Q.- $\boxed{Ex-1}$ 164, 171, 172, 174, 175, 176, 177, 178, 179, 180, -182, 184-186, 193-195, 197, 198, 201

$\frac{10}{7}$ $\boxed{Ex-2}$ 13,

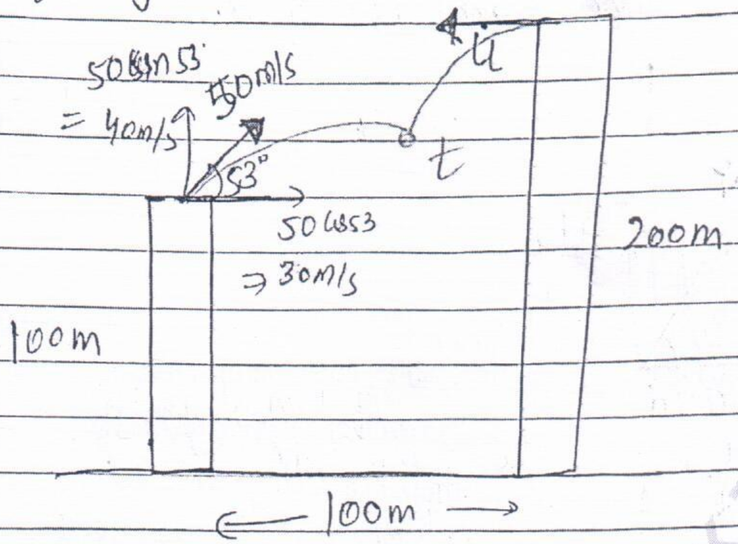
B.B ⇒ 9 (1,)

⇒ 10 (1, 2)

Race-5 (1-8)

14, 17.

Q. In the given fig. Both particle A & B are projected Simultaneously if they collide in air find value of 'u' & time



x-dirn

$a_x = 0$

$V_{rel} = \frac{d_{rel}}{t}$

$30 + u = \frac{100}{t}$ —①

$30 + u = \frac{100 \times 4}{10}$

$\boxed{u = 10\ m/s}$

y-dirn

$\vec{a}_{rel} = 0$ (∵ $\vec{g}$)

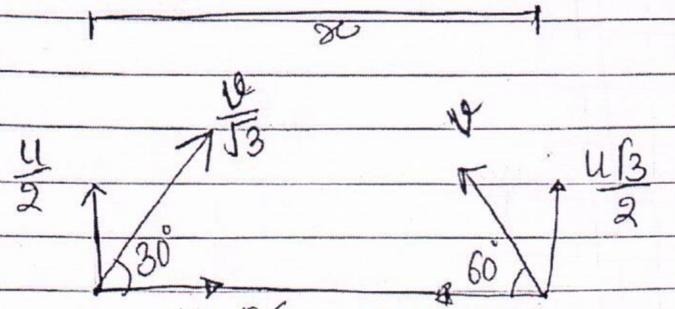
$V_{rel} = \frac{d_{rel}}{t}$

$40 + 0 = \frac{100}{t}$

$\boxed{t = \frac{10}{4}}$

$t = \frac{10}{4} = \frac{5}{2} = 2.5$ sec

Que. ⇒ Both projectile A & B are projected simultaneously from Ground Acc. to the figure find time after which Horizontal sepration b/w them becomes zero.



$= \frac{u}{\cancel{\sqrt{3}}} \times \frac{\cancel{\sqrt{3}}}{2}$ $\qquad$ $= u\cos 60°$

$= u/2$ $\qquad$ $= \frac{u}{2}$

$$V_{rel} = \frac{S_{rel}}{t}$$

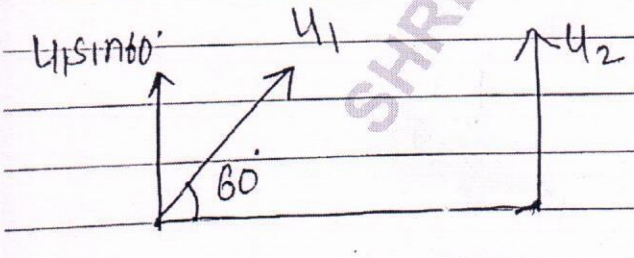
$$\frac{u}{2} + \frac{u}{2} = \frac{x}{t}$$

$$\boxed{t = \frac{x}{u}}$$

⊛ If two projectile projected simult. if they collide in air, if vertical component are equal.

$\{ u_1 \sin\theta_1 = u_2 \sin\theta_2 \}$

Q. Both projectile are fire simultaneously acc. to fig if they collide in air. find $\frac{u_1}{u_2} = ?$



$$u_1 \sin 60 = u_2$$

$$u_1 \times \frac{\sqrt{3}}{2} = u_2$$

$$\frac{u_1}{u_2} = \frac{2}{\sqrt{3}}$$

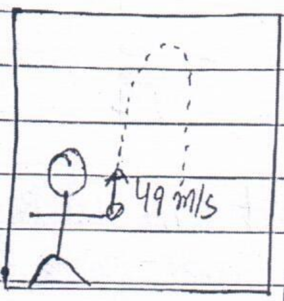
Q. A man standing inside the lift, he throw the ball with speed 49 m/s w.r.t to lift. find the time after which He again caught the ball if —

(I) lift at Rest

(II) Lift ascending with speed 5 m/s

(III) lift ascending with 4.9 m/s^2 (Neet)

(I) Lift at Rest

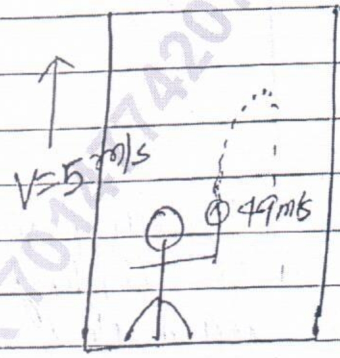


$T = \frac{2u}{g}$

$T = \frac{2 \times 49 \times 10}{98}$

$\boxed{T = 10\ sec}$

(2) left ascending with const velocity.



left frame

Here inertial frame

$g_{eff} = g$

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

$T = \frac{2 \times 49}{9.8}$

$\boxed{T = 10\ sec}$

(3) Lift ascending with accl^n :-

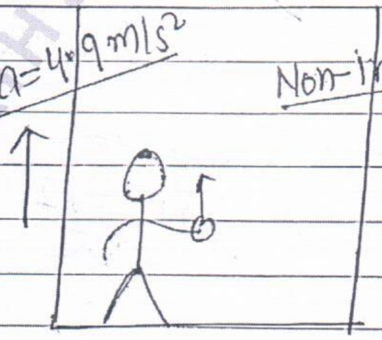
Lift frame

$g_{eff} = g + a$

$T = \frac{2u}{g+a}$

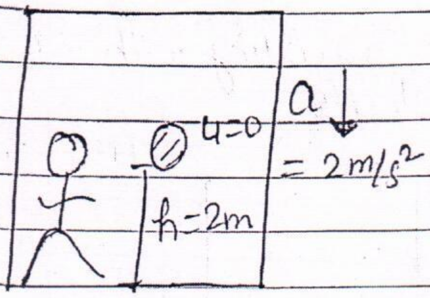
$T = \frac{2 \times 49}{9.8 + 4.9}$

$T = \frac{2 \times 49}{14.7} = \frac{20}{3} = 6.6\ sec$



Note:- Here eff. accl^n of ball from lift frame is $g+a$, while from ground frame it is g, because ball is not contact with lift.

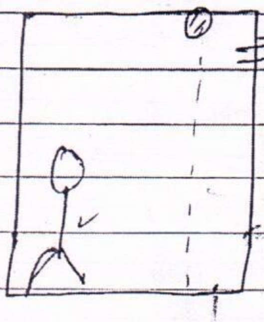
Q. If a lift is descending $2\ m/s^2$. a person standing ~~to~~ ~~of~~ drops a coin from height $2m$ from floor of lift. find time taken by coin to reach floor.



Lift frame.
initial velo. = 0 $\quad g_{eff} = g - a$

$$t = \sqrt{\frac{2h}{g-a}} = \sqrt{\frac{2\times 2}{10-2}} = \frac{1}{\sqrt{2}}\ sec$$

Que. A lift is ascending with accl^n $6\ ft/s^2$ at an instant a bolt in its ceiling begins to fall. Find time taken by bolt to reach floor which is 9.5 ft below the ceiling ($g = 32\ ft/s^2$)



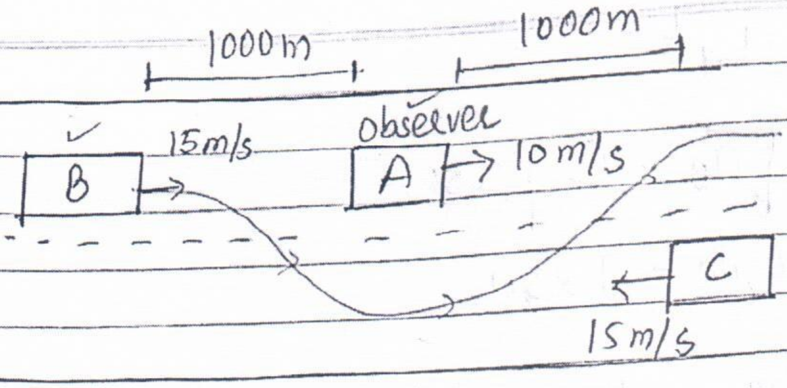
⇒ Lift frame (inertial)

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

$$t = \sqrt{\frac{2\times 9.5}{38}}$$

$$t = \frac{1}{\sqrt{2}}\ sec$$

Que. Car A travelling with speed $36\ km/hr$ on a two lane road. Two car B & C approaches A in opposite Direction with $54\ km/hr$ when $AB = AC = 1\ km$. Driver of B decide to overtake A before C crosses A. find Min^m accl^n of car B ?



A&C time of crossing

$$V_{rel} = \frac{S_{rel}}{t} \qquad 10+15 = \frac{1000}{t} \qquad t = \frac{1000}{25} = \underline{40 \text{ sec}}$$

$$\vec{S}_{rel} = \vec{u}_{rel} t + \frac{1}{2} a_{rel} t^2$$

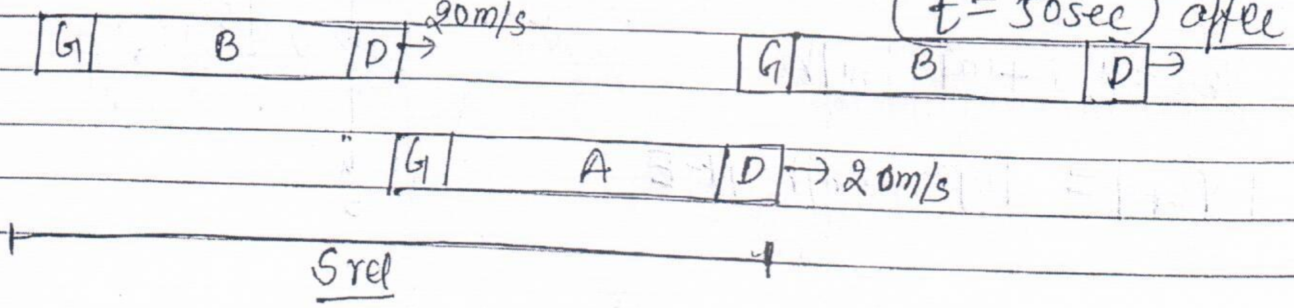
$$+1000 = [\vec{u}_B - \vec{u}_A] t + \frac{1}{2} [\vec{a}_B - \vec{a}_A] t^2$$ initial = 0

$$1000 = (15-10) \times 40 + \frac{1}{2} [a_B - 0] \times 1600$$

$$1000 = 200 + 800 a_B$$

$$a_B = \frac{800}{800} = 1 m/s^2$$

Que. Two train running on a parellel track 70 km/hr in Same Direction train A is ahead of B. driver of B decides to overtake A so hee accl^n at the rate of $1 m/s^2$ after 50sec the Gaurd of B just passes the driver of A. What was the initial sepration b/w Gaurds of B & driver of A.



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$$\vec{S}_{rel} = \vec{u}_{rel}t + \frac{1}{2}a_{rel}t^2$$

$$= 0 + \frac{1}{2}\left[\vec{a}_B - \vec{a}_A\right] \times (50)^2$$

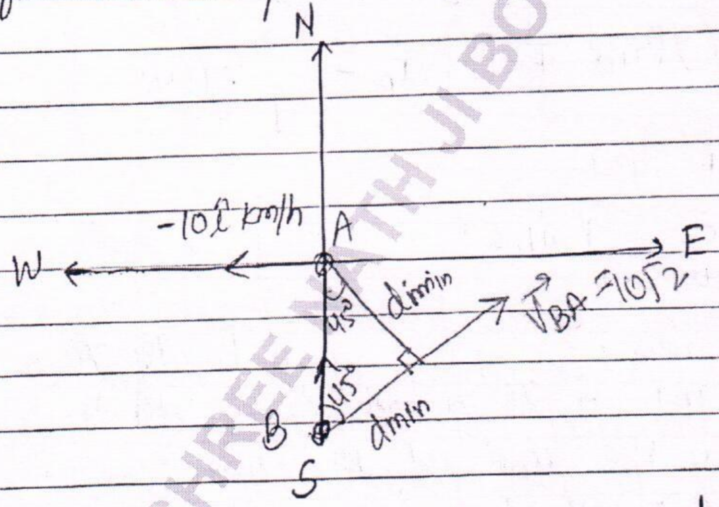
$$= \frac{1}{2} \times 1 \times 2500 = \underline{1250m}$$

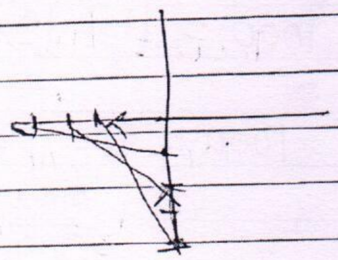
Que. Ship B 100 km south of ship A in open sea. Both starts motion simultaneously with 10 km/hr. Ship A westwards & ship B is Northwards. f/o

(I) velo. of B w.r.t A.

(II) Min^m sepration b/w them

(III) Time after which sepration b/w them becomes min^m.



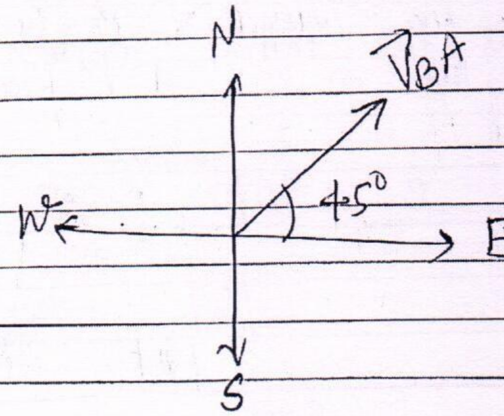


(I) $\vec{V}_{BA} = \vec{V}_B - \vec{V}_A$

$= 10\hat{j} - (-10\hat{i})$

$\vec{V}_{BA} = 10\hat{i} + 10\hat{j}$ km/h

$|\vec{V}_{BA}| = 10\sqrt{2}$ km/h N-E



(II) $\sin 45^\circ = \frac{d_{min}}{100}$

$d_{min} = \frac{100}{\sqrt{2}}$

(III) $t = \frac{d_{min}}{V_{rel}}$

$t = \frac{100}{\sqrt{2} \times 10\sqrt{2}} = \frac{10}{2}$

$\boxed{t = 5\ hr}$

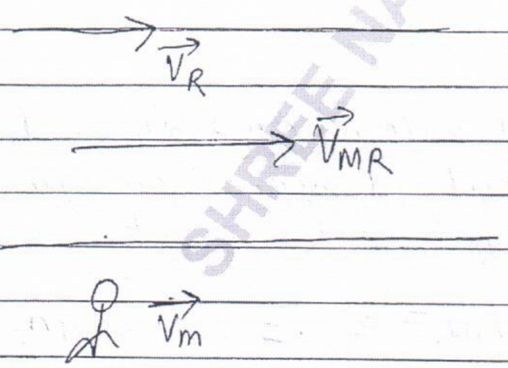
River Boat Problems :-

V_R = speed of river flow

V_{MR} = speed of Man in still water or w.r.t still water

V_m = speed of man in river w.r.t ground.

(1) Swimming in downstream along the river flow



$\vec{V_{MR}} = \vec{V_M} - \vec{V_R}$

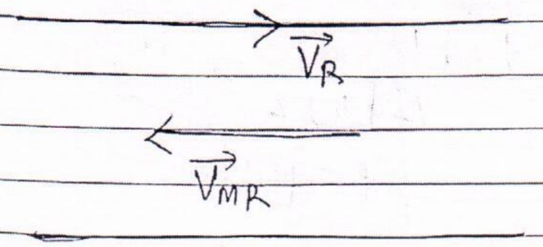
$\vec{V_M} = \vec{V_{MR}} + \vec{V_R}$

$\vec{V_m} = V_{MR}\,\hat{i} + V_R\,\hat{i}$

$\vec{V_m} = (V_{MR} + V_R)\,\hat{i}$

$\boxed{|\vec{V_m}| = V_{MR} + V_R}$

② Swimming upstream opposite to flow



$\vec{V_{MR}} = \vec{V_M} - \vec{V_R}$

$\vec{V_M} = \vec{V_{MR}} + \vec{V_R}$

$= -V_{MR}\,\hat{i} + V_R\,\hat{i}$

$= (V_R - V_{MR})\,\hat{i}$

$= (V_{MR} - V_R)(-\hat{i})$

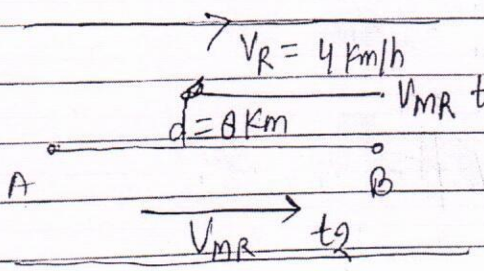
$$\boxed{|\vec{V_M}| = V_{MR} - V_R}$$

① $V_{MR} > V_R$
man seems to be moving upstream w.r.t ground

② $V_{MR} = V_R$
man at rest w.r.t ground

③ $V_{MR} < V_R$
man seems to be moving downstream w.r.t ground.

Q. A boat takes 2 hr to go 8 km & come back in still water. A water starts moving with speed 4 km/hr. Then f/o time taken to go 8 km upstream and Return back.



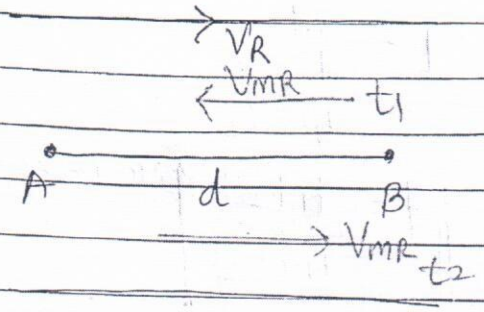
$V_{MR} = \frac{8+8}{2} = \frac{16}{2} = 8$ Km/h

upstream $V_{MR} - V_R = \frac{8}{t_1}$

downstream $V_{MR} + V_R = \frac{8}{t_2}$

$t_1 = 2$ hrs $\quad t_2 = \frac{2}{3}$ hrs $\quad t_{total} = \frac{8}{3}$ hrs Ans.

Q. A boat is moving in a river b/w two fixed point A & B. It takes time t_1 when going in upstream & time t_2 in going in downstream. Then what time it will take to travell in still water.



upstream $V_{mR} - V_R = \frac{d}{t_1}$

downstream $V_{mR} + V_R = \frac{d}{t_2}$

add

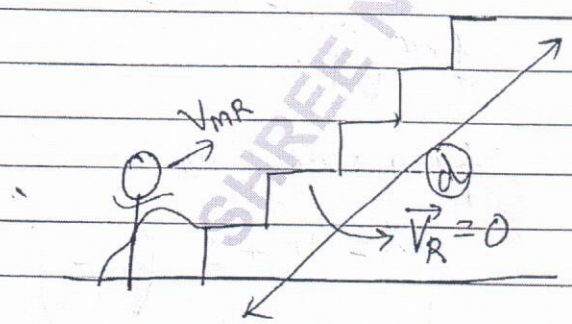
$$2V_{mR} = d\left(\frac{1}{t_1} + \frac{1}{t_2}\right)$$

$$V_{mR} = \frac{d}{2}\left(\frac{1}{t_1} + \frac{1}{t_2}\right)$$

in still water,

$$t = \frac{d}{V_{mR}} \qquad \boxed{t = \frac{2t_1 t_2}{t_1 + t_2}}$$

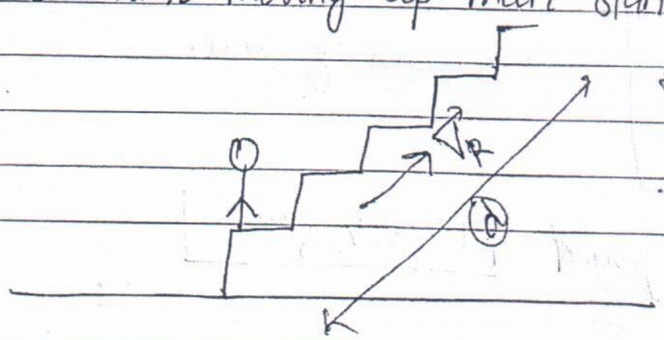
① Escalator at rest, man running up.



$$\boxed{t_1 = \frac{d}{V_{mR}}}$$

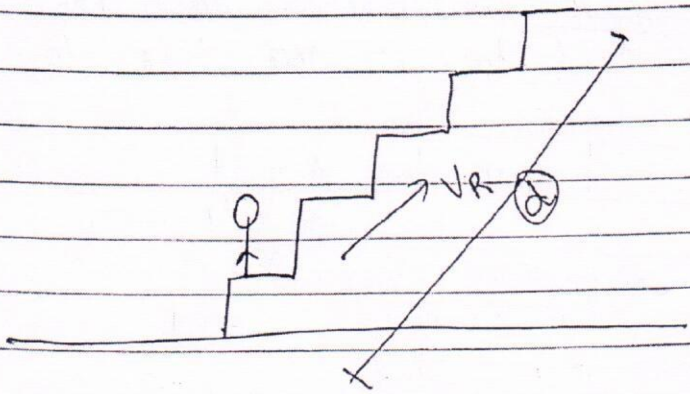
$V_{mR} \rightarrow$ Speed of man relative to escalator.

② Escalator moving up man standing on it.



$$\boxed{t_2 = \frac{d}{V_R}}$$

③ Both moving up, time for same distance.



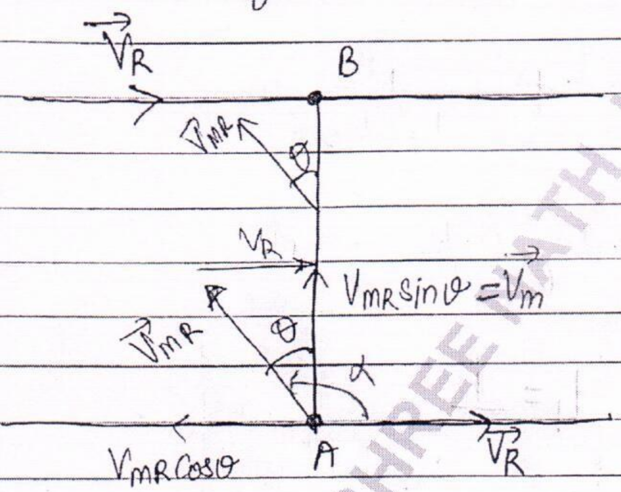
$$t = \frac{d}{V_{mR} + V_R}$$

$$t = \frac{d}{\frac{d}{t_1} + \frac{d}{t_2}}$$

$$\boxed{t = \frac{t_1 t_2}{t_1 + t_2}}$$ Neet-2017

* Crossing the river *

Case-I Along shortest path



$V_{mR}\sin\theta = V_R$

$\sin\theta = \frac{V_R}{V_{mR}}$

$\theta = \sin^{-1}\left(\frac{V_R}{V_{mR}}\right)$ from shortest path.

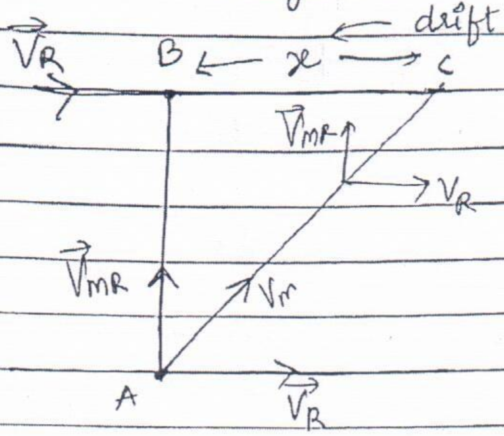
from river flow,

$$\boxed{\alpha = 90° + \sin^{-1}\left(\frac{V_R}{V_{mR}}\right)}$$

$$\boxed{t = \frac{d}{V_{mR}\cos\theta} = \frac{d}{\sqrt{V_{mR}^2 - V_R^2}}}$$ $d \rightarrow$ width of river.

speed of man w.r.t ground $\boxed{V_m = V_{mR}\cos\theta}$

Case-II Crossing the river in min^m time. (t_{min})



$$\downarrow t = \frac{d}{(V_{mR}\cos\theta)\uparrow}$$

max value $\cos\theta = +1$

$$\boxed{\theta = 0}$$

Should swim $\perp$ to river flow or along shortest path.

$$\boxed{t_{min} = \frac{d}{V_{mR}}}$$

Drift

$$x = V_R \times t_{min}$$

$$\boxed{x = V_R \times \frac{d}{V_{mR}}}$$

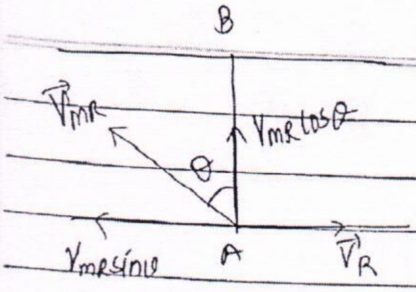
speed of man w.r.t ground,

$$\vec{V_m} = \vec{V_{mR}} + \vec{V_R}$$

$$|\vec{V_m}| = \sqrt{V_{mR}^2 + V_R^2}$$

Que. A river of width 1 km is flowing with speed 1 km/hr. A man can swim in still water with speed 2 km/hr. if he wants to cross the river along the shortest path. find

1. dirfn of swimming
2. time taken to cross river.
3. speed of man w.r.t ground.



① $2\sin\theta = 1$

$\sin\theta = \frac{1}{2}$

$\theta = 30^\circ$

from river flow

$\alpha = 90 + 30$

$\alpha = 120^\circ$

② $t = \frac{d}{V_{mR}\cos\theta}$

$= \frac{1}{2\frac{\sqrt{3}}{2}}$

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

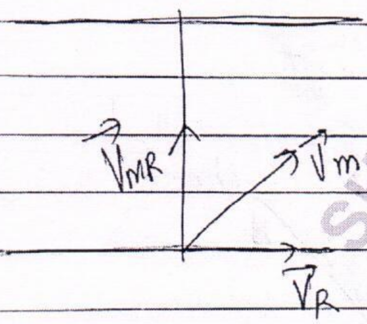
③ $\vec{V_m} = V_{mR}\cos\theta$

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

$= \sqrt{3}\ kmh^{-1}$

Q. A river of width 100m is flowing with speed 10 m/s. A man can swim in still water with speed 5 m/s. He wants to cross the river in min^m time. f/o

① time to cross
② Drift
③ speed of Man w.r.t ground.



① $t = \frac{d}{V_{mR}} = \frac{100}{5} = 20$ sec

② drift $= x = V_R \times t_{min}$

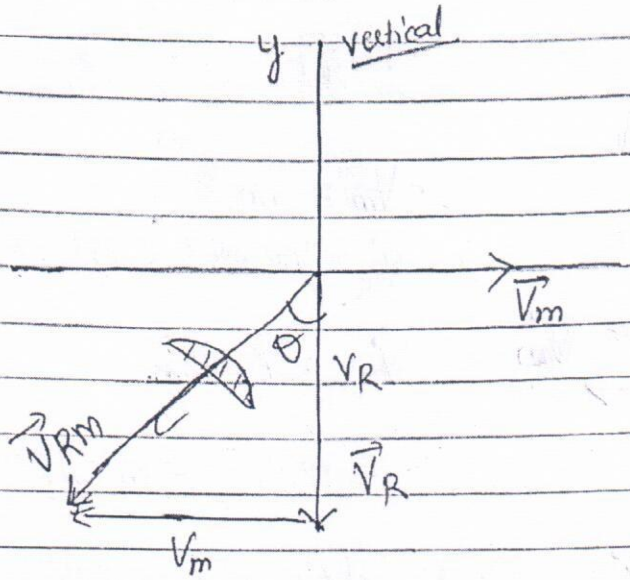
$= 10 \times 20$

$= 200\ m$

③ $|\vec{V_m}| = \sqrt{V_{mR}^2 + V_R^2} = \sqrt{5^2 + 10^2}$

$= 5\sqrt{5}$ m/s.

Rain-Man Problem: Case-I Rain is falling vertically down & Man is running on ground.



$$\vec{V}_m = V_m \hat{i}$$

$$\vec{V}_R = -V_R \hat{j}$$

$$\vec{V}_{RM} = \vec{V}_R - \vec{V}_m$$

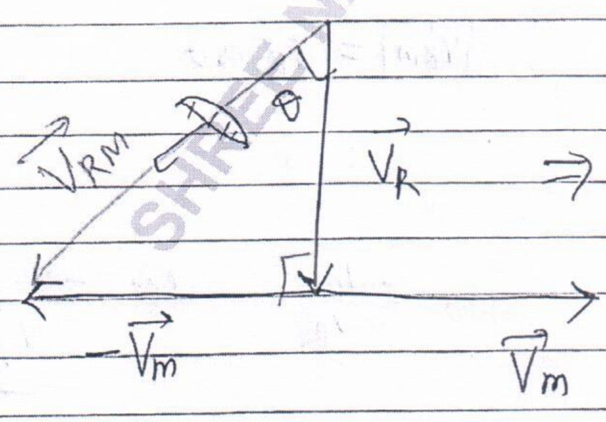
$$\vec{V}_{RM} = -V_R \hat{j} - V_m \hat{i}$$

$$|\vec{V}_{RM}| = \sqrt{V_R^2 + V_m^2}$$

dirtn, $\tan\theta = \dfrac{V_m}{V_R}$

$$\theta = \tan^{-1}\left(\frac{V_m}{V_R}\right)$$

Method-2



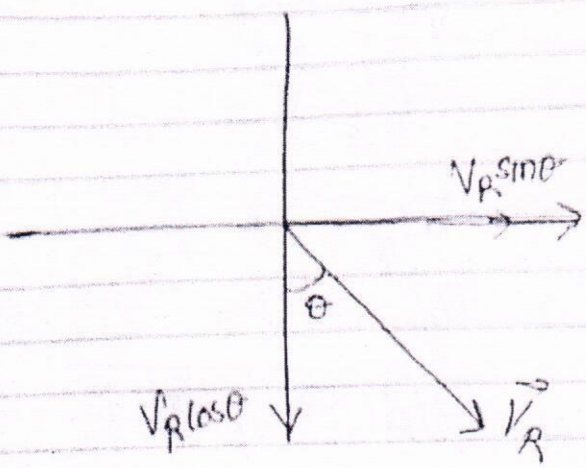
$$\Rightarrow \vec{V}_{RM} = \vec{V}_R + (-\vec{V}_m)$$

$$|\vec{V}_{RM}| = \sqrt{V_m^2 + V_R^2}$$

$$\tan\theta = \frac{V_m}{V_R}$$

⊥ Δ's

Case-II : Rain is falling at an angle 'θ' and man running on ground observer that Rain is falling vertically down.
appears



$\vec{V}_m = V_m \hat{i}$

$\vec{V}_R = V_R \sin\theta\, \hat{i} - V_R \cos\theta\, \hat{j}$

$\vec{V}_{Rm} = \vec{V}_R - \vec{V}_m$

$= V_R \sin\theta\, \hat{i} - V_R \cos\theta\, \hat{j} - V_m \hat{i}$

$\vec{V}_{Rm} = (V_R \sin\theta - V_m)\hat{i} - V_R \cos\theta\, \hat{j}$

Rain appear to fall vertically down

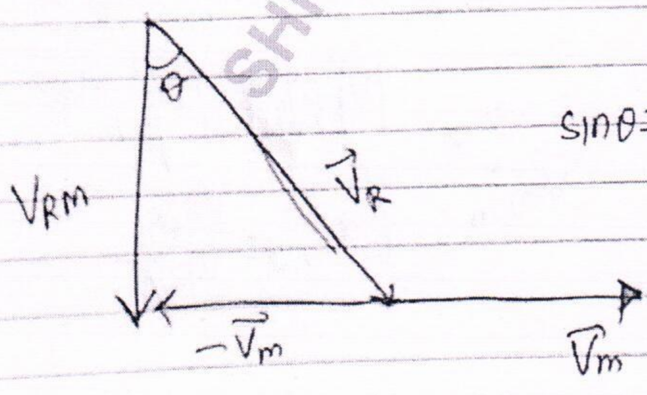
$\Rightarrow V_R \sin\theta - V_m = 0$

$\sin\theta = \dfrac{V_m}{V_R}$

$\Rightarrow \vec{V}_{Rm} = -V_R \cos\theta\, \hat{j}$

$|\vec{V}_{Rm}| = V_R \cos\theta$

Method-2

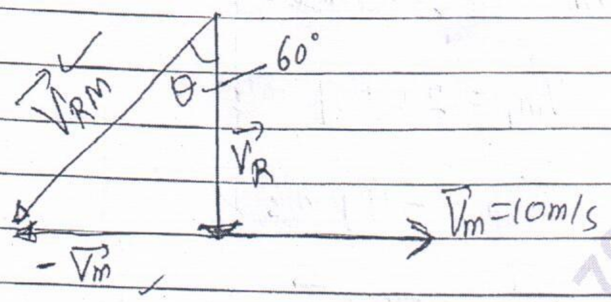


$\sin\theta = \dfrac{V_m}{V_R}$, $\cos\theta = \dfrac{V_{RM}}{V_R}$

Q①Rain drops falling vertically, a man running on ground with speed 10 m/s observes that rain drops are falling at an angle 60° from vertical. Find

(i) Speed of Rain w.r.t ground.

(ii) Speed of Rain Relative to Man.



$\tan 60 = \frac{P}{B} = \frac{10}{V_R} = \sqrt{3}$

$\boxed{\vec{V}_R = \frac{10}{\sqrt{3}}}$ m/s

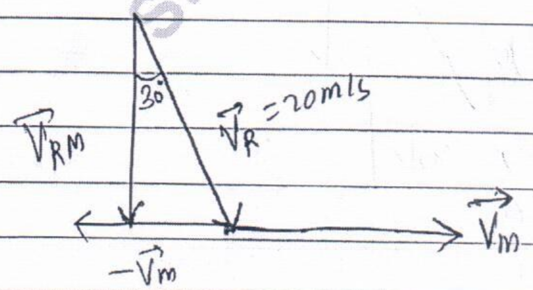
$\sin 60 = \frac{10}{V_{RM}}$

$\frac{\sqrt{3}}{2} = \frac{10}{V_{RM}}$ $\quad \vec{V}_{RM} = \frac{20}{\sqrt{3}}$

Q② Rain is falling at an angle 30° from vertical with speed 20 m/s. A man running on ground observe that rain is hitting vertically down find

(i) Speed of man

(ii) speed of rain w.r.t man.



$\sin 30 = \frac{\vec{V}_m}{20}$

$\frac{1}{2} = \frac{\vec{V}_m}{20}$ $\quad \vec{V}_m = 10$

$\tan 30 = \frac{10}{V_{RM}}$

$\frac{1}{\sqrt{3}} = \frac{10}{\vec{V}_{RM}}$

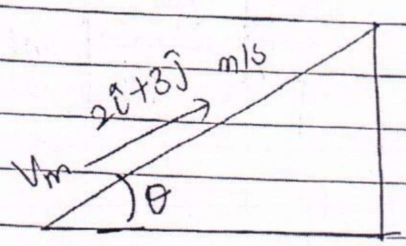
$V_{RM} = 10\sqrt{3}$

R.B.

Q1 A man run on a hill with speed $2\hat{i}+3\hat{j}$ m/s He obseves that run is falling vertically down with speed 4m/sec.
Now the man moving down with same speed then find.

(1) Velocity of Rain w.r.t ground

(2) " " " " man in 2nd case.



$$\vec{V}_{m_1} = 2\hat{i}+3\hat{j} \text{ m/s}$$

$$\vec{V}_{RM} = -4\hat{j} \text{ m/s}$$

$$\vec{V}_{RM_1} = \vec{V}_R - \vec{V}_{m_1}$$

$$\vec{V}_R = \vec{V}_{RM_1} + \vec{V}_{m_1}$$

$$= -4\hat{j} + 2\hat{i} + 3\hat{j}$$

actual $\rightarrow$ $\vec{V}_R = 2\hat{i} - \hat{j}$ m/s

case-(II)

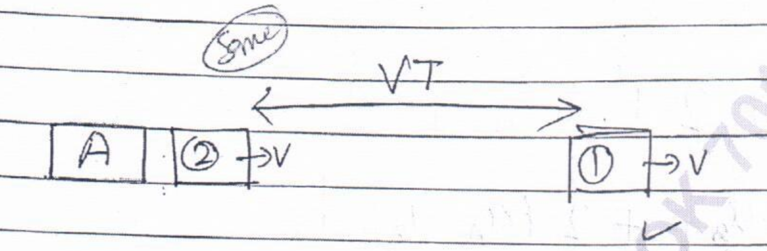
$$\vec{V}_{m_2} = -(2\hat{i}+3\hat{j}) \text{ m/s}$$

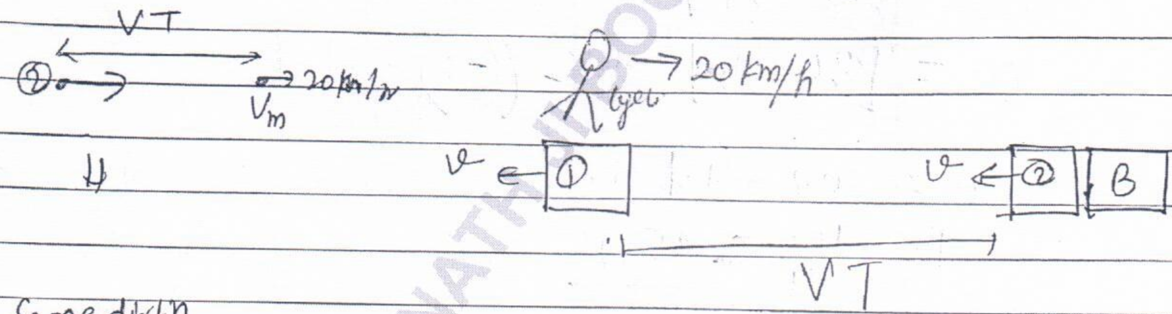
$$\vec{V}_{RM_2} = \vec{V}_R - \vec{V}_{m_2}$$

$$= 2\hat{i} - \hat{j} + 2\hat{i} + 3\hat{j}$$

$$= \underline{4\hat{i} + 2\hat{j} \text{ m/s}}$$

Q: Two towns A & B are connected By regular Bus services. with a Bus leaving either dir^n in every 't' minutes. A man cycling with speed of 20 km/hr in the dir^n of A to B, noticed that a bus goes passed him every 18 minutes in the dir^n of its motion and every 6 minutes in the opposite dir^n. what is the value of interval T and speed of Buses.





Same dir^n

$$V - 20 = \frac{VT}{18} \quad ①$$

opp dir^n

$$V + 20 = \frac{VT}{6} \quad ①$$

① ÷ ①

$$\frac{V-20}{V+20} = \frac{6}{18} = \frac{1}{3}$$

$$3V - 60 = V + 20$$

$$2V = 80$$

$$V = 40\ km/hr$$

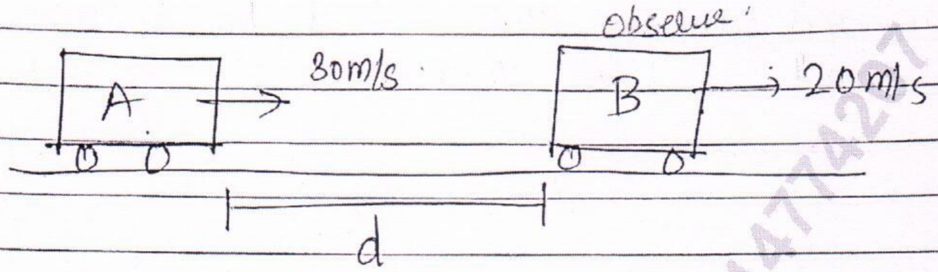
eq ① $\quad 40 + 20 = \frac{40T}{6}$

$$T = 9\ min$$

if final Relative velocity is zero ⇒ No collision.

⇒

Q. Two cars A & B are moving on straight line with speed 30 m/s & 20 m/s. B is ahead. When separation b/w them 'd', driver of A decide to apply break and produced Retardation of $2\ m/s^2$. What should be the value of 'd' to avoid accident.



$$V_{rel}^2 = u_{rel}^2 + 2\vec{a}_{rel}\vec{S}_{rel}$$

$$0 = [\vec{u}_A - \vec{u}_B]^2 + 2(\vec{a}_A - \vec{a}_B)\,d$$

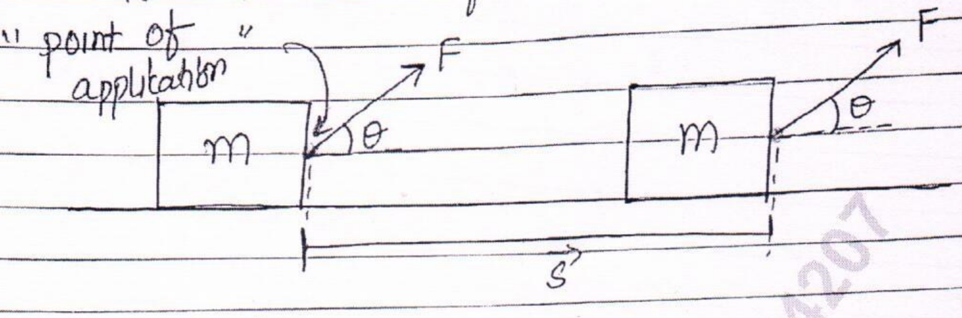
$$0 = [30 - 20]^2 + 2((-2) - 0)\,d$$

$$0 = 100 - 4d$$

$$d = \frac{100}{4} = \underline{25\,m}$$

Work, Energy & Power (WEP)

Work: Product of Force and displacement of "point of application" in dirⁿ of Force.



Work by Const Force

$W = F \times S\cos\theta$

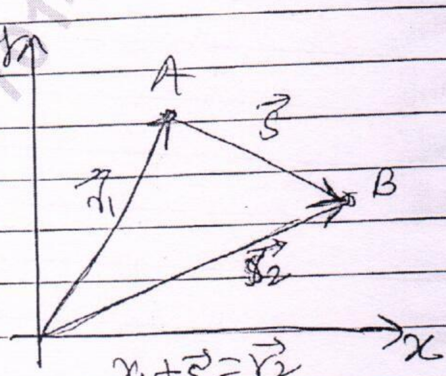
$W = F\cos\theta \times S$

$W = FS\cos\theta$

$\boxed{W = \vec{F}\cdot\vec{S}}$

$\boxed{W = \vec{F}\cdot(\vec{r}_2 - \vec{r}_1)}$

Work — position vector



$r_1 + \vec{s} = \vec{r}_2$

$\vec{s} = \vec{r}_2 - \vec{r}_1$

displacement.

Scalar,

unit. $\frac{kg\,m}{s^2}\,m = kg\frac{m^2}{s^2}$ $[ML^2T^{-2}]$

SI = Joule

$1J = 10^7$ erg

$10^{-7}J = 1$ erg

C.G.S

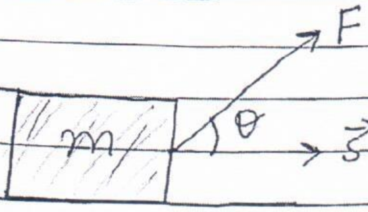
$gm\,cm^2/s^2$

erg

$1eV = 1.6 \times 10^{-19} J$

$1cal = 4.2 J$ $1kWh = 3.6 \times 10^6 J$

① positive work:

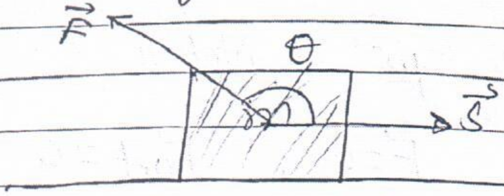


$0^\circ \leq \theta < 90^\circ$

$W = +ve$

KE of Body ↑↑s

② Negative work:

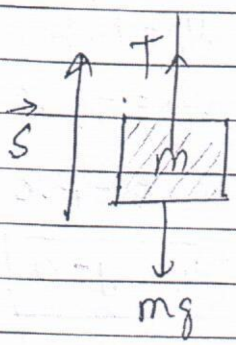


$90^\circ < \theta \leq 180^\circ$

$W = -ve$

KE ↓↓

⊛



$W_T = T \times S \times \cos 0^\circ$

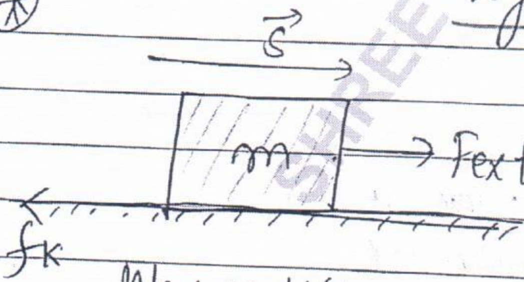
$\underline{W_T = +ve}$

$W_g = mg \times S \times \cos 180$

$= -mg \cdot s$

$\underline{W_g = -ve}$

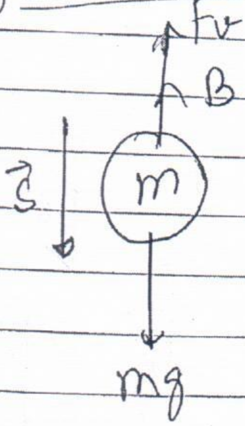
⊛



$W_{ext} = +ve$

$W_{friction} = -ve$

⊛ Stoke's law



$W_g = +ve$

$W_{F_b} = -ve$

$W_{F_V} = -ve$

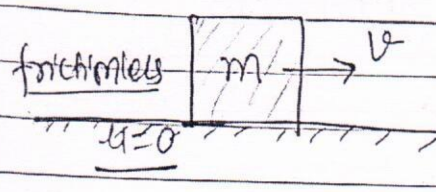
$\underline{B = V_i \rho_L g}$

③ Zero work, $W = FS\cos\theta$

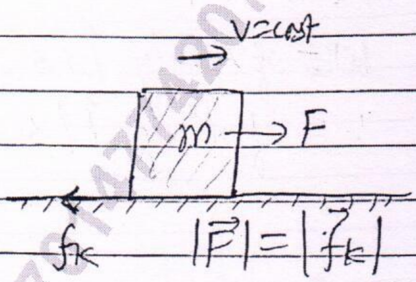
ⓐ Eqb^m of Motion

$\vec{F} = 0$, $\vec{F}_{net} = 0$

$\vec{v}$ const



$\vec{s} \neq 0$
$F = 0$
$W = 0$



$|\vec{F}| = |\vec{f_k}|$

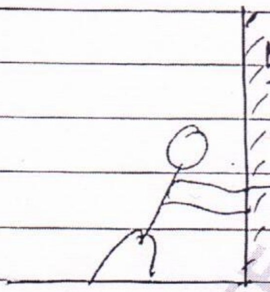
$W_F = Fx$

$W_f = -fx$

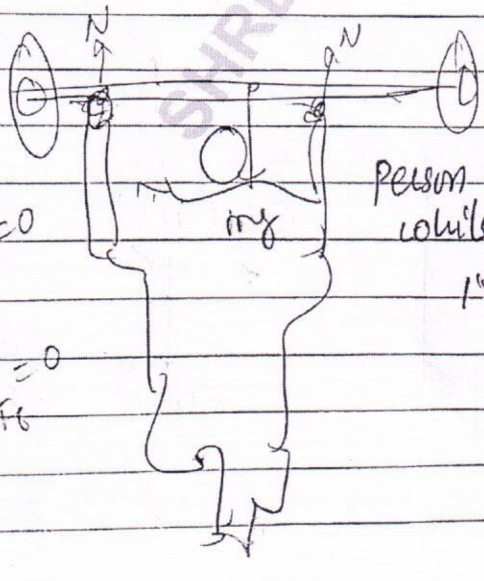
$W_f = -Fx$

$\boxed{W_{total} = 0}$

ⓑ



$F \neq 0$
$\vec{s} = 0$
$W = 0$



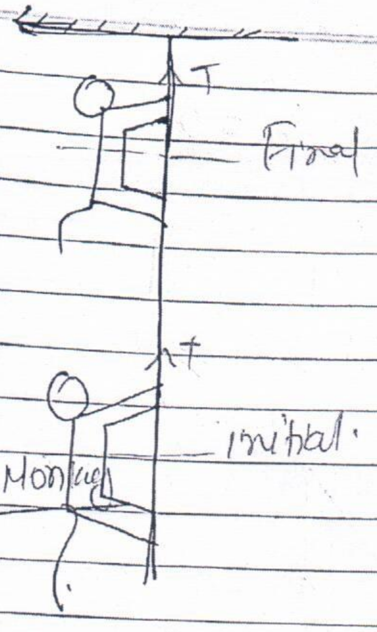
$\vec{s} = 0$

$W_{F_G} = 0$

person hold wt for a while no movement in its duration

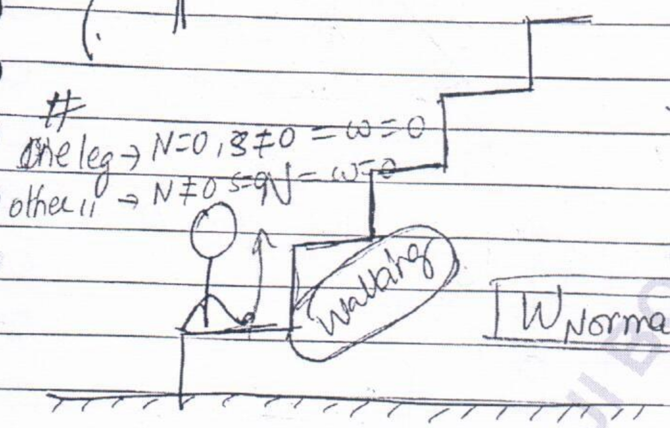
$W_{F_i} = 0$

One hand ⇒ $T \neq 0$, $\vec{S} = 0 \Rightarrow W = 0$
other 〃 ⇒ $T = 0$, $S \neq 0 \Rightarrow W = 0$



⊗ while climbing the force ~~on the~~ which ~~hand~~ on hand which have no displacement.
&
the hand have displacement have no Force.

one leg → $N = 0, S \neq 0 \Rightarrow W = 0$
other 〃 → $N \neq 0$, $S = 0 \Rightarrow W = 0$



$\boxed{W_{Normal} = 0}$

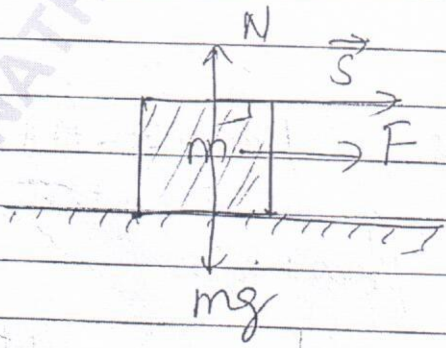
* legs which have Normal Force have no displacement
&
legs which have displacement have no Normal force.

⓪ $W = FS\cos\theta$

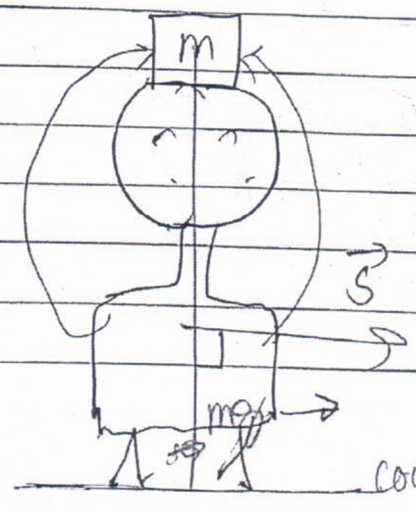
$\cos\theta = 0$

$\theta = 90$

$\vec{F} \perp \vec{S}$

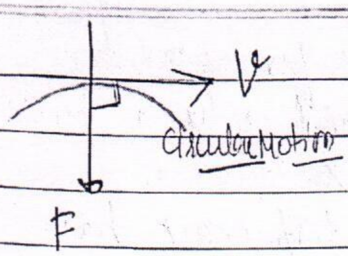


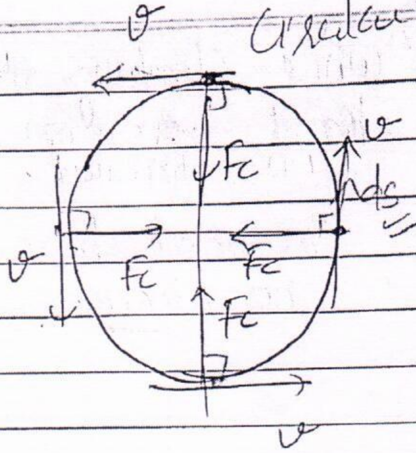
$\left.\begin{array}{l} W_N = 0 \\ W_{mg} = 0 \end{array}\right\} \theta = 90^\circ$



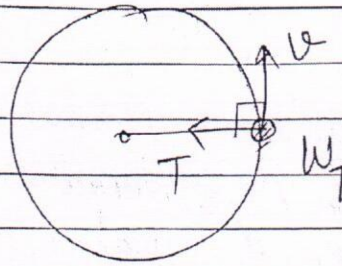
$\boxed{W_g = 0}$

Circular Motion

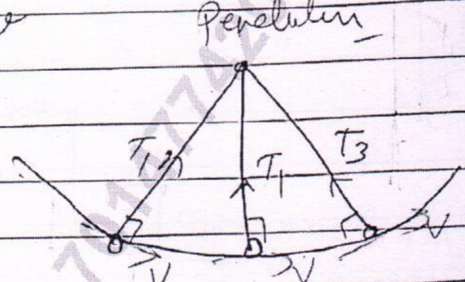




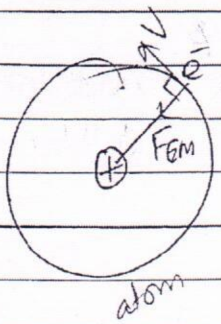
$W_{F_c} = 0$



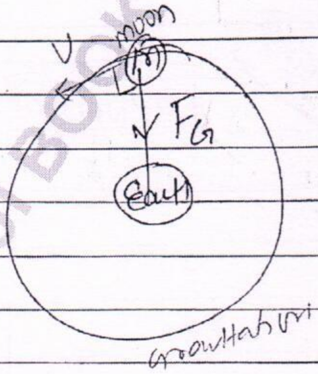
$W_T = 0$



$W_T = 0$



$W_{EM} = 0$

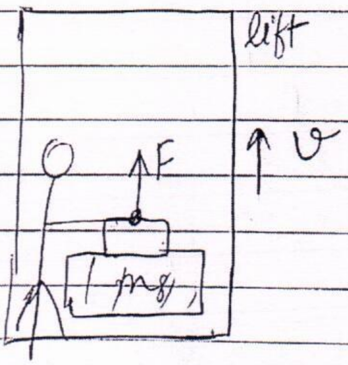


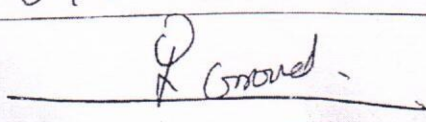
$W_{F_G} = 0$

(X) Work depends on frame of Reference, because $\vec{S}$ depends on frame of Refer. while 'Force' is independent on frame.

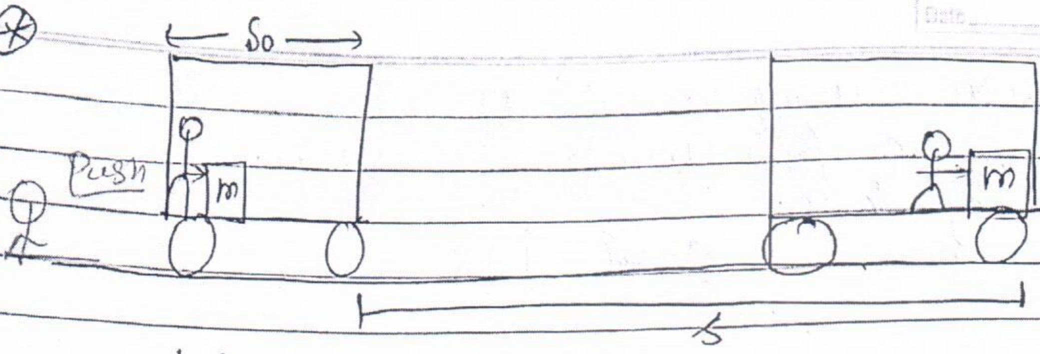
Ex:- lift frame,
$W_F = 0$
$\vec{S} = 0$

ground frame, $W_F \neq 0$
$\vec{S} \neq 0$





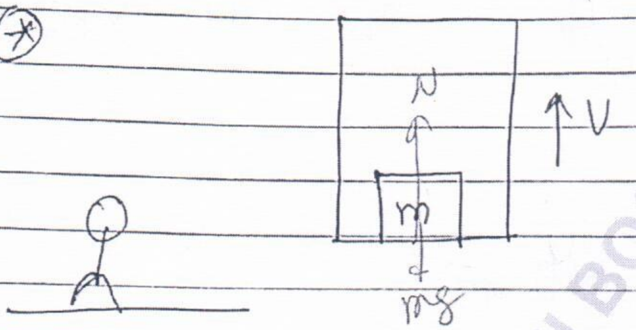
(*)



ground frame, $w = F(s + s_0)$

Car frame, $w_{car} = F \times s_0$

(*)



<u>lift frame</u>

$w_N = 0 \quad \vec{S} = 0$

$w_N \neq 0$

ground.

Que. A Force $\vec{F} = (3\hat{i} - 2\hat{j} + \hat{k})N$ displaces a particle from position $(3,2,1)m$ to $(1,-1,2)m$. Find W.D by force.

$\vec{r}_2 = \hat{i} - \hat{j} + 2\hat{k}$

$\vec{r}_1 = 3\hat{i} + 2\hat{j} + \hat{k}$

$\vec{S} = \vec{r}_2 - \vec{r}_1$

$= -2\hat{i} - 3\hat{j} + \hat{k}$

$w = \vec{F} \cdot \vec{S} = (3\hat{i} - 2\hat{j} + \hat{k}) \cdot (-2\hat{i} - 3\hat{j} + \hat{k})$

$= 1J$

JEE Mains

Q. A Force 20N is acting in dir^n of $(6\hat{i}+8\hat{j})$ this force displaces a particle from $(1,2,0)$ m to $(2,-1,1)$ m. Find W.D by force.

Soln → $\vec{S} = \hat{i} - 3\hat{j} + \hat{k}$

$F = 20$ N

$6\hat{i}+8\hat{j}$

$\vec{F} = |\vec{F}|\hat{F}$

unit vector in the dir^n of vector

$\hat{r} = \frac{\vec{r}}{|\vec{r}|} = \frac{6\hat{i}+8\hat{j}}{10}$ unit vector.

$\vec{F} = 20\left(\frac{6\hat{i}+8\hat{j}}{10}\right)$

$\vec{F} = 12\hat{i} + 16\hat{j}$

$W = \vec{F}\cdot\vec{S} = 12 - 48 = -36J$ Ans

$-36J$

Que.

In the given fig, Body starts from rest, find workdone by following Forces in 4 sec.

(i) 50N

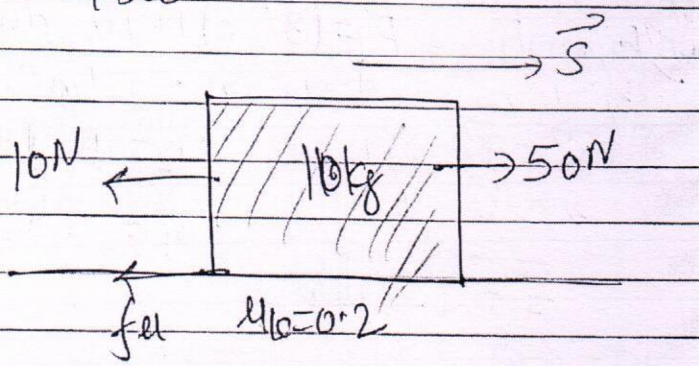
(ii) ~~20N~~ 10N

(iii) friction force

(iv) Normal Force

(v) Gravity Force

(vi) Total workdone (W.D by Fnet)



$f_k = \mu N = 0.2 \times 100 = \underline{20\,N}$

$a = \dfrac{50-20-10}{10} = 2\,m/s^2$

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

$= \frac{1}{2} \times 2 \times 16$

$\underline{\vec{s} = 16m\,\hat{i}}$

① $W_{50N} = 50 \times 16 \cos 0^\circ = 800J$

② $W_{10N} = -10 \times 16 \quad \cancel{= 320J} = -160J$

③ $W_{friction} = -20 \times 16 = -320J$

④ $W_N = 0 \quad \theta = 90^\circ \quad N \perp \vec{s}$

⑤ $W_g = 0 \quad " \quad w \perp \vec{s}$

⑥ $W_{total} = 800 - 160 - 320 = \underline{320J}$

Q. A block of mass 10kg is pulled upward with the help of a light string with accl^n 2.5 m/s^2 up to height 4m. Find W.D by following Forces on the block.

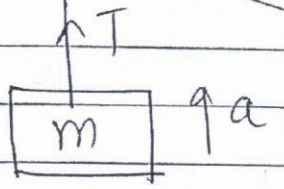
(i) Tension Force → $W_T = 125 \times 4 = 500J$

(ii) gravity Force → $W_g = -mgh = -10 \times 10 \times 4$

$= -400J$

(iii) Total work. → $W_{net} = 500 - 400$

$= \underline{100J}$

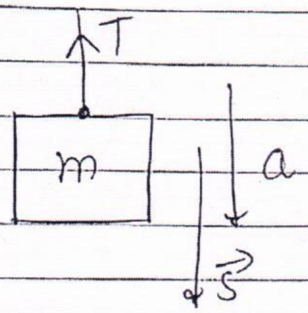


$T = m(g+a)$

$T = 10(10 + 2.5) = \underline{125N}$

Que. A block of mass 'm' is lowered with accⁿ g/3 with the help of a light string up to depth 'd'. Find W.D by following Force.

(1) Tension Force
(2) Gravity "
(3) Net work done.



$T = m(g-a)$

$T = m\left(g - \frac{g}{3}\right)$

$T = \frac{2mg}{3}$

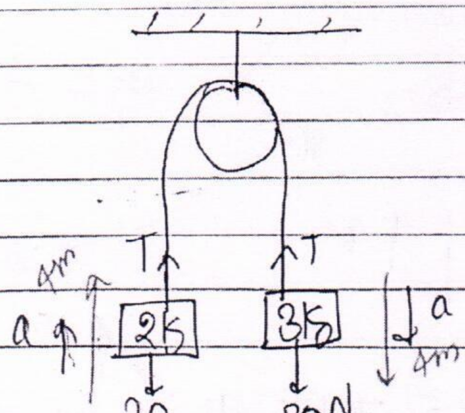
(1) $W_T = -\frac{2mg}{3} \times d = -\frac{2}{3}mgd$

(2) $W_{gravity} = mg \times d$

(3) $W_{net} = -\frac{2}{3}mgd + mgd = \frac{mgd}{3}$

Que. In the given fig, Pulley is massless & frictionless when the blocks are released from rest. find W.D by following forces on Blocks 3kg & 2kg in First 2 seconds

(1) Tension Force
(2) Gravity Force
(3) Total Workdone.



$a = \frac{30-20}{5}$

$= \frac{10}{5} = 2\,m/s^2$

$T - 20 = 2 \times 2$

$T = 24\,N$

$S = \frac{1}{2} \times a \times t^2 = \frac{1}{\cancel{2}} \times 2 \times 4 = \underline{4m}$

(1) $W_{T(2kg)} = 24 \times 4 = 96J \Rightarrow$ W_{net} by Tension $= 0$

$W_{T(3kg)} = -24 \times 4 = -96J$

$\cancel{T_1 x_1 = T_2 x_2}$

$T_1 x_1 - T_2 x_2 = 0$

(2) $W_{g(2kg)} = -mgh = -2 \times 10 \times 4 = -80J$

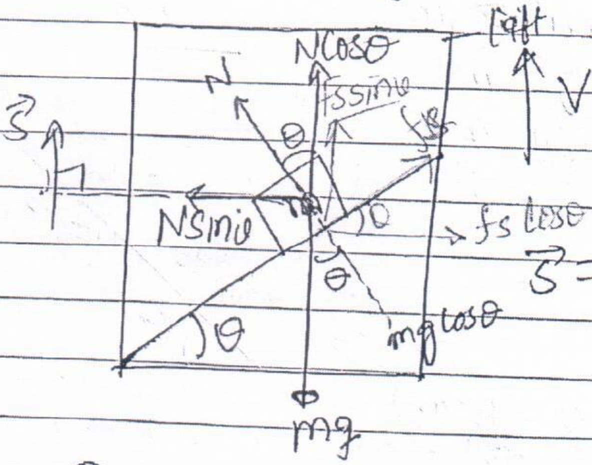
$W_{g(3kg)} = mgh = 3 \times 10 \times 4 = 120J$

(3) $W_{net} = \underline{40J}$

$\because$ Here, W.D By Tension on the system is "Zero" and it is -internal Force-.

Que. In the given, Fig Block is resting on rough Inclined Plane which is resting on floor of lift. Now lift starts ascending with speed 'V'. Find W.D by following Forces in time 't' w.r.t ground"

(1) Gravity Force
(2) Normal Force
(3) Friction Force



$\vec{S} = V \times t$

(1) $W_g = -mg(vt)$
$= -mgvt$

(2) $W_N = +N\cos\theta \times vt$
$= mg\cos\theta \times \cos\theta \times vt$
$= mg\cos^2\theta\, vt$

(3) $W_{friction} = +f_s \sin\theta \times vt$

Block rest
$= mg\sin\theta \times \sin\theta \times vt$

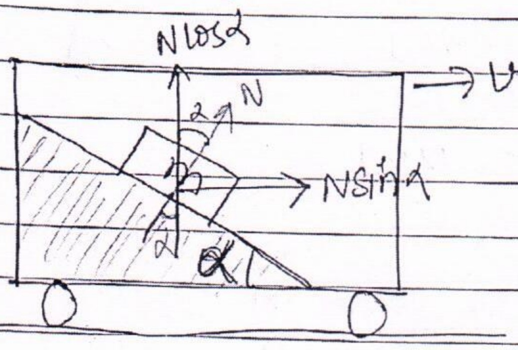
$\star$ $\boxed{f_s = mg\sin\theta}$ $= mg\sin^2\theta\, vt$ — (3)

$W_{net} = 0$ $= V = const \Rightarrow \Delta K = 0$ $(W = 0)$

Date ______ Page ______

Que A Cart is moving with speed 'V' which contains an inclined plane of Inclination 'α' on which a block is placed. (α less than angle of Repose)
f/o W.D by Normal Rxn Force in time 't'.

$\vec{S} = V \times t$



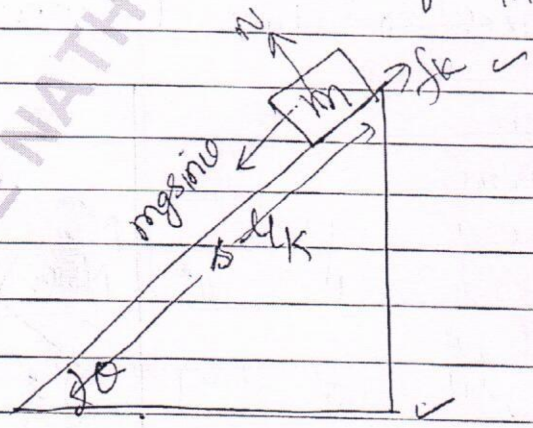
$W_N = N\sin\alpha \times vt$

$= mg\cos\alpha \sin\alpha \, vt \times \frac{2}{2}$

$$\boxed{W_N = \frac{mgvt \sin 2\alpha}{2}}$$

Q. A block is released from top of an Inclined plane. Coeff. of friction is μ_k. Find W.D by following Forces during it reaches Foot of Inclined.

(1) Normal Force
(2) gravity "
(3) friction "



① $W_N = 0$ $(\theta = 90)$

② $W_g = +mg\sin\theta \times S$ or $mg(S\sin\theta)$ ↗ F_g → conservative

③ $W_f = -f_k S = -\mu_k mg\cos\theta \times S$

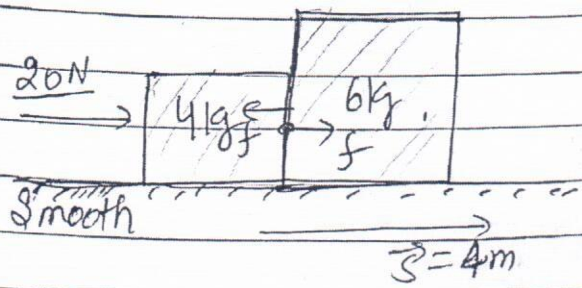
B.B-1 (1-3, 7, 9) | Race - 1, 2.

Ex-I (1)

Ex-II (13, 19)

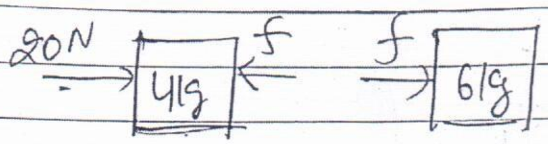
Ex-III (1)

Que. In the given Fig, Find W.D by contact Force b/w 4kg & 6kg on 6kg & 4kg in 1st 2 second.



$a = \frac{20}{10} = 2 m/s^2$

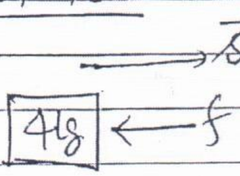
$s = \frac{1}{2} \times 2 \times (2)^2 = 4m$



$20 - f = 4 \times 2$

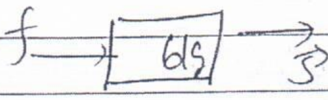
$f = 12 N$

(1) Contact Force



$W_{C_{4kg}} = -12 \times 4 = -48 J$

(2)

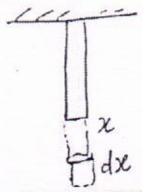


$W_{C_{6kg}} = 12 \times 4 = 48 J$

$W_{nett(f)} = 0$ (Internal Force)

$F = 50N \rightarrow$ const

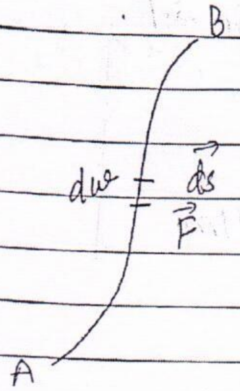
$\left.\begin{array}{l} F = 20x \\ F = 20t \\ F = 20V \end{array}\right]$ variable



$F = \frac{YAx}{l}$

$w = \int \frac{YAx}{l} dx$

Workdone By variable Force:



$dw = \vec{F} \cdot \vec{ds}$

$w = \int \vec{F} \cdot \vec{ds}$

$\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$

$\vec{ds} = dx\hat{i} + dy\hat{j} + dz\hat{k}$

$W = \int (F_x dx + F_y dy + F_z dz)$

$$\boxed{W = \int_{x_1}^{x_2} F_x dx + \int_{y_1}^{y_2} F_y dy + \int_{z_1}^{z_2} F_z dz}$$

$$\left[\begin{array}{ll} F = \text{const} & W = \vec{F} \cdot \vec{S} \\ F = \text{variable} & W = \int \vec{F} \cdot \vec{ds} \end{array}\right]^{*}$$

Q. A Force $\vec{F} = (3x^2 - 8x + 5)$ N acts on particle and displaces from ~~exp.~~ $x = 1m$ to $x = 3m$.

$$W = \int \vec{F} \vec{ds} = \left[\frac{\cancel{3}x^3}{\cancel{3}} - \frac{\cancel{8}^{4}x^2}{\cancel{2}} + 5x\right]_1^3$$

$$= (27 - 4 \times 9 + 15) - (1 - 4 + 5) = 6 - 2$$

$= 4$ Joule

Q. A Force $\vec{F} = (3x^2\hat{i} - 4y\hat{j})$ N acts on particle & displaces it from $(2,1)$m to $(3,4)$m. Find W.D

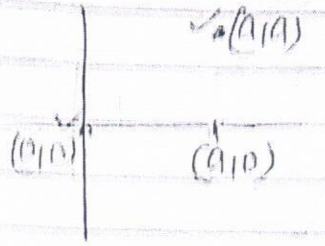
$$W = \int_2^3 3x^2 dx - \int_1^4 4y\,dy = \left[\frac{3x^3}{3}\right]_2^3 - \left[\frac{4y^2}{2}\right]_1^4$$

$= \underline{-11 \text{ Joule}}$

JEE Prime

$K \to$ const

Q. A Force $\vec{F} = Kx\hat{i} + Ky\hat{j}$ N acts on particle and it displaces it from (0,0) to (a,0) ~~in x-direction~~ ~~from~~ and (a,0) to (a,a).



$$W = \int_0^a Kx\,dx + \int_0^a Ky\,dy$$

$$= K\left[\frac{x^2}{2}\right]_0^a + K\left[\frac{y^2}{2}\right]_0^a$$

$$= K\left[\frac{a^2}{2} + \frac{a^2}{2}\right] = Ka^2$$

$$\boxed{W = Ka^2}$$

JEE Mains

Q. In Previous Que. the force acting on the particle is $F = (Ky\hat{i} + Kx\hat{j})$ N W.D?

$$W = \int_0^a Ky\,dx + \int_0^a Kx\,dy$$

$$d(xy) = x\,dy + y\,dx$$

$$= K\int_{0,0}^{a,a} (y\,dx + x\,dy)$$

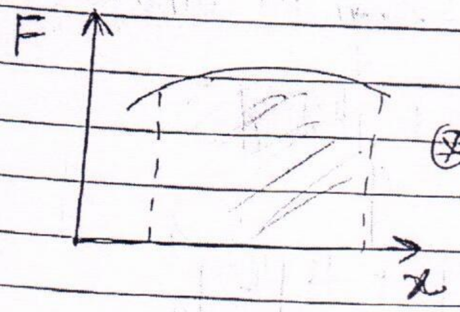
$[xy]$

$$= K\int_{0,0}^{a,a} d(xy) = K\left[xy\right]_{0,0}^{a,a}$$

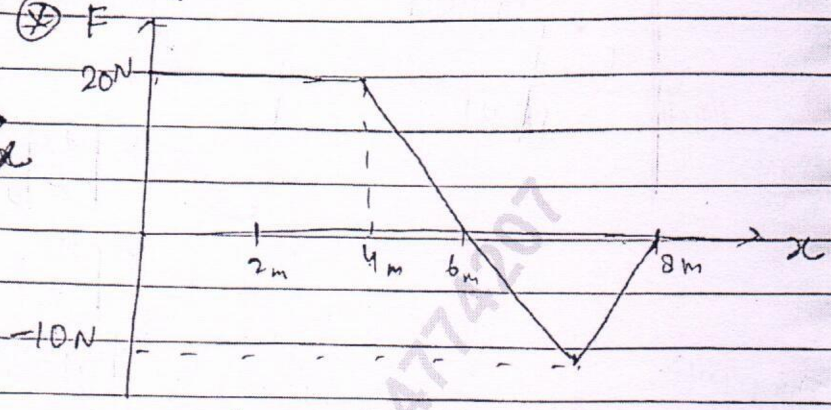
$$= K(x)_0^a\,(y)_0^a$$

$$W = Ka^2$$

Work From Force – displacement Graph :-



$W = \int F\,dx$ = Area under the F-x curve

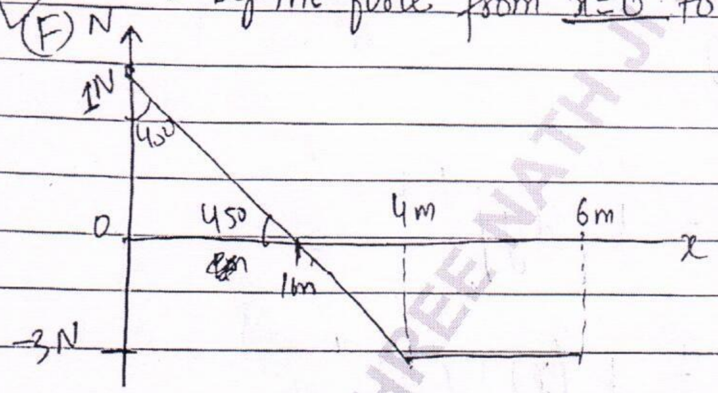


W.D from $x=0$ to $x=8m$

$W = \frac{1}{2}(4+6)\times 20 - \frac{1}{2}\times 2\times 10$

$= 100 - 10 = 90$ Joule

* Find W.D by the force from $x=0$ to $x=6m$



~~$= \frac{1}{2}\times 1\times 1 - \frac{1}{2}\times 3\times 3 - 2\times 3$~~

~~$= \frac{1}{2} - \frac{9}{2} - 6 =$~~ $-10J$

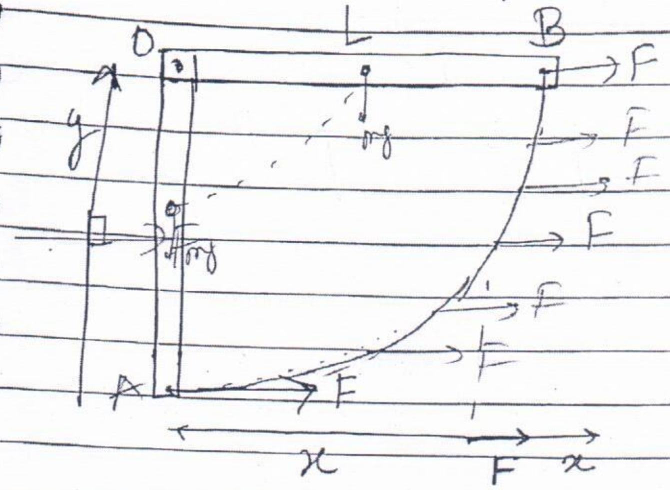
$= \frac{1}{2}\times 1\times 1 - \frac{1}{2}(5+2)\times 3$

$= \frac{1}{2} - \frac{21}{2} = -\frac{20}{2}$ $-10J$

Work

- F = const: $W = \vec{F}\cdot\vec{S}$
- F = variable: $W = \int \vec{F}\cdot d\vec{s}$
- F-s graph: Area

Q. Find W.D by const Force 'F' acting on the rod A/c to the Fig to move from A position to B position.

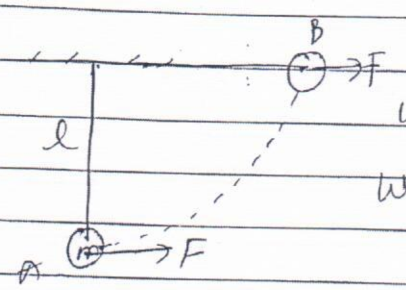


$W_x = F \times L$ $[W_y = 0]$

$W = F \times L$

$\boxed{W_{gravity} = -\frac{mgL}{2}}$

mg → act on COM



$w = F \times l$

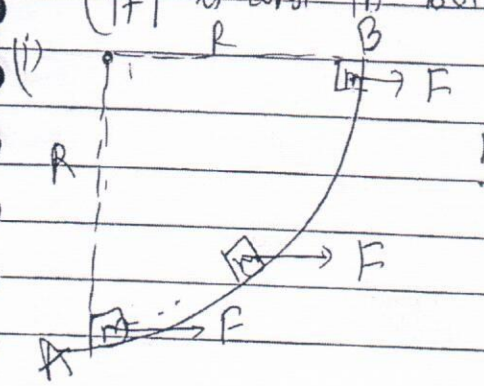
$W_g = -mgl$

Q. A block is taken by force 'F' on a smooth path of Quater Circle of Radius 'R' from position A to B. Find W.D by 'F' if

(i) 'F' is always horizontal.

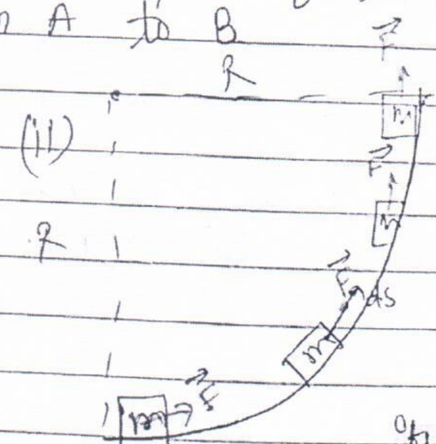
(ii) 'F' is always tangential to the path.

($|\vec{F}|$ is const in Both case)



$W = F \times R$

Rae



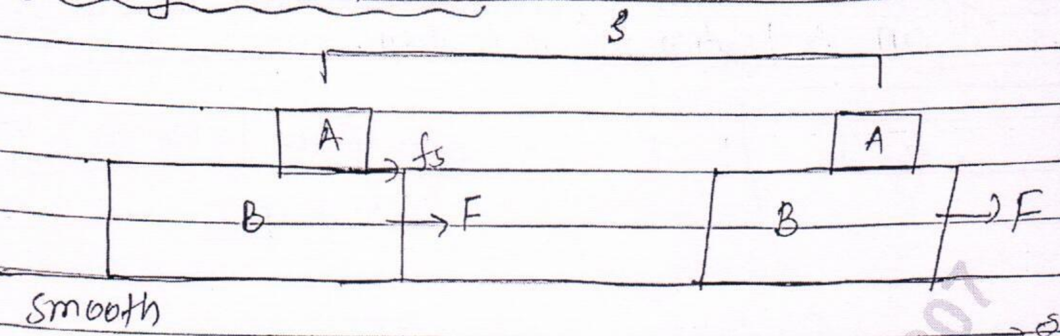
$\vec{F}$ is variable due to chang in dirn

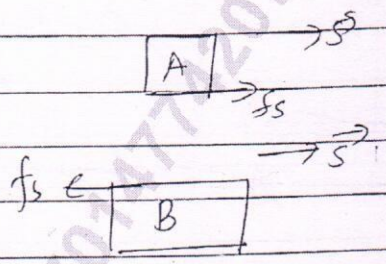
$W = \int \vec{F} \cdot d\vec{s} = \int F\, ds \cos 0°$

$= F \int ds$

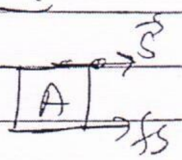
$= F \times \frac{2\pi R}{4} = \frac{F\pi R}{2}$ Joule

W.D By static Friction:

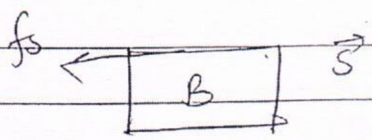




W.r.t ground

① 

$W_A = f_s \times s$

② 

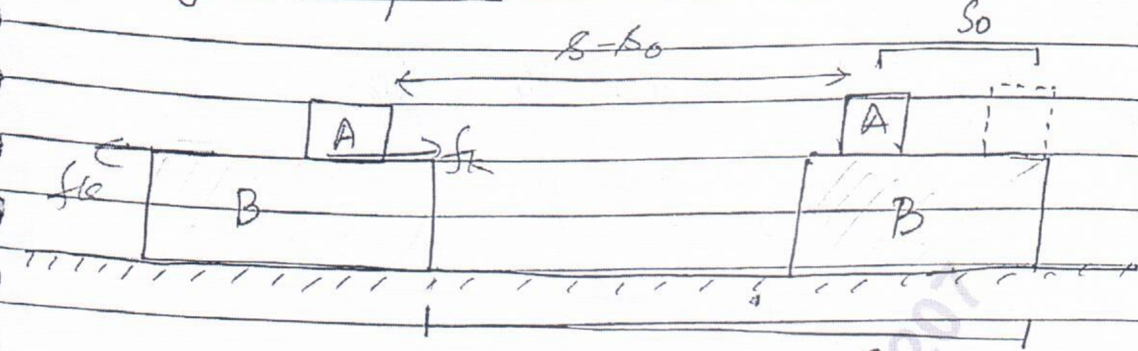
$W_B = -f_s \times s$

③ $W_{\text{Total static friction}} = f_s \times s - f_s \times s = 0$

$\Rightarrow$ f_s can do +ve, -ve work, But ~~fs~~ W.D by f_s on system is zero.

~~B.B-1 (compt (6X)~~ Race-10 (Ans-1)
~~Ex-1 (1-17 complete)~~
~~Ex-2 (Q-10,~~

W.D By Kinetic friction:



ground

① $\boxed{A}$ $W_A = f_k(s - s_0)$

② $\boxed{B}$ $W_B = -f_k \times s$

③ $W_{Total} = f_k(s - s_0) - f_k \times s$

$= \cancel{f_k s} - f_k s_0 - \cancel{f_k s}$

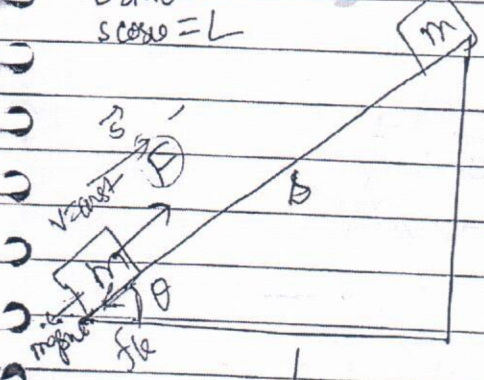
$= -f_k s_0$

Result: f_k Can do +ve work, and -ve work, But W.D on the system is -ve.

Revision

Q. Find W.D to take a block from foot of Inclined plane to the top a/c to fig., with const velocity. (μ)

$s\sin\theta = h$
$s\cos\theta = L$



$W = +(mg\sin\theta + f_k)\, s$

$= (mg\sin\theta + \mu_k mg\cos\theta)\, s$

$= mg[s\sin\theta + \mu_k s\cos\theta]$

$W = mg[h + \mu_k L]$

$F = f_k + mg\sin\theta$

Instantaneous work is meaning less. work is independent of time

Kinetic Energy

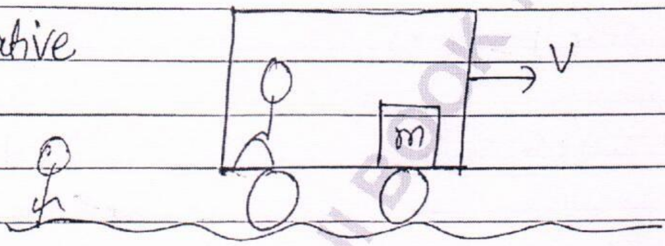
Energy possesed by particle virtue of its Motion.

$K.E = \frac{1}{2}mv^2$ $KE = \frac{1}{2}m[\vec{v}.\vec{v}]$

KE → Can never be negative
KE → is positive. it may be zero

KE depends on frame of reference

→ It is a relative quantity

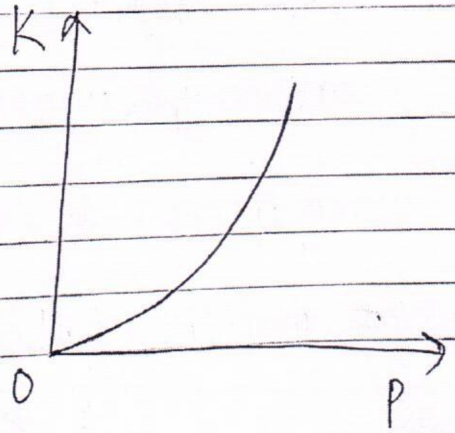


$KE_{car} = 0$ $K.E_{ground} = \frac{1}{2}mv^2$

$K = \frac{1}{2}mv^2 \times \frac{m}{m}$

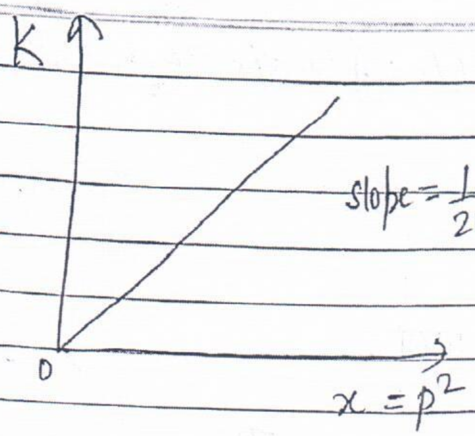
$K = \frac{1}{2}mv^2$

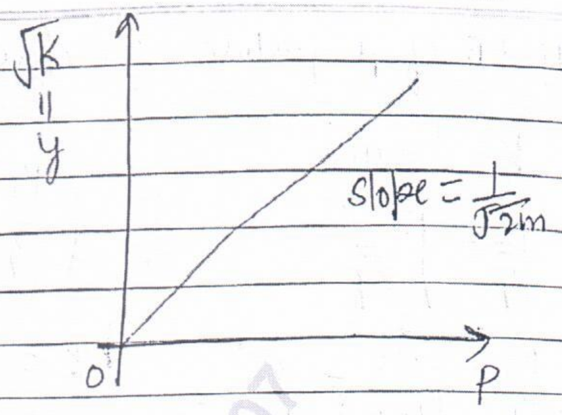
$$\boxed{K = \frac{P^2}{2m} \quad P = \sqrt{2mK}}$$



$K = \frac{P^2}{2m}$

$y = kx^2$





$K = \frac{p^2}{2m}$

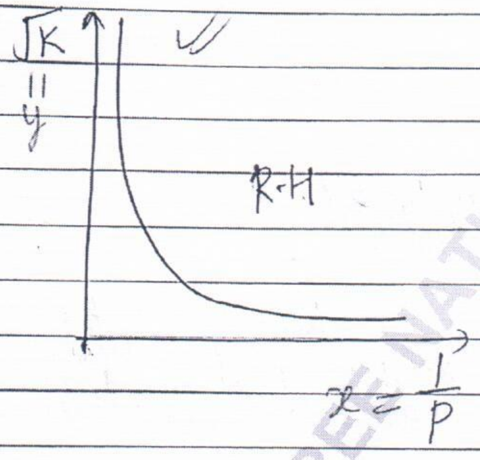
$K = \frac{x}{2m} + 0$

$y = mx + c$

$P = \sqrt{2mK}$

$P = \sqrt{2m}\, y$

$y = \frac{1}{\sqrt{2m}} P$



$K = \frac{p^2}{2m}$

$\frac{\sqrt{2mK}}{P} = 1$

$\sqrt{K}\, \frac{1}{P} = \frac{1}{\sqrt{2m}} = \text{const}$

$x \times y = \text{const}$

$y \propto \frac{1}{x}$

Que. If linear momentum of particle ↑ses 40% then f/o percentage change in its K.E.

$x\% > 5\%$

$K \propto p^2$

$\frac{K_1}{K_2} = \left(\frac{P_1}{P_2}\right)^2 = \left(\frac{100}{140}\right)^2 = \frac{25}{49}$

$= \frac{K_2 - K_1}{K_1} \times 100\%$

$= \left(\frac{K_2}{K_1} - 1\right) \times 100\%$

$= \left(\frac{49}{25} - 1\right) \times 100$

$= 96\%$ Increasing KE

Date ______ Page ______

Q. If KE of A particle is deceases by 84%. f/o % change in $\vec{P}$.

$P = \sqrt{2mK}$

$\frac{P_2}{P_1} = \sqrt{\frac{K_2}{K_1}}$ $\quad \% \frac{\Delta P}{P} = \left(\frac{P_2}{P_1} - 1\right) \times 100$

$\frac{P_2}{P_1} = \sqrt{\frac{36}{100}} = \frac{6}{10} = \frac{2}{5}$ $\quad \% \frac{\Delta P}{P} = \left(\frac{2}{5} - 1\right) \times 100$

$= \left(\frac{2-5}{5}\right) \times 100 = \frac{-3}{5} \times 100 = -60\%$

-60% decrease

Q. If KE of a particle decreases by 4%. Then f/o % change in it linear momentum.

$x\% << 5\%$

$P \propto K^{1/2}$

$\frac{\Delta P}{P} = \frac{1}{2} \frac{\Delta K}{K}$

$= \frac{1}{2} \times -4 = -2\%$ decay by 2%

Q. A man is running on Road if he ↑ses his speed by 1 m/s then his KE becomes double find his initial speed.

$K_f = 2K_i$

$\frac{1}{2} m (v+1)^2 = \frac{1}{2} m v^2 \times 2$

$v + 1 = \sqrt{2} v$

$v(\sqrt{2} - 1) = 1$

$v = \frac{1}{\sqrt{2}-1} = \frac{1}{1.4-1} = \frac{10}{0.4} = 2.5 \text{ m/s}$

$v = \frac{1}{\sqrt{2}-1} \times \frac{\sqrt{2}+1}{\sqrt{2}+1}$

$= 2.5$

Revision

Q. K.E of a man is half that of boy whose mass is half of man. If the man rises his speed by 2 m/s then their K.E becomes equal find their initial speed.

Case-I

$K_{man} = \frac{1}{2} K_{boy}$

$\frac{1}{2} m V_m^2 = \frac{1}{2} \times \frac{1}{2} \frac{M}{2} V_b^2$

$V_m = \frac{V_b}{2}$

$V_b = 2V_m$

Case-II

$K'_{man} = K_{boy}$

$\frac{1}{2} m (V_m + 2)^2 = \frac{1}{2} \frac{M}{2} V_b^2$

$V_m + 2 = \frac{V_b}{\sqrt{2}}$

$V_m + 2 = \frac{2V_m}{\sqrt{2}}$

$V_m = \frac{2}{\sqrt{2}-1}$ m/s $\simeq$ 5 m/s

$V_b = \frac{4}{\sqrt{2}-1}$ m/s $\simeq$ 10 m/s

Work Energy Theorem:

$\boxed{W = \Delta K}$

↳ IIIrd eqn of Motion (Planck's)

↳ Coren of Bun

$W_{all\ Forces} = K_f - K_i = \frac{1}{2} m [V_f^2 - V_i^2]$

work with sign convention.

$$\left[\begin{array}{l} W = Fs = \frac{1}{2} m [V_f^2 - V_i^2] \\ W = \int F\,ds = \frac{1}{2} m [V_f^2 - V_i^2] \end{array}\right]$$

Date ______ Page ______

Q. The displacement acts on a body of 2kg on a smooth horizontal surface as funtn of time is given by $x = \frac{t^3}{2}$ where $x \to m$, $t \to sec$. find W.D by external Force in 1st 2 seconds.

$x = \frac{t^3}{2}$ $\quad V = \frac{3t^2}{2}$

$V_i = 0 \quad V_f = \frac{3 \times \cancel{4}^{2}}{\cancel{2}} = 6\ m/s$

$W = \frac{1}{2} \times 2 \left[36 - 0 \right] = \underline{36\ \text{Joule}}$

B.B=6
NCERT

Q. A particle of mass 0.5 Kg travells in a straight line with velocity $V = a x^{3/2}$, where $a = 5\ m^{-1/2} s^{-1}$ f/o W.D by net Force during its displacement from $x_1 = 0$ to $x_2 = 2$.

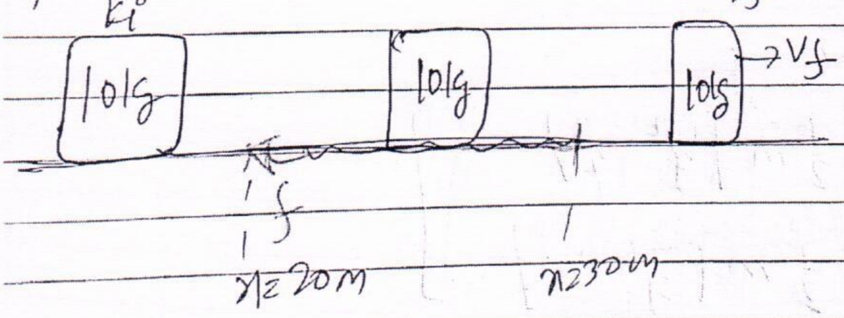
$V = 5 x^{3/2}$

$V_i = 0 \qquad V_f = 5(2)^{3/2} = 5(8)^{1/2} = 10\sqrt{2}$

$K = \frac{1}{\cancel{2}} \times \frac{0.5 \times}{10} \left(10\cancel{0} \times \cancel{2} - 0 \right) = \underline{50\ \text{Joule}}$

★ JEE Main
★★ Neet-17

Q. A block of mass 10kg is moving in x-dirtn with const speed 10m/s is subjected to a retarding Force $F = 0.1x$ J/m during it's travells from $x = 20m$ to $x = 30m$. final K.E will be.



B.B-2 (comp) Race-2 (Q-1, 2, 8, 11)

Ex-1 (1-33)

Ex-2 (1, 2, 3, 6, 10, 14, 20)

Ex-3 (1, 3, 5, 7)

$F = 0.1x \ J/m$

w.d by retarding Force

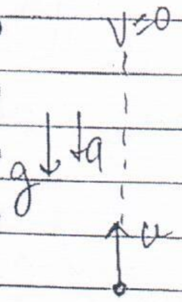
$$-\int_{20}^{30} 0.1\,x\,dx = K_f - \frac{1}{2}\times 10\times 100$$

$$-\frac{0.1}{2}\left[x^2\right]_{20}^{30} = K_f - 500$$

$$-\frac{0.1}{2}\times 500 + 500 = K_f$$

$$\underline{K_f = -25 + 500 = 475\ J}$$

Q. A Ball is projected vertically up with speed 14 m/s it Attains maxm height 8m. find Energy dissipated against air friction during ascent. (mass = 0.5 kg & g = 9.8 m/s²) → loss



$$W_g + W_f = K_f - K_i$$

$$-mgh + W_{air} = 0 - \frac{1}{2}\times 0.5\times (14)^2$$

$$-0.5\times 9.8\times 8 + W_{air} = -0.5\times \frac{196}{2}$$

~~$h = \frac{u^2}{2g} = \frac{(14)^2}{2\times 10}$~~

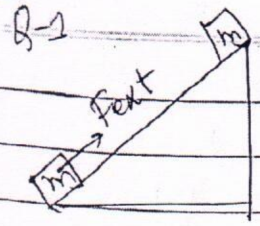
$$W_{air} = -49 + 39.2$$

$$\boxed{W_{air} = -9.8\ J}$$

Energy dissipated ⇒ loss 9.8 J Ans

Ex-2

Q-1



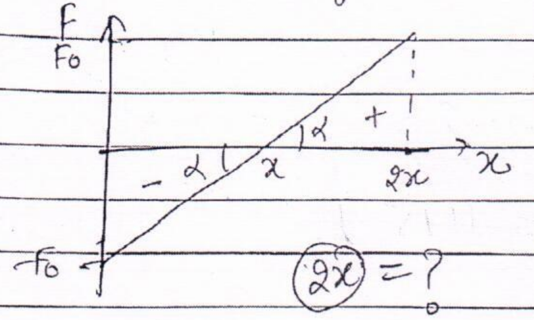
$$W_g + W_f + W_{ext} = 0 - 0$$

$$-mgh + W_f + 300 = 0$$

$$\underline{W_f = -100\,J}$$

Race

Q-11 $K_i = 0$ $K_f = 0$



$(2x) = ?$

$$\tan\alpha = \frac{F_0}{x}$$

$$x = \frac{F_0}{\tan\alpha}$$

$$\text{position} = 2x = \frac{2F_0}{\tan\alpha}$$

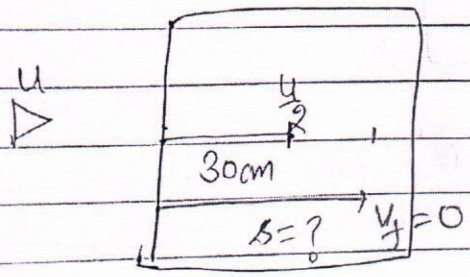
Que A Bullet is fired on wall after travelling a distance of 30 cm its

(i) Speed becomes half

(ii) K.E " half

(iii) Momentum becomes half

(iv) Find total distance travelled by bullent in all 3 cases assumme resistive force to be const



$$\boxed{W = -Fs = \frac{1}{2}m\left[v_f^2 - v_i^2\right] = K_f - K_i = \frac{P_f^2}{2m} - \frac{P_i^2}{2m}}$$

① ②

① $\boxed{s \propto (v_f^2 - v_i^2)}$

$$\frac{30}{s} = \frac{\left(\frac{u}{2}\right)^2 - u^2}{0 - u^2}$$

$$\frac{30}{s} = \frac{\frac{1}{4} - 1}{-1} = \frac{-\frac{3}{4}}{-1}$$

$$s = \frac{4 \times 30}{3} = 40\,cm$$

② $\boxed{s \propto (K_f - K_i)}$

$$\frac{30}{s} = \frac{\frac{K}{2} - K}{0 - K}$$

$$\frac{30}{s} = \frac{-\frac{1}{2}}{-1}$$

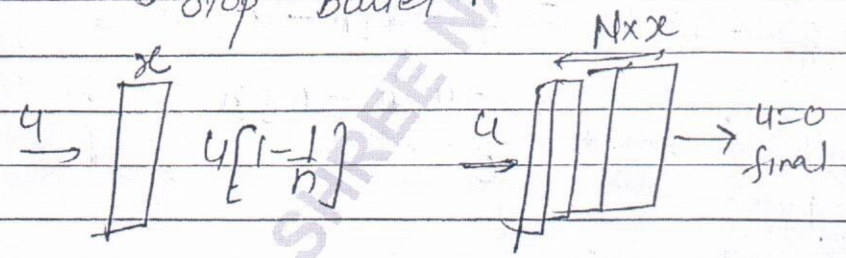
$$s = 60\,cm$$

③ $\boxed{s \propto (P_f^2 - P_i^2)}$

$$\frac{30}{s} = \frac{\left(\frac{P}{2}\right)^2 - P^2}{0 - P^2}$$

$$s = 40\,cm$$

Or also ⇒ After penetration from one plank speed reduces by $\left(\frac{1}{n}\right)$ times of initial. How many plank required to stop bullet.



$$s \propto (v_f^2 - v_i^2)$$

$$\frac{x}{Nx} = \frac{u^2\left(1-\frac{1}{n}\right)^2 - u^2}{0^2 - u^2}$$

$$\frac{1}{N} = 1 - \left(\frac{n-1}{n}\right)^2 = \frac{n^2 - (n^2 + 1 - 2n)}{n^2}$$

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

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

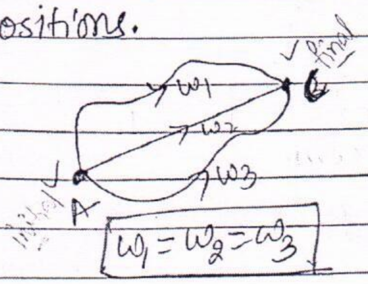
$$\boxed{N = \frac{n^2}{2n-1}}$$

Conservative Forces:-

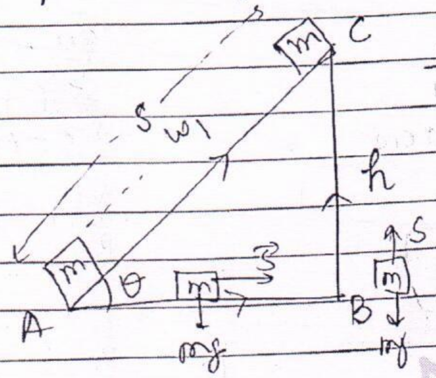
(1)

* W.D by conservative Force depends on initial & final "position" it is independent of path b/w these positions.

(1)



$\boxed{w_1 = w_2 = w_3}$



gravity

A to C

$w_1 = -mg\sin\theta \times s$

$w_1 = -mgh$

A to C

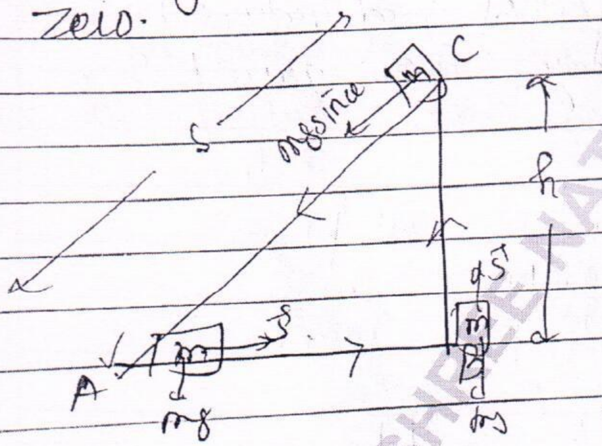
$w_2 = w_{AB} + w_{BC}$

$= 0 - mgh$

$w_2 = -mgh$

(2)

* W.D by conservative Force in close loop or path is always zero.

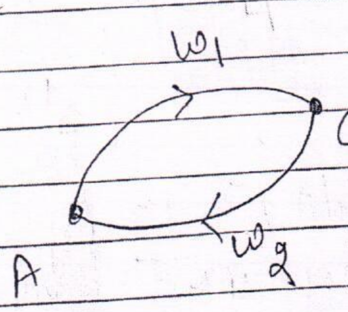


$w_{ABCA} = w_{AB} + w_{BC} + w_{CA}$

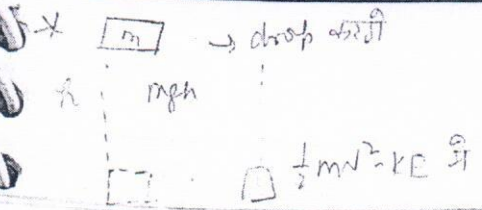
$= 0 - mgh + mg\sin\theta \times s$

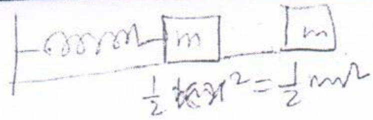
$= -mgh + mgh$

$= 0$



$\boxed{w_1 + w_2 = 0}$





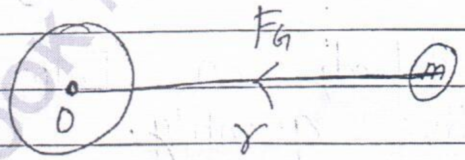
* W.D against conservative forces is compeletey recoverable.

Eg - Gravitational Forces, Columb Force, spring Forces
Elastic Force, intermolecular Force etc.

Central Force

* line of Action passes through through a fixed pt inside the Body
* magnitude of these Forces changes when distance from this fixed point changes.

eg → Gravition force
&
Columb Force



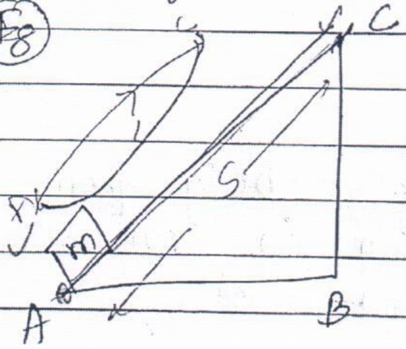
$$\vec{F} = \frac{K}{r^2}\hat{r}$$

"All central Forces are Conservative"

Non-conservative Force

* W.D by non-conservative Force depends on Path.
* W.D by " " " in closed loop is ~~not~~ not zero.
$W \neq 0$

Eg



$$W_{ACA} = W_{AC} + W_{CA}$$
$$= -f_k S - f_k S$$
$$= -2f_k S$$

⊛ B.B=3 (1/2

Ex-I (34-36, 38, 41, 44, 45,

Ex-II (·

Date ___ Page ___

→ Rubbing if hand → Heat loss

⊛ W.D against non-conservative Force is not recoverable, it is lost in heat

Ex→ Friction force, Viscous Force, air friction, Drag Force.
↳ dimension

Potential Energy:

* Energy possessed by body virtue of its position or orientation of configuration.

⇒ P.E is associated with only conservative Force field.

⇒ P.E is depends on Frame of Reference & it is a Relative quantity.

⊛ To Find P.E at a pt in conservative Force field we have to decided Reference pt where P.E is Zero

⇒ P.E may be +ve, -ve or Zero

*⇒ -ve of the W.D by conservative Force to move a body from Reference level to a given position in conservative field is P.E at that point.

$$\boxed{U = -W_c}$$

⇒ W.D by external force to bring a body from reference line to ~~a~~ the given position in conservative field without change in ~~K.E~~ or with const velocity, is P.E at that position.

$\boxed{W_{ext} = U}$

If $\Delta K = 0$, $v = const$, $a = 0$ — slowly.

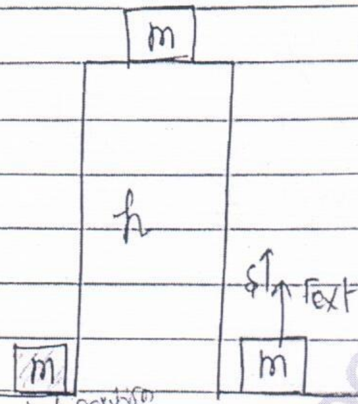
⇒ P.E depends on Frame of reference while change in P.E is independent on Frame.

$W_g = -mgh$

$U_c = -W_g$

$U = mgh$

reference level $U = 0$, Initial position of Block



$W_{ext} = F_{ext}\,h$

$W_{ext} = mgh$

$U = mgh$

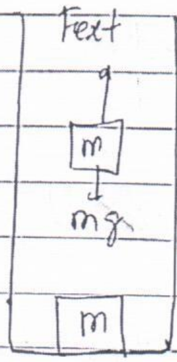
$\Delta K = 0$

$v = const$

$|\vec{F}_{ext}| = |\vec{F}_g| = mg$

$W_{ext} = -mgh$

$U = -mgh$



$W_g = mgh$

$U = mgh$

⇒ ~~change in ...~~

Change in P.E in Conservative field.

U_i at A, U_f at B

$\vec{F}_c = -\frac{dU}{dr}$

$dU = -\vec{F}_c \cdot d\vec{r}$

$\int_{U_i}^{U_f} dU = -\int \vec{F}_c \cdot d\vec{r}$

$U_f - U_i = -\int \vec{F}_c \cdot d\vec{r}$

$\boxed{W_c = -\Delta U}$

* W.D by conservative Force is loss in P.E of the system.

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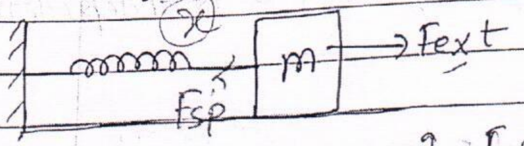
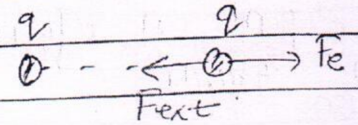
$\boxed{W_{ext} = \Delta U}$ $\vec{V} = const$, $\Delta K = 0$

W.D by External Force against Conservative Force ↑ses P.E of the system.





$F_c \Rightarrow U \downarrow$ (+ve work करेगा) $F_{ext} \Rightarrow U \uparrow$ [system] ([illegible] work)

Determination Of Force From P.E:-

$U \quad F_c = ?$

1-D $\quad F_c = -\dfrac{dU}{dx}$

$\vec{\nabla} \Rightarrow$ gradient

3-D $\quad \boxed{\vec{F_c} = -\vec{\nabla} U}$

$$\vec{\nabla} = \left[\frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{k}\right]$$

$$F_c = -\left[\frac{\partial U}{\partial x}\hat{i} + \frac{\partial U}{\partial y}\hat{j} + \frac{\partial U}{\partial z}\hat{k}\right]$$

Q:- P.E at a place is given,

$$U = xy^2z \text{ Joule}$$

Find 'Force' acting at $(1, 1, -1)$ m.

$$\vec{F_c} = -\left[\frac{\partial(xy^2z)}{dx}\hat{i} + \frac{\partial\, xy^2z}{dy}\hat{i} + \frac{\partial(xy^2z)}{dz}\right]$$

$$= -\left[y^2z\,\hat{i} + xy \times 2y\,\hat{j}\right.$$

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$$\boxed{F_c = +\hat{i} + 2\hat{j} - \hat{k} \ N} \text{ Ans.}$$

Q. $U = \frac{x^2 y}{z}$, find Force at $(2,2,1)$ m.

$$U = \frac{x^2 y}{z} = x^2 y z^{-1}$$

$$F = -\frac{\partial U}{\partial x}$$

$$F = -\left[\frac{2xy}{z}\hat{i} + \frac{x^2}{z}\hat{j}\right] \qquad F_c = -\frac{\partial U}{\partial r}$$

$$= -\left[4\hat{i} + \frac{4}{2}\hat{j}\right]$$

$$F = -4\hat{i} - 2\hat{j}$$

$$F_c = -\left[\frac{y}{z} \times 2x\,\hat{i} + \frac{x^2}{z}\hat{j} - \frac{x^2 y}{z^2}\hat{k}\right]$$

$$\boxed{F_c = -8\hat{i} - 4\hat{j} + 8\hat{k} \ N}$$

Q.

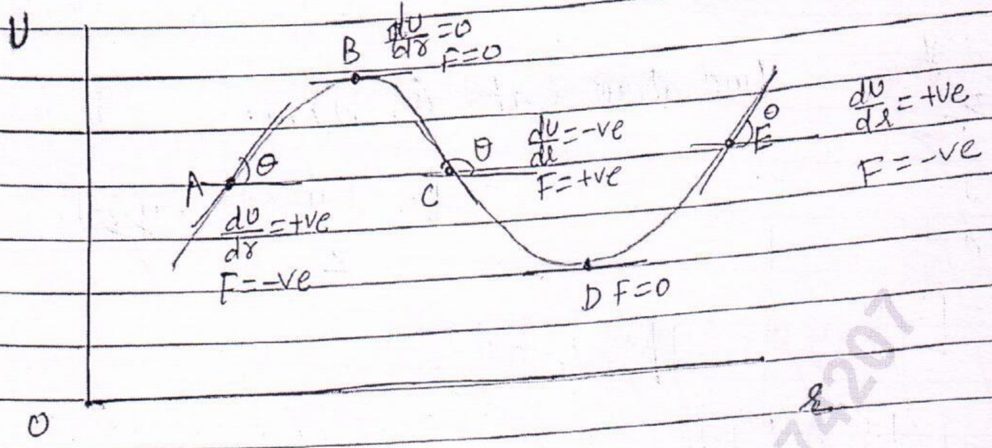
$U = x^2 + y^2 + z^2$ Force $(2,-1,-2)$ m

$$F_c = -\left[(2x + 0 + 0)\hat{i} + (0 + 2y + 0)\hat{j} + (0 + 0 + 2z)\hat{k}\right]$$

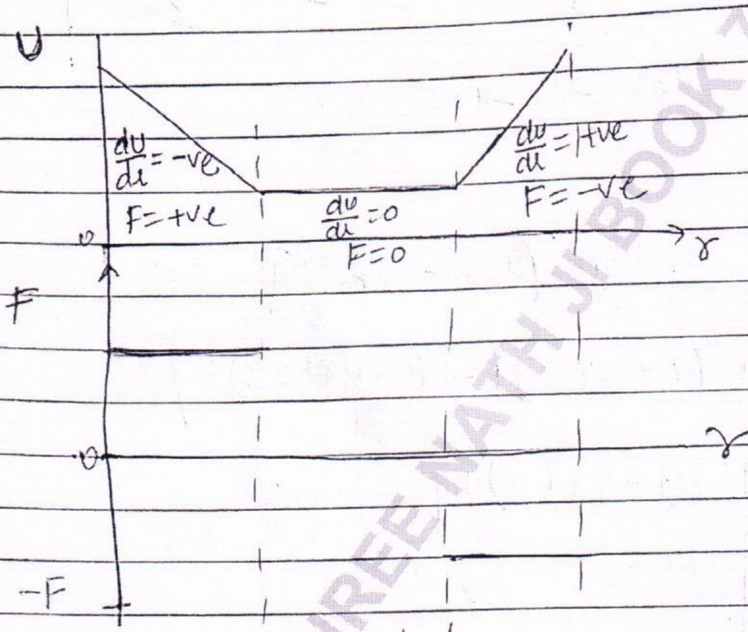
$$F_c = -\left[2 \times 2\,\hat{i} + 2(-1)\hat{j} + 2(-2)\hat{k}\right]$$

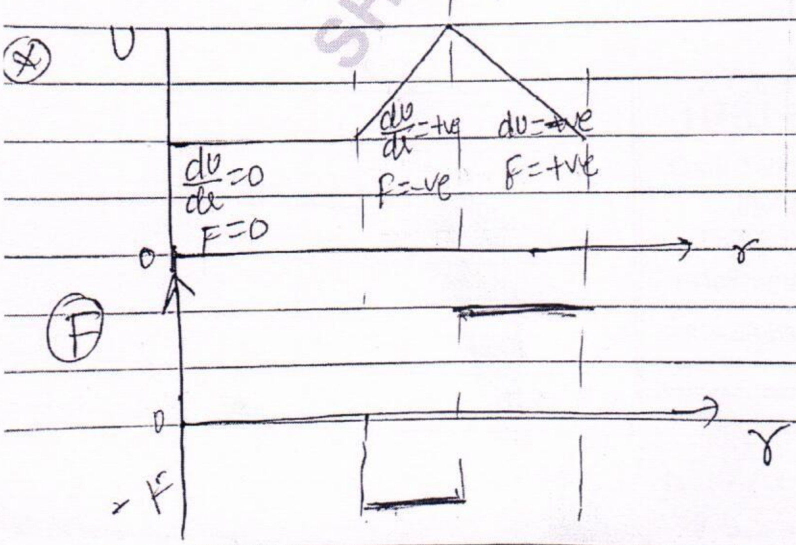
$$\boxed{F_c = -4\hat{i} + 2\hat{j} + 4\hat{k}} \ N$$

Graphical Relations b/w P.E & Force.



Draw Force-displacement graph from U-r graph.





Q. P.E of a particle at a places $U = x^3 - 3x^2 + 6$ Joule. find

① Value of 'x' where P.E have max^m & min^m value

② max^m & min^m value of P.E

Step ① $\frac{dU}{dx} = 3x^2 - 6x$

Step ② $\frac{dU}{dx} = 0$ Find roots $x(3x-6) = 0$

$x = 0$, $x = 2m$

Step ③ Checking step,

$$\frac{d^2U}{dx^2} = 6x - 6$$

$$\frac{d^2U}{dx^2} = 6x - 6$$

(a) $x = 0$

$\frac{d^2U}{dx^2} = -6$

$\frac{d^2U}{dx^2} < 0$ U = maximum

(b) $x = 2$

$\frac{d^2U}{dx^2} = +6$

$\frac{d^2U}{dx^2} > 0$ U = minimum

② $x = 0m$ $U_{max} = 6$ Joule

$x = 2m$ $U_{min} = (2)^3 - 3(2)^2 + 6$

$= 8 - 12 + 6$

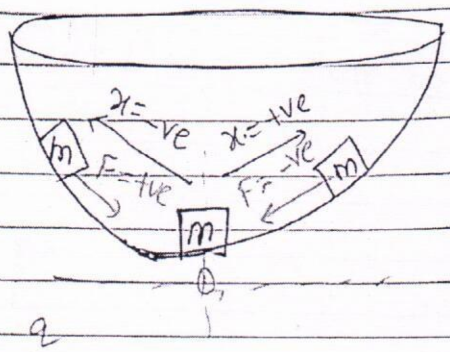
$= 2$ Joule

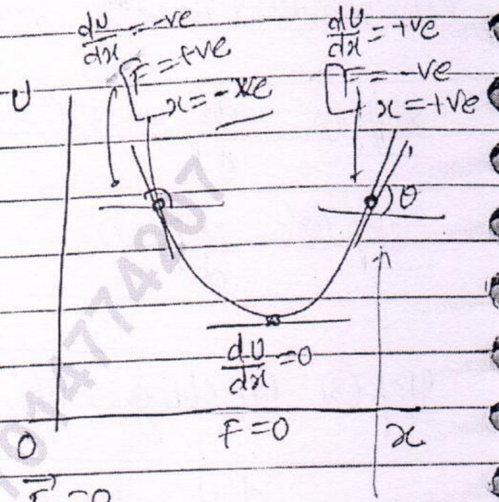
Eqb^m in Conservative Field –

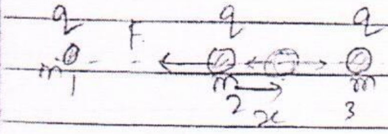
① **Stable Eqb^m** ⇒ after displacement body have tendency to go back initial position.

$\vec{F_c} = 0$

$\frac{dU}{dx} = 0$







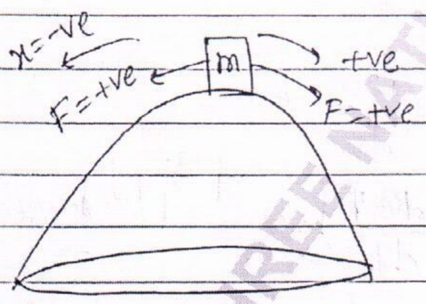
$\vec{F_c} = 0$

$\frac{dU}{dx} = 0$

$\frac{d^2U}{dx^2} > 0$

U_{min^m}

② **Unstable Eqb^m** ⇒ after displacement body moves away.

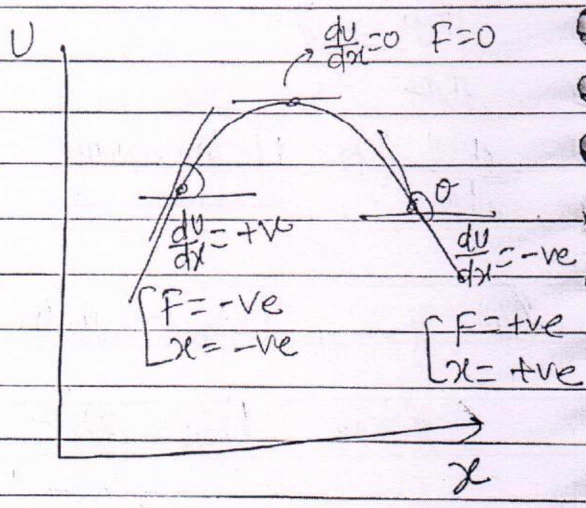


$\vec{F_c} = 0$

$\frac{d^2U}{dx^2} < 0$

$\frac{dU}{dx} = 0$

$U = maximum$



B.B-3 (41-49)
Ex-1 (34-41, 44-45, 53, 30)   Ex-II (B)   Ex-III (3,5,7)   Race-1 (6,7,8   Race-2 (6,7,11,

③ **Neutral Eqb^m** : after displacement body neither move away or initial position.

$x = -ve$
$F = 0$
$\leftarrow$ m

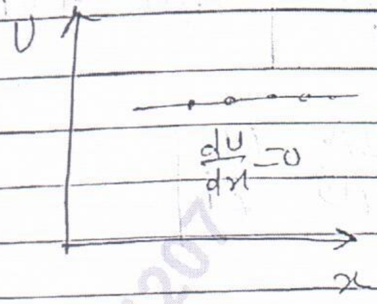
$\rightarrow x = +ve$
m $F = 0$

$F_c = 0$

$\frac{dU}{dx} = 0$

$\frac{d^2U}{dx^2} = 0$

$U = const$



eg → ⓜ ⓜ ⓜ

Que. P.E of a particle at place is given by –

$$U = 2x^2 - 4x$$

Find
(i) Force
(ii) Eqb^m distance
(iii) P.E at Eqb^m.

$F = -\frac{dU}{dx} = -[4x - 4]$

$F = (4 - 4x)\hat{i}$ (i)

$F = 4 - 4x = 0$

$4 = 4x$

$\boxed{x = 1\,m}$ (ii)

$P.E_{x=1} = 2 - 4 = -2$ Joule (iii)

Que. P.E – distance Relation of 2 molecule is given

$$U = \frac{A}{r^{12}} - \frac{B}{r^6}$$ where A & B are const. Find

(i) Force-distance relation
(ii) Eqb^m distance.
(iii) P.E at Eqb^m.

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(i) $U = A r^{-12} - B r^{-6}$

$$F = -\frac{dU}{dr} = -\left[-12 A r^{-13} + 6 B r^{-7}\right]$$

$$F = \left[\frac{12A}{r^{13}} - \frac{6B}{r^{7}}\right]$$

(ii) $F = 0$

$$\frac{^{2}\cancel{12}A}{r^{6}\,\cancel{r^{13}}} = \frac{\cancel{6}B}{\cancel{r^{7}}}$$

$$\frac{2A}{B} = r^{6}$$

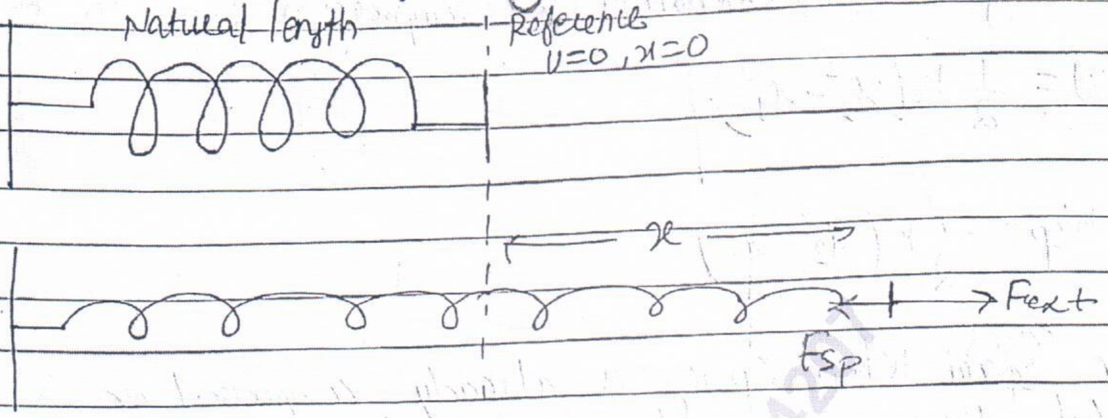
$$r = \left(\frac{2A}{B}\right)^{1/6}$$

(iii) $$U = \frac{A}{\left[\left(\frac{2A}{B}\right)^{1/6}\right]^{12}} - \frac{B}{\left[\left(\frac{2A}{B}\right)^{1/6}\right]^{6}}$$

$$= \frac{\cancel{A} B^{2}}{4A^{\cancel{2}}} - \frac{B^{2}}{2A}$$

$$U = \frac{B^{2}}{4A} - \frac{B^{2}}{2A}$$

Spring



$$\boxed{\vec{F}_{sp} = -k\vec{x}}$$

$$W_{sp} = \int \vec{F}_{sp}\cdot d\vec{x}$$

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

$$\boxed{W_{sp} = -\frac{1}{2}kx^2}$$

$$\boxed{U = -W_{sp} = \frac{1}{2}kx^2}$$

Spring either compressed or extended workdone By spring for

$$\boxed{W_{sp} = -\frac{1}{2}kx^2}$$

In Both case $\boxed{U = \frac{1}{2}kx^2}$

Method-2

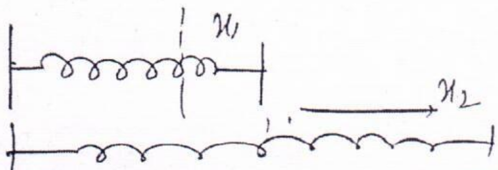
$$W_{ext} = \int F_{ext}\,dx$$

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

$$\left[\begin{array}{l} \Delta K = 0 \\ \vec{v} = const \\ a = 0 \end{array}\right.$$

$$\boxed{W_{ext} = \frac{1}{2}kx^2}$$

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



(*) W'D To give an extension or compression from x_1 to x_2

$$\boxed{W = \frac{1}{2}K(x_2^2 - x_1^2)}$$

$$W_{sp} = -\frac{1}{2}K(x_2^2 - x_1^2)$$

Note!

* In Some ~~spacei~~ cases when spring is already compressed or extended then spring force Can do +ve work

Two spring k_1 & k_2

(a) Both given same extension

$$\frac{W_1}{W_2} = \frac{U_1}{U_2} = \frac{\frac{1}{2}k_1 x^2}{\frac{1}{2}k_2 x^2}$$

$$\boxed{\frac{W_1}{W_2} = \frac{W_1}{U_2} = \frac{k_1}{k_2}}$$

(b) Both are streached or compress by same force:

$$F = k_1 x_1 = k_2 x_2$$

$$\frac{x_1}{x_2} = \frac{k_2}{k_1}$$

$$\frac{W_1}{W_2} = \frac{U_1}{U_2} = \frac{\frac{1}{2}k_1 x_1^2}{\frac{1}{2}k_2 x_2^2}$$

$$\boxed{\frac{W_1}{W_2} = \frac{U_1}{U_2} = \frac{k_2}{k_1}}$$

(c) $U = \frac{1}{2} K x^2 \times \frac{K}{K}$

$U = \frac{K^2 x^2}{2K}$

$$\boxed{U = \frac{F_{sp}^2}{2K}}$$

Que. When extension of 2cm is given in spring then stored P.E is U. If the same spring is extended by 5cm then find store P.E.

$U = \frac{1}{2} K (2)^2$

$U' = \frac{1}{2} K (5)^2$

$U' = \frac{U}{4} \times 25 = \frac{25}{4} U$

Que. Find W.D to give extension in a spring from 1cm to 5cm. $K = 2000\ N/m$

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

$= \frac{1}{2} \times 2000 \left[\left(\frac{5}{100}\right)^2 - \left(\frac{1}{100}\right)^2 \right]$

$= 1000 \left[\frac{1}{10^4} [25 - 1] \right]$

$= \frac{1}{10} \times 24 = 2.4\ J$

Q. Two springs of spring const K_1 & K_2 are compressed by forces F_1 & F_2 if P.E stored in both springs is same then find $\frac{F_1}{F_2} = ?$

$U_1 = U_2$

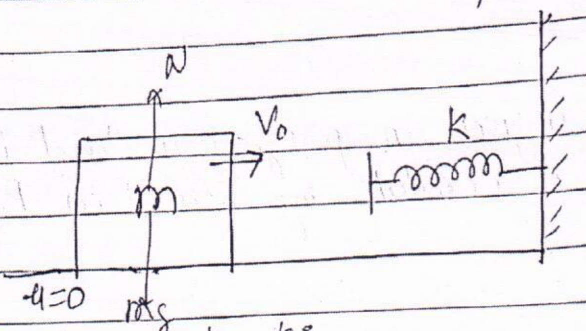
$\frac{F_1^2}{2K_1} = \frac{F_2^2}{2K_2}$ $\quad \frac{F_1^2}{F_2^2} = \frac{K_1}{K_2}$ $\quad \boxed{\frac{F_1}{F_2} = \sqrt{\frac{K_1}{K_2}}}$

W.E.T

$$\left[\begin{array}{l} W_{\text{all the forces}} = \Delta K = K_f - K_i \\ W_C + W_{NC} + W_{ext} + W_{Int.} = \frac{1}{2} m (V_f^2 - V_i^2) = K_f - K_i \end{array}\right]$$

* Work should be with sign

Que. the block strikes with spring, find Max^m compression.



$$W_N + W_{mg} + W_f + W_{sp} = \Delta K$$

$$W_{sp} = K_f - K_i$$

$$-\frac{1}{2} K x_{max}^2 = 0 - \frac{1}{2} m V_0^2$$

$$x_{max} = \sqrt{\frac{m}{K}}\, V_0$$

Que. In the previous que. when the compression in spring is x, speed of the block is half of initial. find max^m compression.

$$-\frac{1}{2} K x^2 = \frac{1}{2} m \left[\left(\frac{V_0}{2}\right)^2 - V_0^2\right]$$

$$-\frac{1}{2} K x_{max}^2 = 0 - \frac{1}{2} m V_0^2$$

$$\frac{x^2}{x_{max}^2} = \frac{-\frac{3}{4}}{-1}$$

$$\boxed{x_{max} = \frac{2}{\sqrt{3}} x}$$

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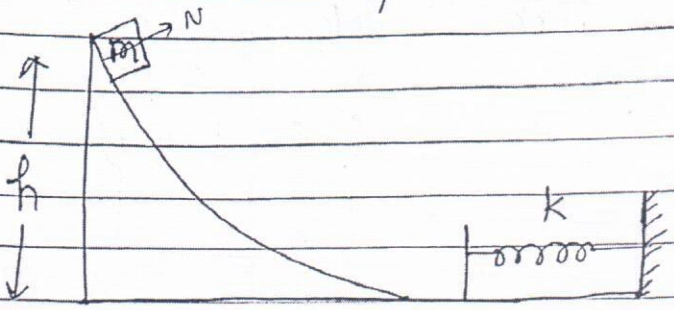
B.B. (1-5   Ex-II (3, 11,)

Ex-I (46-59,)   Race-1 (9)

Race-2 (3, 51)

Que. Block is released a/c to fig., all surfaces are frictionless. Find max^m compression in the spring.



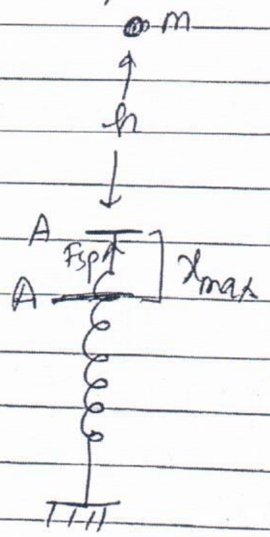
$$W_g + W_{sp} = 0 - 0$$

$$mgh - \frac{1}{2} k x_{max}^2 = 0 - 0$$

$$mgh = \frac{1}{2} k x_{max}^2$$

$$x_{max} = \sqrt{\frac{2mgh}{K}}$$

Q. A particle of mass 'm' is dropped from height 'h' above A end of the spring & stick with it. Find max^m compression of the spring.

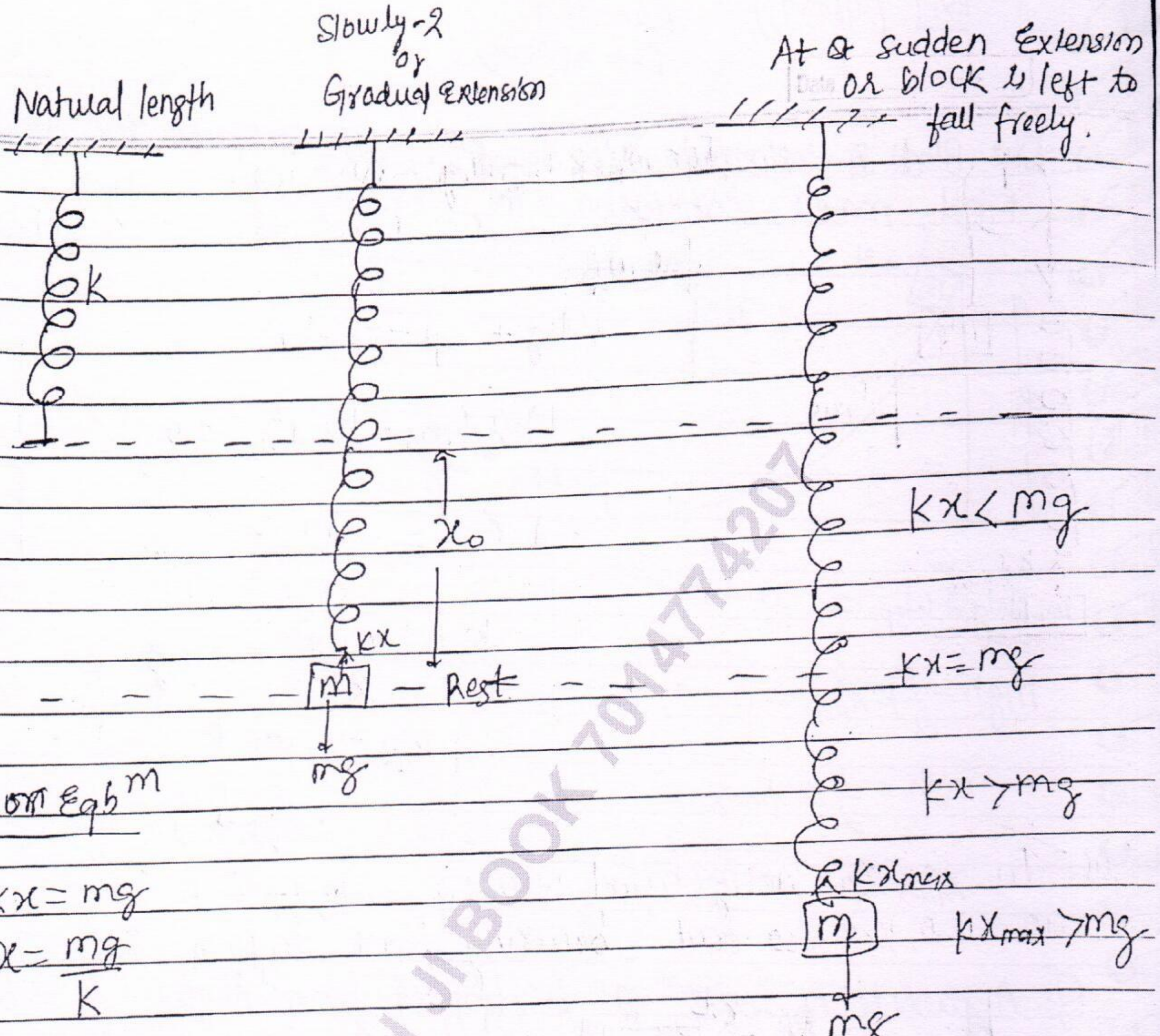


$$W_g + W_{sp} = 0 - 0$$

$$+ mg(h + x_{max}) - \frac{1}{2} k x_{max}^2 = 0$$

$$mg(h + x_{max}) = \frac{1}{2} k x_{max}^2$$

Que.



Rest on Eqb^m

$kx = mg$

$x = \frac{mg}{K}$

$$\boxed{x = \frac{mg}{K}}$$

$$w_g + w_{sp} = K_f - K_i$$

$$mg x_{max} - \frac{1}{2} K x_{max}^2 = 0$$

$$mg \cancel{x_{max}} = \frac{1}{2} K x_{max}^{\cancel{2}}$$

$$\boxed{x_{max} = \frac{2mg}{K}}$$

Que. In the Given fig. find minimum value of M_2 so that when it is left to fall then block M_1 just leave the floor.

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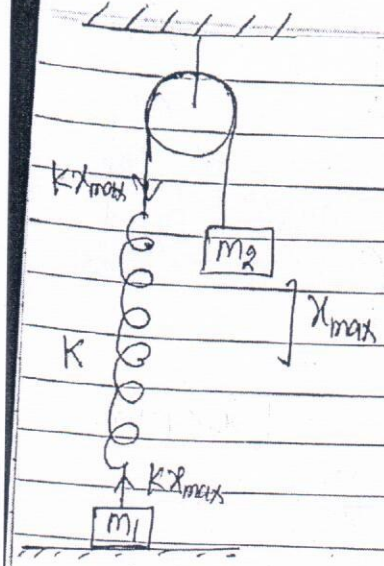


For m_1 $\quad Kx_{max} = m_1 g$ —(1)

for m_2

$$W_g + W_{sp} = K_f - K_i^{0}$$

$$M_2 g x_{max} - \frac{1}{2}Kx_{max}^2 = 0$$

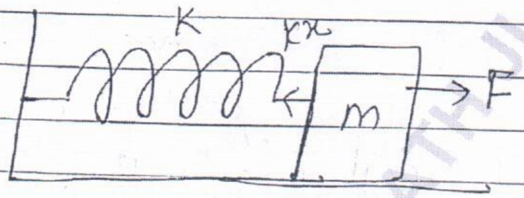
$$x_{max} = \frac{2m_2 g}{K} \quad \text{—(2)}$$

$$K \times \frac{2m_1 g}{K} = m_1 g$$

$$\boxed{m_2 = \frac{m_1}{2}}$$

A same as previous

Que. In the Given fig. find W.D by const. force F to give max^m possible extension without breaking (all surface are frictionless)



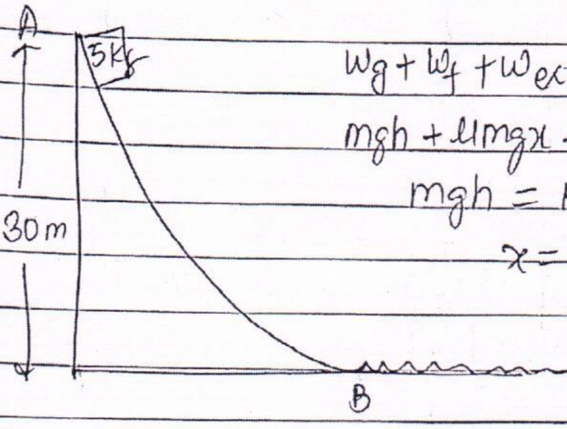
$$W_{sp} + W_{ext} = K_f - K_i^{0}$$

$$+Fx_{max} - \frac{1}{2}Kx_{max}^2 = 0$$

$$\frac{1}{2}Kx_{max}^2 = Fx_{max}$$

$$\boxed{x_{max} = \frac{2F}{K}}$$

Que. Block of mass 5Kg is left from top of a smooth curved track of height 30m the horizontal surface on the foot is rough with $\mu = 0.6$ find distance travelled by the block on Horizontal rough before coming to rest.



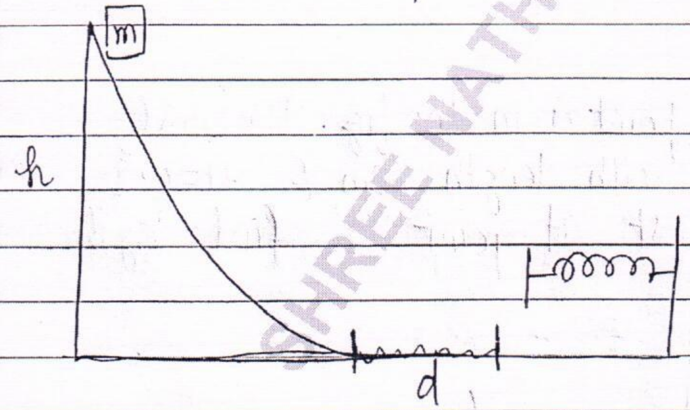
$$W_g + W_f + W_{ext} = K_f - K_i$$

$$mgh + \mu mgx + 0 = 0 - 0$$

$$mgh = \mu mgx$$

$$x = \frac{h}{\mu} = \frac{300}{6} = \underline{50m}$$

Que. A block is released from pt 'A' at a height 'H' acc to the figure the block hit the spring & Max^m Compression is 'x' the part BC enters path travelled is rough with length 'd' find 'μ'



$$W_g + W_{sp} + W_f = K_f - K_i$$

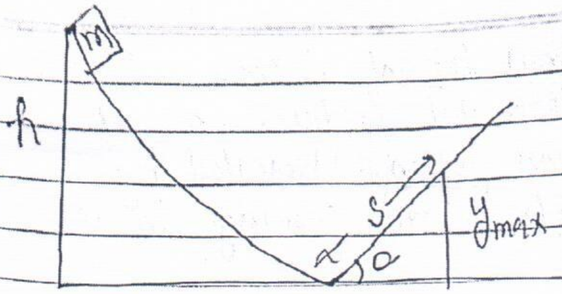
$$mgH - \frac{1}{2}kx^2 - \mu mgh = 0 - 0$$

$$\mu mgd = mgh - \frac{1}{2}kx^2$$

$$\boxed{\mu = \frac{mgh - \frac{1}{2}kx^2}{mgd}}$$

Que. The block after moving on smooth curve track now moves up on a rough incline plane of inclination 'θ' find max^m Height by it on incline plane coeff. frick = μ

SHREE NATH JI BOOK DEPOT



$\sin\theta = \frac{y}{s}$

$s = \frac{y}{\sin\theta}$

$W_g + W_f = K_f - K_i$

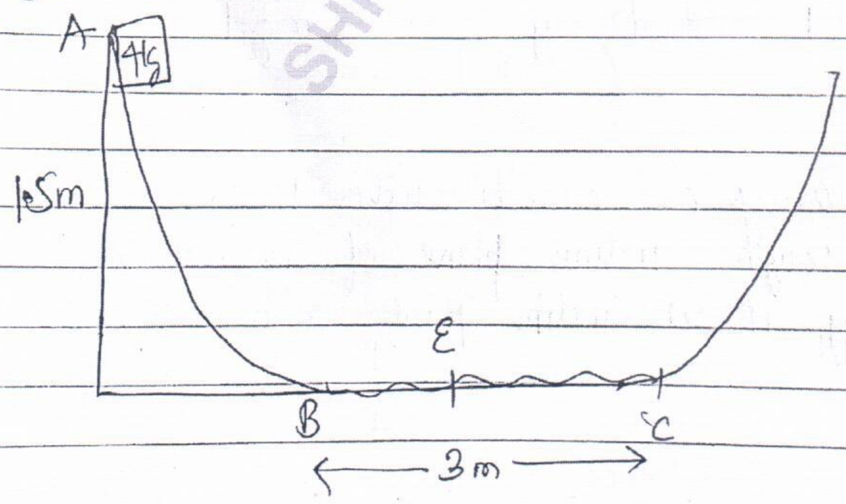
$mgh - mgy_{max} - \mu mg\cos\theta \cdot s = 0$

$h - y_{max} = \mu\cos\theta \times \frac{y_{max}}{\sin\theta}$

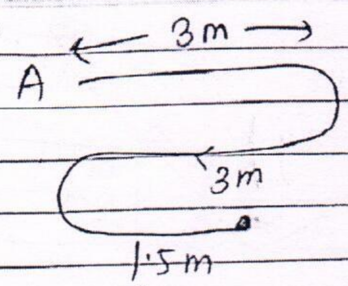
$h - y_{max} = \mu\cot\theta \, y_{max}$

$$\boxed{y_{max} = \frac{h}{1+\mu\cos\theta}}$$

Que. the block is released from point A in the fig. the only Horizontal path BC is rough with length 3m & $\mu = 0.2$ the block finally comes to rest at point 'E' find length BE.



$\cancel{W_g + W_f = K_f - K_i^{0}}$



$mgh - \mu mg x = 0 - 0$

$mgh = \mu mg x$

$\cancel{x = \frac{h}{\mu} = \frac{1.5}{T}}$

$BE = 1.5m$

$2\frac{1}{2}$ trip.

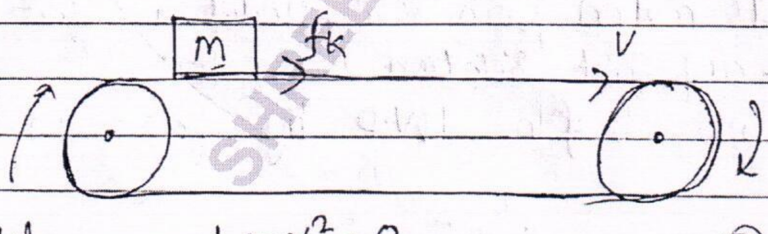
$x = \frac{h}{\mu} = \frac{1.5}{0.2} = 7.5\,cm$

Que. A conveyer Belt is moving with const speed 'V' now a block of mass 'm' is gently dropped on it coefficient of friction b/w block & belt is 'μ_k' find

(i) W.D by friction

(ii) Distance travelled by block w.r.t Belt before it attains max^m speed.

(iii) Distance travelled by Belt in a during the block attain max^m speed.



(i) $W_{friction} = \frac{1}{2} mv^2 - 0$

③ $S_{belt} = vt$

$S_{block/belt} = \left[\frac{u+v}{2}\right] t$

② $f_K \cdot d = \frac{1}{2} mv^2$

$\mu_k mg d = \frac{1}{2} mv^2$

$\frac{S_{belt}}{d} = \frac{V}{0+V} \times 2$

$\boxed{d = \frac{V^2}{2\mu_K g}}$ → ~~यह वही Relative~~ Motion है।

$\boxed{S_{belt} = 2d}$

$\boxed{S_{belt} = \frac{V^2}{\mu g}}$ Ans.

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method 2 (kinematics)

$f_k = \mu mg = ma$

$\cancel{a = m}$ $\boxed{a = \mu g}$

$v = 0 + \mu g t$

$V^2 = 0 + 2\mu g d$

$d = \frac{V^2}{2\mu g}$

$S_{belt} = v t$

$= v \times \frac{V}{\mu g}$

$= \frac{V^2}{\mu g}$

(i) $W = f_f \cdot d$

$= \mu mg \times \frac{v^2}{2\mu g} = \frac{1}{2} mv^2$

(i) Initially due to Relative sliding b/w block & belt f_k comes into Play which speeds up the block from $0 \rightarrow V$

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

(ii) the distance travelled by the block w.r.t belt is equal to the displacement during sliding or the displacement of point of action of friction.

$d = \frac{V^2}{2\mu g}$ meth-2 (kine)

NCERT JEE

Que. A (m) particle starts its motion from rest under a effect of a force its velocity-displacement relation is given $V = \alpha\sqrt{s}$ where $\alpha \rightarrow$ const, find W.D by force in time (t).

$V = \alpha s^{1/2}$

$\frac{ds}{dt} = \alpha s^{1/2}$

$\int_0^s s^{-1/2} ds = \int_0^t \alpha \, dt$

$\frac{s^{1/2}}{1/2} = \alpha t$

$s^{1/2} = \frac{\alpha t}{2}$

$s = \frac{\alpha^2 t^2}{4}$

$V = \frac{ds}{dt} = \frac{2\alpha^2 t}{4 \, 2}$

Scanned by CamScanner

$$W = \frac{1}{2} m \left[\left(\frac{\alpha^2 t}{2} \right)^2 - 0 \right]$$

$$W = \frac{1}{8} m \alpha^4 t^2$$

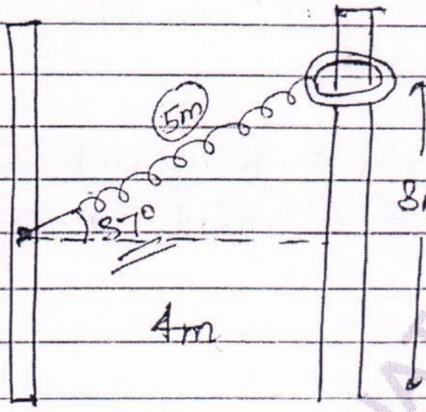
also
$$v^2 = \alpha^2 s$$
$$v^2 = u^2 + 2as$$

$$2a = \alpha^2$$
$$a = \frac{\alpha^2}{2}$$

$$v = 0 + \frac{\alpha^2}{2} t$$

<u>Que.</u> A Ring of mass 10kg can slide through vertical rod without friction. It is connected with spring of force const $k = 400\,N/m$. The Relaxed length of spring is 4m, the ring is displaced <u>3m</u> as shown. find final velocity.

↳ $W_{sp} = +ve$



$$W_{sp} + W_g = \frac{1}{2} m v^2 - 0$$

$$+\frac{1}{2} k x^2 + mgh = \frac{1}{2} m v^2$$

$$\frac{1}{2} \times 400 \times (1) + 10 \times 10 \times 3 = \frac{1}{2} \times 10 \times v^2$$

$x = 1m$

$$V = 10\,m/s$$

Date ______ Page ____

Mechanical Energy (E):

⇒ Sum of K.E & P.E is c/a M.E of an object or a system.

$$\boxed{E = K + U}$$

⇒ M.E depends on frame of reference or it is a relative quantity. becoz K.E & P.E depends on frame of Reference

⇒ A body can have M.E without having either K.E or P.E

$K = 0 \quad U \neq 0 \Rightarrow E \neq 0$

$K \neq 0 \quad U = 0 \Rightarrow E \neq 0$

⇒ If M.E is zero then Both K.E & P.E may not be Zero means the magnitude of KE is equal to magnitude of P.E and U = −ve.

$E = 0$ $\qquad$ $K = 25J \quad U = -25J$

$K = 0,\ U = 0$ $\qquad$ $E = 25 - 25 = 0$

$$\boxed{K = |U| \Rightarrow,\ U = -ve}$$

(If $E = 0$, then either $K = 0$, $U = 0$, or $K \neq 0$, $U \neq 0$)

⇒ $E = K + U$

$E - U = K \quad \therefore K \geq 0$

$E - U \geq 0$

$\boxed{E \geq U}$ ⇒ condition of a particle to exist in a field.

$\Rightarrow$ $E \geq U$

(i) $U = +ve$ E = must be positive

(ii) $U = -ve$ E = may be positive, negative, zero

$$E = K - U$$

$U = -ve$

(a) $K > |U|$

$E = +ve$

unbounded System

(b) $K < |U|$

$E = -ve$

bound System

$E = 0$ unbounded

$K = |U|$

$U = -ve$

A particle does not posses momentum, ~~still~~ it's K.E will be zero

If particle does not posses momentum, still it can have M.E

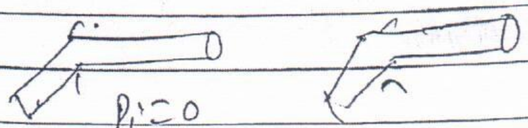
$E \neq 0$ $K = 0$, $U \neq 0$

A particle possess momentum still it's M.E may be zero

$E = 0$ $K = |U|$ $U \ni -ve$

If a system of particle does not possess momentum still it can have K.E

eg → Gun-bullet, Bomb explosion.



$p_i = 0$

$$\vec{P}_G + \vec{P}_{bullet} = 0$$

$$K_{system} = K_G + K_b \neq 0$$

Conservation of "Mechanical Energy". (COME)

* If only conservative Force are doing work, then M.E of the System remains const.

OR

If NO external Force is act or W.D by them is Zero and Internal forces are conservative, then M.E of the System Remains const.

$$W_C + W_{NC} + W_{ext} = K_f - K_i$$

$$\left.\begin{array}{l} W_{NC} = 0 \\ W_{ext} = 0 \end{array}\right]$$

$$\boxed{W_C = \Delta K}$$

$$\boxed{-\Delta U = \Delta K}$$

$$\boxed{\Delta K + \Delta U = 0}$$

$$K_f - K_i + U_f - U_i = 0$$

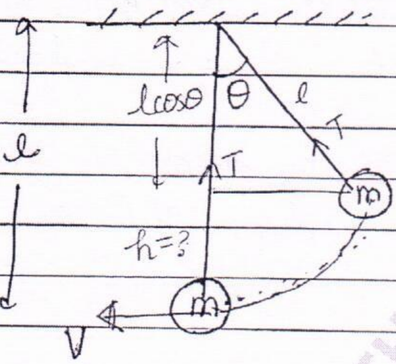
$$\boxed{K_i + U_i = K_f + U_f}$$

$$\boxed{K + U = const}$$

⊛ If sum of the internal forces are non-conservative and they do some work, the M·E of the system is not conserved

$$\boxed{W_{ext/NC} = \Delta K + \Delta U}$$

Ques. A pendulum of length 'l' & mass 'm' is given and angular displacement 'θ' from mean position & released find speed of the bob when it is at lowest point.



$W_T = 0$

only conservative Force (g)

$$\boxed{-\Delta U = \Delta K}$$

loss in P·E = Gain in K·E

$$mg(l - l\cos\theta) = \frac{1}{2}mv^2 - 0$$

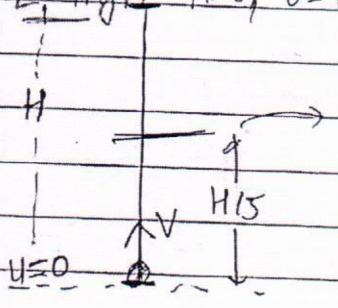
$$\sqrt{2gl(1-\cos\theta)} = V$$

$h = l - l\cos\theta$

$$\boxed{h = l(1-\cos\theta)}$$

Q: A particle of mass 'm' is projected vertically up so that it can attain max^m height of 'H'. Find Ratio of it's K·E to P·E when it is at height $\frac{H}{5}$ from point of projection.

$E = mgh$ $K=0$, $U = mgH$

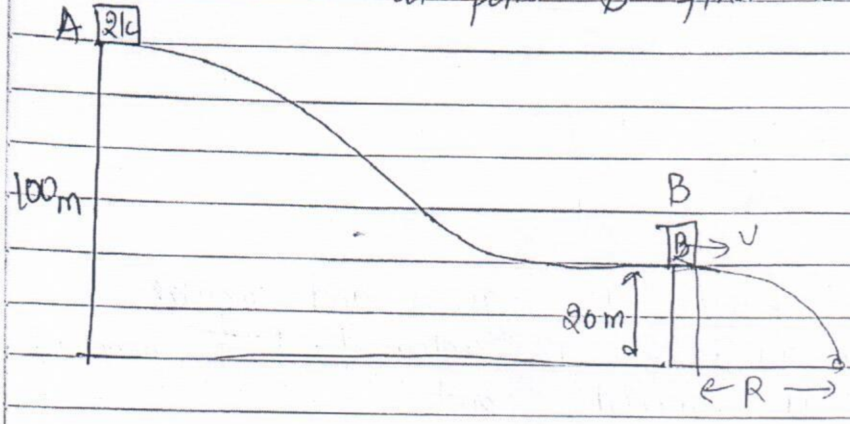


$PE = \frac{mgH}{5}$

$$KE = mgH - \frac{mgH}{5}$$

$$\frac{KE = \frac{4}{5}mgH}{PE = \frac{mgH}{5}} = \frac{4}{1}$$

Que. A block starts sliding from point ~~a~~ 'A' A/c to the figure. When it is at point 'B' find it speed & also Range.



loss in PE = gain in KE

$mg \times 80 = \frac{1}{2} m v_B^2 - 0$

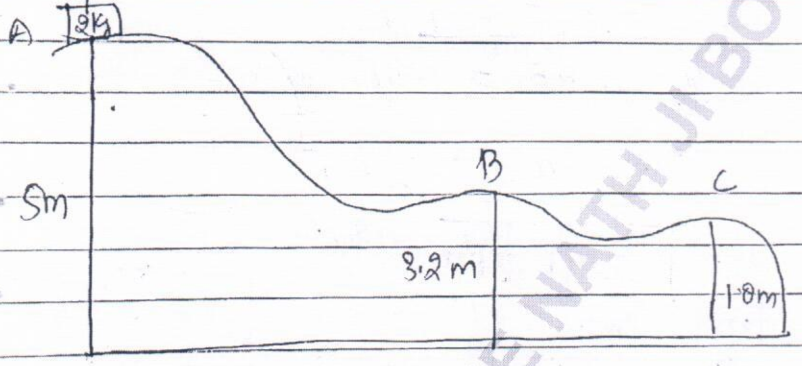
$v_B = 40 m/s$

$R = u_x \times T$

$= 40 \sqrt{\frac{2 \times 20}{10}}$

$R = 80 m$

Que. A block starts its motion from pt 'A' a/c to fig. Find it's speed at B & C.



B/w A & B

loss in PE = Gain in KE

$mg(5-3.2) = \frac{1}{2} m v_B^2$

$v_B = 6 m/s$

b/w A & C

loss in PE = gain

$mg(5-1.8) = \frac{1}{2} m v_C^2$

$v_C = 8 m/s$

Q. P.E of a particle of mass 2kg in a region is given $U = \left[\frac{x^2}{2} - x\right]$ Joule. if Total M.E of particle is 2 Joule. Find it max^m speed.

$$U = \frac{x^2}{2} - x$$

$$E = K + U$$

$$2 = K_{max} + U_{min}$$

$$2 = \frac{1}{2} m V_{max}^2 - \frac{1}{2}$$

$$2 + \frac{1}{2} = \frac{1}{2} \times 2 V_{max}^2$$

$$V_{max} = \sqrt{\frac{5}{2}} \text{ m/s}$$

$$U = \frac{x^2}{2} - x$$

① $\frac{dU}{dx} = \frac{\cancel{2}x}{\cancel{2}} - 1$

② $\frac{dU}{dx} = 0 \quad x - 1 = 0$

$x = 1m$

at $x = 1m$, $U = min$

$$U_{min} = \frac{(1)^2}{2} - 1 = -\frac{1}{2} \text{ Joule}$$

Q. In the previous Ques. if P.E of the particle is $U = \frac{x^3}{3} - \frac{x^2}{2}$ Joule. find V_{max} of Particle. $\boxed{V_{max} = \sqrt{\frac{13}{6}}}$

$x =$

$$U = \frac{x^3}{3} - \frac{x^2}{2}$$

$$\frac{dU}{dx} = \frac{\cancel{3}x^2}{\cancel{3}} - \frac{\cancel{2}x}{\cancel{2}} = x^2 - x$$

$\frac{dU}{dx} = 0 \quad x^2 - x = 0$

$x(x-1) = 0$

$x = 0$, $x = 1$

max^m min

$$\frac{d^2U}{dx^2} = 2x - 1$$

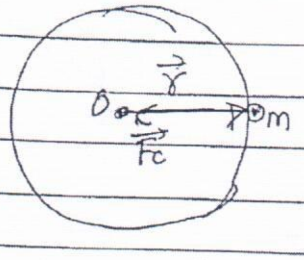
(a) $x = 0$, $\frac{d^2U}{dx^2} < 0$ min ~~maxima~~

(b) $x = 1 \Rightarrow$ ~~minima~~

Neet

Que. A particle of mass 'm' is moving on a circle under a effect of a Force $F = -\frac{k}{r^2}$. Find Total M.E of the particle, take P.E zero at ∞.

$F \,\&\, r \Rightarrow$ in opp. dir

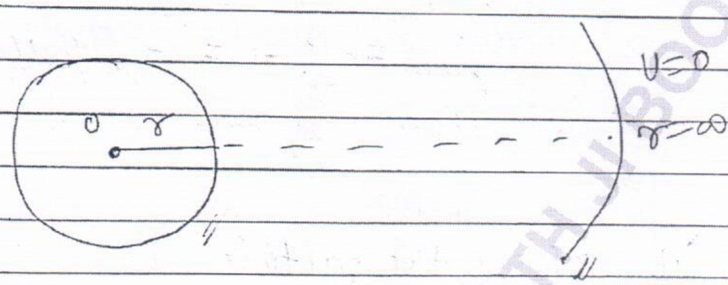


$$|\vec{F}| = \frac{k}{r^2}$$

$$\frac{mv^2}{r} = \frac{k}{r^2}$$

$$\frac{1}{2}mv^2 = \frac{1}{2}\frac{k}{r}$$

$$\boxed{KE = \frac{k}{2r}}$$



$$U = -W_c$$

$$U = -\left[\int_{\infty}^{r} \vec{F}\cdot d\vec{r}\right]$$

$$U = -\left[\int_{\infty}^{r} -\frac{k}{r^2}\,dr\right]$$

$$U = k\int_{\infty}^{r} r^{-2}\,dr$$

$$U = k\left[-\frac{1}{r}\right]_{\infty}^{r}$$

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

$$E = \frac{k}{2r} - \frac{k}{r}$$

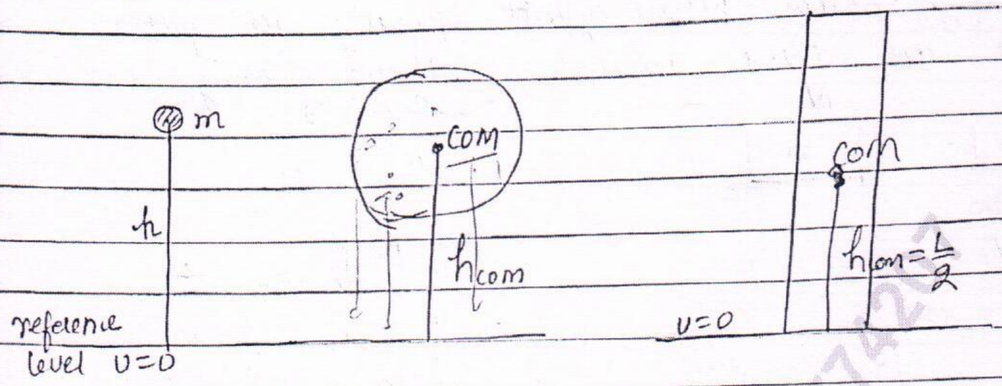
$$\boxed{E = \frac{-k}{2r}}$$

$$\boxed{E = -K} \qquad \boxed{E = \frac{U}{2}}$$

For bounded system

$v_\infty \to 0$

P.E of Extended Bodies:

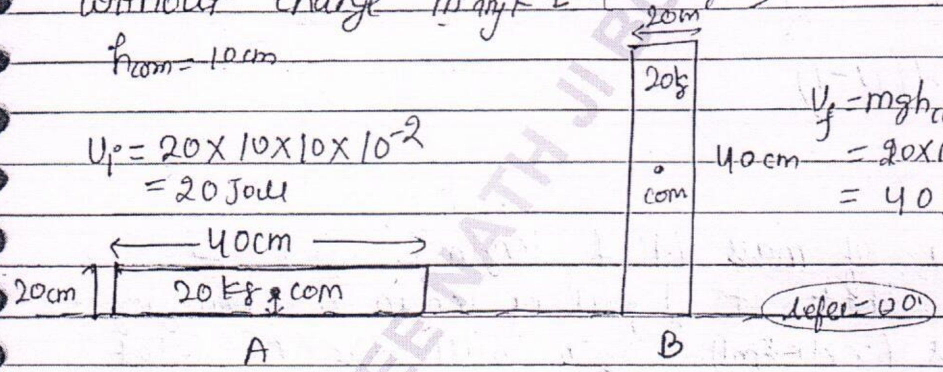


$U = mgh$
(point mass)

$U = \frac{MgL}{2}$

Q. Find W.D by us ($F \to$ external) to change the orientation of the slab from position A to position B against gravity without change in any K.E. (Slowly)

$h_{com} = 10\,cm$



$U_i = 20 \times 10 \times 10 \times 10^{-2}$
$= 20$ Joule

$U_f = mgh_{com}$
$= 20 \times 10 \times 20 \times 10^{-2}$
$= 40\,J$

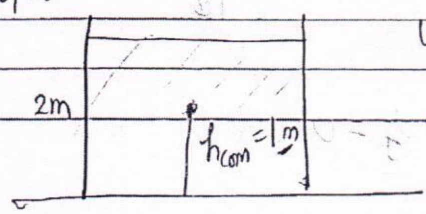
$W_{ext} = \Delta K + \Delta U \qquad \Delta K = 0$

$W_{ext} = U_f - U_i = 40 - 20$

$\underline{W.D = 20\,J}$

Q. Find W.D to fill a cubical container of side 2m with water.

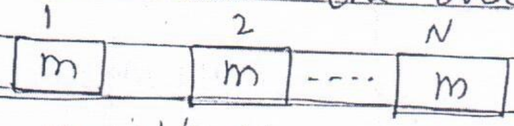
$U_i = 0$



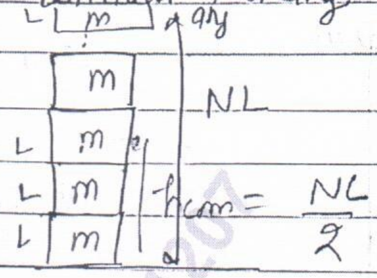
$U_f = mgh_{com}$
$= V\rho g h_{com}$
$= (2)^3 \times 10^3 \times 10 \times 1$
$U_f = 80\,kJ$

$W_{ext} = U_f - U_i$
$= 80\,kJ - 0$
$= 80\,kJ$

Q. 'N' cubical blocks of each mass 'm' and side 'L' are placed on horizontal surface. Find W.D against gravity to place these blocks one over another without change in K.E.



$U_i = N\left(\frac{mgL}{2}\right)$



$U_f = N\, mgh_{com}$

$= N\, mg \frac{NL}{2}$

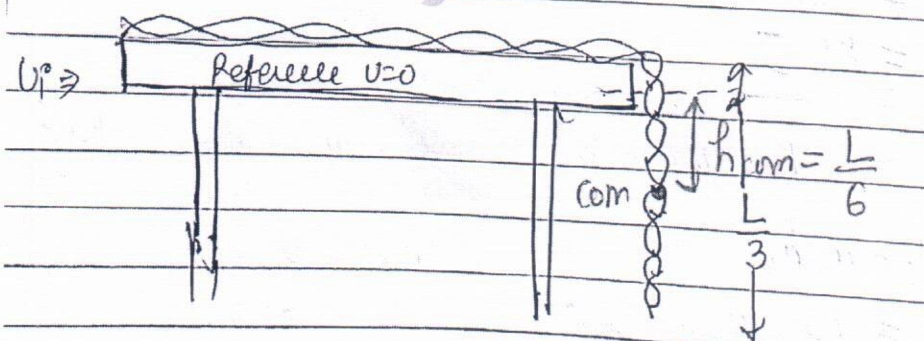
$= N^2 mg\frac{L}{2}$

$W_{ext} = U_f - U_i$

$= N^2 mg\frac{L}{2} - \frac{NmgL}{2}$

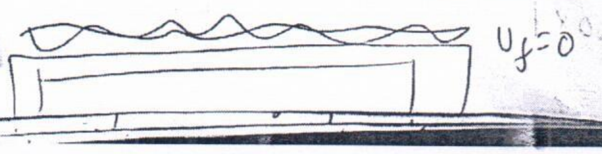
$W_{ext} = \frac{mgL}{2} N(N-1)$

Q. A uniform chain of mass 'M' & length 'L' is placed on table top such that it $\frac{1}{3}$ part of length is hanging. Find W.D by us (external) to pull the complete chain on the table against gravity without change in K.E.



$U_i = -\frac{M}{L} \times \frac{L}{3} g \times \frac{L}{6}$

$U_i = -\frac{MgL}{18}$



$U_f = 0$

$W_{ext} = U_f - U_i = 0 - \left[-\frac{MgL}{18}\right]$ $\quad W_{ext} = \frac{MgL}{18}$ ✓

Que. A uniform chain of mass 'M' & length 'L' is placed on a table such that it's $\frac{1}{n}$ parts of length is hanging. Find W.D against gravity to pull the entire chain on table without change in KE.

$U_i = mgh$ $\quad L \longrightarrow M$ $\quad h_{com} = \frac{L}{2n}$

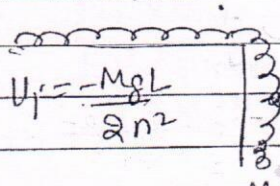
$1 \longrightarrow \frac{M}{L}$

$= -\frac{M}{\cancel{L}} \times \frac{\cancel{L}}{n} \times g \times \frac{L}{2n}$

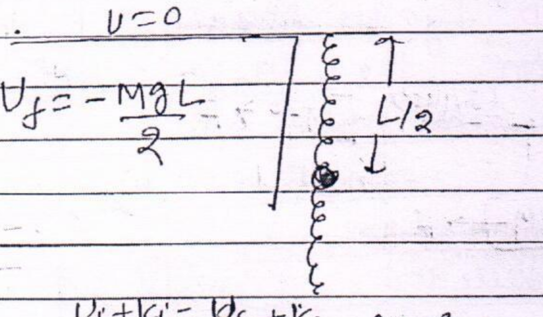
$U_i = -\frac{MgL}{2n^2}$ $\quad U_f = 0$ $\quad W_{ext} = U_f - U_i$

$\boxed{W = \frac{MgL}{2n^2}}$

Q. A uniform chain of mass 'm' and length 'L' is placed on table such that it's $\frac{1}{n}$ part of length is hanging. Now the chain is left to fall freely, there is no friction. find speed of chain when last end of chain is just leaving the Table?



$U_i = -\frac{MgL}{2n^2}$



$U_f = -\frac{MgL}{2}$

C.O.M.E $\quad \frac{M}{L} \times \frac{L}{n} g$

loss in P.E = Gain in K.E

$\boxed{-\Delta U = \Delta K}$

$U_i + K_i = U_f + K_f$ solve -

$U_i - U_f = \frac{1}{2} M v^2$

$-\frac{MgL}{2n^2} + \frac{MgL}{2} = \frac{1}{2} m v^2$

$gL\left(1 - \frac{1}{n^2}\right) = v^2$

$v = \sqrt{gL\left(1 - \frac{1}{n^2}\right)}$ ✓

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Neet

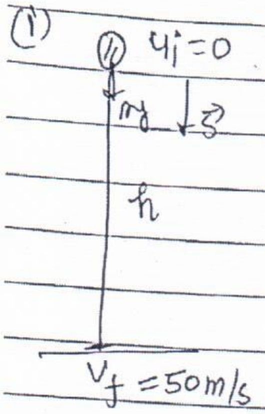
Date ______ Page ______

Q. A rain drop of mass 1gm starts falling from height 1km from earth surface. It strikes on ground with speed 50 m/s. Find W.D by

i) Gravity Force

ii) air resistance.

(i)



$W_g = +mgh$

$= 10^{-3} \times 10 \times 10^3$

$W_g = 10 J$

(ii) $W_g + W_{air} = k_f - k_i$

$10 + W_{air} = \frac{1}{2} \times 10^{-3} [(50)^2 - 0]$

$W_{air} = \frac{1}{2} \times 10^{-3} \times 2500 - 10$

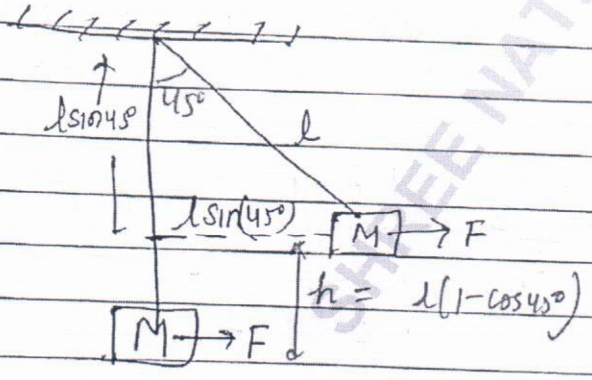
$W_{air} = 1.25 - 10$

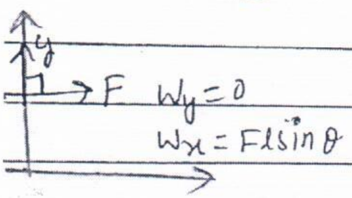
$W_{air} = -8.75 J$

AIPMT 2010

Q. A block of mass 'M' is suspended by massless string. A horizontal Force that is required to displace it ~~unit~~ untill the string making an angle 45° from initial direction.

Tension → variable.





$\underline{W = Fl \sin 45°}$ (x-dirn $\vec{S}$ & $\vec{F}$)

$\boxed{W_g + W_F = 0 - 0}$

$-Mgl(1 - \cos 45°) + Fl \sin 45° = 0$

$Mg\left[1 - \frac{1}{\sqrt{2}}\right] = F \times \frac{1}{\sqrt{2}}$

$F = Mg(\sqrt{2} - 1)$

★ Condition For Force to be Conservative:

$\vec{F} = F_x \hat{i} + F_y \hat{j}$ $\qquad \dfrac{\partial F_x}{\partial y} = \dfrac{\partial F_y}{\partial x}$

Condition for a Force to be conservative

$$\boxed{\frac{\partial F_x}{\partial y} = \frac{\partial F_y}{\partial x}}$$

$\partial \Rightarrow$ जिसके respect में करेंगे. any — बाकी (const) रहेगा।

⊛ $\vec{F} = kx\hat{i} + ky\hat{j}$

$\dfrac{\partial F_x}{\partial y}$ $\qquad \dfrac{\partial F_y}{\partial y}$

$= \dfrac{\partial kx}{\partial y} = 0$ $\qquad = \dfrac{\partial ky}{\partial y} = 0$

$\dfrac{\partial F_x}{\partial y} = \dfrac{\partial F_y}{\partial x}$

$0 = 0$

Conservative

⊛ $\vec{F} = ky\hat{i} + kx\hat{j}$

$\dfrac{\partial ky}{\partial y} = k$

$\dfrac{\partial kx}{dx} = k$

Same

Conservative

⊛ $\vec{F} = 3x\hat{i} + 4y\hat{j}$

$\dfrac{\partial 3x}{\partial y} - 0$

$\dfrac{\partial 4y}{dx} = 0$

Conservative

⊛ $\vec{F} = 4y\hat{i} + 3x\hat{j}$

$\dfrac{\partial 4y}{\partial y} = 4$

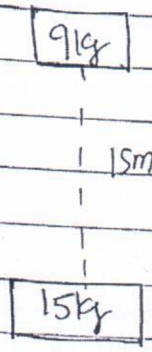
$\dfrac{\partial(3x)}{\partial x} = 3$

$\dfrac{\partial F_x}{\partial y} \neq \dfrac{\partial F_y}{\partial x}$

Non-Conservative

→ variable है
Integration से आता है।

Q. A bucket filled with water having weight 15kg it is pulled up slowly & water is leaking at const rate after moving up a height 15m it mass remains 9kg. Find w.d by us against gravity.



$$F_{av} = \frac{F_i + F_f}{2} = \frac{(9+15)g}{2}$$

$$= 12g$$

$$W = F_{av} \times S$$
$$= 12g \times 15$$
$$= \underline{1800 J} \quad \underline{1.8 kJ}$$

$P_{in} = \vec{F} \cdot \vec{V}$

$P_{av} = \frac{W}{t}$

POWER ⇒ Rate of doing work.

⇒ Average power = $\frac{\text{total work done}}{\text{total time}} = \frac{\Delta W_{total}}{\Delta t}$ J/s

S.I unit watt

$P_{av} = \frac{\Delta W}{\Delta t}$

$1 KW = 10^3$ watt
$1 MW = 10^6$ watt
$1 H.P = 746$ watt

Scalar, $[ML^2T^{-3}]$

⇒ Instantaneous Power:

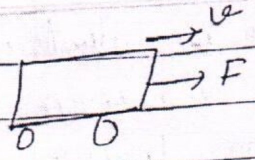
$$P_{ins} = \lim_{\Delta t \to 0} \frac{\Delta W}{\Delta t} = \frac{dW}{dt}$$

$$P_{ins} = \frac{d\, \vec{F} \cdot \vec{S}}{dt} \qquad \vec{F} = \text{const.}$$

$$P_{ins} = \vec{F} \cdot \frac{d\vec{S}}{dt}$$

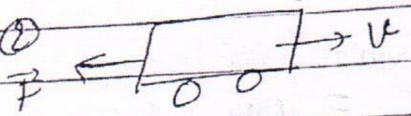
$\boxed{P_{ins} = \vec{F} \cdot \vec{v}}$

$P_{ins} = FV\cos\theta$

① 

$\theta = 0$

$\boxed{P_{in} = Fv}$

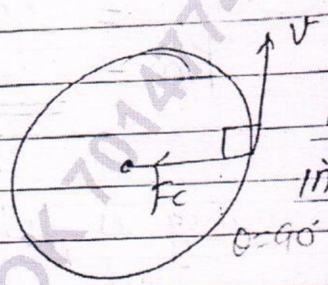
② 

$\theta = 180°$

$\boxed{P_{ins} = -Fv}$

③ $\theta = 90°$

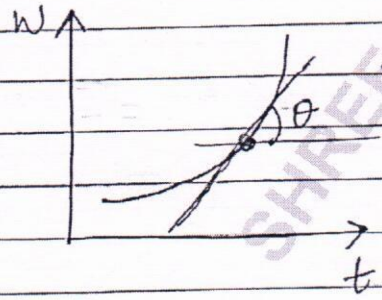
$\boxed{P_{ins} = 0}$



So No power delivered by centripetal force in circular motion.

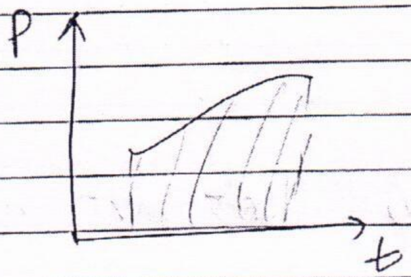
$$\begin{cases} P_{ins} = \vec{F} \cdot \vec{v} \\ P_{av} = \dfrac{W}{t} \end{cases}$$

⊛ Work-time graph



$\tan\theta = m = \text{slope} = \boxed{\dfrac{dW}{dt} = P_{ins}}$

Slope → P_{ins}



$P = \dfrac{dW}{dt}$ $\int dW = \int P\,dt$

$W = \int P\,dt$ = Area of P-t graph.

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$P_{av} = \frac{W}{t} = \frac{\vec{F}\cdot\vec{S}}{t} = \frac{\Delta K}{t} = P\frac{dV}{dt}$ ← Volume

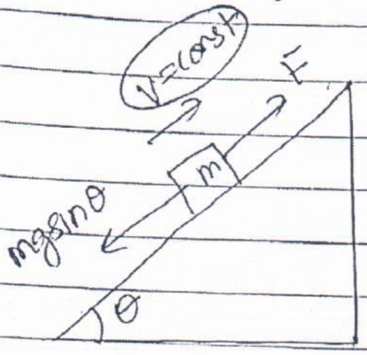
pressure

* Constant velocity $P_{av} = P_{in}$

Q. A block of mass 4000 kg is pulled upwards on inclined plane of inclination 1 in 50, with velocity 10 m/s. Find Power delivered by the pulling force.

const

$\sin\theta = \frac{1}{50}$



$P_{in} = \vec{F}\cdot\vec{v}$

$= mg\sin\theta \times v$

$= 4000 \times 10 \times \frac{1}{50} \times 10$

$= 8000$ watt

$P_{in} = \underline{8 kW}$

Q. A block of mass 5000 kg is pulled upwards on an inclined plane of inclination 3 in 5 with velocity 20 m/s. If coeff. of friction is 0.5. Find power produced by the pulling force.

const ⇒ velocity

$F_f + F_g = F_{ext}$

$P_{in} = 10^6$ watt

$P_{in} = 1$ MW

$P_{in} = \vec{F}\cdot\vec{v}$

$= [mg\sin\theta + \mu mg\cos\theta]\, v$

$= mg[\sin\theta + \mu\cos\theta]\, v$

$= 5000 \times 10 \left[\frac{3}{5} + \frac{0.5 \times 4}{10 \cdot 5}\right] \times 20$

$= 5 \times 10^4 \times \frac{8}{5} \times 20$

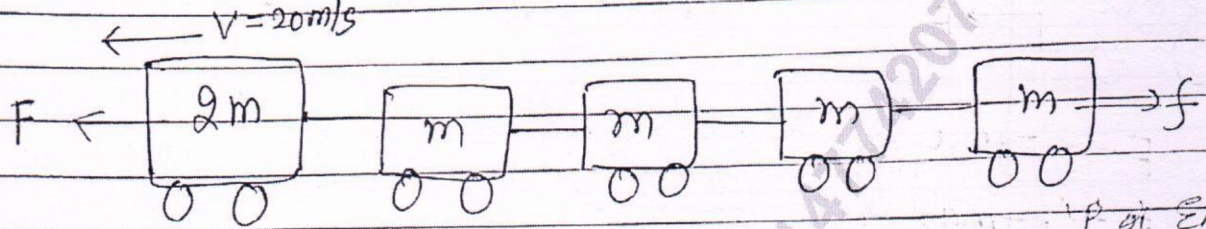
$P_{in} = 10 \times 10^5 = 10^6$ watt

$P_{in} = 1$ MW

If Block moving with const Velocity then, $P_{in} = P_{av} =$ same.

NCERT

Q. An Engine pulls a train of 4 coaches with speed 20 m/s on a straight track. mass of engine is twice that of coach. If the same Engine pulls the train of 12 coach & 6 coaches. Find speed of train in Both case. (frictional $\propto$ to the weight)



Power of engine; $F = f$ (v = const)

P of Engine does not change on [illegible]

$$Power = Fv \qquad f \propto wt$$

$$Power = fv \qquad f = 6mg$$

$$Power = 6mg \times 20 = 120mg \quad (P_T \text{ Engine})$$

(I) 12 coaches

$$f = (12m + 2m)g$$

$$f = 14mg$$

$$Power = f \times v_1$$

$$120mg = 14mg \times v_1$$

$$v_1 = \frac{120}{14} = \frac{60}{7} = 8.5\ m/s$$

(II) 6 coaches

$$f_2 = (6m + 2m)g$$

$$f_2 = 8mg$$

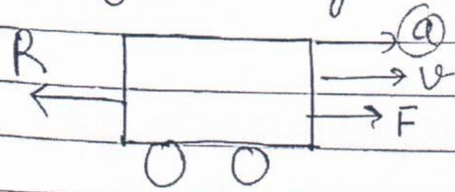
$$Power = 8mg \times v_2$$

$$120mg = 8mg \times v_2$$

$$v_2 = \frac{\cancel{120}^{30}}{\cancel{8}_{2}} = 15\ m/s$$

Date ______ Page ____

Q. A car of mass 'm' is moving with $acel^n$ 'a' on a st. road a constant resistive force 'R' is acting on it. when the velocity of car is V. Find the rate at which engine doing work.



$$\text{Power} = Fv$$

$$\text{Power} = (R+ma)v$$

$$F - R = ma$$

$$F = (R+ma)_{\text{put}}$$

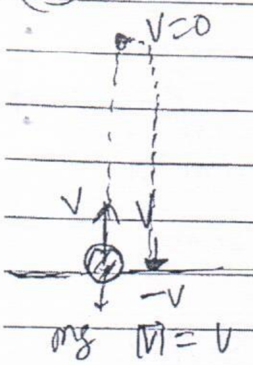
AIPMT

Q. A ball of mass 'm' is projected vertically up with speed 'V' find power produced by gravity force.

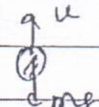
(i) at an Instant of projection

(ii) at an Instant when it attains max^m height.

(iii) at " " when it strikes on Earth Surface.

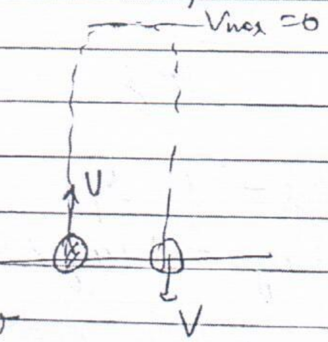


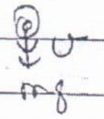
(i) $P_1 = -mgv$



(ii) $P_2 = mg \times 0 = 0 \quad (V=0)$

(iii) $P_3 = mgv$ max^m AIPMT





Que. A particle of mass 2kg begins to move under the action of a time dependent Force $F = (6t^2\hat{i} + 4t\hat{j})N$. Find power produced by the Force at time $t = 1 sec$

$P_{in} = ?$

$$a = \frac{F}{m} = 3t^2\hat{i} + 2t\hat{j}$$

Ex-I (61, 64, 66) 68, 78)
-II (9, 12, 15, 17, 18, 21)
Race $\Rightarrow$ 8-4, 9

$\Delta V = \int a\,dt$

$V_f - \cancel{V_i} = \int_0^1 (3t^2\hat{i} + 2t\hat{j})\,dt$

$\cancel{V_f = \left[\frac{3t^3}{3} + \frac{2t^2}{2}\right]_0^1}$

$\cancel{V_f = \left[t^3 + t^2\right]_0^1}$

$\cancel{V_f = 2\ m/s}$

$V_f = \frac{3t^3}{3}\hat{i} + \frac{2t^2}{2}\hat{j}$ (10)

$V_f = t^3\hat{i} + t^2\hat{j}$

$P_{in} = \vec{F}\cdot\vec{v}$

$= (6t^2\hat{i} + 4t\hat{j})\cdot(t^3\hat{i} + t^2\hat{j})$

$P_{ins} = 6t^5 + 4t^3$

$P_{ins} = 6(1)^5 + 4(1)^3 = \underline{10\text{ watt}}$

Q. A particle of mass 'm' initially at rest acting upon by a Force which delivers const power P_0. Find

(1) v-t relation $\Rightarrow V \propto t^{1/2}$
(2) x-t relation
(3) x-V relation
(4) F-t relation

Neet-2016

(I)

$P_0 = Fv$

$P_0 = mav$

$P_0 = m\left(\frac{dV}{dt}\right)v$

$\int_0^t \frac{P_0}{m}\,dt = \int_0^V V\,dV$

$\frac{P_0}{m}\int dt = \int V\,dV$

$\frac{P_0}{m}t = \frac{V^2}{2}$

$V^2 = \frac{2P_0}{m}t$

$V = \left(\frac{2P_0}{m}t\right)^{1/2}$

$\boxed{V \propto t^{1/2}}$

(ii) $V \propto t^{1/2}$

$\frac{dx}{dt} = \sqrt{\frac{2P_0}{m}}\,t^{1/2}$

$\int_0^x dx = \sqrt{\frac{2P_0}{m}}\int_0^t t^{1/2}\,dt$

$x = \sqrt{\frac{2P_0}{m}}\,\frac{t^{\frac{1}{2}+1}}{\frac{1}{2}+1}$

$x = \sqrt{\frac{2P_0}{m}}\,\frac{t^{3/2}}{3/2}$

$\boxed{x \propto t^{3/2}}$

(iii) $x \propto (t^{1/2})^3$

$x \propto (v)^3$

$\boxed{x \propto V^3}$

(iv) $F = m\frac{dv}{dt}$

$F = m\sqrt{\frac{2P_0}{m}}\,\frac{d\,t^{1/2}}{dt}$

$F = \sqrt{2P_0 m} \times \frac{1}{2}\,t^{\frac{1}{2}-1}$

$F = \sqrt{\frac{mP_0}{2}}\,t^{-\frac{1}{2}}$

$\boxed{F \propto t^{-\frac{1}{2}}}$

Date ____ Page ____

Q. A car of mass 'm' begins its motion under effect of a Force which produces const Power P_0. Find speed of the particle as funtn of travelled distance.

$$P_0 = Fv = mav$$

$$\frac{P_0}{m} = \frac{v\,dv}{ds} v$$

$$\frac{P_0}{m}\int ds = \int v^2 dv$$

$$\frac{P_0}{m} s = \frac{v^3}{3}$$

$$\left[\begin{array}{l} s \propto v^3 \\ v \propto s^{1/3} \end{array}\right.$$

Q. A particle of mass 'm' is uniformly accelerated from rest and attains velocity(V_1) in time t_1. Find Power produced by Force as funtn of time 't'

$P_{in} = Fv$ $\quad$ $a = \text{const}$

$= ma \times at$ $\quad$ $v = 0 + at$

$P_{in} = ma^2 t$ $\quad$ $v = at$

$P_{in} = ma^2 t$ $\quad$ $v_1 = 0 + at_1$

$\quad$ $a = \frac{v_1}{t_1}$ ← acquire V_1 speed.

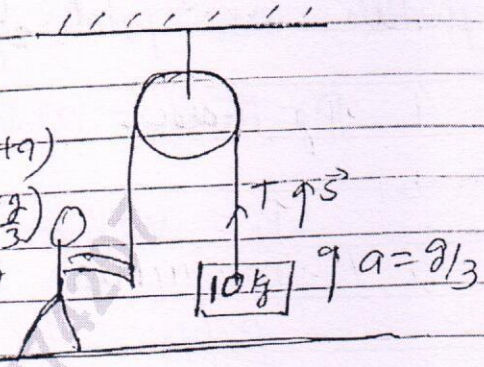
$$= m\left(\frac{V_1}{t_1}\right)^2 t$$

$$\boxed{P_{in} = \frac{mV_1^2}{t_1^2}\,t}$$

Averge Powe

Que. In the given dig. Find ~~work~~ Power by Tension force in 1^{st} 2 second

$$P_{av} = \frac{W}{t} = \frac{\vec{F}\cdot\vec{s}}{t} = \frac{Ts}{t}$$



$T = m(g+a)$

$= m\left(g+\frac{g}{3}\right)$

$T = \frac{4}{3}mg$

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

$s = \frac{1}{2} \times \frac{g}{3} \times (2)^2 = \frac{20}{3}$ m

$$P_{av} = \frac{Ts}{t}$$

$$= \frac{\frac{4}{3}mg \times \frac{20}{3}}{2}$$

$$= \frac{4000}{9} = \underline{444.4 \text{ watt}}$$

Q. velocity of a particle moving on straight road is given. $(v = 2t^2 + 1)$ m/s, Find Power delivered by the Net Force in first 2 second. (mass of particle = 2kg)

$$P_{av} = \frac{\Delta W}{t} = \frac{F \times S}{t} = \frac{\cancel{8}}{\cancel{8}} = 0$$

$\cancel{v = ut}$

$\cancel{a = 0}$ m/s

$W = \Delta K = \cancel{\frac{1}{2} \times 2 \times (3^2 - 1^2)}$

$= 8$

$$P_{av} = \frac{\Delta K}{t}$$

$$= \frac{\frac{1}{2}m(v_f^2 - v_i^2)}{t}$$

$v_f = 9$

$v_i = 1$

$$= \frac{\frac{1}{2} \times 2 \times (81 - 1)}{2}$$

$$= \underline{40 \text{ watt}}$$

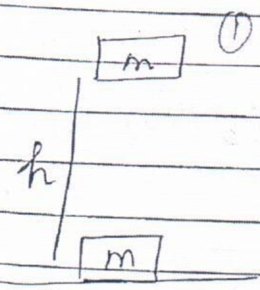
Q. A block of mass 'm' is taken up to height 'h' by us (or external agent) against gravity. in time 't' find Power delivered by

① gravity Force

$P_g = -\frac{mgh}{t}$

② By us

in this duration of time. $P_{ex} = +\frac{mgh}{t}$ (Motor pump)

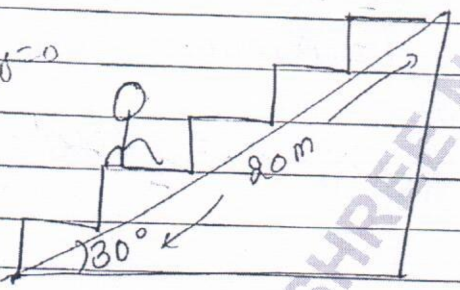


① Power by gravity

$P_g =$

Que. In 90 kg Man walks up on stair case in 10 sec A/c to the fig. Find Power produced by him.

$W_{ext} = 0$



$P = \frac{W}{t}$ $\quad$ $W_N + W_g = \Delta K = 0$

$P = \frac{mgh\sin\theta}{t}$

$= \frac{90 \times 10 \times 2\cancel{0} \times \frac{1}{\cancel{2}}}{\cancel{10}} = 900$ watt.

Que. A 700 Newton Commando in Basic training climb a 10m verticle rope at const speed in time 8 sec. find power produced by him

$W_f = 0$

$P = \frac{mgh}{t} = \frac{700 \times 10}{8} = \cancel{8340} = 875$

$P = \frac{mgh}{t} = \frac{700 \times 10}{8}$

$= 125 \times 7 = 875$

54000 L

Q. 54000 L water falls / per hour from Height 100m and $\frac{1}{3}$rd of P.E is converted into electrical energy. How much power is generated.

$1\,\text{Litre} = 10^{-3}\,m^3$

$$P_{av} = \frac{mgh}{t} \times \frac{1}{3} = \frac{V\rho gh}{t} \times \frac{1}{3}$$

$$= \frac{54000 \times 10^{-3} \times 10^3 \times 10 \times 100}{3600 \times 3} = 5\,kW$$

$= \cancel{0.5}$ ×

Q. Find Average Power produced by Engine which can lift 0.6 tonne coal per minute from a 20m deep well.

$1\,\text{ton} = 10^3$

$$P = \frac{mgh}{t} = \frac{0.6 \times 10^3 \times 20}{60} = 2\,kW$$

NCERT

Q. The heart of a boy pumps 75 cc blood in every beat against a pressure of 10cm of Hg column. ~~Effect~~ If heart beat rate of Boy is 72 per/min, Find Power of heart. $\rho_{Hg} = 13.6 \times 10^3\,kg/m^3$

$$\text{Power} = \frac{P\,dV}{dt}$$

$$P_{av} = \frac{W}{t} = \frac{FS}{t} = \frac{PAS}{t} = \frac{PV}{t} = (h\rho g)\frac{V}{t}$$

$60s \longrightarrow 72$ beat

$1s \longrightarrow \frac{72}{60} = 1.2$ beat

Vol^m in 1 sec $\rightarrow \frac{V}{t} = 75 \times 1.2\,cc/s$

$= 90 \times 10^{-6}\,\frac{m^3}{s}$ put

$$P_{av} = 0.1 \times 13.6 \times 10^3 \times 10 \times 90 \times 10^{-6}$$

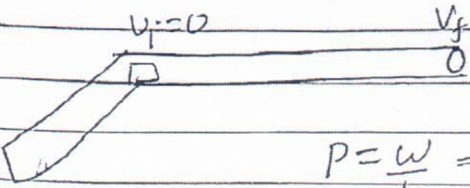
$P_{av} = 1.224$ watt

Ans

$\frac{120}{60} \times 50 \times 10^{-3} \times 700$

700 watt

Que. A Gun Fires 120 bullet/min each of mass 50gm with speed 700 m/s Find power of the gun.



$$P = \frac{W}{t} = \frac{\frac{1}{2}m(v_f^2 - v_i^2) \times N}{t}$$

$$= \frac{1}{2} \times 50 \times 10^{-3} \times (4900 \times 100 - 0) \frac{120}{60}$$

$$= 50 \times 49 \times 10^{-3} \times 10^4$$

$$P_{av} = 24.5 \text{ kW}$$

Q. A particle begins it's motion under effect of Force 'F' Find power produced by in direction particle attain in velocity 'V' Force

$0 \longrightarrow V \Rightarrow P_{av}$

$S = 0 + \frac{1}{2}at^2$

$$P_{av} = \frac{W}{t} = \frac{\frac{1}{2}m(V_f^2 - V_i^2)}{t} = \frac{FS}{t}$$

$$= \frac{F \times \frac{1}{2}at^2}{t}$$

$V = 0 + at$

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

$$= \frac{F}{2}\frac{V}{t} \times t$$

$$\boxed{P_{av} = \frac{FV}{2}}$$

M-II

$a = \text{const}$

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

$= \frac{F}{t} \times \frac{V}{2} \times t$

$P = \frac{FV}{2}$

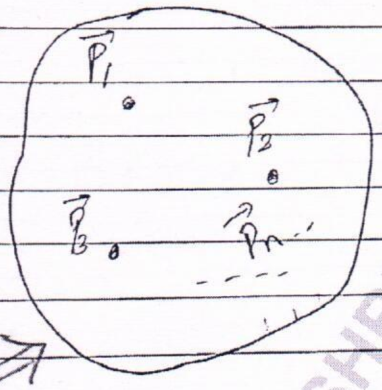
Conservation of linear Momentum. COLM

• If there is no External Force acting on a System of particle. Then the Net momentum of the particles remains constant *

⇒ $\vec{F}_{ext} = 0$, then resultant of linear momentum of the particle before application of Internal force is equal to after application of internal force.

⇒ Due to internal forces the individual linear momentum of the particle may change but their resultent remains const.

⇒ Only internal force can't change the net momentum of the system.



$F_{ext} = 0$

IInd Law of Motion

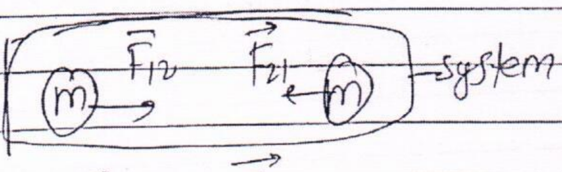
$$\vec{F}_{ext} = \frac{d\vec{p}}{dt}$$

$$\because \vec{F}_{ext} = 0$$

$$\frac{d\vec{p}}{dt} = 0 \quad d\vec{p} = 0$$

$$\boxed{\vec{P}_{system} = const}$$

$$\boxed{\vec{P}_1 + \vec{P}_2 + \dots + \vec{P}_n = const}$$



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

$$\vec{F}_{12} + \vec{F}_{21} = 0$$

Gravitational Force ⇒ internal

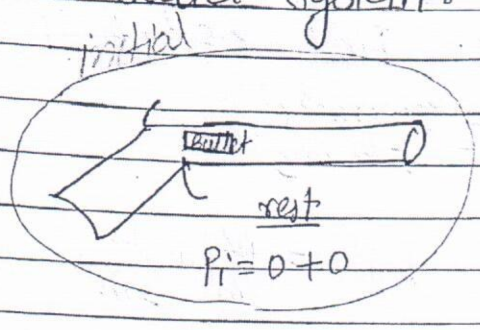
Toy gun → spring ∈ internal force

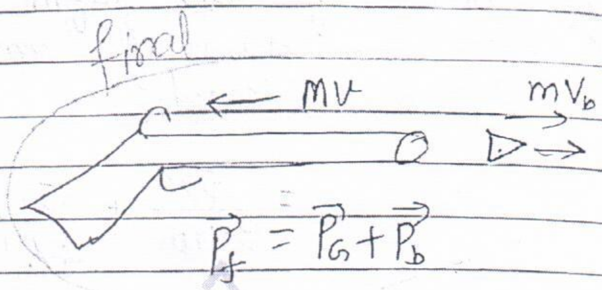
Gun → gun powered → gases speed fixed

$m \rightarrow \quad \leftarrow m \Rightarrow F_g \Rightarrow$

$q \rightarrow \quad \leftarrow q_2 \Rightarrow F_e \Rightarrow$ internal force.

Gun-Bullet system:





COLM,

$$\vec{P_i} = \vec{P_f}$$

$$0 = \vec{P_G} + \vec{P_b}$$

$$\boxed{\vec{P_G} = -\vec{P_b}}$$

$$|\vec{P_G}| = |\vec{P_b}|$$

Direct

$$M\vec{V_G} = -m\vec{V_b}$$

$$\vec{V_G} = -\frac{m\vec{V_b}}{M}$$

$$\boxed{|\vec{V_G}| = \frac{m\vec{V_b}}{M}}$$

recoil speed of Gun.

$$* \; |\vec{P_G}| = |\vec{P_b}| = P$$

$$\boxed{K_{system} = \frac{P^2}{2M} + \frac{P^2}{2m}}$$

$$K = \frac{P^2}{2m}$$

$$\uparrow K \propto \frac{1}{m\downarrow} \qquad \boxed{K_{bullet} > K_{Gun}}$$

Date ______ Page ______

Q. A bullet of mass 50gm is fired with velocity 100 m/s from a Gun of mass 10 kg. Find K.E of the system released.

$p = mv_b = 50\times10^{-3}\times100$
$= 5$ kg m/s

$K_{system} = \frac{(5)^2}{2\times10} + \frac{(5)^2}{2\times10}$

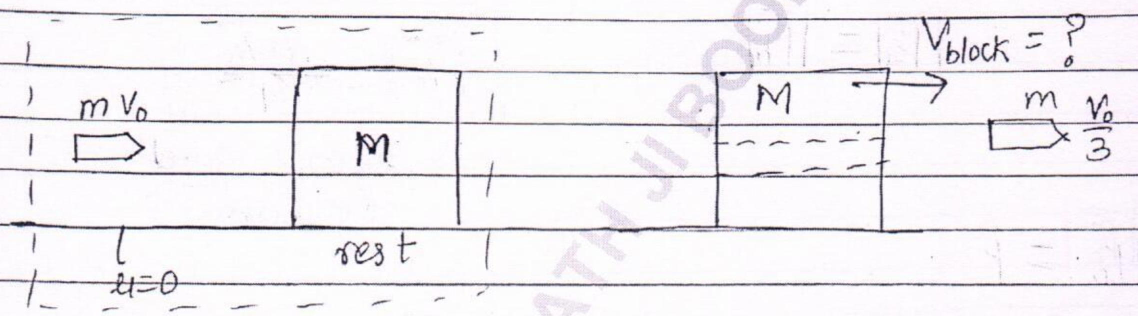
$K_{system} = \frac{p^2}{2M} + \frac{p^2}{2m}$

$= \frac{p^2}{2}\left[\frac{1}{M} + \frac{1}{m}\right]$

$= 1.25 + 250$
$= \underline{251.25}$ joule

Block-Bullet system:

(1)



COLM, $\vec{P_i} = \vec{P_f}$

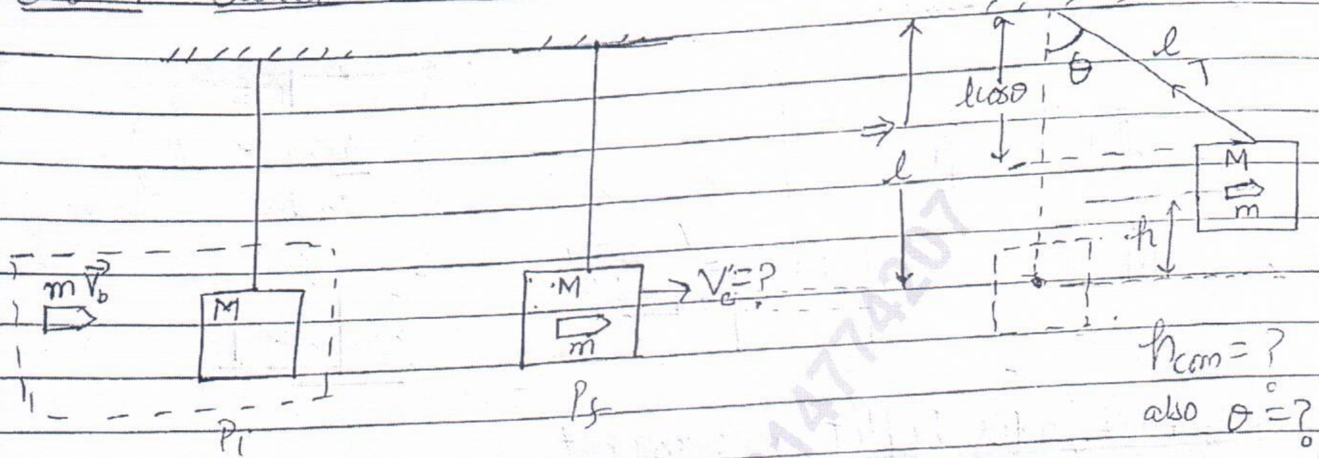
$m\vec{v_0} + M\times0 = MV_{block} + \frac{mv_0}{3}$

$mv_0\left[1 - \frac{1}{3}\right] = M\,V_{block}$

$$\boxed{V_{block} = \frac{2}{3}\frac{mv_0}{M}}$$

⊛ Block is suspended by inextensible & massless string :-

<u>Case-I Bullet embeded into the block</u>



⊛ <u>speed of bullet just after bullet embedded,</u>

COML,

$$m\vec{V}_b + 0 = (M+m)\vec{V}_c$$

speed. $$\boxed{\vec{V}_c = \frac{m\vec{V}_b}{M+m}}$$

⊛ <u>height up to which COM rises.</u> (COME)

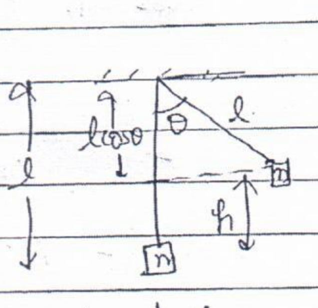
loss in K.E = Gain in P.E

$$\frac{1}{2}\cancel{(M+m)}\frac{m^2 V_b^2}{(M+m)^2} = \cancel{(M+m)}gh$$

$$\boxed{h = \frac{m^2 V_b^2}{2g(M+m)^2}}$$

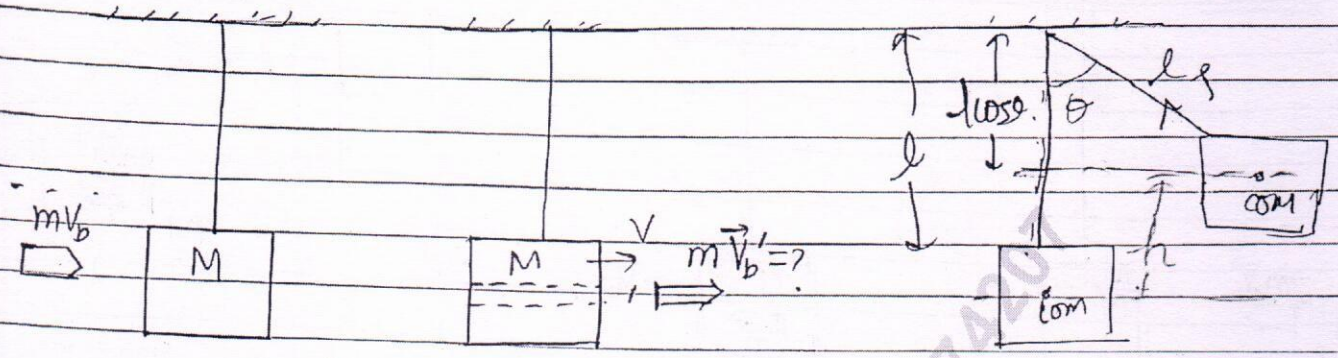
⊛ <u>θ = ? angle b/w them. initial & final.</u>

$$\boxed{h = l - l\cos\theta}$$



$h = l - l\cos\theta$
$= l(1-\cos\theta)$

Case-II. If Bullet penetrates (or emergees out) the block.



(*) Speed of block just after bullet emergees out.

COMM

$\vec{P_i} = \vec{P_f}$

$mV_b + 0 = M\vec{V} + mV_b'$

$\vec{V} = \frac{m(\vec{V_b} - \vec{V_b}')}{M}$

$$\boxed{V = \frac{m(V_b - V_b')}{M}}$$

(*) $\theta = ?$

$h = l - l\cos\theta$

(*) Height up to which COM rises : (COME)

loss in K.E = gain in P.E

$\frac{1}{2} M \times \frac{m^2 (V_b - V_b')^2}{M^2} = Mgh$

$$\boxed{h = \frac{m^2 (V_b^2 - V_b'^2)}{2gM^2}}$$

P-99
Neet-2016

Q. A bullet of mass 10gm is moving horizontaly with speed 400 m/s, strickes a wooden bloock of mass 2 kg which is suspended by a light inextensible string of lengh 5m, as a result centre of gravity of the block is found to be rise a which is distance of 10cm. the speed of bullet after it emeyes out horizontally from the block.

$V_b' = 120$ m/s

$V_b' = 120$ m/s

$$mV_b = MV + mV_b'$$

$$V = \frac{m(V_b - V_b')}{M}$$

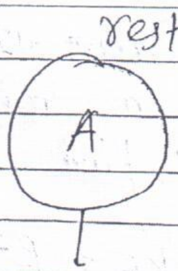
$$\frac{1}{2}\cancel{M}\,\frac{m^2(V_b-V_b')^2}{M^2} = \cancel{M}gh$$

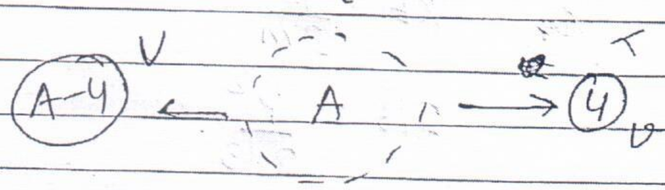
$$\frac{1}{2}\times\frac{(10\times10^{-3})^2(400-V_b')^2}{4} = 10\times 0.1$$

$$V_b' = 120 \text{ m/s}$$

⊛ α- emission from Nucleus at Rest:

A = mass number
m = mass of one nucleon
mass of the nucleus = mA





COLM, $\vec{P_i} = \vec{P_f}$

$$0 = (A-4)m\vec{V_N} + 4m\vec{v}$$

$$\vec{V_N} = -\frac{4\vec{v}}{A-4}$$

recoil speed $\boxed{V_N = \frac{4v}{A-4}}$

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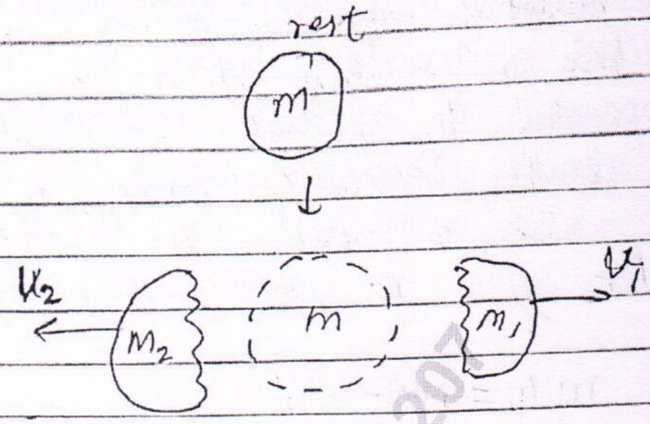
Bomb explosion

(I) into Two parts:



COLM,

$$\vec{P}_i = \vec{P}_f$$

$$0 = m_1\vec{v}_1 + m_2\vec{v}_2$$

$$\vec{v}_2 = -\frac{m_1\vec{v}_1}{m_2}$$

$$\boxed{\frac{v_1}{v_2} = \frac{m_2}{m_1}}$$

$$|\vec{v}_2| = \frac{m_1 v_1}{m_2}$$

$$K_{system} = \frac{p^2}{2m_1} + \frac{p^2}{2m_2}$$

$$\uparrow K = \frac{p^2}{2m\downarrow}$$

Que. A bomb of mass 12 kg at rest explod into 2 parts having masses in ratio 1:3. If K.E of lighter part is 216 Joule. find magnitude of linear momentum of havier part.

$$\frac{m_1}{m_2} = \frac{1}{3}$$

$$m_1 = \frac{1}{4} \times 12 = 3\,kg$$

$$KE = \frac{p^2}{2m}$$

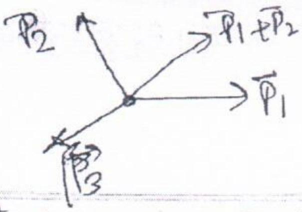
$$216 = \frac{p^2}{2 \times 3}$$

$$p = \sqrt{216 \times 2 \times 3} = \sqrt{1296}$$

~~p = 1496~~

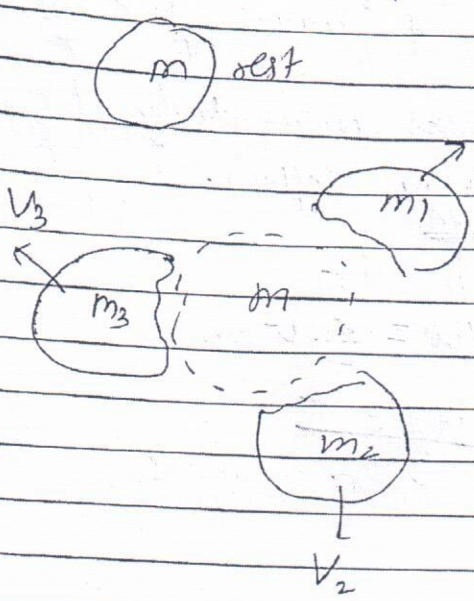
$$p = 36\ kg\ m/s$$

→ same of heavier part.



$|\vec{P_3}| = \vec{P_1} + \vec{P_2}$

(II) explosion in 3-parts :-



COLM,

$\vec{P_i} = \vec{P_f}$

$0 = \vec{P_1} + \vec{P_2} + \vec{P_3}$

$\vec{P_3} = -(\vec{P_1} + \vec{P_2})$

$|\vec{P_3}| = \sqrt{P_1^2 + P_2^2 + 2P_1P_2\cos\theta}$

$m_3V_3 = \sqrt{(m_1V_1)^2 + (m_2V_2)^2 + 2(m_1V_1)(m_2V_2)\cos\theta}$

Que. A bomb at rest explod into three parts having masses in ratio 1:1:3, if equal mass flys off in mutually ⊥ dirn with speeds 8 m/s & 6 m/s in speed of Third part.

let mass of bomb ⇒ m

~~m, m, 3m~~

1 : 1 : 3

$\frac{m}{5}, \frac{m}{5}, \frac{3m}{5}$

$\frac{3m}{5} v_3 = \sqrt{\left(\frac{m}{5}\times 8\right)^2 + \left(\frac{m}{5}6\right)^2}$

$= \frac{m}{5}\sqrt{8^2+6^2}$

$\frac{3\cancel{m} V_3}{\cancel{5}} = \frac{\cancel{m}}{\cancel{5}} \times 10$

$V_3 = \frac{10}{3}$ m/s

~~$K_{system} = \frac{P^2}{2m_1} + P$~~

$K_{system} = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 + \frac{1}{2}mv_3^2$

★ Speed ⇒ before Explosion की लेना है।

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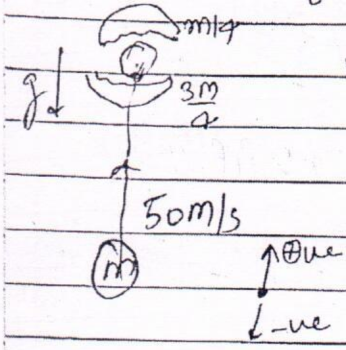
Q. A bomb of mass 'M' is projected up vertically with speed 50 m/s after 2 sec it explode into two parts of masses $\frac{M}{4}$ & $\frac{3M}{4}$. The heavier part just after explosion comes momentarily at rest find velocity of other part just after Explosion.



$v = u + gt$

$= 50 - 10 \times 2$

$= 30$ m/s before

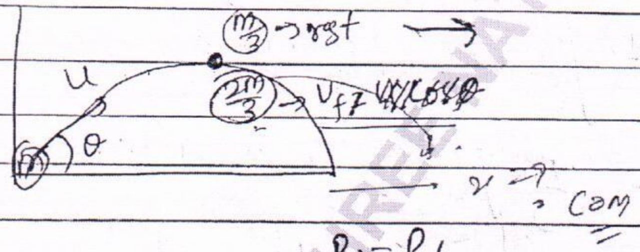
COLM

$P_i = P_f$

$M \times 30 = \frac{M}{4}\vec{v} + 0$

$\underline{120 = \vec{v}}$ m/s ⊕ ⇒ upwards.

Q. A shell of mass 'm' is projected with speed 'u' at angle θ from ground at highest point of its ~~pa~~ trajectory it Explodes into 2 parts having masses $\frac{m}{3}$ & $\frac{2m}{3}$. the lighter part just after explosion comes to rest momentarily, find velocity of other parts just after Explosion.



~~$m u \sin\theta \hat{j} + \frac{m}{3} u\cos\theta \hat{j} + \frac{2m}{3} u \cos\theta \hat{i}$~~

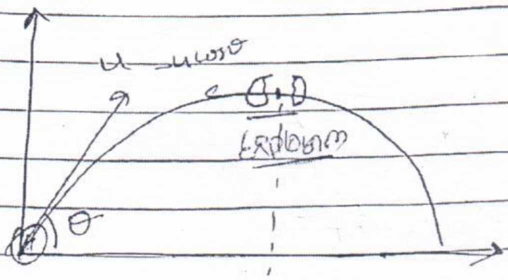
~~$\sin\theta \hat{j} = \frac{2}{3}\cos\theta \hat{j} + \frac{2}{3}\cos\theta \hat{i}$~~

$P_i = P_f$

$m u \cos\theta = \frac{m}{3} \times 0 + \frac{2m}{3}\vec{v}$

$$\boxed{\vec{v} = \frac{3}{2} u \cos\theta}$$

Q. A Shell of mass 'm' is projected with speed 'u' at an angle 'θ' from ground at heighest pt at its trajectory it explodes into 2 equal parts. one part retraces it's trajectory find velocity of other part just after Explosion.



COLM

$\vec{P_i} = \vec{P_f}$

$m u\cos\theta = -\frac{m u\cos\theta}{2} + \frac{m\vec{v}}{2}$

$\boxed{\vec{v} = 3u\cos\theta}$

Collision

⇒ Bodies intracts with each other with strong impulsive force which results change in momentum of the bodies.

⇒ For ~~pto~~collision physical contact is not neccessary.
eg → α-scattering from gold nucleus.

⇒ If centres of the bodies are on same line before & after collision then it is a Head-on.

⇒ If centres of bodies are not on same line then it is oblique collision.

⇒ Linear momentum is conserved in all collision, while KE is conserved only in elastic collision.

Q→ 17-29, 31, 80, 96, 82, . Ex-11 (15, 1, 11, 2, 6)
PS-93

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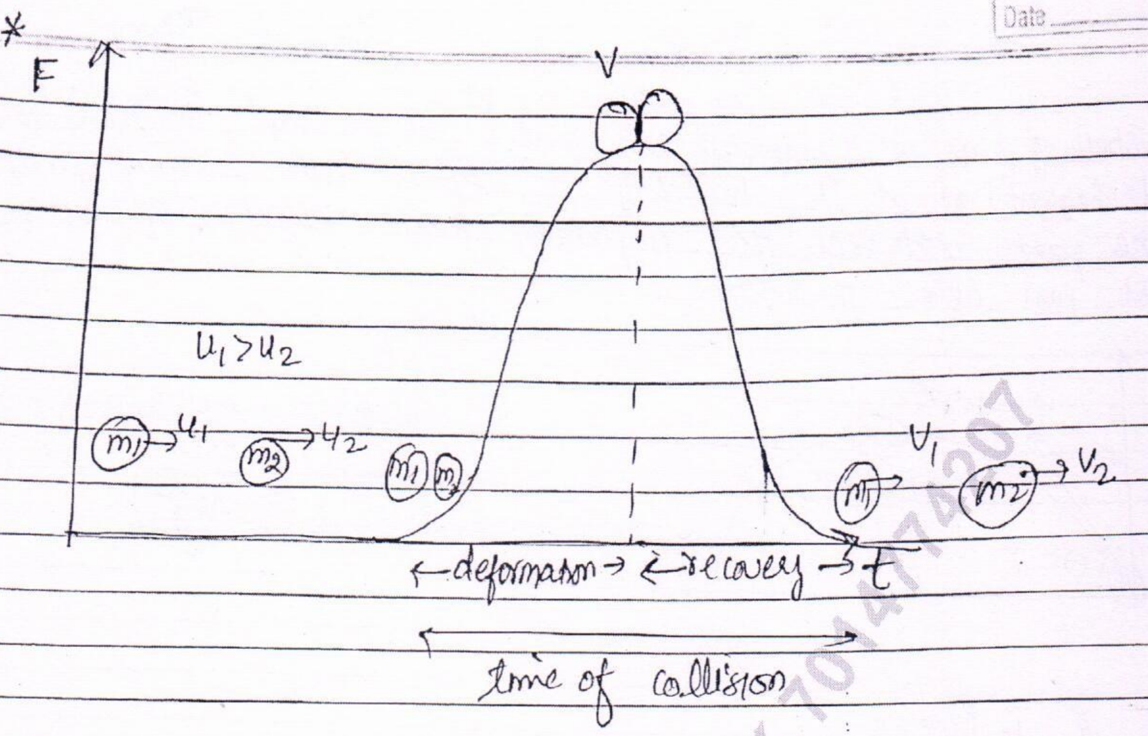
*


★ Coefficient of restitution: (e)

$0 \leq e \leq 1$ (usually).

$$e = \frac{\text{Impulse of recovery}}{\text{Impulse of deformation}}$$

$$e = -\frac{v_2 - v_1}{u_2 - u_1}$$ $$\boxed{e = \frac{v_2 - v_1}{u_1 - u_2}} = \frac{\text{relative velocity of separation}}{\text{relative velocity of approach}}$$

e → unitless & dimensionless

elastic collision → $e = 1$
perfectly inelastic collision ⇒ $e = 0$

★ $$\boxed{\vec{v}_2 - \vec{v}_1 = e(\vec{u}_1 - \vec{u}_2)}$$

(A) ~~During collision if internal energy is Released then final K.E of system more than initial, so~~
'e' will be more than 1 (Bombs explode)

Types of collision

① Elastic collision $\boxed{e=1}$

COLM ✓
COKE ✓
COME ✓
COTE ✓
No loss in KE

$\vec{u}_1$ (m₁) → $\vec{u}_2$ (m₂) ⟹ $\vec{v}_1$ (m₁) → $\vec{v}_2$ (m₂) →

COLM,
$$m_1\vec{u}_1 + m_2\vec{u}_2 = m_1\vec{v}_1 + m_2\vec{v}_2$$

* ⇒ During the bodies are in contact K.E is not conserved in elastic collision, some part of K.E is convert into Potential energy.

configuration change during collision

COKE
$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v^2$$

$$\vec{v}_2 - \vec{v}_1 = 1(\vec{u}_1 - \vec{u}_2)$$

then

$$\vec{v}_1 = \frac{(m_1-m_2)\vec{u}_1}{m_1+m_2} + \frac{2m_2\vec{u}_2}{m_1+m_2}$$

$$v_2 = \frac{(m_2-m_1)\vec{u}_2}{m_1+m_2} + \frac{2m_1\vec{u}_1}{m_1+m_2}$$

$\vec{u}_1$ \$ $\vec{u}_2$ → with Sign

← −ve → +ve (opposite)

Special case

① $m_1 = m_2 = m$

$\vec{v}_1 = \vec{u}_2$
$\vec{v}_2 = \vec{u}_1$

velocities interchanges

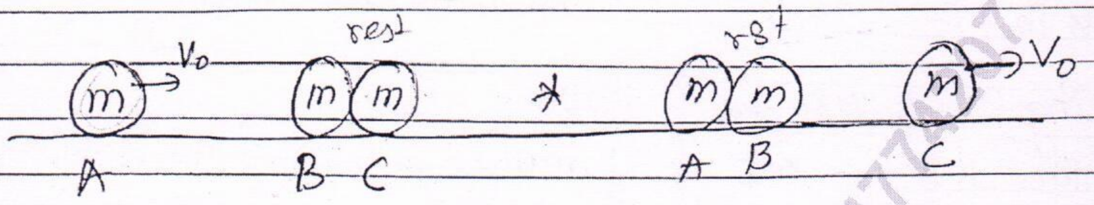
A (m) → 5 m/s   B (m) → 3 m/s   *   A (m) → 3 m/s   B (m) → 5 m/s

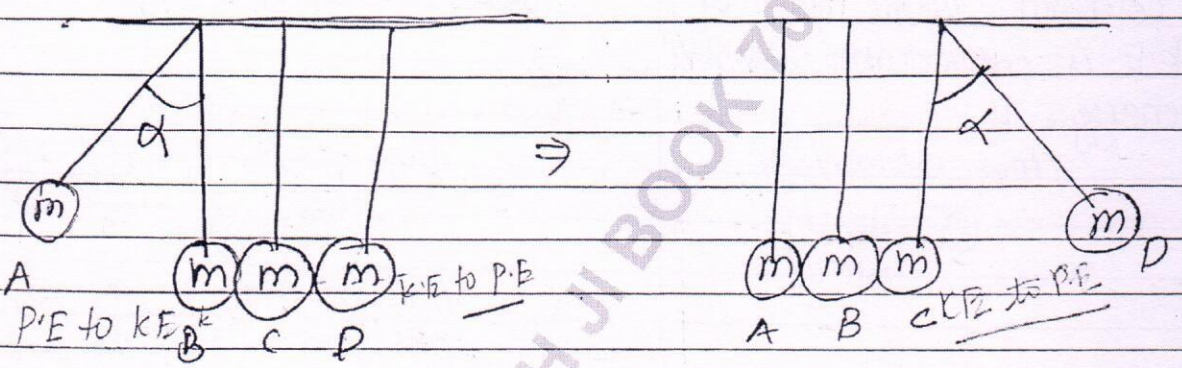
A (m) → 5 m/s   −3 m/s ← (m) B   *   −3 m/s ← (m) A   B (m) → 5 m/s

Sub case $\quad m_1 = m_2 = m \quad (e=1)$

$$\vec{u}_2 = 0$$

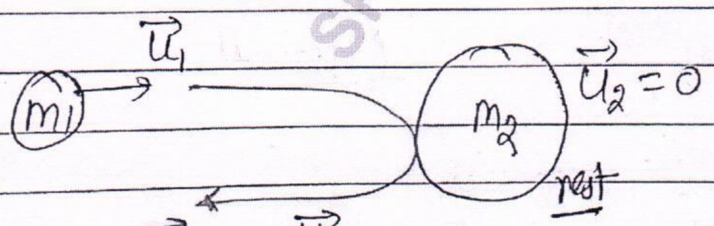
$$\left[\begin{array}{l} \vec{V}_1 = 0 \\ \vec{V}_2 = \vec{u}_1 \end{array}\right]$$





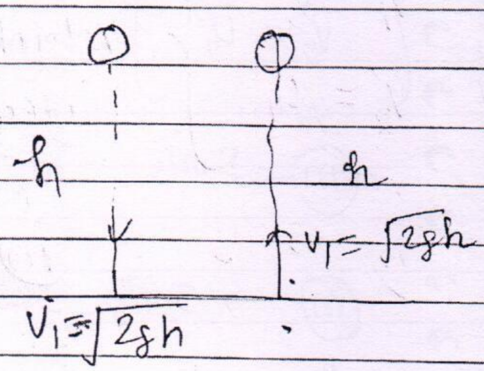
② If one body massieve $(m_1 <<< m_2)$

(i) If massive body is at rest

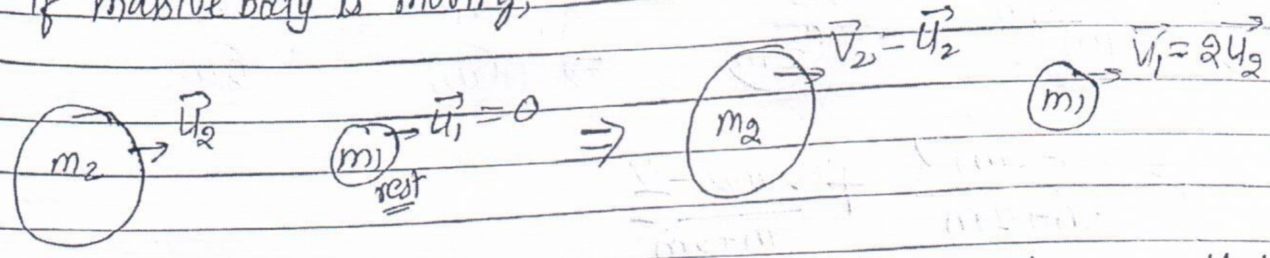


$\vec{V}_1 = -\vec{u}_1$

Rebound with same speed.

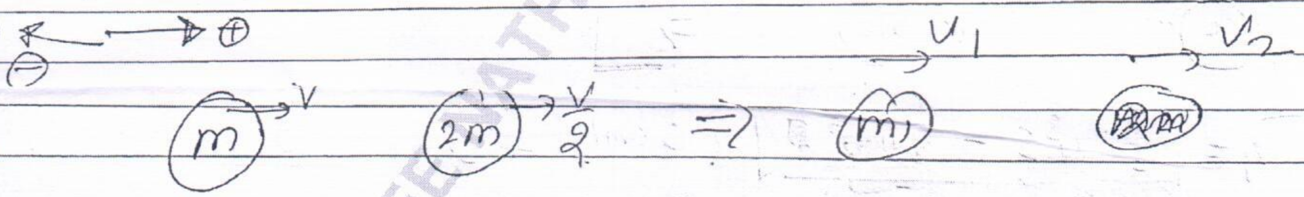


(ii) if massive body is moving,



* Velocity of massive body after collision remains as that of initial.

Que. A body of mass 'm' moving with velocity 'V' on frictionless horizontal surface collides head on elastically with another body of mass '2m' moving with velocity $V/2$. find their velocities after collision.
If 2m is moving with speed $\frac{V}{2}$ in opposite direction, in this case also find their velocities after collision.



$$\vec{V}_1 = \frac{(m-2m)}{m+2m}V + \frac{2\times 2m\times \frac{V}{2}}{m+2m}$$

$$= -\frac{V}{3} + \frac{2V}{3} = \frac{V}{3}$$

$$\vec{V}_2 = \frac{(2m-m)}{3m}\frac{V}{2} + \frac{2mV}{3m}$$

$$= \frac{V}{6} + \frac{2V}{3} = \frac{5V}{6}$$

after collision moves in same dirn

Date ______ Page ______

IInd

$\underset{}{(m)} \xrightarrow{V}$ $\quad \xleftarrow{-V/2} (2m)$ $\quad \Rightarrow \quad \overset{V_1}{(m)} \qquad \overset{V_2}{(2m)}$

$$V_1 = \frac{(m-2m)V}{m+2m} + \frac{2(2m)\times -\frac{V}{2}}{m+3m}$$

$$= -\frac{V}{3} - \frac{2V}{3} = -\frac{3V}{3} = -V$$

$$V_2 = \frac{(2m-m)\left(\frac{-V}{2}\right)}{3m} + \frac{2mV}{3m} = \frac{V}{2}$$

Neet

Q. A frictionless stell ball of radius 2cm is moving with velocity 5cm/sec on horizontal plane collides head on elastically with another stationary steel ball of radius 3cm. Find the velocities after collision.

$(m_1) \xrightarrow{5cm/s} \qquad \overset{u_2=0}{(m_2)} \Rightarrow \qquad m = \rho \times V$

$$V_1 = \left[\frac{\frac{4}{3}\pi r_1^3 \rho - \frac{4}{3}\pi r_2^3 \rho}{\frac{4}{3}\pi r_1^3 \rho + \frac{4}{3}\pi r_2^3 \rho}\right] \times 5\,cm/s + 0$$

$$V_1 = \left(\frac{(2)^3-(3)^3}{2^2+3^3}\right)\times 5 = \left(\frac{8-27}{8+27}\right)\times 5\,cm/s$$

$$= \frac{-19}{\cancel{35}\;7} \times \cancel{5}\ cm/s$$

$$= -2.7\ cm/s$$

$$\vec{V}_2 = 0 + \frac{2 \times \frac{4}{3}\pi r_1^3 \rho \times 5 \text{ cm/s}}{\frac{4}{3}\pi \rho [r_1^3 + r_2^3]} = \frac{2 \times 2^3 \times 5 \text{ cm/s}}{2^3 + 3^3}$$

$$= \frac{2 \times 8 \times 5}{8 + 27} = \frac{2 \times 8}{35} \times 5 \text{ cm/s}$$

$$= \frac{16}{7} = 2.28 \text{ cm/s}$$

Q. A ball of mass m_1 moving on horizontal plane collides head on elastically of another ball of mass m_2 which is at rest.

find.

(I) ratio of K.E of m_1 & of system after collision.

(II) fraction of KE imparted to m_2

$(m_1) \rightarrow u \qquad (m_2) \quad u_2 = 0$

$$v_1 = \frac{(m_1 - m_2)u}{m_1 + m_2} + 0$$

(I)
$$\frac{K_{m_1}}{K_{system}} = \frac{\frac{1}{2} m_1 \left[\frac{m_1 - m_2}{m_1 + m_2}\right]^2 u^2}{\frac{1}{2} m_1 u^2}$$

$$= \left[\frac{m_1 - m_2}{m_1 + m_2}\right]^2$$ ⇒ It can be said → left fraction of KE of m_1

(II)

$$\frac{K_{m_2}}{K_{system}} = \frac{\frac{1}{2} m_2 \left[\frac{4 m_1^2 u^2}{(m_1 + m_2)^2}\right]}{\frac{1}{2} m_1 u^2}$$

Neet.

$$\boxed{\frac{K_{m_2}}{K_{system}} = \frac{4 m_1 m_2}{(m_1 + m_2)^2}}$$

It can be said, lose fraction of K.E of m_1 or gain fraction of KE by m_2.

B.B-3 (1, 12 - ix

Ex II - (17-29) 30, 33, 34, 35, 38, 40, 41, 44, 45, 47, 48, 51, 52, 53, 55, 56, 58, 59, 62, 63

Ex-II (1, 3, 64, 6, 15, 16, 18,   Ex-II (2, 5, 10,

Q. A neutron collides head on elastically with a stationary α-particle. then f/o % of KE imparted to α-particle.

$$\frac{K_\alpha}{K_{system}} = ?$$

$n \to m$

$\alpha \to 4m$

$$\frac{K_\alpha}{K_{sys}} = \frac{4 \times m \times 4m}{(m+4m)^2} \times 100\%$$

$$= \underline{\underline{64\%}}$$

Q. Neet, 19

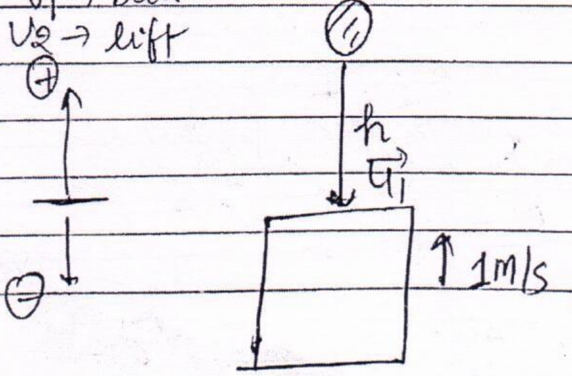
(2m) $\to u$ (4m) $\to u_2 = 0$

$$\frac{K_{4m}}{K_{sys}} = \frac{4 \times 2m \times 2m}{(2m+4m)^2} = \frac{16 m^2}{36 m^2} = \frac{8}{9} \text{ Ans.}$$

Q. A ball after falling through a distance 5m, collide elastically (e=1) with a lift moving upwards with velocity 1m/s. find velocity of the ball just after collision.

$V_1 \to$ ball

$V_2 \to$ lift



one body is massive

[floor, wall, lift]

$$\vec{V_2} - \vec{V_1} = e\left[\vec{u_1} - \vec{u_2}\right]$$

$$+1 - \vec{V_1} = \left[-\sqrt{2gh} - (1)\right]$$

$1 - \vec{V_1} = -10 - 1$

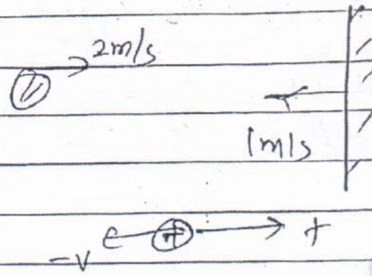
$1 + 11 = \vec{V_1}$

$\vec{V_1} = 12\ m/s$

Q. A ball is moving towards a wall with velocity 2 m/s the wall is also moving towards ball with speed 1 m/s. Find velocity just after collision.

$u_1 \rightarrow$ ball

$u_2 \rightarrow$ wall



$\vec{V_2} - \vec{V_1} = e\,[\vec{u_1} - \vec{u_2}]$

$-1 - \vec{V_1} = [2 - (-1)]$

$\vec{V_1} = -4\ m/s$

$|\vec{V_1}| = 4\ m/s$

② Inelastic collision:

→ $e \neq 0$

→ COLM ✓

→ COKE ✗

→ COME ✗

→ COTE ✓

→ loss in K.E

COLM

$$m_1\vec{u_1} + m_2\vec{u_2} = m_1\vec{v_1} + m_2\vec{V_2}$$

$$\vec{V_2} - \vec{V_1} = e\,[\vec{u_1} - \vec{u_2}]$$

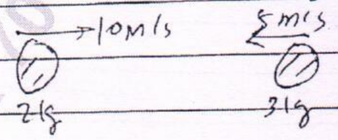
$$\boxed{V_1 = \frac{[m_1 - e m_2]\vec{u_1}}{m_1 + m_2} + \frac{(1+e)m_2\vec{u_2}}{m_1 + m_2} \qquad V_2 = \frac{[m_2 - e m_1]\vec{u_2}}{m_1 + m_2} + \frac{(1+e)m_1\vec{u_1}}{m_1 + m_2}}$$

COLM → in Both elastic & Inelastic

loss in K.E = $K_i - K_f$

$$\boxed{\Delta K = \frac{1}{2} \times \frac{m_1 m_2}{m_1+m_2}(1-e^2)(\vec{u_1}-\vec{u_2})^2}$$

Que. A ball of mass 2kg is moving with velocity 10m/s collides with another ball of mass 3kg moving in opposite dirn with speed 5m/s, if $e = 2/3$ find their velocities after collision & loss in KE of system.



$$V_1 = \frac{(m_1 - em_2)\vec{u_1}}{m_1+m_2} + \frac{(1+e)m_2\vec{u_2}}{m_1+m_2}$$

$$V_1 = \frac{\left(2 - \frac{2}{3}\times 3\right)10}{5} + \frac{\left(1+\frac{2}{3}\right)3(-5)}{5}$$

$$\boxed{\Delta K = 75 \text{ Joule}}$$

$$= 0 + \frac{\cancel{5}}{\cancel{3}}\times\cancel{3}\times\frac{-5}{\cancel{5}} = -5 \text{ m/s}$$

$$V_2 = \frac{(m_2 - em_1)\vec{u_2}}{m_1+m_2} + \frac{(1+e)m_1\vec{u_1}}{m_1+m_2}$$

$$= \frac{\left[3 - \frac{2}{3}\times 2\right](\cancel{-5})}{\cancel{5}} + \frac{\left(1+\frac{2}{3}\right)\times 2\times 10}{5}$$

$$\left(3 - \frac{4}{3}\right)(-1) + \frac{\cancel{5}}{3}\times\frac{2\times 10}{\cancel{5}}$$

$$\left(\frac{4}{3} - 3\right) + \frac{20}{3}$$

$$= -\frac{5}{3} + \frac{20}{3} = \cancel{-\frac{15}{3}} = \cancel{+5 \text{ m/s}}$$

$$= \frac{20-5}{3} = \frac{15}{3} = 5 \text{ m/s}$$

Q. A body collides with another identical body ~~initially~~ which is at rest find ratio of their velocities after collision & also find fractional loss in K.E. $e \to$ coff. of restitution.

$\vec{u_1}$

m $\qquad$ m

rest

$\cancel{\vec{v_2} - \vec{v_1} = e(\vec{u_1} - \vec{u_2})}$

$$\vec{v_1} = \frac{(m - em)\vec{u_1}}{2m} + 0$$

$$V_2 = 0 + \frac{(1+e)mu_1}{2m}$$

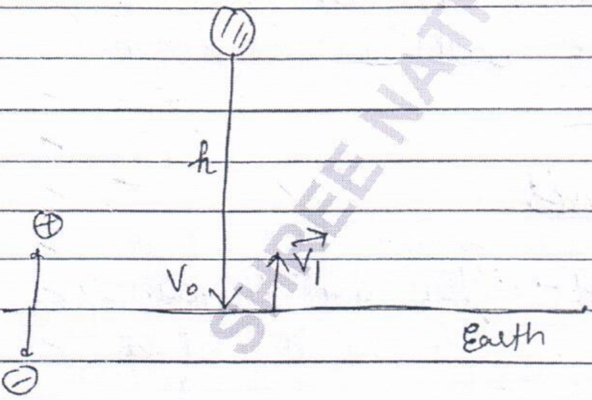
$$\boxed{\frac{V_1}{V_2} = \frac{1-e}{1+e}}$$

loss $= K_f - K_i$

$$\frac{\Delta K}{K_{system\ initial}} = \frac{\left[\frac{1}{2} \times \frac{m^2}{2m}\left[1-e^2\right]\left[\vec{u_1} - 0\right]^2\right]}{\frac{1}{2}m u_1^2}$$

$$= \frac{1-e^2}{2}$$

Q. A ball is dropped from height 'h' on a floor if coefficient of restitution is e find speed of ball just after collision.



Newton's law of collision,

$$\vec{V_2} - \vec{V_1} = e\left[\vec{u_1} - \vec{u_2}\right]$$

$$0 - \vec{V_1} = e\left[-V_0 - 0\right]$$

$$\boxed{V_1 = eV_0}$$

$$\boxed{V_1 = e\sqrt{2gh}}$$

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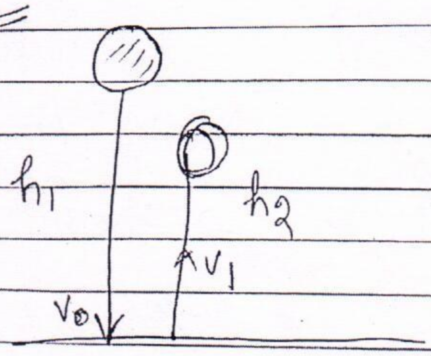
Q. A ball is dropped from height 25cm. after rebouncing from floor it attain highest 9cm. find $e = ?$

Sol^n



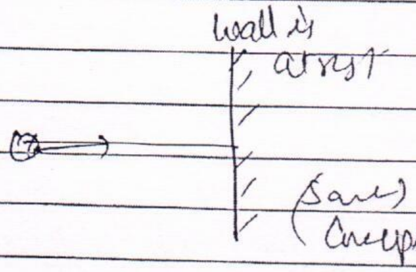
$v_1 = eV_0$

$\cancel{\sqrt{2gh_2} = e\sqrt{2gh_1}}$

$\cancel{e = \sqrt{\frac{h_2}{h_1}} = \sqrt{\frac{25}{9}} = \frac{5}{3}}$

$\sqrt{2g \times 9} = e\sqrt{2g \times 25}$

$e = \frac{3}{5} = 0.6$



Q. A ball is dropped from height 'h' on floor, coff. of restitution is 'e'. the ball is continously bounces on the floor. find

1. Speed just after n^{th} bounds
2. Max^m height attains just after n^{th} bounces
3. time taken to attains max^m height after n^{th} bounce
4. Total time before the ball comes to rest
5. Total distance travelled by the ball before coming to rest.