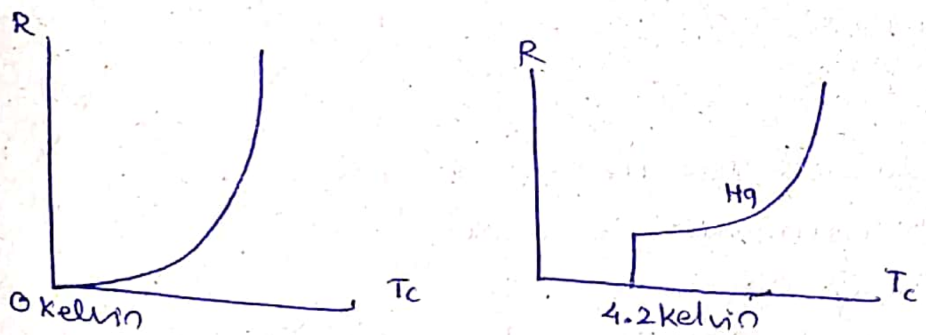
d = 50μ – 150μ

- Optical fibre are used for telecommunication
- In endoscopic
- To send secret msgs. in defence
- As a sensor in the factories to measure temp, pressure

→ The substance for which the resistance become zero before reaching the abs. zero kelvin is called super conductor.

Ex:- Hg, tin with mixer, lead oxides etc.

- Superconductivity was discovered by kamer lingh onnes
- The temp. at which the substance exhibits the super-conductivity is called critical temp. (T_c)
- Super conductivity was first observed in mercury at 4.2 kelvin temp.



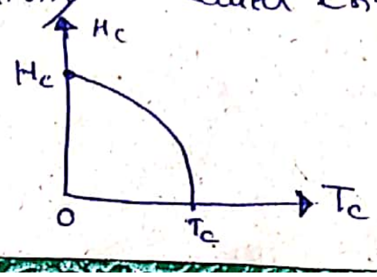
Ordinary conductor Superconductor

→ Critical field

- The min. intensity of magnetic field required to destroy the superconductivity is called critical field

→ H_c is max. in 0K

→ H_c is zero in T_c



Critical Current (I_c)

- The max. can be passed through the superconductor is called critical current

$$\boxed{H_c = \frac{I_c}{2\pi r}}$$

A/m   A/m

r = radius of the superconductor

→ Superconductor has zero resistan and pure diamagnestim ⊖

→ Missner's effect:

When the temp. of the substance is less than Critical temp. then the magnetic field in substance will be evacuvated.

$T > T_c$ $T < T_c$

→ Superconductors are used

- In power transmission as cables
- In switching circuits
- In measuring instruments like galvanometer
- In mechanical transportation
- To generate high intensity magnetic field

1) $i = 60°$ $r = 30°$

$\mu = ?$

$\mu = \frac{\sin i}{\sin r}$

$= \sqrt{3} = 1.72$

2) ${}_a\mu_g = 1.5$ $V_g = ?$

$\mu \propto \frac{1}{V}$

$\frac{\mu_a}{\mu_g} = \frac{V_g}{V_a}$

$\frac{1}{1.5} = \frac{V_g}{3 \times 10^8}$

$V_g = 2 \times 10^8$

3) ${}_a\mu_g = 1.414 = \sqrt{2}$

$c = ?$

$\mu = \frac{1}{\sin c}$

$\sin c = \frac{1}{\mu}$

$= \frac{1}{1.414} = \frac{1}{\sqrt{2}}$

$C = 45°$

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