MECHANICS

FORCE → $\boxed{\text{BODY}}$ → REACTION

BODY → RIGID, DEFORMABLE

RIGID: object is considered as particle.

REACTION → MOTION

- NO → STATICS (balanced force)
- YES → DYNAMICS

DYNAMICS: CAUSE OF MOTION

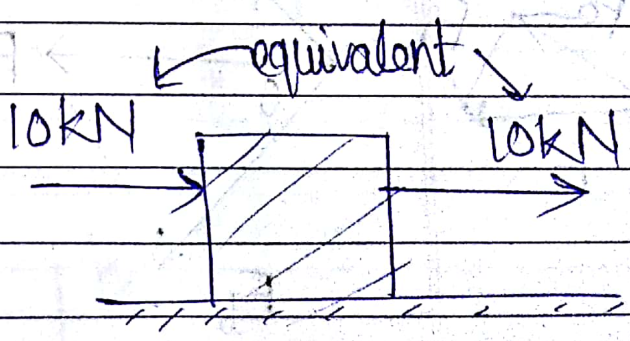
- NO → KINEMATICS: v, a, s, t.
- YES → KINETICS: F, E

FORCE

- Magnitude
- Direction
- Point of application

FORCE

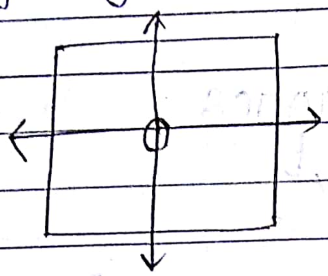
- CONTACT: eg. push, pull, etc.
- NON-CONTACT: eg. gravity, nuclear, electrostatic

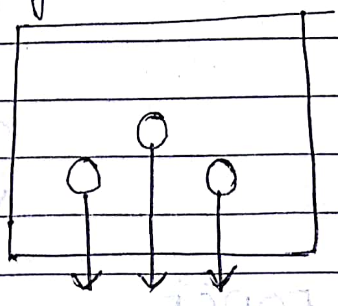


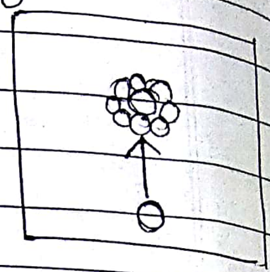
FORCE

- PLANAR (2D)
  - CONCURRENT
    eg. acting at a point
  - PARALLEL
    eg.
  - GENERAL
    eg.
- NON-PLANAR (3D)

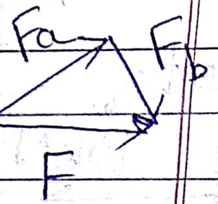
carromboard examples for 2D.

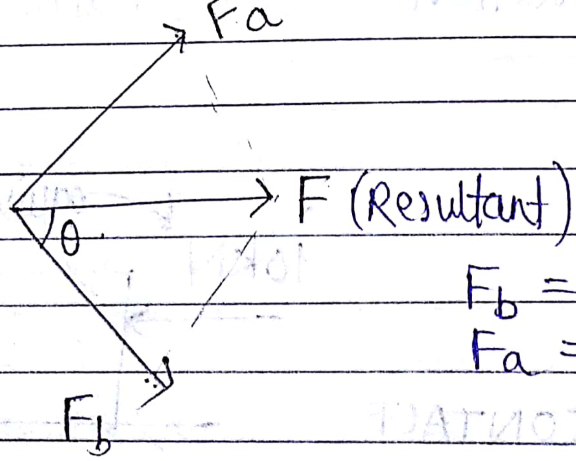


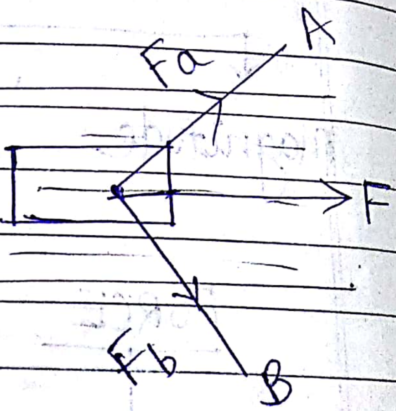




☆ RESOLUTION :-

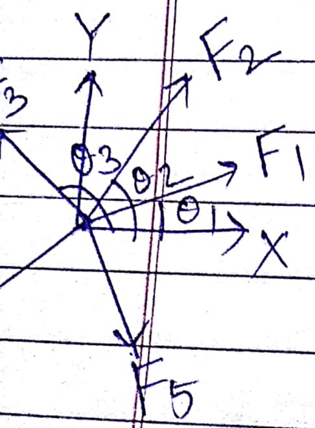






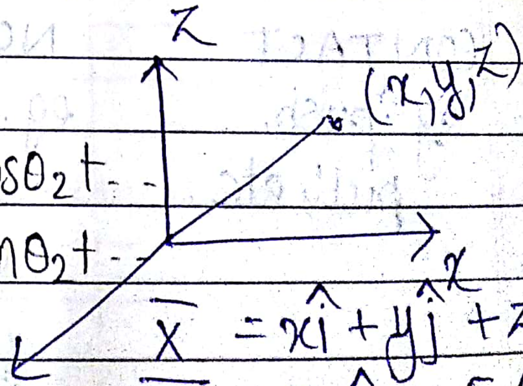
$F_b = F\cos\theta$

$F_a = F\sin\theta$



$\Sigma F_X = F_1\cos\theta_1 + F_2\cos\theta_2 + \dots$

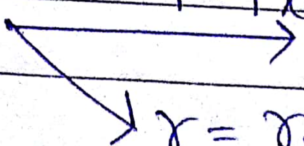
$\Sigma F_Y = F_1\sin\theta_1 + F_2\sin\theta_2 + \dots$



$\bar{X} = x\hat{i} + y\hat{j} + z\hat{k}$

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

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



$\gamma = \gamma_x\hat{i} + \gamma_y\hat{j}$

$\vec{F}.\vec{\gamma}$

$F_x = \vec{F}.\hat{i}$, $F_y = \vec{F}.\hat{j}$

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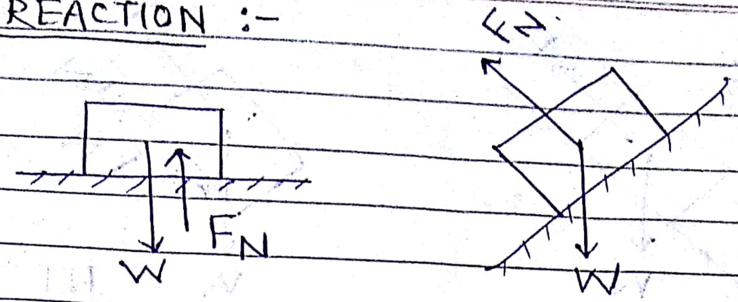
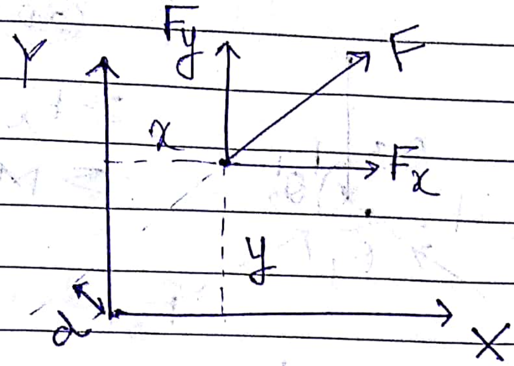
* NORMAL REACTION :-

$\perp$



* Moment of force :-



$$M = Fd$$

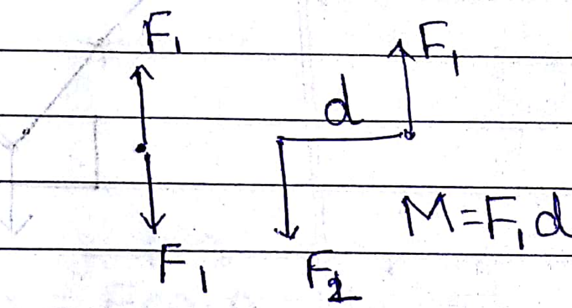
$$M = -F_x y + F_y x$$

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

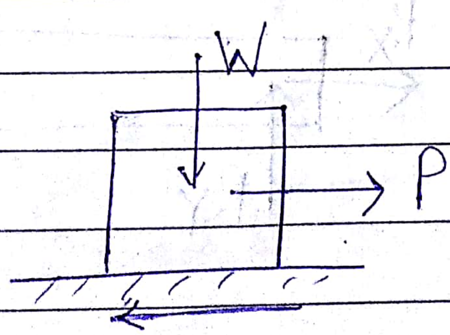
$$\vec{r} = r_x\hat{i} + r_y\hat{j} + r_z\hat{k}$$

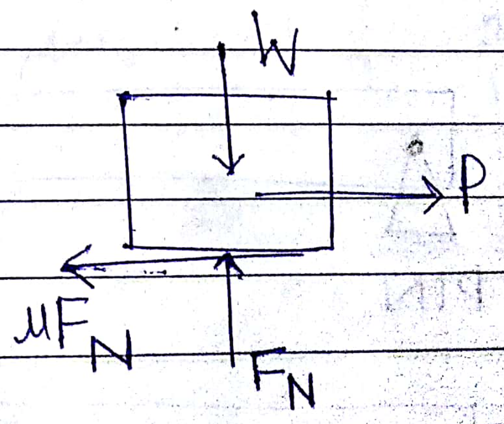
$$\overline{M} = \vec{r} \times \vec{F} = -\vec{F} \times \vec{r}$$

$$= \begin{vmatrix} i & j & k \\ r_x & r_y & r_z \\ F_x & F_y & F_z \end{vmatrix}$$

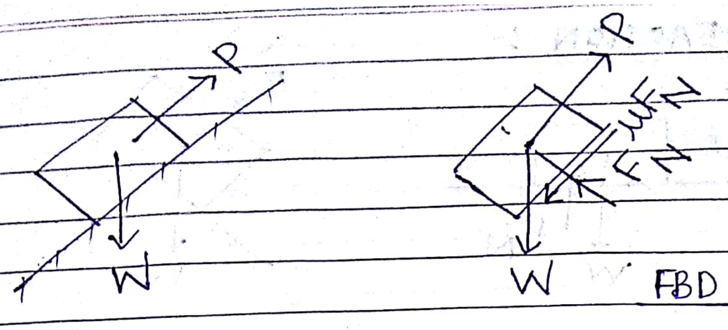


* Free body diagram (FBD) :-





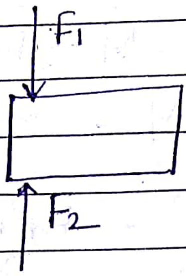
FBD of block



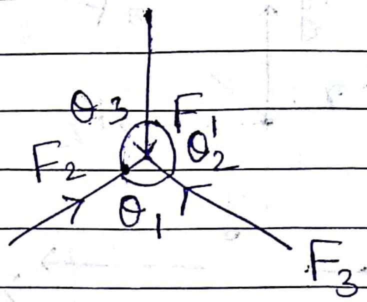
* Equilibrium :- $\Sigma F = 0$ & $\Sigma M = 0$

equal, opposite & collinear

$|F_1| = |F_2|$



2D

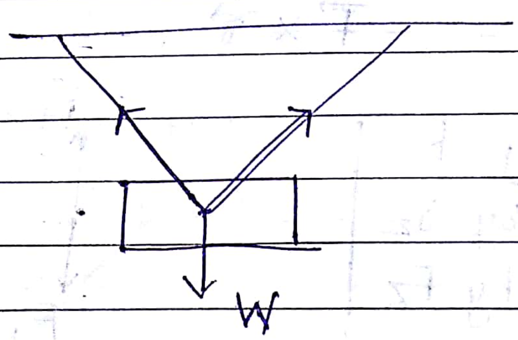


$\Sigma F_x = 0, \Sigma F_y = 0$

$\Sigma M_z = 0$

$$\frac{F_1}{\sin\theta_1} = \frac{F_2}{\sin\theta_2} = \frac{F_3}{\sin\theta_3}$$

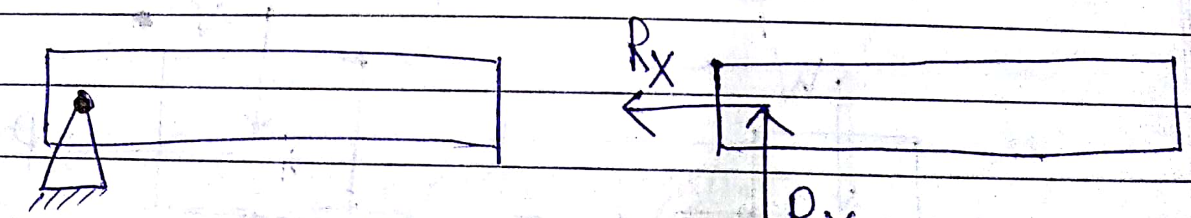
Q



3D $\Sigma F_x = 0$, $\Sigma F_y = 0$, $\Sigma F_z = 0$

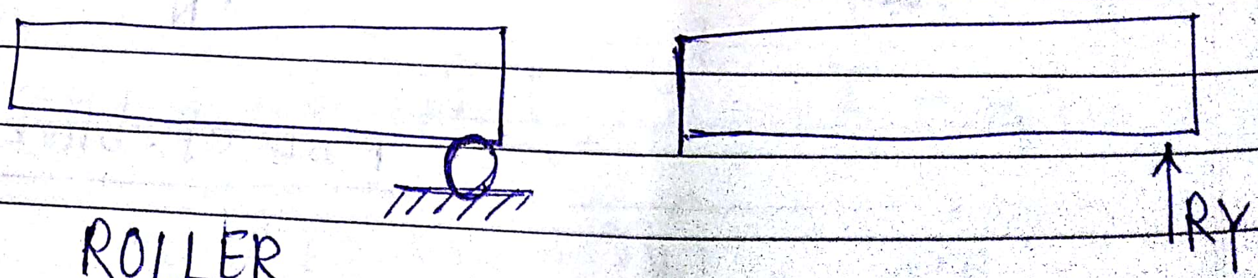
$\Sigma M_x = 0$, $\Sigma M_y = 0$, $\Sigma M_z = 0$.

*

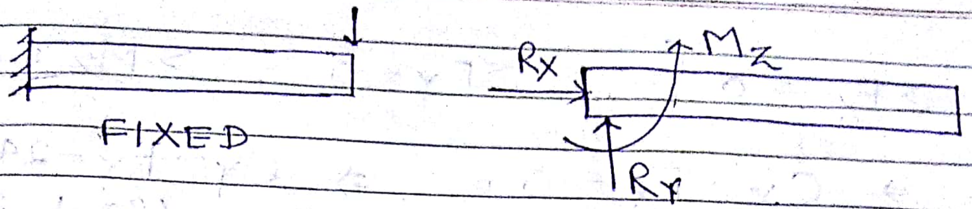


PIN

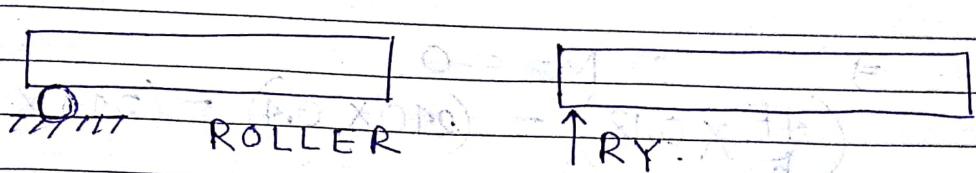
*

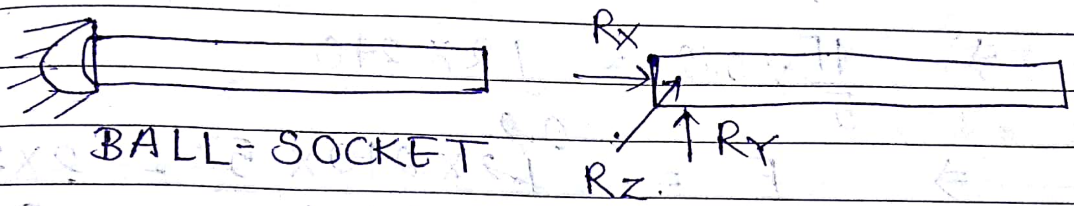


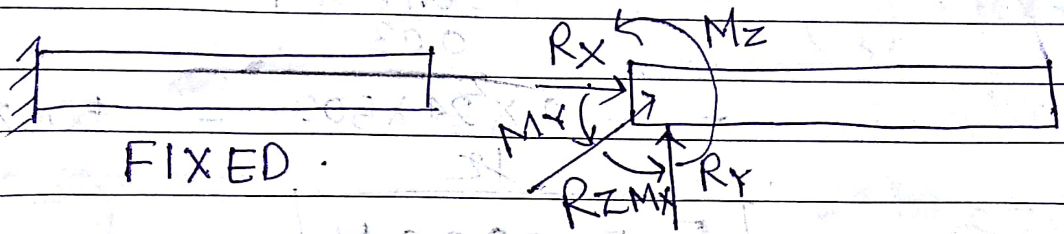
ROLLER

* 

3D Joints

* 

* 

* 

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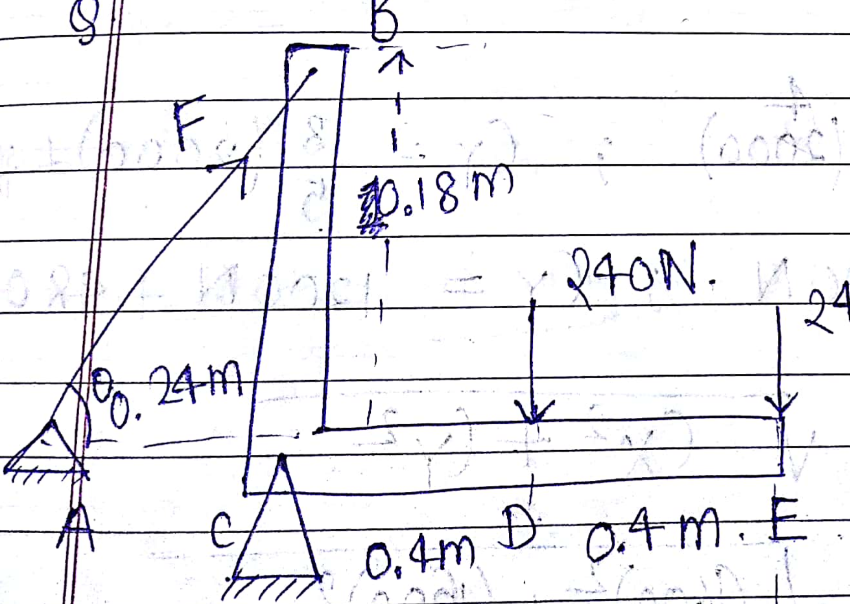
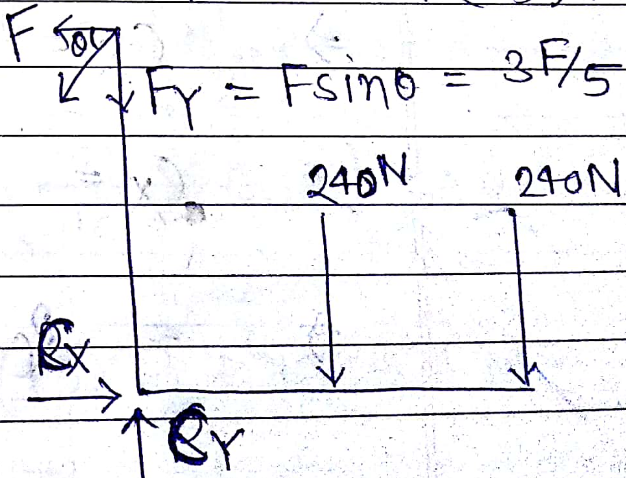


FBD.

$F_x = F\cos\theta = F(4/5)$.

$F_y = F\sin\theta = 3F/5$.



$F = ?$

$R_C = ?$

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$\Sigma F_x = 0$; $\Sigma F_Y = 0$; $\Sigma M_z = 0$

$\Rightarrow C_x - F_x = 0$ $\Rightarrow C_Y - F_Y - 240 - 240 = 0$

$\Rightarrow C_x = \frac{4F}{5}$ $\Rightarrow C_Y = 480 + \frac{3F}{5}$

$\Rightarrow \Sigma M_z = 0$

$\left(\frac{4F}{5} \times 0.18\right) - (240 \times 0.4) - (240 \times 0.8) = 0$

$\Rightarrow \frac{4F}{5} \times 0.18 = 1.2 \times 240$

$\Rightarrow F = \frac{\cancel{1.2}^{0.2} \times 240 \times 5}{\cancel{0.18}_{0.03} \times 4} = \frac{2 \times 24 \times 5}{0.12} \times$

$= \frac{2 \times \cancel{24}^{2} \times 500}{\cancel{12}} = 500 \times 4$

$\Rightarrow \boxed{F = 2000\,N}$

$\Rightarrow C_x = \frac{4}{\cancel{5}}(\cancel{2000})^{4}$; $C_Y = \frac{3}{5}(2000) + 480$

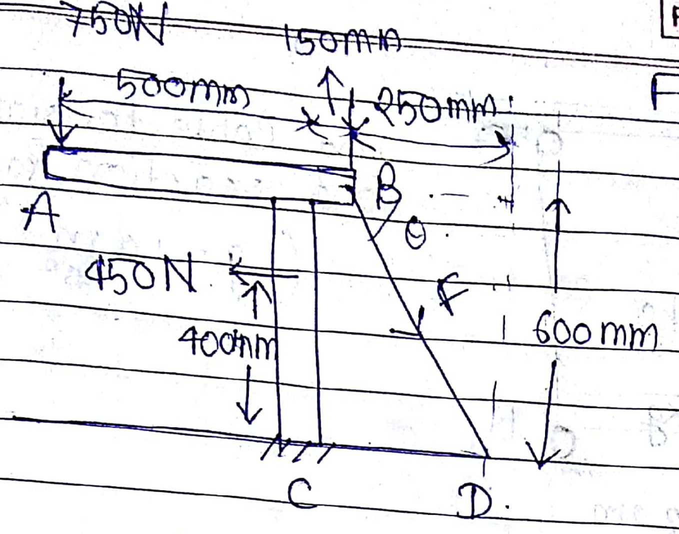
$C_x = 1600\,N$; $C_Y = 1200\,N + 480$

$\Rightarrow R_C = \sqrt{C_x^2 + C_Y^2}$

$= \sqrt{(1600)^2 + (1680)^2}$

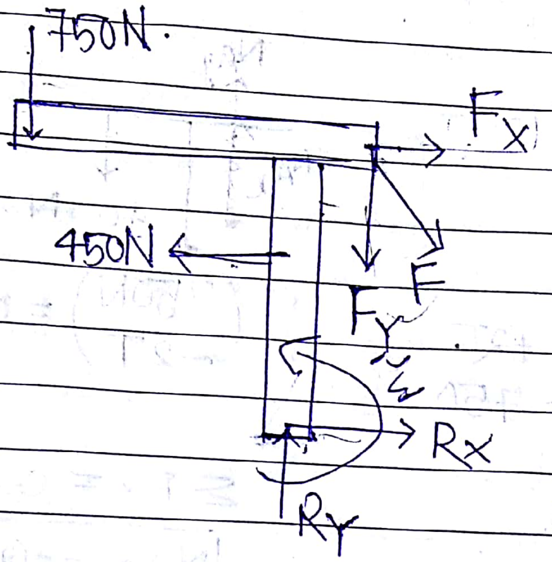
$R_C = \cancel{100 \times 20} = \cancel{2000}$ $2320\,N$

Q.



$F = 1800\,N$

find Reaction point at C.



$\Sigma F_x = 0$

$\cancel{F_x + R_x - 450 = 0}$

$\cancel{F\left(\frac{5}{13}\right) + R_x - 450 = 0}$

$\boxed{R_x = -50N}$

$\Sigma F_y = 0.$

$\cancel{R_y - F_y - 750 = 0}$

$R_y = -\overset{1300}{F}\left(\frac{12}{13}\right) - 750 = 0.$

$\boxed{R_y = 1950N}$

$R_c = \sqrt{R_x^2 + R_y^2}$

$\Sigma M_z = 0.$

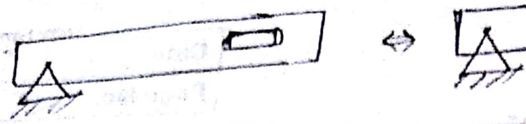
$(450 \times 0.4) + (750 \times 0.5) - \left(\frac{5F}{13} \times 0.6\right) - \left(\frac{12F}{13} \times 0.15\right) + M_c = 0.$

$\Rightarrow (45 \times 4) + 75 \times 5 + M_c = \frac{3F + 1.8F}{13}$

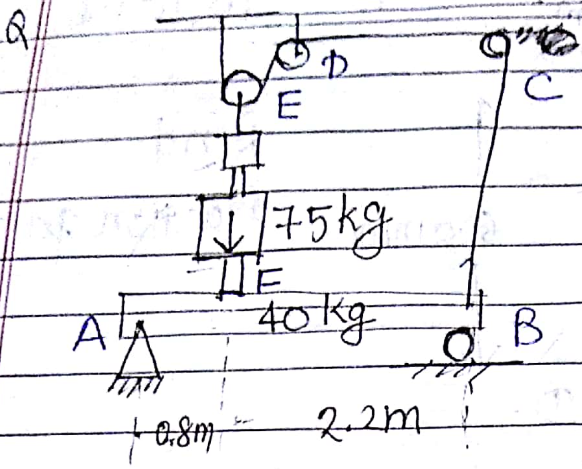
$\Rightarrow M_c = 480 - 375 - 180$

$= 300 - 375$

$M_c = -75\ Nm$

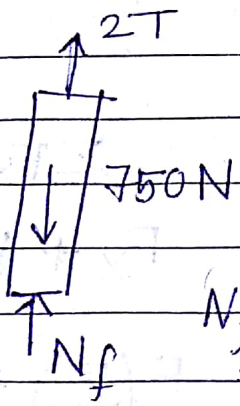


Q

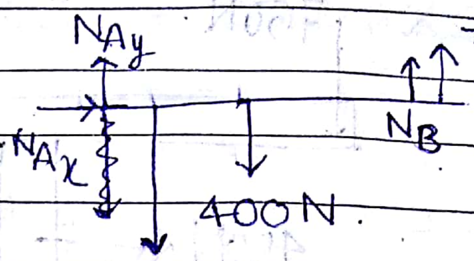


Find cable tension and reaction forces ($g = 10\ \frac{m}{s^2}$).

Ans →



$N_f + 2T = 750$



$\begin{pmatrix} 750N \\ -2T \end{pmatrix} = N_f$

we have to take $\boxed{N_B = 0}$

$\sum M_B = 0.$ $\qquad$ $\sum F_x = 0$

$\therefore \boxed{N_{Ax} = 0}$

$\therefore (400 \times 1.5) + ((750 - 2T) \times 2.2 - (N_{Ay} \times 3) = 0.$

$\therefore \dfrac{(400 \times 1.5) + ((750 - 2T) \times 2.2}{3} = N_{Ay}$

$\sum F_y = 0.$

$\Rightarrow N_{Ay} + N_B + T - 400 - 750 + 2T = 0$

$\Rightarrow$

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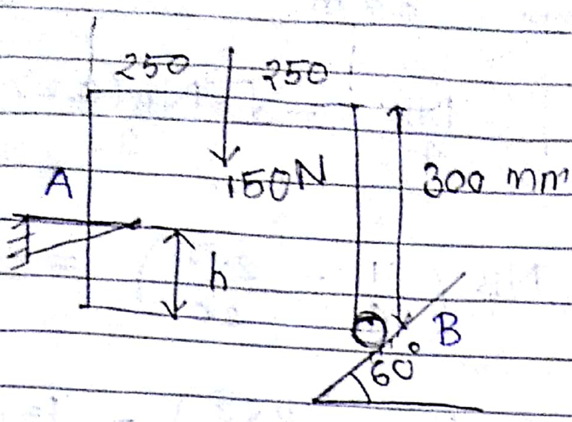
Q.

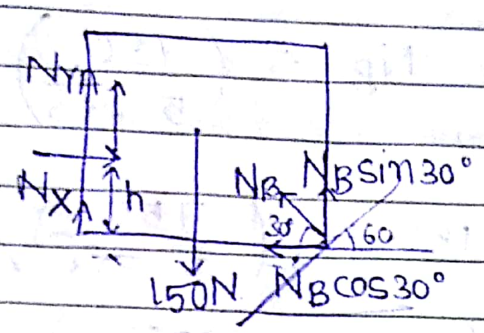


① $h=0$

② $h = 200$ mm

Find reaction forces.

Ans →



$$N_{YA} + \frac{N_B}{2} = 150$$

$$N_{XA} = \frac{\sqrt{3} N_B}{2}$$

$$\Sigma M_B = 0$$

$$(150 \times 0.25) - (N_{YA} \times 0.5) - (N_{XA} \times h) = 0.$$

$$\frac{150}{4} - \left(\left(150 - \frac{N_B}{2}\right) \times \frac{1}{2}\right) - \left(\frac{\sqrt{3} N_B h}{2}\right) = 0$$

$$\frac{150}{4} - 75 + \frac{N_B}{4} - \frac{\sqrt{3} N_B h}{2} = 0.$$

① $h=0$

$$\frac{N_B}{4} = 75 - \frac{150}{4} = \frac{150}{4} \rightarrow \boxed{N_B = 150}$$

$$N_{YA} = 150 - \frac{150}{2} = 75 \text{ N}$$

$$N_{XA} = \frac{\sqrt{3}}{2}(150) = 75\sqrt{3} \text{ N}.$$

$$\therefore N_A = \sqrt{(75)^2 + (\sqrt{3}\,75)^2} = \boxed{150 \text{ N}}$$

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(2) $h = 200\ mm = 0.2m.$

$$\frac{-150}{4} + \frac{N_B}{4} - \frac{\sqrt{3}N_B(0.2)}{2} = 0.$$

$$\Rightarrow N_B\left(\frac{1}{4} - \frac{2\sqrt{3}}{20}\right) = \frac{150}{4}$$

$$\Rightarrow N_B\left(1 - \frac{2\sqrt{3}}{5}\right) = 150$$

$$\Rightarrow N_B = \left(\frac{750}{5-2\sqrt{3}}\right) N$$

$$N_{YA} = 150 - \left(\frac{750}{5-2\sqrt{3}}\right)/2$$

$$= \left(150 - \frac{375}{5-2\sqrt{3}}\right) N$$

$$N_{XA} = \frac{\sqrt{3}}{2}\left(\frac{750}{5-2\sqrt{3}}\right) N.$$

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$m = 2j - 3$ $\quad m \Rightarrow$ no. of members
$\quad\quad\quad\quad\quad j \Rightarrow$ no. of joints.

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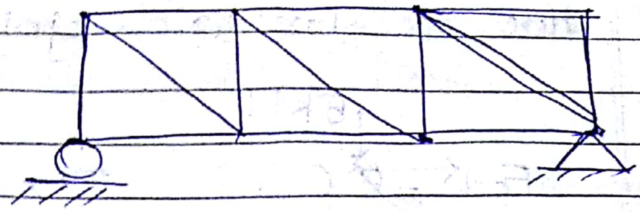
TRUSS

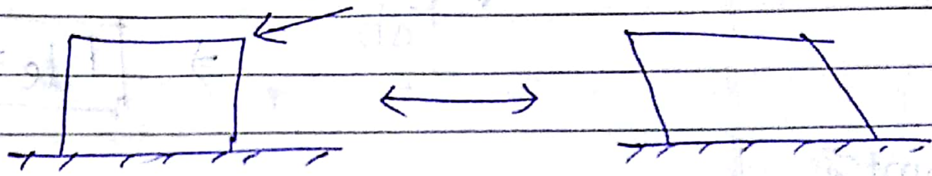


One roller joint is present to handle with the force applied due to vehicles or thermal stress.

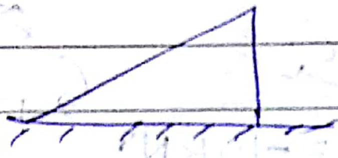
Truss $\rightarrow$ A framework typically supporting a load, bridge or other structure.

- A basic unit of ~~triangle~~ truss is a triangle.

if rectangle



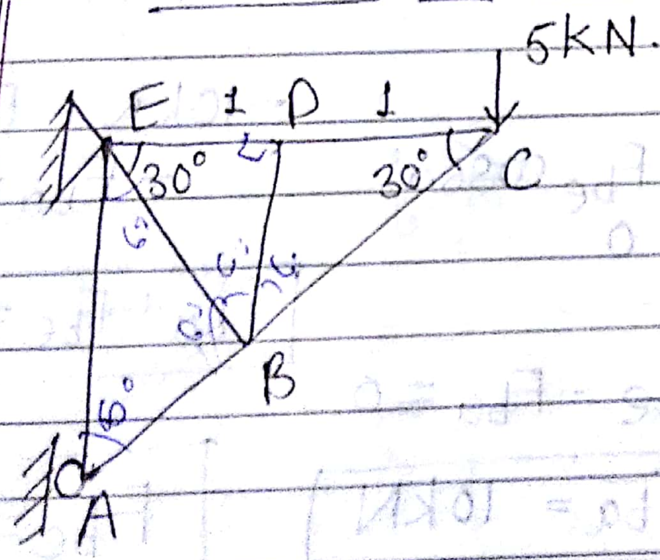
if triangle

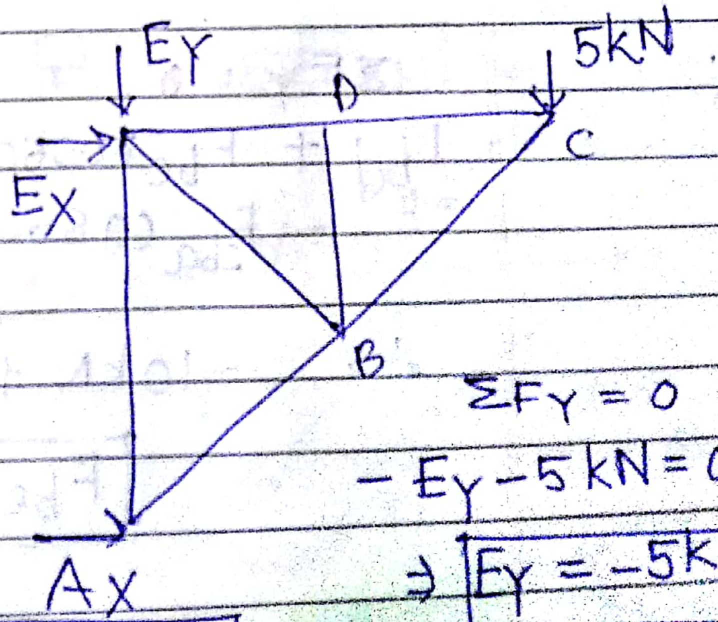


will not bend (strong)

☆ Method of Joints for solving TRUSS problem

Q.





$\Sigma F_Y = 0$

$-E_Y - 5\,kN = 0$

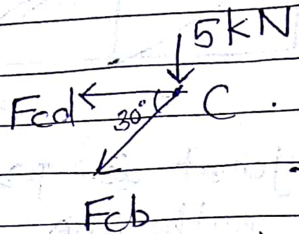
$\Rightarrow \boxed{E_Y = -5\,kN}$

$\Sigma F_X = 0$

$E_X + A_X = 0 \Rightarrow \boxed{E_X = -A_X}$

Start with the joint which has max two unknowns
Here, we start with joint C . (starting with A) is also possible

Joint C.



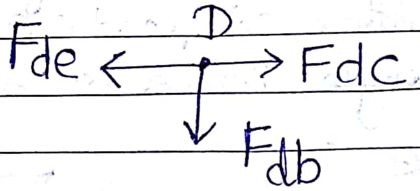
$\Sigma F_x = 0$; $\Sigma F_y = 0$

$-F_{cd} - F_{cb}\cos 30° = 0$ $\quad -F_{cb}\cos 60° - 5k = 0$

$\Rightarrow F_{cb}\cos 30° = -F_{cd}$ $\quad F_{cb} = \frac{-5k}{\cos 60°}$ N

$\Rightarrow F_{cd} = \frac{-(-10kN)\sqrt{3}}{2}$ $\Rightarrow \boxed{F_{cd} = 5\sqrt{3}\ kN}$ $\quad \boxed{F_{cb} = -10kN}$

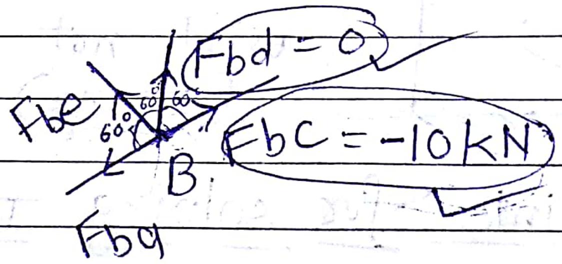
Joint D.



$F_{de} = F_{dc}$; $\boxed{F_{db} = 0}$

$\Rightarrow \boxed{F_{de} = 5\sqrt{3}\ kN}$

Joint B.



$\Sigma F_x = 0$ $\quad \cancel{\Sigma F_y = 0}$

$F_{bc}\cancel{\cos 30°} - F_{be}\cancel{\cos 30°} - F_{ba}\cancel{\cos 30°} = 0$

$-10kN - F_{be} - F_{ba} = 0$.

$\boxed{F_{ba} + F_{be} = -10kN}$

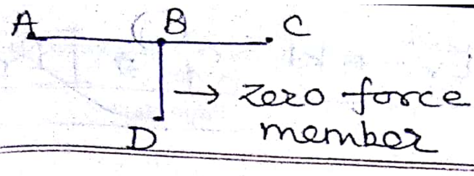
$\Sigma F_y = 0$

$\underbrace{F_{bd}}_{=0} + F_{bc}\cancel{\cos 60°} + F_{be}\cancel{\cos 60°} - F_{ba}\cancel{\cos 60°} = 0$

$\therefore -10kN + F_{be} - F_{ba} = 0$.

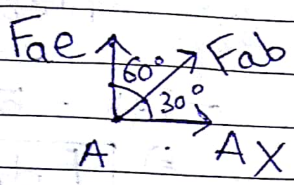
$\therefore \boxed{F_{be} - F_{ba} = 10kN}$

$\boxed{\begin{array}{l} F_{be} = 0 \\ F_{ba} = -10kN \end{array}}$



If A, B, C are collinear & BD is ⊥ to them, A, C are in equilibrium then BD is called zero-force member
& There is no external force at B & no reaction force.

JOINT A :



$\Sigma F_x = 0$

$A_x + F_{ab}\cos 30^\circ = 0$

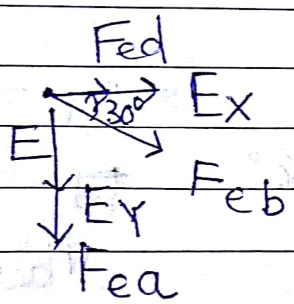
$\boxed{A_x = 5\sqrt{3}\,kN}$

$\Sigma F_y = 0$

$F_{ae} + F_{ab}\cos 60^\circ = 0$

$\boxed{F_{ae} = 5\,kN}$

JOINT E



$\Sigma F_x = 0$

$F_{ed} + E_x + F_{eb}\cos 30^\circ = 0$

$F_{eb} = 0$

$\boxed{E_x = -5\sqrt{3}\,kN}$

$(\because E_x = -A_x)$

$\therefore F_{ed} = -E_x$

$\therefore \boxed{F_{ed} = 5\sqrt{3}\,kN}$

$\Sigma F_y = 0.$

$-E_y - F_{ea} - F_{eb}\cos 60^\circ = 0.$

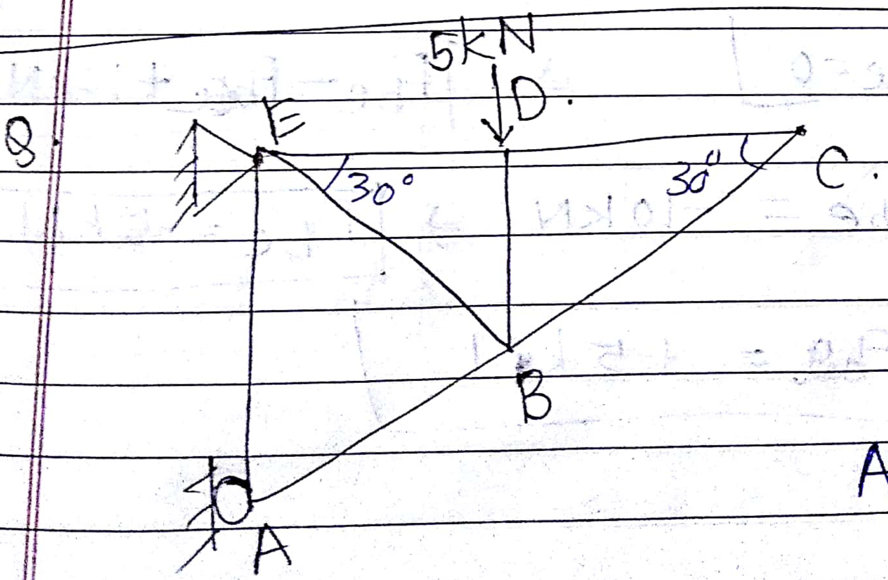
$F_{eb} = 0$

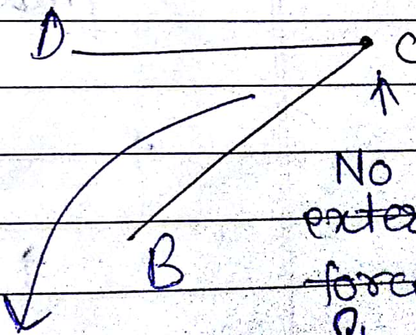
$F_{ea} = -E_y$

$\boxed{F_{ea} = 5\,kN}$

$\boxed{E_y = -5\,kN}$

Q



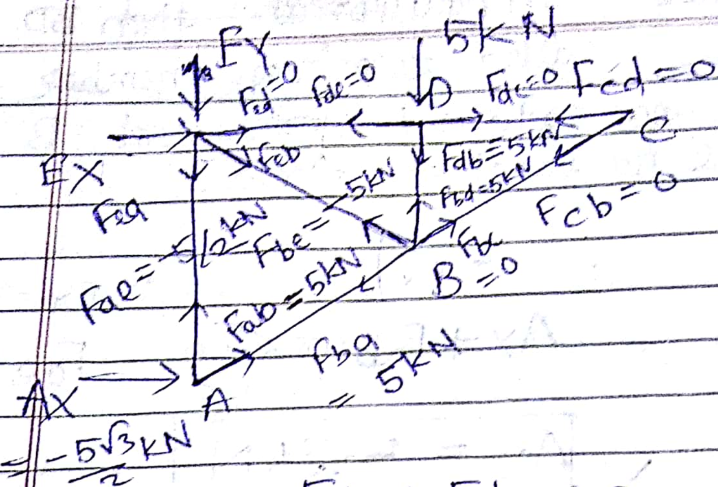


Any angle

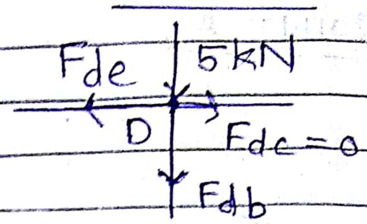
No ~~external~~ force & No reaction force

DC & BC are zero force members

$\boxed{E_X + A_X = 0}$ & $\boxed{E_Y - 5kN = 0} \Rightarrow \cancel{E_Y} = -5kN$



JOINT D



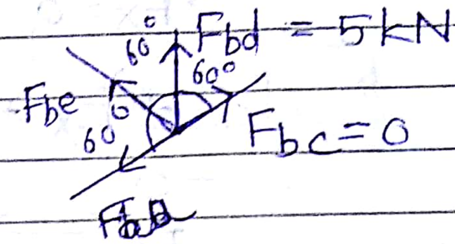
$-F_{de} + F_{dc} = 0$

$\Rightarrow \boxed{F_{de} = 0}$

$-F_{db} - 5kN = 0$

$\Rightarrow \boxed{F_{db} = -5kN}$

JOINT B



$\Sigma F_X = 0$ & $\Sigma F_Y = 0$.

$-F_{be}\cos 30° - F_{ba}\cos 30° = 0$

$\Rightarrow \boxed{F_{ba} = -F_{be}}$

$\Rightarrow \boxed{F_{ba} + F_{be} = 0}$

$F_{bd} + F_{be}\cos 60° - F_{ba}\cos 60° = 0$.

$\Rightarrow 5kN + \frac{F_{be}}{2} - \frac{F_{ba}}{2} = 0$

$\Rightarrow \boxed{F_{be} - F_{ba} + 10kN = 0}$

$\Rightarrow 2F_{be} = -10kN \Rightarrow \boxed{F_{be} = -5kN}$

$\Rightarrow \boxed{F_{ba} = +5kN}$

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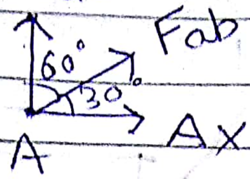
JOINT A



$\Sigma F_x = 0$ $\quad\quad$ $\Sigma F_y = 0$

$A_x + F_{ab}\cos 30° = 0$ $\quad\quad$ $F_{ae} + F_{ab}\cos 60° = 0$

$A_x = -F_{ab}\cos 30°$ $\quad\quad$ $F_{ae} = \frac{-F_{ab}}{2}$

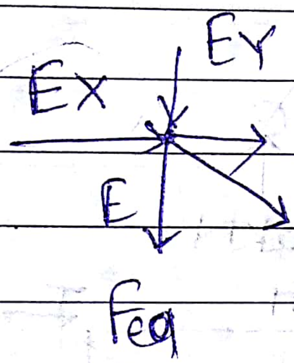
$\Rightarrow A_x = -(-5\,kN)\frac{\sqrt{3}}{2}$

$\boxed{A_x = +\frac{5\sqrt{3}}{2}\,kN}$

$F_{ae} = \frac{-(+5\,kN)}{2}$

$\boxed{F_{ae} = -\frac{5}{2}\,kN}$

JOINT E



$F_{ed} = 0$

$E_x + F_{ed} + F_{eb}\cos 30° = 0$

$E_x + 0 + \left(-5\,kN\frac{\sqrt{3}}{2}\right) = 0$

$\boxed{E_x = +\frac{5\sqrt{3}}{2}\,kN}$

$-E_y - F_{eq} - F_{eb}\cos 60° = 0$

$-(-5\,kN) - \left(\frac{+5}{2}\,kN\right) - \left(\frac{+5}{2}\right) = 0$

(Identify ...

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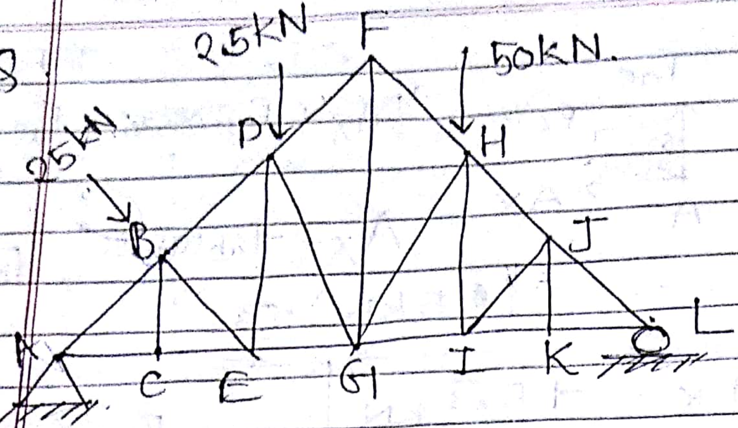
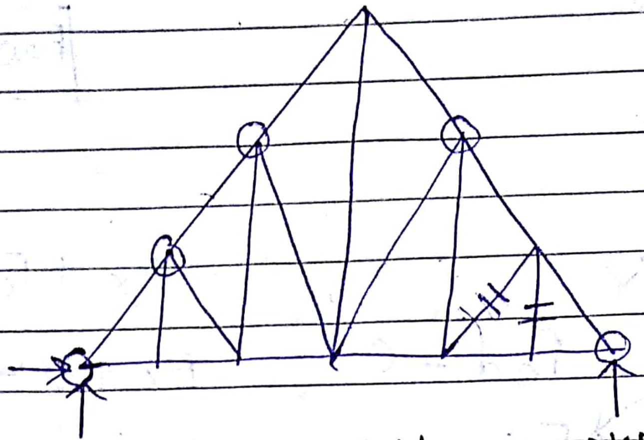
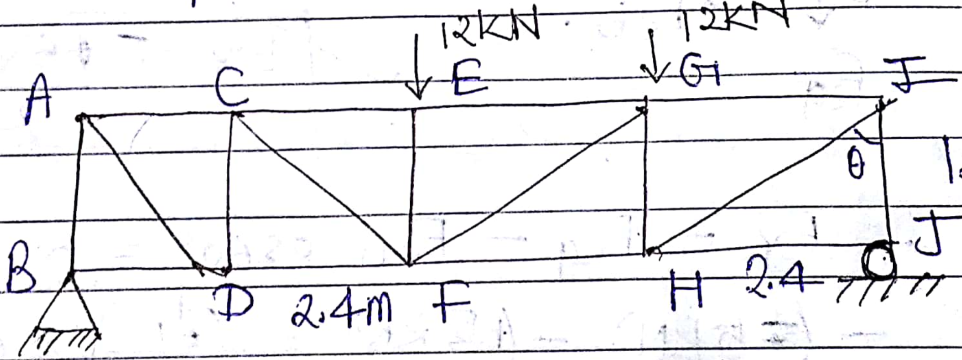
Q.



Ans



Q.

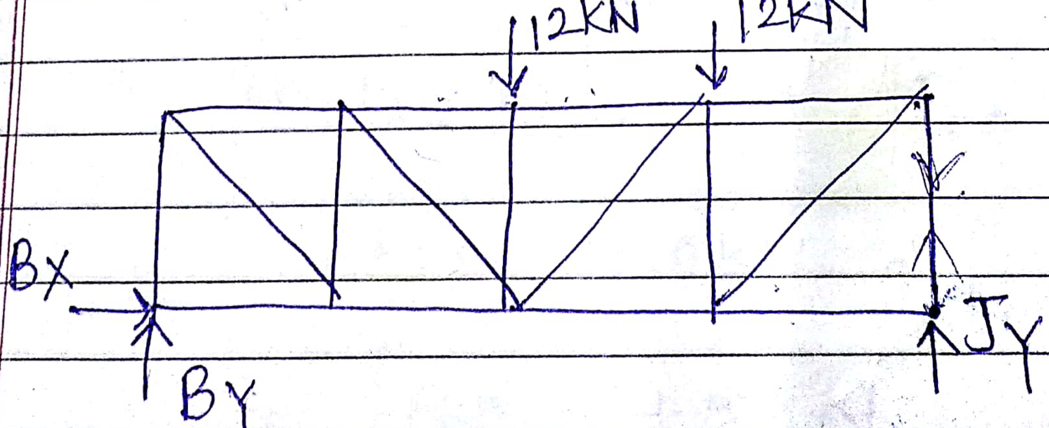


$\tan\theta = \frac{4}{3}$

$\sin\theta = 4/5$

$\cos\theta = 3/5$

Ans



$\Sigma F_x = 0$

$\boxed{B_x = 0}$

$\Sigma F_y = 0$

$\rightarrow$ ~~Bx~~ $\boxed{B_Y + J_Y = 24\,KN}$

$F_{GH} = 5\ kN \quad F_{HF} = 20\ kN$.

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$\Sigma M_B = 0$

$\Rightarrow J_Y \times 9.6 - 12 \times 4.8 - 12 \times 7.2 = 0$.

$\Rightarrow J_Y = \dfrac{12 \times \cancel{4.8}^{2} + 12 \times \cancel{7.2}^{3}}{\cancel{9.6}\ 4}$

$= \dfrac{60}{4} = 15\ kN$.

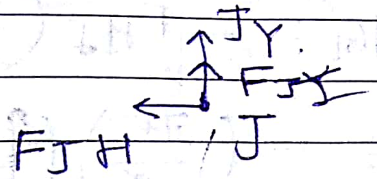
$\Rightarrow \boxed{J_Y = 15\ kN}$

$\Rightarrow B_Y + 15\ kN = 24\ kN$.

$\Rightarrow \boxed{B_Y = 9\ kN}$

$\Rightarrow B_{net} = \sqrt{(0)^2 + (9)^2} = 9\ kN$.

Joint J



$\boxed{F_{JH} = 0}$

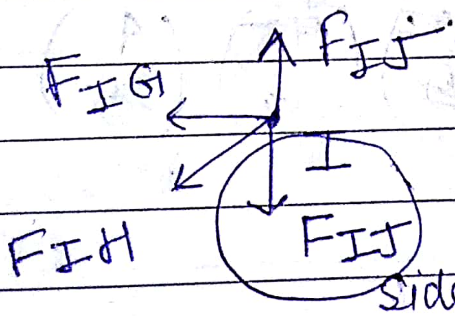
$J_Y + F_{JI} = 0$

$\Rightarrow \boxed{F_{JI} = -15\ kN}$

we got −ve so
it will be in opp. side

Joint I

$-F_{IG} - F_{IH}\sin\theta = 0 \qquad + F_{IJ} - F_{IH}\cos\theta = 0$.



side changed

$F_{IG} = -F_{IH}\dfrac{4}{5} \qquad F_{IH} = \dfrac{+F_{IJ}}{\cos\theta}$

$F_{IG} = -\dfrac{4}{5}(F_{IH}) \qquad F_{IH} = \dfrac{+(15)(5)}{3}$

$F_{IG} = \dfrac{-4}{\cancel{5}}\left(\dfrac{-\cancel{75}^{\ 15\ 5}}{\cancel{3}}\ kN\right) \qquad \boxed{F_{IH} = \dfrac{+75}{3}\ kN}$

$\boxed{F_{IG} = 20\ kN} \qquad \boxed{F_{IH} = 25\ kN}$

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$20 - \frac{32}{3} = \frac{28}{3}$

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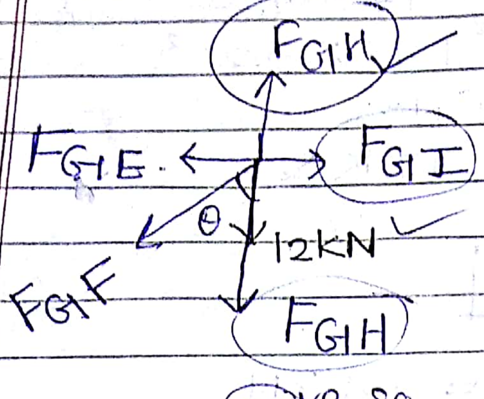
For joint G



$F_{GI} - F_{GE} - F_{GF}\sin\theta = 0$

$(+20kN) - F_{GE} - \left(\frac{40}{3}\right)\left(\frac{4}{5}\right) = 0$

$\therefore \boxed{F_{GE} = \frac{28}{3} kN}$

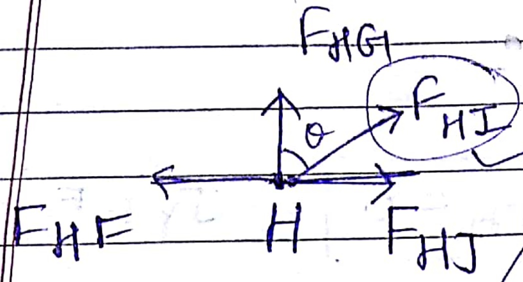
$-12kN + F_{GH} - F_{GF}\cos\theta = 0$

$-12kN + (20kN) = F_{GF}\left(\frac{3}{5}\right)$

−ve so on opp side.

$\boxed{F_{GF} = \cancel{\frac{45 kN}{3}}\ \frac{40}{3}}$

for joint H



$F_{HG} + F_{HI}\cos\theta = 0$

$-F_{HF} + F_{HJ} + F_{HI}\sin\theta = 0$

$F_{HJ} = 0$

$F_{HG} = -F_{HI}\left(\frac{4}{5}\right)$

$\boxed{F_{HG} = -\left(\frac{75}{3}\right)\left(\frac{4}{5}\right) = -20kN}$

$-F_{HF} + F_{HI}\sin\theta = 0$

$\Rightarrow F_{HF} = \left(\frac{3}{5}\right)\left(\frac{75}{3}\right)\left(\frac{4}{5}\right) = \cancel{12kN}\ 20kN.$

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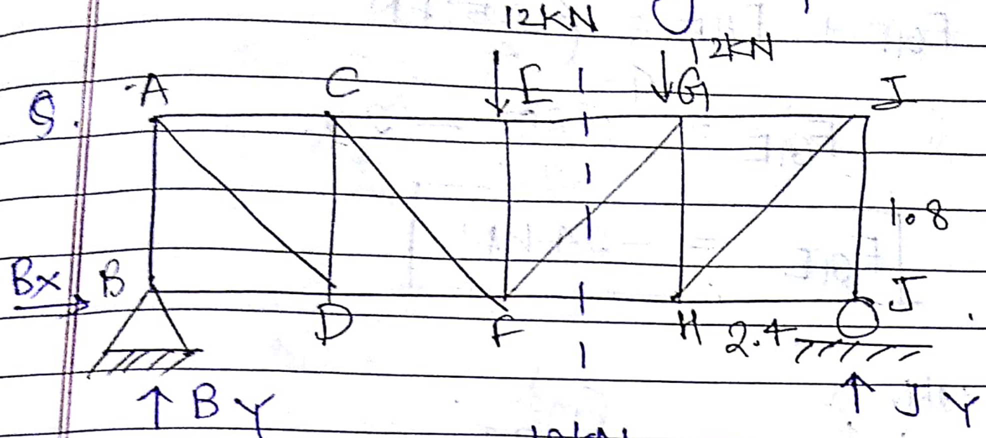
★ METHOD OF SECTIONS. Select a part by :

S. ① Area of Interest.

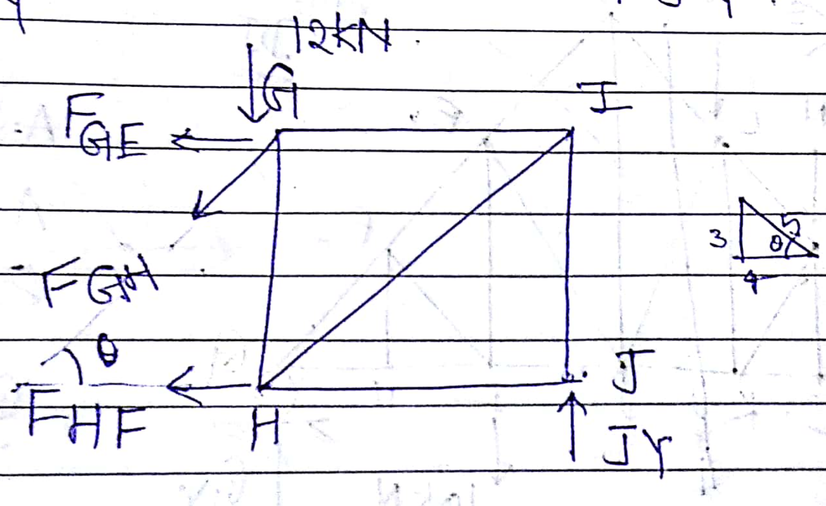
② Parting line should pass through three members only.

③ Draw the FBD of area of interest (part) and solve using equilibrium equations.

Q.



Ans.



$\tan\theta = \frac{1.8}{2.4} = \frac{3}{4}$

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

$\cos\theta = \frac{4}{5}$

$\Sigma F_Y = 0$

$-F_{GH}\sin\theta - \cancel{F_{GE}}\ 12kN + 15kN = $

$\Rightarrow F_{GH}\sin\theta = 3kN.$

$\Rightarrow F_{GH} = \frac{3kN}{\sin\theta}.$

$\boxed{F_{GH} = 5kN}$

$\Sigma F_X = 0$

$-F_{GE} - F_{GH}\cos\theta - F_{HF} = 0$

$\Rightarrow F_{GE} + F_{HF} + \frac{\cancel{5}kN\left(\frac{4}{\cancel{5}}\right)}{\cancel{4/5}} = 0$

-4

$\Rightarrow F_{GE} + F_{HF} = \frac{-25}{4}kN$ — ①

$\Sigma M_G = 0$.

$\Rightarrow (-F_{HF} \times 1.8) + (2.4 \times J_Y) = 0$.

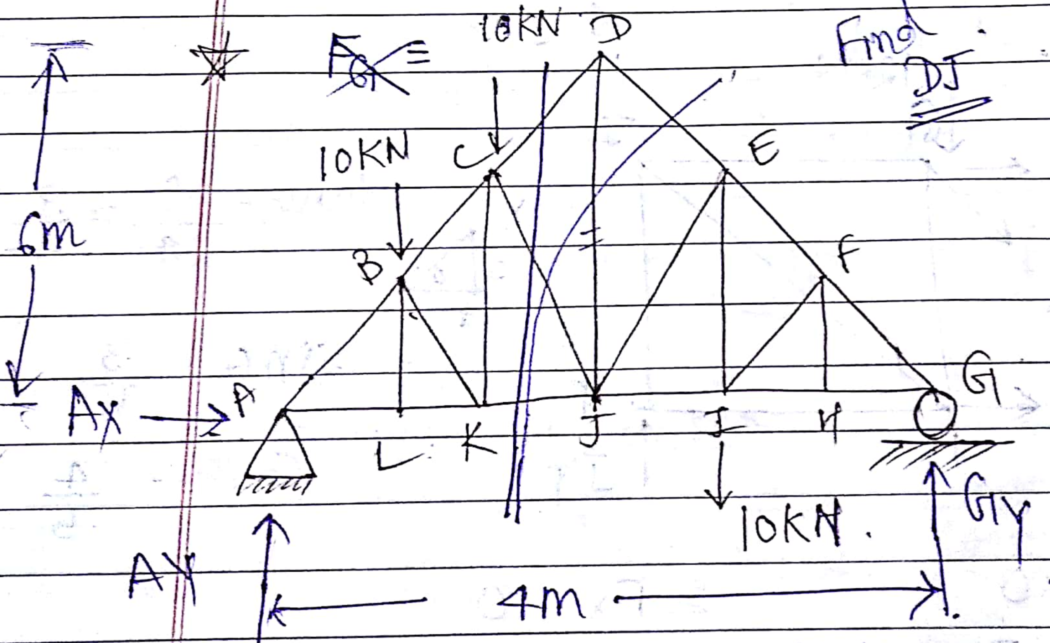
$\Rightarrow F_{HF} = \frac{2.4}{1.8} \times J_Y = \frac{4}{3} \times 15kN$

$\boxed{F_{HF} = 20kN}$

$\therefore F_{GE} + F_{HF} = \frac{-25}{4} kN$

$\Rightarrow F_{GE} = \frac{-25}{4} - 20$

$\therefore \boxed{F_{GE} = -24kN}$

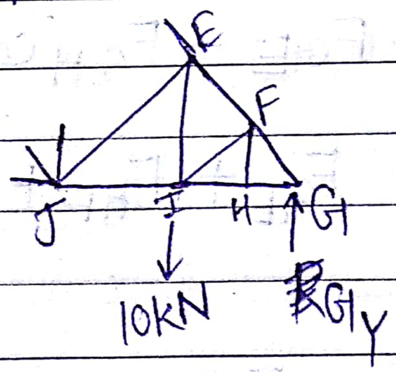


$A_Y + G_Y = 30$

$A_X = 0$.

$\Sigma M_A = 0$

$\underline{G_Y = ?}$



$-\left(\frac{2}{3}\right)(10kN) - \left(\frac{4}{3}\right)(10kN)$

$-\left(\frac{8}{3}\right)(10kN) + 4(G_Y)$

$= 0$

$\cancel{4}G_Y = \frac{\cancel{14}\ 7\ 5}{3} \times \cancel{10}kN$

$\Rightarrow A_Y = 30 - 35/3$

$\boxed{A_Y = 55/3\ kN}$

$G_Y = 35/3\ kN$

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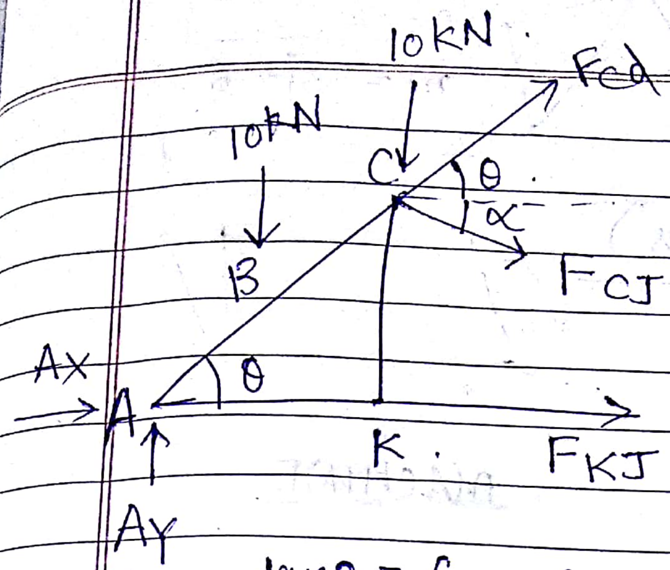


$=18.33$

$\Sigma F_x = 0$

$F_{cd}\cos\theta + F_{CJ}\cos\alpha = 0$

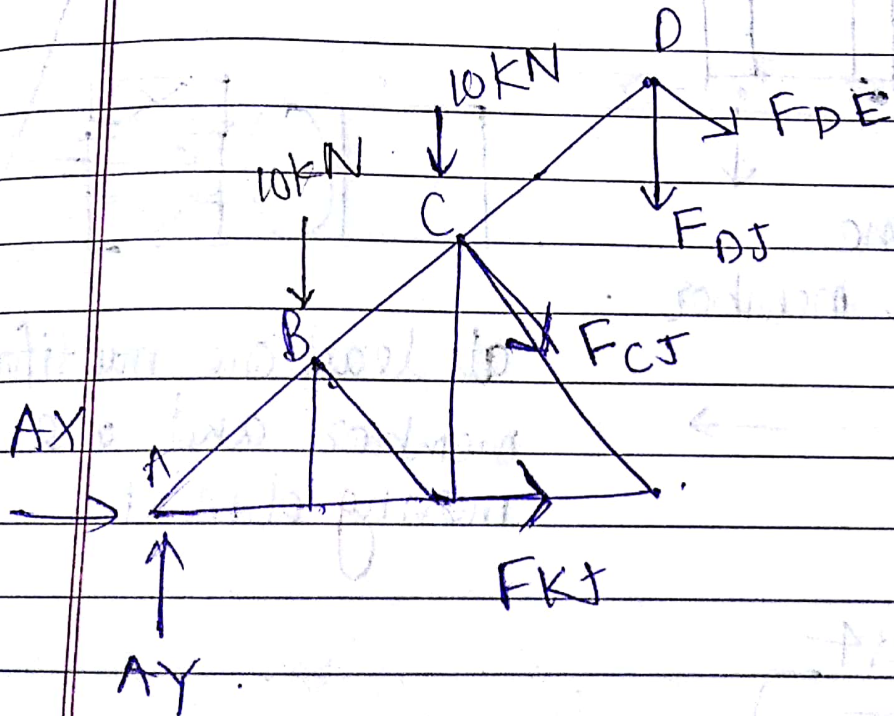
$\Sigma F_y = 0$

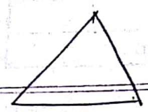
$F_{cd}\sin\theta - F_{CJ}\sin\theta - 10 - 10 + 18.33 = 0$

$\Sigma M_J = 0.$

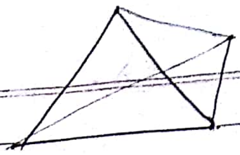
$\tan\theta = \frac{6}{2} = 3.$

$\sin\theta =$



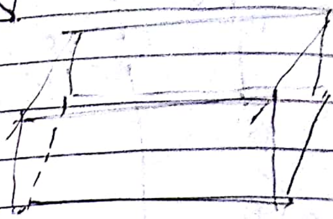


$m = 2j - 3$

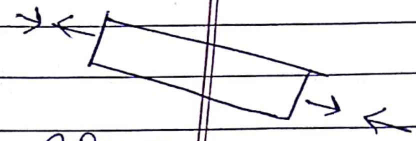


$m = 3j - 6$

☆ 3D Truss (Space Truss)

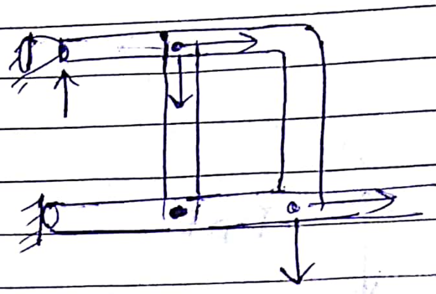


TRUSS

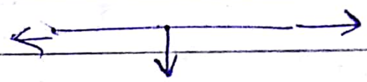


2 Force Member.

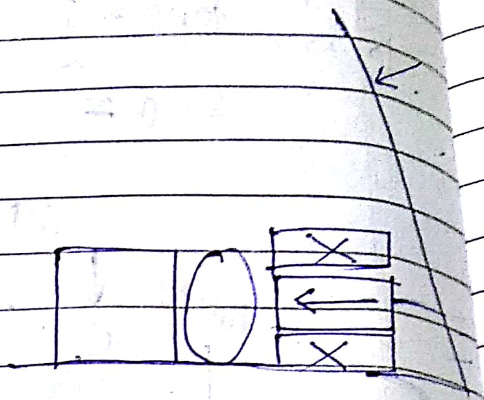
FRAME



at least one multiforce member.

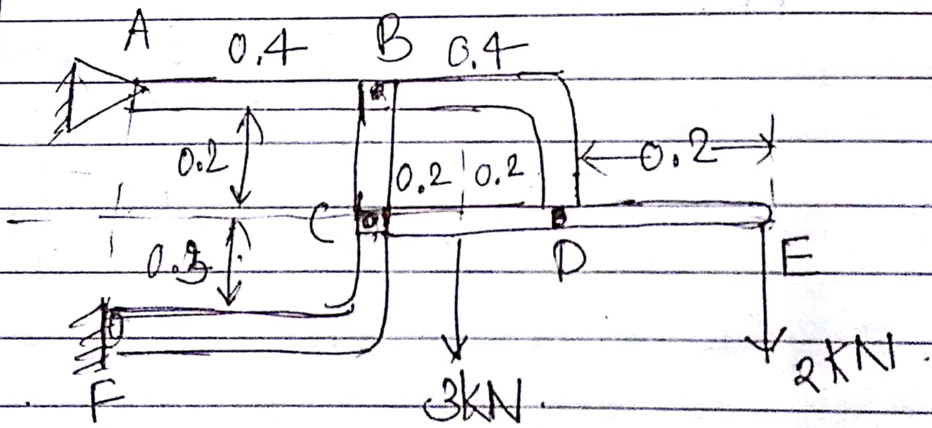


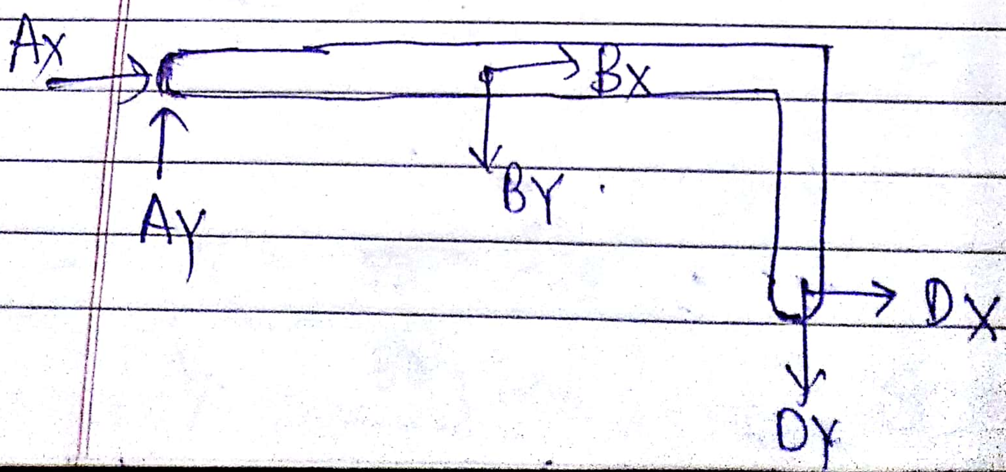
MACHINE

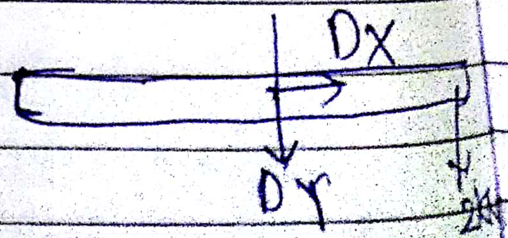


at least one multiforce member and one moving element.

Q







Tutorial

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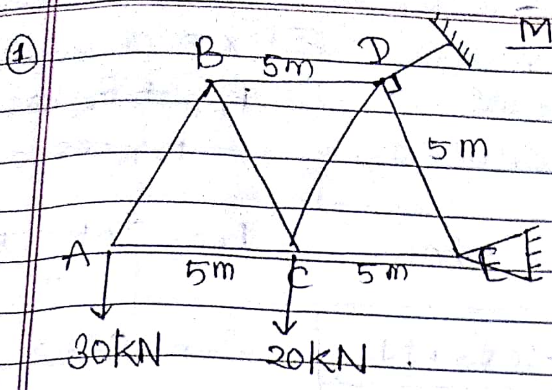
$\left(\frac{5}{2}\right)^2 + x^2 = 5^2$

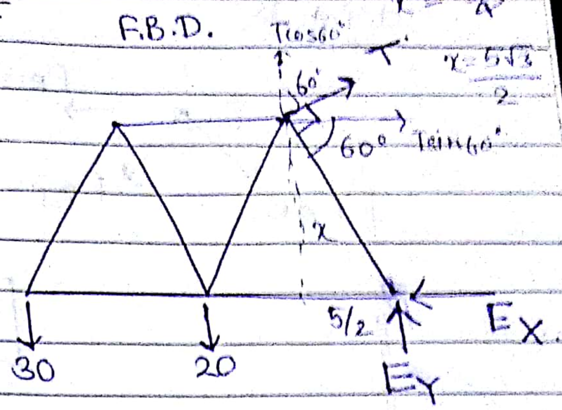
$x^2 = \frac{75}{4}$

$x = \frac{5\sqrt{3}}{2}$

① METHOD OF JOINTS



F.B.D.



$\Sigma F_X = 0$

$\therefore -E_X + T\sin 60° = 0$

$\Rightarrow \underline{E_X = T\sin 60°}$ — ①

$\Sigma F_Y = 0$

$\therefore -30 - 20 + E_Y + T\cos 60° = 0$

$\Rightarrow \underline{E_Y = 50 - T\cos 60°}$ — ②

$\Sigma M_E = 0$

$\Rightarrow (5 \times 20) + (10 \times 30) - \left(\frac{5}{2} T\cos 60°\right) - \left(\frac{5\sqrt{3}}{2} T\sin 60°\right) = 0$

$\Rightarrow 400 = \frac{5T}{4} + \frac{15T}{4}$

$\Rightarrow 5T = 400 \Rightarrow \boxed{T = 80\text{kN}}$

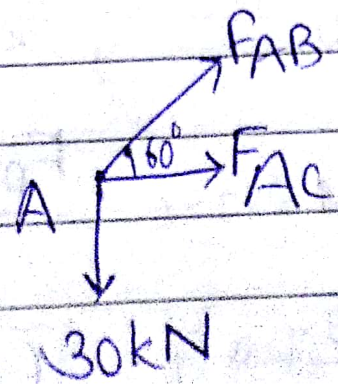
$\Rightarrow E_X = 80 \times \frac{\sqrt{3}}{2}$

$\Rightarrow \boxed{E_X = 40\sqrt{3}\text{ kN}}$

$\Rightarrow E_Y = 50 - \overset{40}{(80)}\left(\frac{1}{2}\right)$

$\Rightarrow \boxed{E_Y = 10\text{kN}}$

Joint A :-



$\Sigma F_X = 0$

$F_{AC} + \frac{F_{AB}}{2} = 0$

$F_{AC} = \frac{-F_{AB}}{2} = -10\sqrt{3}\text{kN}$

$\boxed{F_{AC} = -10\sqrt{3}\text{kN}}$

$\Sigma F_Y = 0$

$F_{AB}\left(\frac{\sqrt{3}}{2}\right) - 30 =$

$\boxed{F_{AB} = \frac{60}{\sqrt{3}} = 20\sqrt{3}}$

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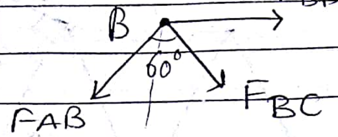
Joint B



$\Sigma F_y = 0$

$-F_{AB}\cos 30° - F_{BC}\cos 30° = 0$

$F_{BC} = -F_{AB}$

$$\boxed{F_{BC} = -20\sqrt{3}\ \text{kN}}$$

$\Sigma F_x = 0$

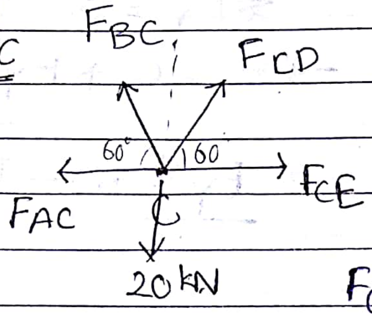
$F_{BD} + F_{BC}\cos 60° - F_{AB}\cos 60° = 0$

$F_{BD} = \dfrac{F_{AB} - F_{BC}}{2}$

$= \dfrac{20\sqrt{3} - (-20\sqrt{3})}{2}$

$$\boxed{F_{BD} = 20\sqrt{3}\ \text{kN}}$$

Joint C



$\Sigma F_x = 0$

$F_{CE} - F_{AC} + \dfrac{F_{CD}}{2} - \dfrac{F_{BC}}{2} = 0$

$F_{CE} - (-10\sqrt{3}) + \left(\dfrac{100}{\sqrt{3}}/2\right) - \left(\dfrac{-20\sqrt{3}}{2}\right) = 0$

$F_{CE} + 10\sqrt{3} + \dfrac{50}{\sqrt{3}} + 10\sqrt{3} = 0.$

$F_{CE} = \left(-20\sqrt{3} - 50/\sqrt{3}\right)$

$$\boxed{F_{CE} = \frac{-60-50}{\sqrt{3}} = \frac{-110}{\sqrt{3}}\ \text{kN}}$$

$\Sigma F_y = 0.$

$-20 + (F_{BC} + F_{CD})\dfrac{\sqrt{3}}{2} = 0$

$\Rightarrow (F_{BC} + F_{CD})\sqrt{3} = 40$

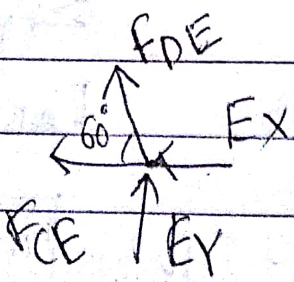
$\Rightarrow (-20\sqrt{3} + F_{CD})\sqrt{3} = 40$

$\Rightarrow -20(3) + \sqrt{3}F_{CD} = 40$

$\Rightarrow \sqrt{3}F_{CD} = 100$

$\Rightarrow \boxed{F_{CD} = \dfrac{100}{\sqrt{3}}\ \text{kN}}$

JOINT E



$\Sigma F_x = 0$

$-\dfrac{F_{DE}}{2} - F_{CE} - E_x = 0$

$\dfrac{+\cancel{20}\,10}{\sqrt{3}\,(\cancel{2})} - F_{CE} - 40\sqrt{3} = 0$

$\Rightarrow \boxed{F_{CE} = \dfrac{-110}{\sqrt{3}}\ \text{kN}}$

$\Sigma F_y = 0.$

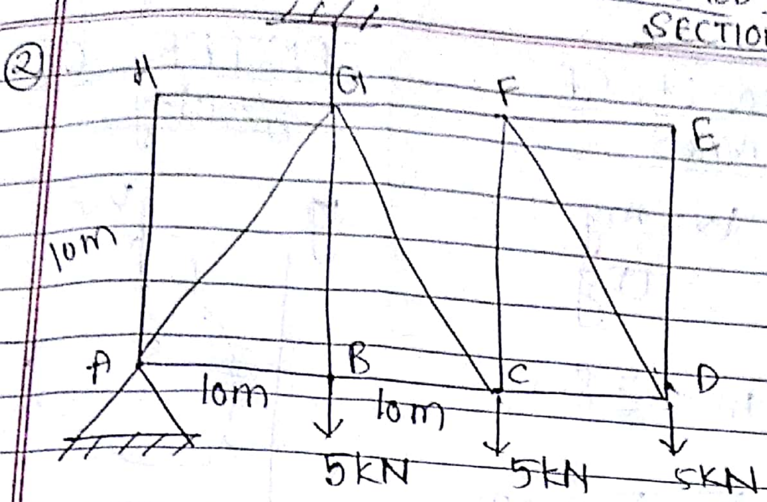
$\dfrac{F_{DE}\sqrt{3}}{2} + E_y = 0$

$\dfrac{F_{DE}\sqrt{3}}{2} = -E_y$

$$\boxed{F_{DE} = \frac{-20}{\sqrt{3}}\ \text{kN}}$$

METHOD OF SECTION

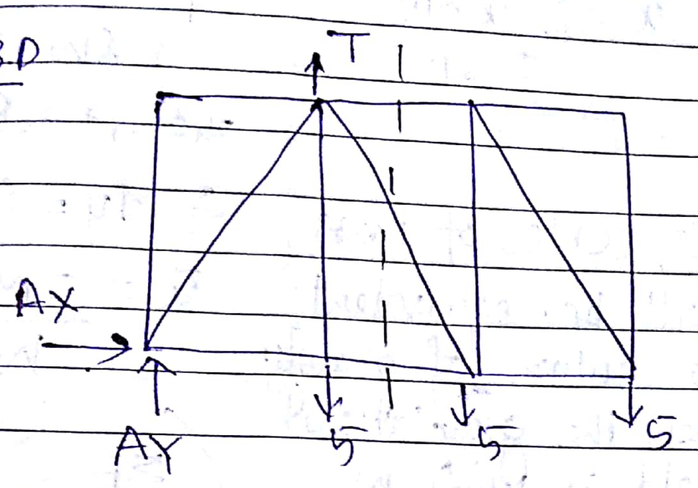
(2)



Find $F_{CG} = ?$

Use method of section

FBD



$\Sigma F_x = 0$

$\Rightarrow \boxed{A_X = 0}$

$\Sigma F_Y = 0$

$\Rightarrow A_Y - 15 + T = 0$

$\boxed{A_Y = 15 - T}$

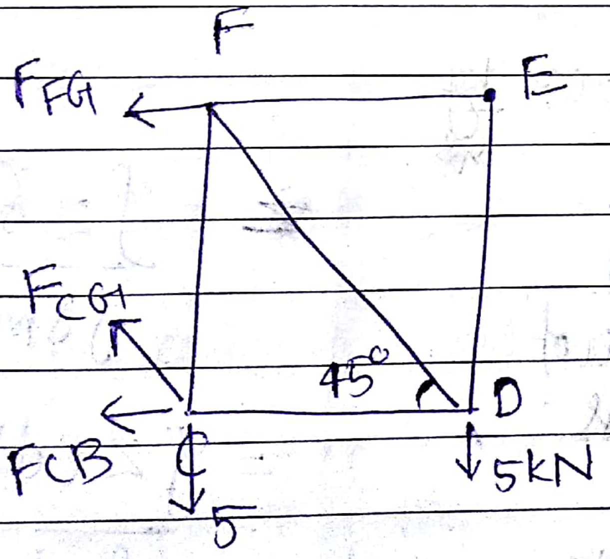
$\Rightarrow \cancel{T \times 10 - 5\times 10 - 5 \times 20 - 5 \times 30 = 0}$

$\Rightarrow 10T = 5(60)$

$\boxed{T = 30\,kN}$

$\Rightarrow A_Y = 15 - 30$

$\boxed{A_Y = -15\,kN}$



~~Joint E~~

$\Sigma M_C = 0$

$F_{FG} \times 10 - 5 \times 10 = 0$

$\Rightarrow \boxed{F_{FG} = 5\,kN}$

$\Sigma F_x = 0$

$-F_{FG} - \frac{F_{CG}}{\sqrt{2}} + F_{CB} = 0$

$-5 - 10 = F_{CB}$

$\boxed{F_{CB} = 15\,kN}$

$\Sigma F_Y = 0$

$-10 + \frac{F_{CG}}{\sqrt{2}} = 0$

$\boxed{F_{CG} = 10\sqrt{2}\,kN}$

$\boxed{F_{CG} = 10\sqrt{2}\,kN}$

CENTROID

Geometrical centre of the body.

$V = \sum dV$

$\bar{x} = \frac{\sum x \delta V}{\sum \delta V}$

So, when density is uniform then centroid and center of mass will be same.

CENTER OF MASS

$W = mg$
$= \rho V g$.

$m = \sum \delta m$.

$\bar{x} = \frac{\sum x \delta m}{\sum \delta m}$

So, center of mass will be equivalent to center of gravity when the gravitational field is uniform.

CENTER OF Gravity

$n\delta W = W = \sum \delta W$

~~$x_1 \delta w_1 + x_2 \delta w_2 + \ldots$~~

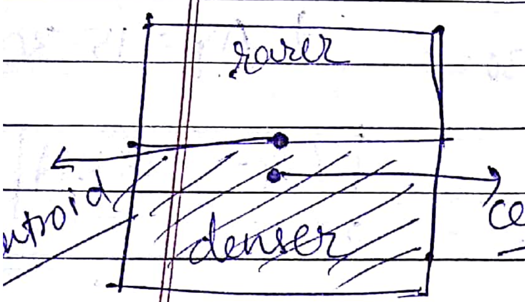
$\sum M_y = \sum x dW$.

$\bar{x} = \frac{\sum M_y}{W} = \frac{\sum x dW}{\sum dW}$

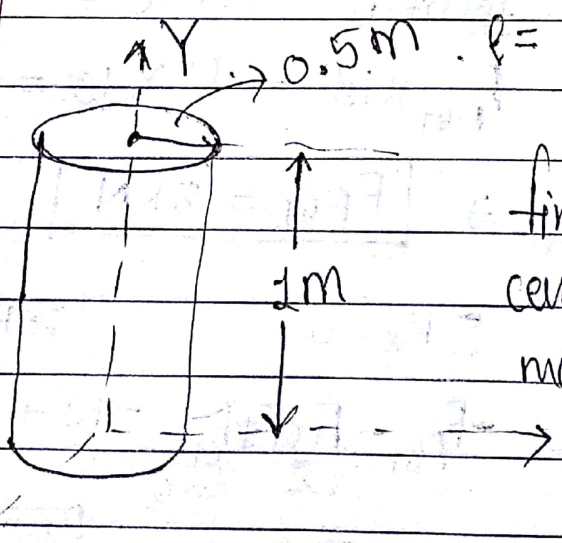
$\sum F = 0$

$\sum M = 0$.

$\bar{x} = \frac{\sum x \delta m g}{\sum \delta m g}$.



☆



$\rho = 2007 \frac{kg}{m^3}$.

find center of mass.

$\bar{z} = \frac{\int z\, \delta m}{\int \delta m}$

$= \frac{\int z \rho dV}{\int \rho dV}$

as it is axi-symmetric body so center will lie on z-axis only $\Rightarrow$ $\bar{x} = 0$, $\bar{y} = 0$.

$$\Rightarrow \bar{z} = \frac{\int 200 z^2 \, dV}{\int 200 z \, dV} \qquad V = \pi r^2 h$$

$$= \frac{\int z^2 (\pi/4) \, dz}{\int z \, (\pi/4) \, dz} \qquad V = \pi (0.5)^2 (z)$$

$$dV = \frac{\pi}{4} dz$$

$$\bar{z} = \frac{\left(z^3/3\right)_0^1}{\left(z^2/2\right)_0^1} = \frac{1/3}{1/2} = \frac{2}{3}$$

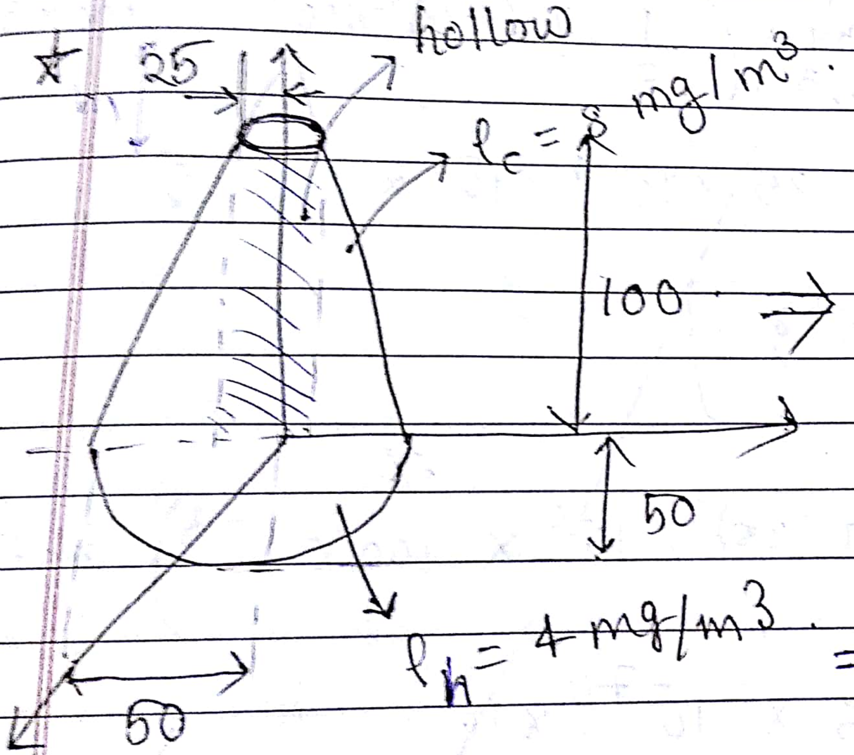
$$\boxed{\text{center of mass} = \left(0, 0, \frac{2}{3} m\right)}$$

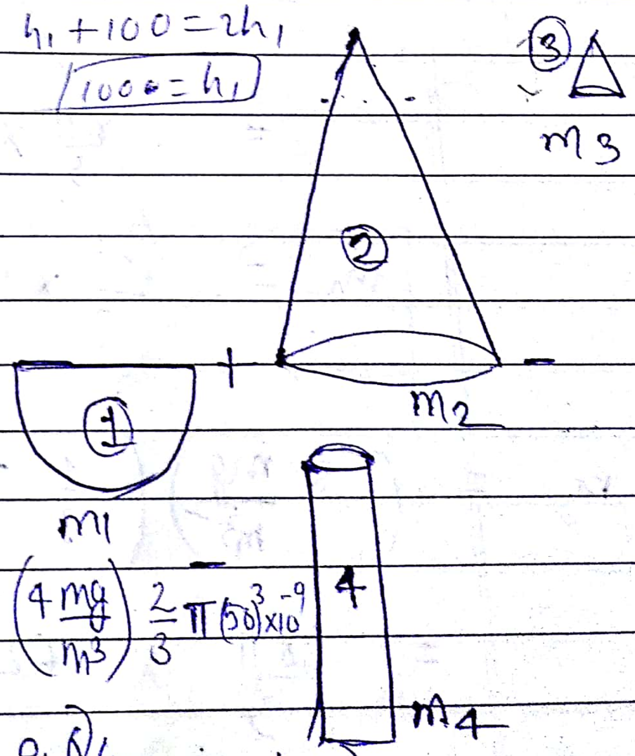
$$\cancel{= \frac{2}{3}\hat{k}}$$

$$\frac{h_1 + 100}{50} = \frac{h_1}{25}$$

$$h_1 + 100 = 2h_1$$

$$\boxed{100 = h_1}$$



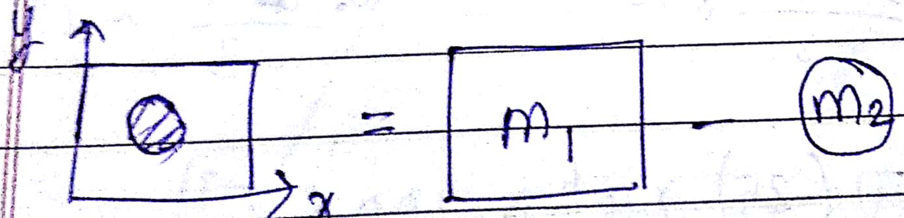


$$m_1 = \left(4 \frac{mg}{m^3}\right) \frac{2}{3} \pi (50)^3 \times 10^{-9}$$

$$= \rho_h (V_{Hemisphere})$$

find center of mass.

$$m = m_1 + m_2 - m_3 - m_4$$

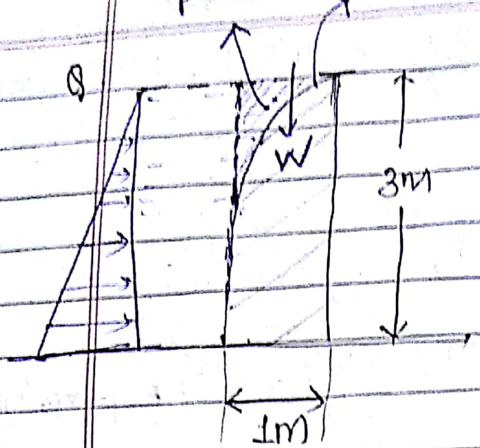


$$m = m_1 - m_2$$

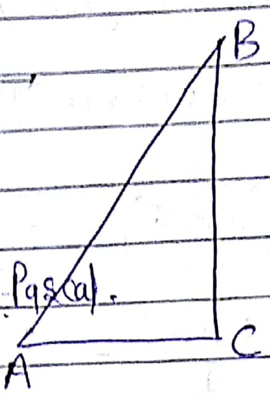
$$\bar{x} = \frac{x m_1 - x m_2}{m_1 - m_2}$$

$A_w = \frac{1}{3}$

$L = 5m, \quad \rho = 1020 \frac{kg}{m^3}$



Find the net force acting on parabolic dam.



$A = \frac{1}{2} AC \cdot BC$

$F_h = \frac{1}{2} \times 150.1 \times 3$

$\boxed{F_h = 225.1 \text{ kN}}$

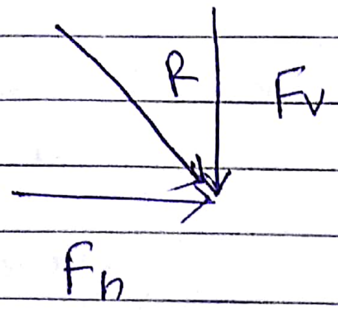
$P = \rho g h = 1020 \times 9.8 \times 3$ Pascal.

$F|_L = 1020 \times 9.8 \times 3 \times 5 \ \frac{N}{m}$

$W = F_V = A_w \times L \times \rho_w g$

$\boxed{F_V = 50 \text{ kN}}$

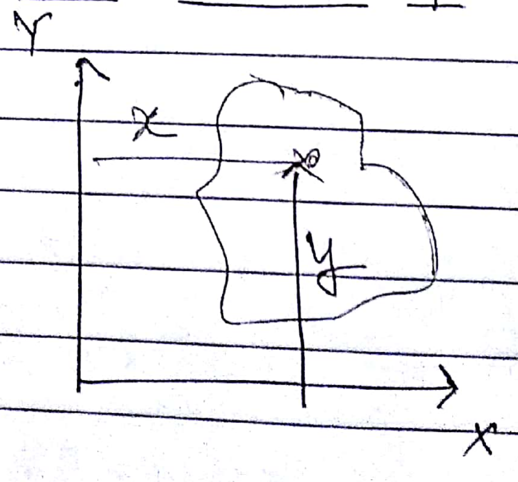
$F|_L = 150.1 \ \frac{kN}{m}$



$R = \sqrt{F_h^2 + F_V^2}$

$= 231 \text{ kN}.$

★ Area Moment of Inertia :- (second moment)



$I_Y = \Sigma x^2 dA$

$I_X = \Sigma y^2 dA$

$I_{XY} = \Sigma xy\, dA$

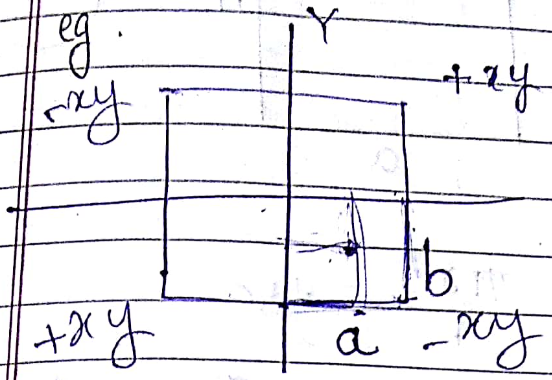
SI unit $= m^2 \cdot m^2 = m^4$

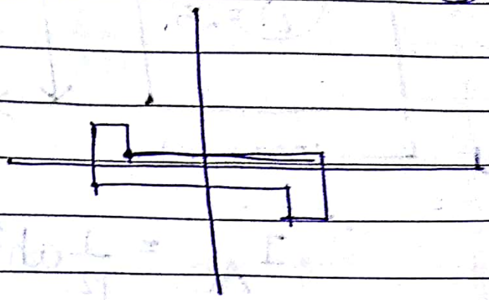
$I_Y = \cancel{x^2 dA} \quad x^2 b\,dx$

$\frac{a^2 ab}{4} = \frac{ba^3}{4} \quad b\int_0^{a} x^2 dx \quad b\int_{-a/2}^{a/2} x^2 dx$

For any symmetric body if axes are passing through centroid then Area moment of Inertia will be zero.

eg.   to be calculated.

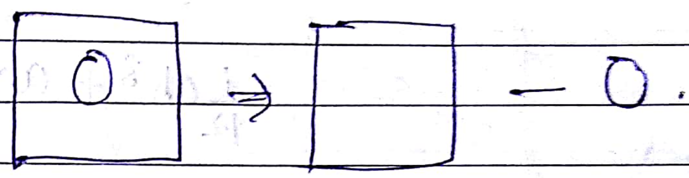




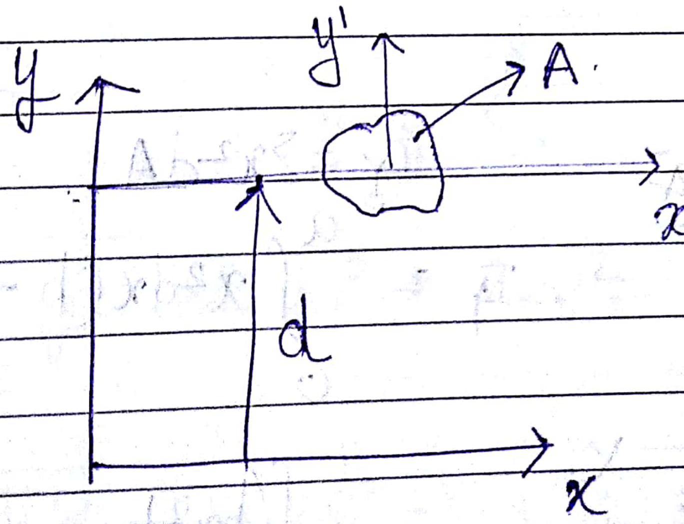
$$I_X = \frac{1}{12} ab^3$$

$$I_Y = \frac{1}{12} ba^3$$

$$I_{XY} = 0.$$



★ <u>PARALLEL AXIS THEORY</u> :-



$$I_x = I_{x'} + Ad^2.$$

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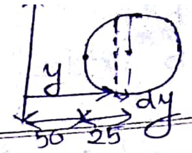
$I_X = \Sigma y^2 . dy ($



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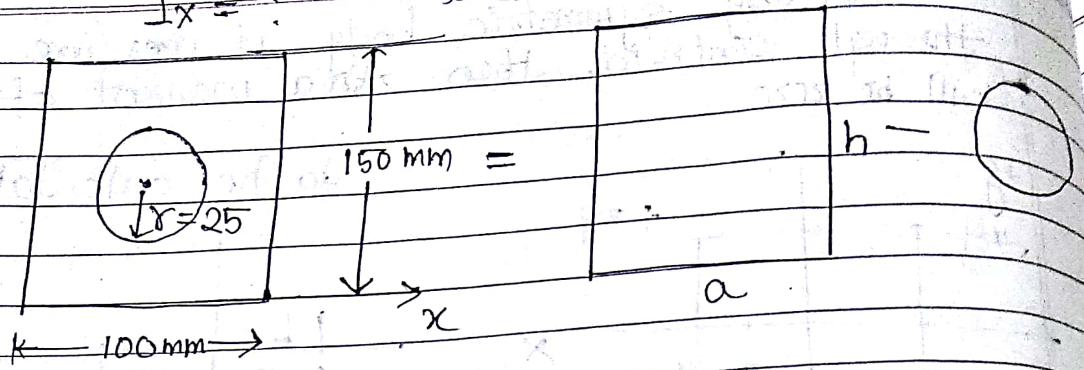
$I_X = ?$



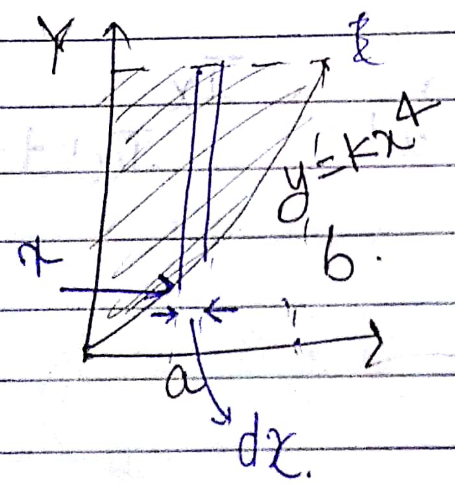
$$\Rightarrow I_{AC} = \frac{1}{12} ah^3 - \frac{\pi r^4}{4} = I_{BC}$$

$$I_{AX} = I_{AC} + A_A d_A^2 \qquad I_{BX} = I_{BC} + A_B d_B^2$$

$$= \frac{1}{12} ah^3 + ah(75)^2 \qquad = \frac{\pi}{4} r^4 + \pi r^2 (75)^2$$

$$I_X = I_{AX} - I_{BX}$$

$$= 101 \times 10^6 \text{ mm}^4$$



$$I_Y = \Sigma x^2 dA$$

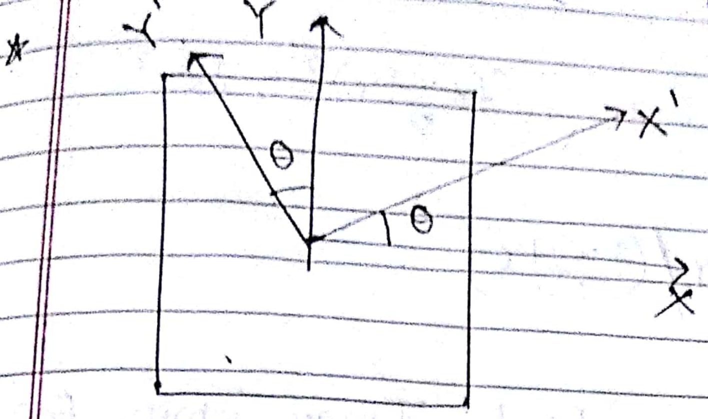
$$I_Y = \int_0^a x^2 dx (b - kx^4)$$

$$= \int_0^a (bx^2 dx - kx^6 dx)$$

$$= b\left(\frac{x^3}{3}\right)_0^a - k\left(\frac{x^7}{7}\right)_0^a$$

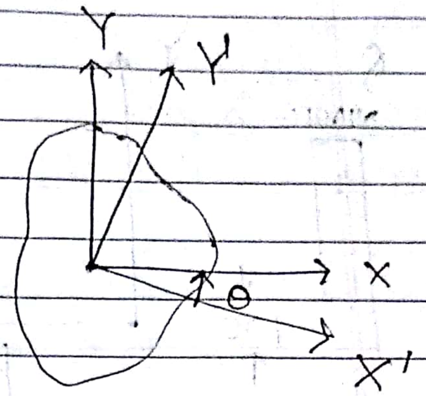
$$= \frac{ba^3}{3} - \frac{ka^7}{7} = a^3\left(\frac{b}{3} - \frac{ka^4}{7}\right)$$

$$I_Y = a^3\left(\frac{b}{3} - \frac{b}{7}\right) = \frac{4a^3b}{21}$$

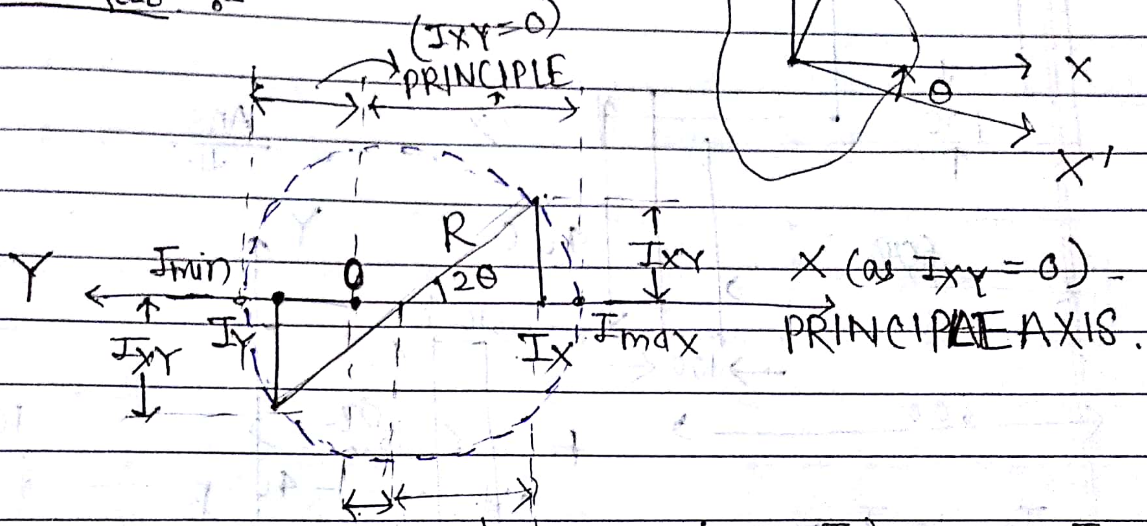


$I_{x'}$ $I_{y'}$ $I_{x'y'}$

Principal axes I_x I_y 0



MOHR'S CIRCLE :-



$$\frac{I_x + I_y}{2} \qquad I_x - \left(\frac{I_x + I_Y}{2}\right) = \frac{I_X - I_Y}{2}$$

$$R = \sqrt{\left(\frac{I_X - I_Y}{2}\right)^2 + (I_{XY})^2}$$

$$\text{PRINCIPLE} = \frac{I_X + I_Y}{2} + R = \frac{I_X + I_Y}{2} + \sqrt{\left(\frac{I_X - I_Y}{2}\right)^2 + (I_{XY}}$$

and

$$= R - \left(\frac{I_X + I_Y}{2}\right) \cancel{R}$$

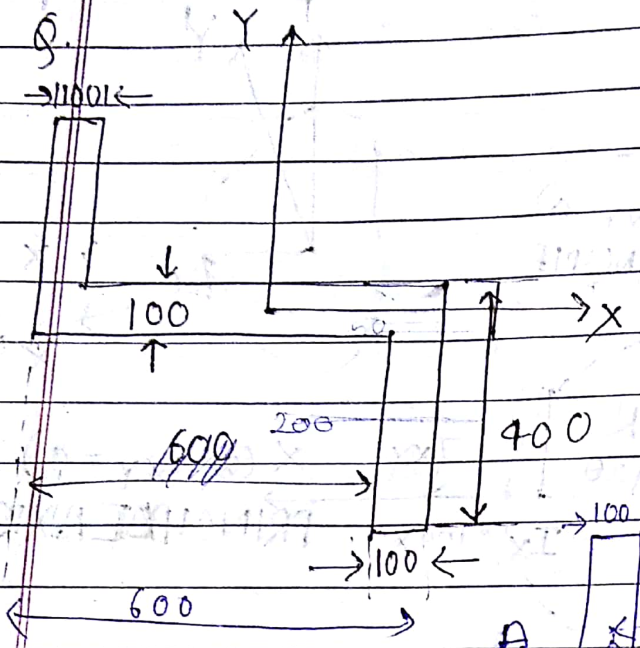
$$\cancel{= R = \sqrt{\left(\frac{I_X - I_Y}{2}\right)^2 + (I_{XY})^2}}$$

$$I_{max} = \frac{I_X + I_Y}{2} + \sqrt{\left(\frac{I_X - I_Y}{2}\right)^2 + I_{XY}^2}$$

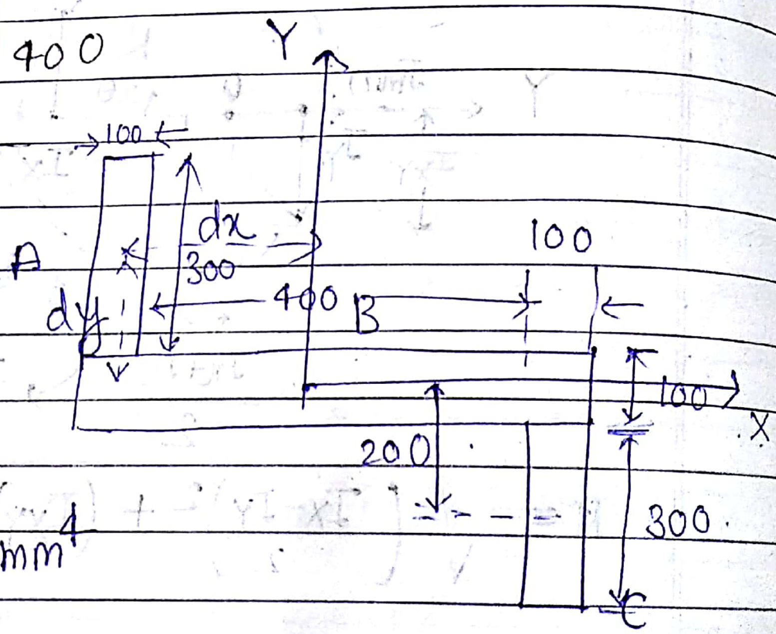
$$I_{min} = \frac{I_X + I_Y}{2} - \sqrt{\left(\frac{I_X - I_Y}{2}\right)^2 + I_{XY}^2}$$

$$\tan 2\theta = -I_{XY} \Big/ \left(\frac{I_x - I_Y}{2}\right)$$

Q. Find I_{max}, I_{min}, $\theta = ?$



Ans
⇓



$I_{AX} = I_{CX}$

$I_{ACX} = I_{CCX}$

$= \frac{1}{12} \times 300 \times 100^3 \ mm^4$

$I_{AX} = I_{ACX} + A_A (200)^2 = 1.425 \times 10^9 \ mm^4$

$I_{BCX} = I_{BX} = \frac{1}{12} (100)^3 (600) \ mm^4 = 0.05 \times 10^9 \ mm^4$

$I_X = I_{AX} + I_{BX} + I_{CX}$

$\therefore \boxed{I_X = 2.9 \times 10^9 \ mm^4}$

$I_{AY} = I_{CY}$ $\quad I_{ACY} = I_{CCY}$

$= \frac{1}{12} \times 300 \times (100)^3 \text{ mm}^4$

$I_{AY} = I_{ACY} + A_A (250)^2$

$I_{BCY} = I_{BY}$

$I_Y = 5.6 \times 10^9 \text{ mm}^4$

$I_{XYAC} = 0$; $I_{XYA} = I_{XYAC} + A dx dy$

$= 0 + (300 \times 100)(-250)(200)$

$= -150 \times 10^7 \text{ mm}^4 = -1.5 \times 10^9 \text{ mm}^4$

$I_{XYB} = 0$; $I_{XYC} = 0 + (300 \times 100)(250)(-200)$

$= -1.5 \times 10^9 \text{ mm}^4$

$\therefore I_{XY} = I_{XYA} + I_{XYB} + I_{XYC}$

$= -3 \times 10^9 \text{ mm}^4$

$\therefore I_X = 2.9 \times 10^9 \text{ mm}^4$

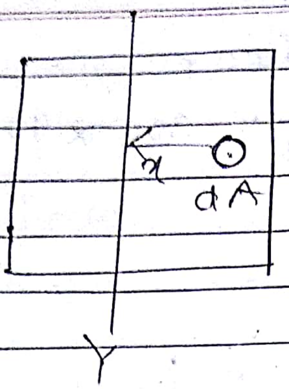
$I_Y = 5.6 \times 10^9 \text{ mm}^4$

$I_{XY} = -3 \times 10^9 \text{ mm}^4$

Calculate I_{max}, I_{min}, ϕ

$= 7.5 \times 10^9$ $\quad = 6.9 \times 10^9$ $\quad = -65.8^\circ$

★



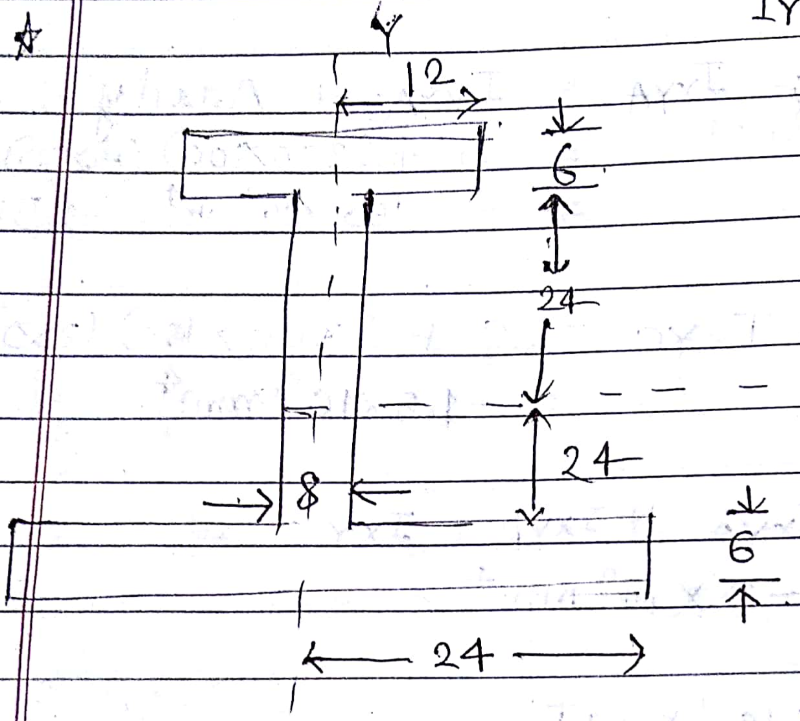
$$I_Y = \sum x^2 \, dA$$

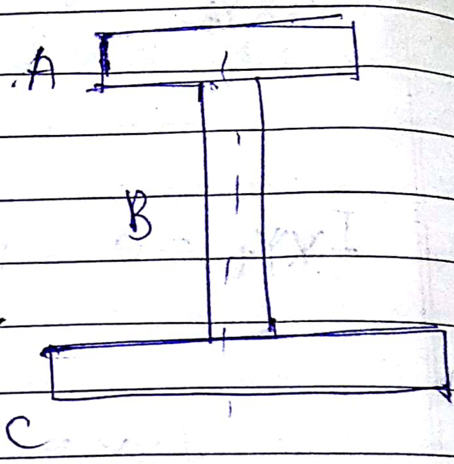
$$= K_Y^2 A$$

$$\boxed{K_Y = \sqrt{\frac{I_Y}{A}}}$$

★

$I_Y = ?\quad K_Y = ?$





$$I_Y = I_{YA} + I_{YB} + I_{YC}$$

$$A = A_A + A_B + A_C.$$

$$K_Y = \sqrt{\frac{I_Y}{A}}$$

$$A = (6 \times 24) + (8 \times 24) + (6 \times 48).$$

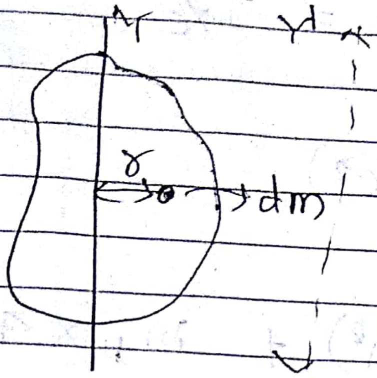
$$I_{YA} = \frac{1}{12}(6)(24)^3$$

$$I_{YB} = \frac{1}{12}(48)(8)^3$$

$$I_{YC} = \frac{1}{12}(6)(48)^3$$

Page No.

★ MASS MOMENT of Inertia.



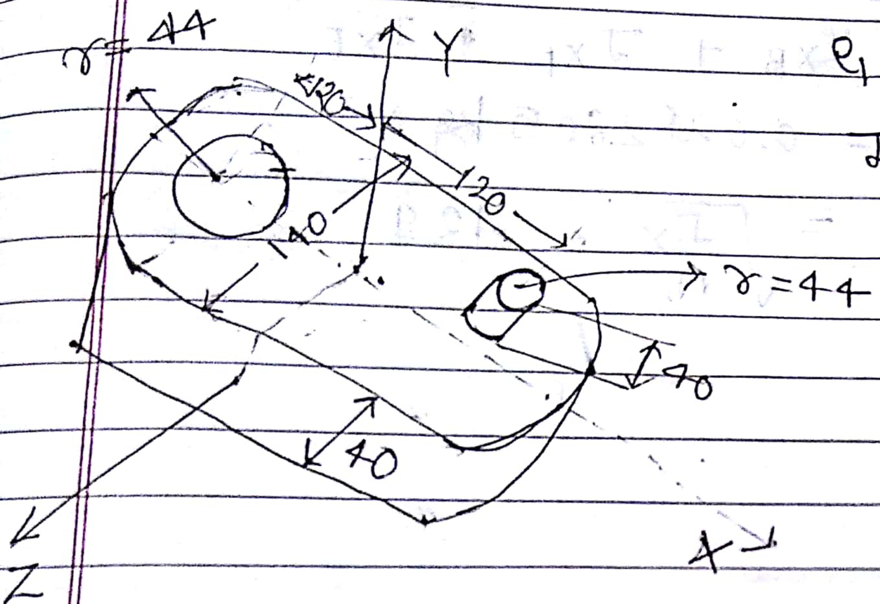
$I_y = \sum r^2 dm$

$= \sum r^2 \rho dV$

$= \rho \sum r^2 dV$

$I_{Y'} = I_Y = d^2 m$

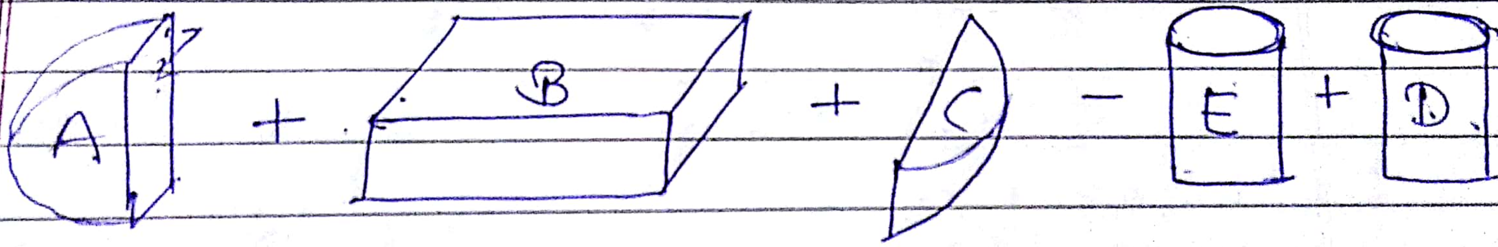
$I = k^2 m$



$\rho_1 = 7850\ kg/m^3$

$I_X =$ $K_X =$

$I_Y =$ $K_Y =$



$m_A = m_C$; $m_E = m_D$; m_B.

$m_A = m_C = \frac{\pi}{2}(40)^2 \rho \times 40$

$m_E = m_D = \pi(44)^2 \times 40 \times \rho$

$m_B = (40 \times 140 \times 240)\rho$.

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$I_x = ?$

$I_{xA} = \frac{m_A}{12}(3r^2+h^2) = I_{xc}$

$I_{xB} = \frac{m_B}{12}(b^2+c^2)$

$I_{xD} = \frac{m_d}{12}(3r^2+h^2) + m_D \times 40$

$I_x = 2I_{xA} + I_{xB} + I_{xD} + I_{xE}$

$= k_x^2 m = 0.0282605\ kg.m^2$

$\Rightarrow \quad k_x = \sqrt{\frac{I_x}{m}} = 42.9$

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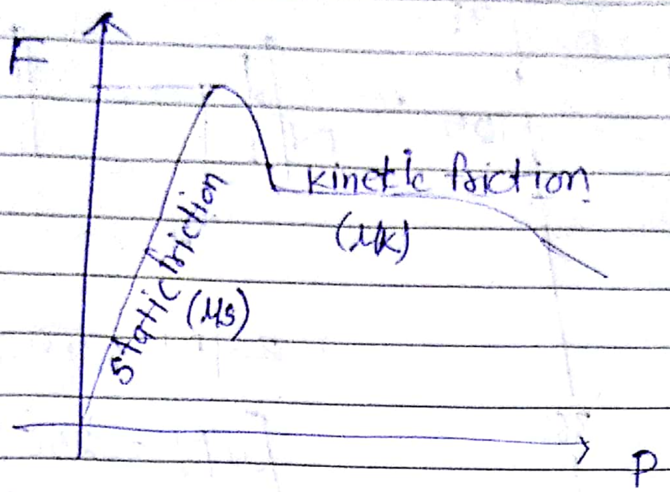
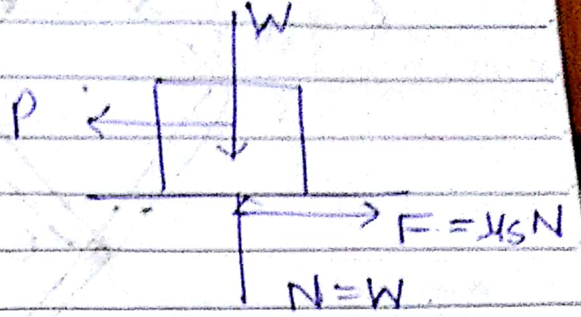
FRICTION

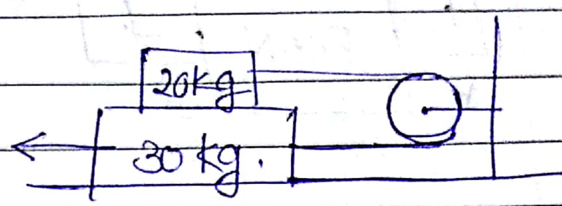




$\mu_s > \mu_k$

☆ Find the minimum force to be applied on 30 kg mass to just move it.

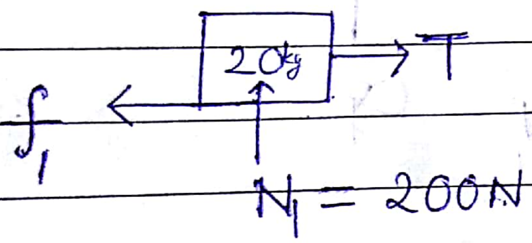
Given, $\boxed{g = 10\ m/s^2}$

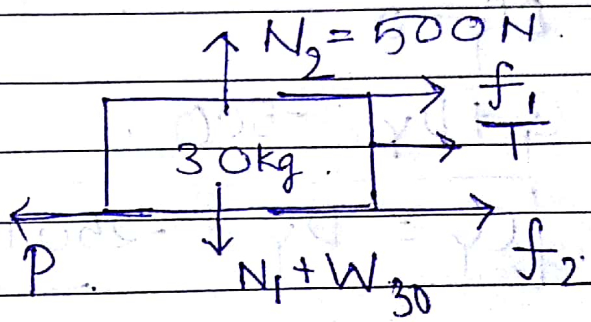


$\mu_s = 0.4$

$\mu_k = 0.5$

⟹





$\Sigma F_x = 0 \quad f_1 = T$

$f_1 = \mu_s N_1$

$= (0.4)(200)$

$f_1 = 80\ N.$

$T = 80\ N.$

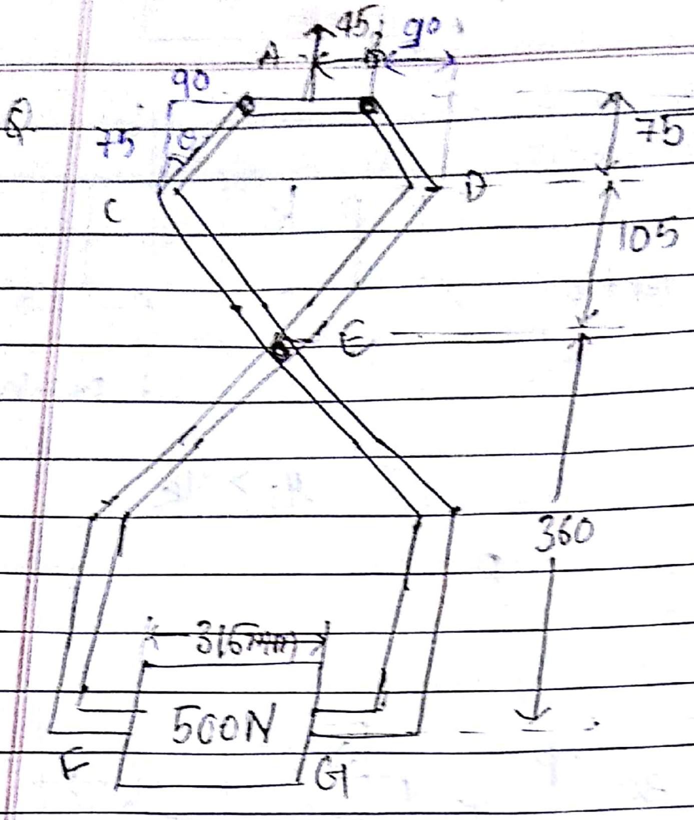
$\Sigma F_x = 0$

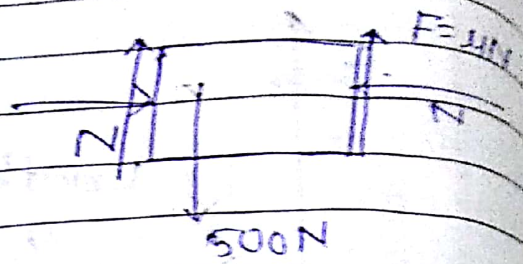
$f_1 + T + f_2 = P.$

$\Rightarrow 80 + 80 + (0.4)(500) = P.$

$\boxed{P = 360\ N}$

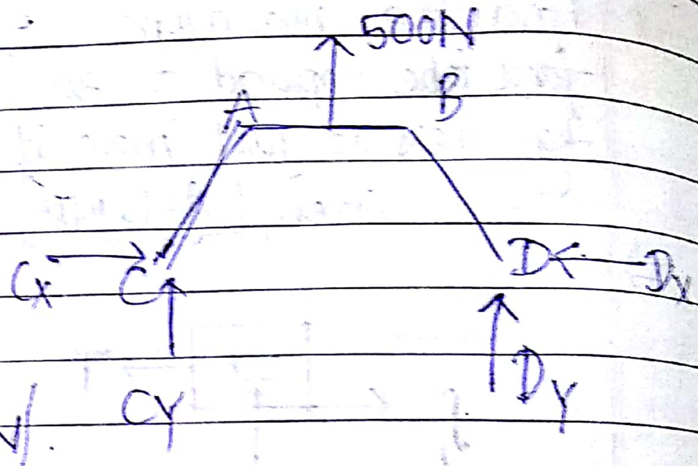
find $\mu = ?$





$2\mu N = 500$

$\boxed{\mu N = 250}$



$\Sigma F_y = 0$

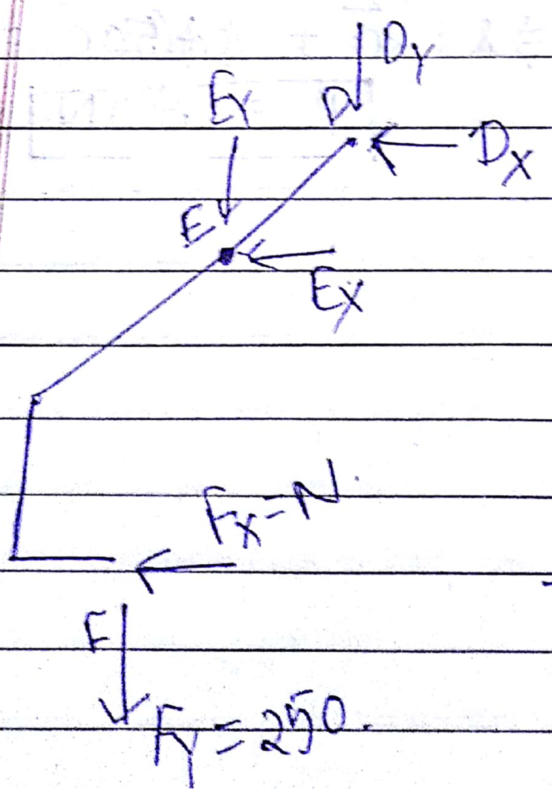
$C_y + D_y = -500$.

$\boxed{C_y = D_y = -250\,N}$

$\Sigma F_x = 0 \rightarrow \boxed{C_x = D_x}$

As $C_x = -300\,N$

$\boxed{D_x = -300\,N}$



$\Sigma M_E = 0$

$-(D_y)\times(135) + (D_x)\times(105)$

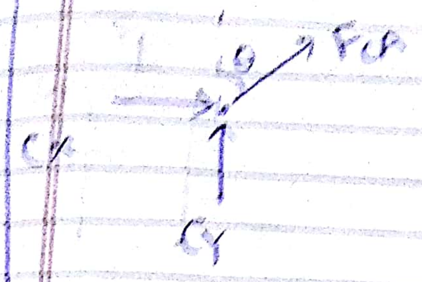
$+ -(360 \times N) + \left(\frac{315}{2} \times 250\right)$

$-(250 \times 135) + (-300 \times 105)$

$-(360 \times N) + (315 \times 125) = 0$

$\tan\theta = \frac{90}{75} = \frac{6}{5}$

Pt. C.



$F_{CA}\cos\theta + C_y = 0$

$C_x + F_{CA}\sin\theta = 0$

$F_{CA} = \frac{-C_y}{\cos\theta}$

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

$C_x = C_y\tan\theta$

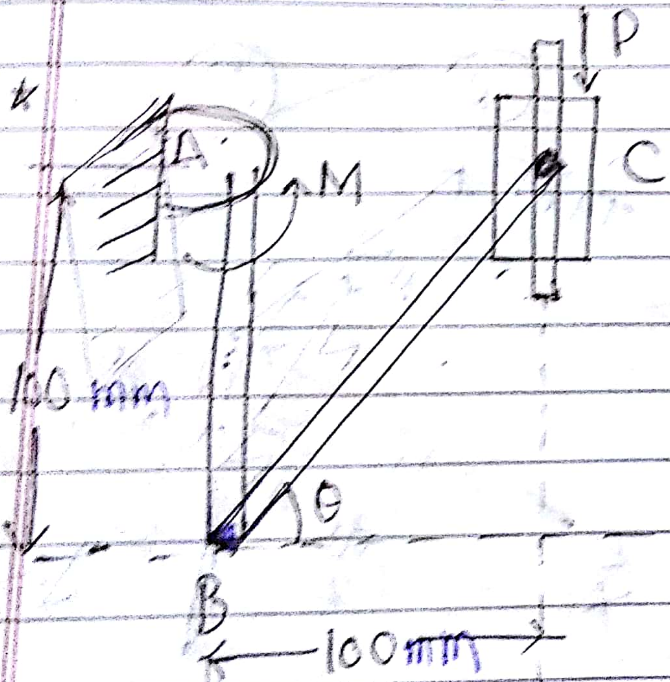
$= (-250)\left(\frac{6}{5}\right)$

$\boxed{C_x = -300N}$

$360 \times N = (315\times125) - (250\times135) - (300\times105)$

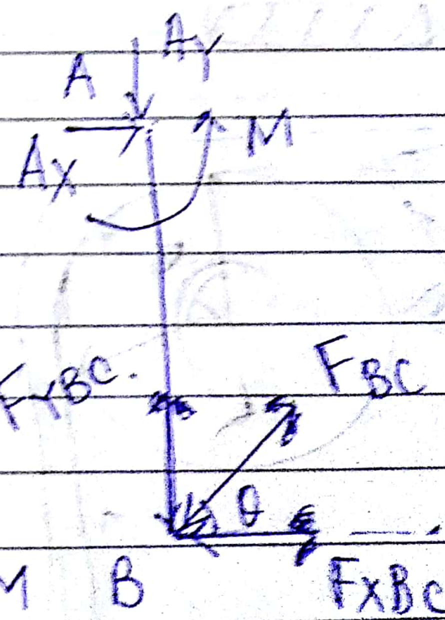
$N = \frac{(315\times125) - (250\times135) - (300\times105)}{360}$

$= -71.875$



$\mu = 0.4$, $\theta = 60^\circ$

$P = 200\,N$, $M = ?$ (RANGE)

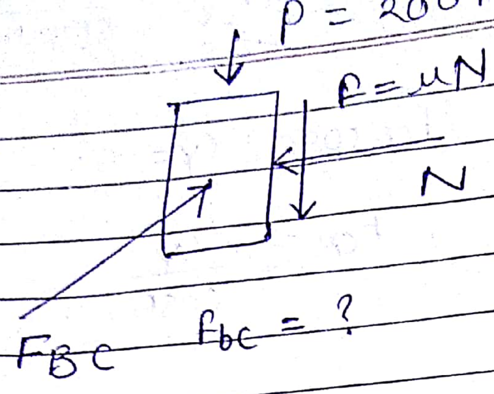


$\Sigma M_A = -F_{XBC}\times 0.1 + M$

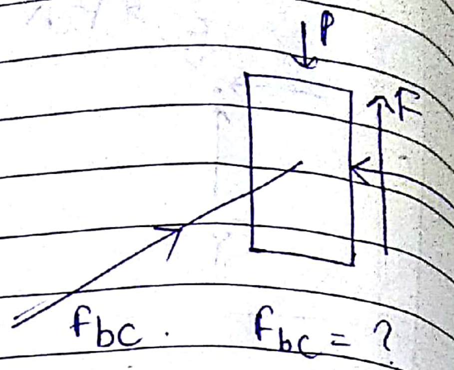
$F_{XBC} = F_{BC}\cos$

$M = 0.1\,F_{BC}\cos60^\circ$

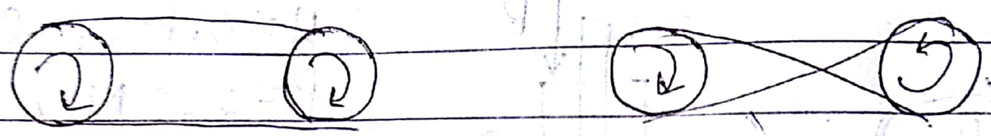
UPWARD

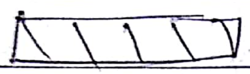


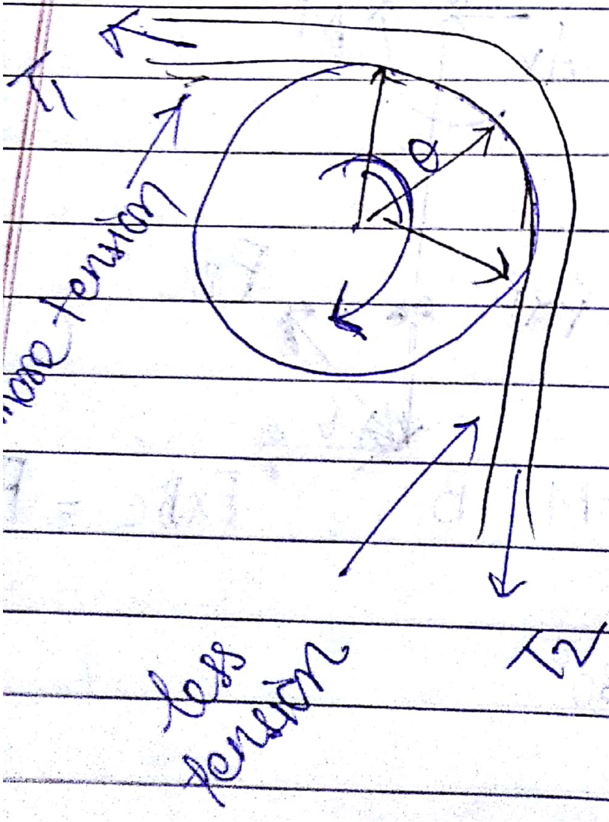
DOWNWARD

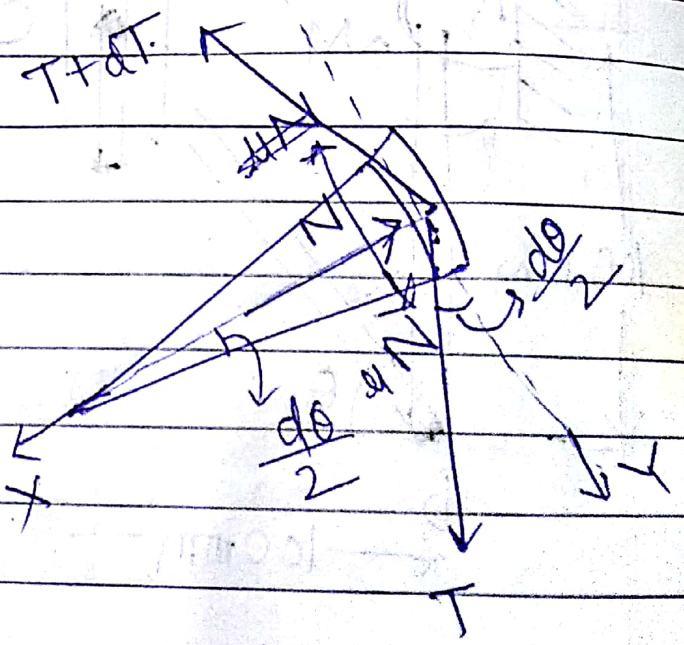


★ Flat Belt :- $P = Tv$.









$$\Sigma F_x = 0$$

$$N - T\sin\frac{d\theta}{2} - (T+dT)\sin\frac{d\theta}{2}$$

$$N = 2T\sin d\theta$$

Page No.

$$\Rightarrow \quad N = \cancel{2}T\frac{d\theta}{\cancel{2}} \Rightarrow \boxed{N = Td\theta} \quad \text{— (1)}$$

$\Sigma F_y = 0 \Rightarrow$

$$T\cos\frac{d\theta}{2} + \mu N - (T+dT)\cos\frac{d\theta}{2} = 0.$$

$$\boxed{\mu N = dT} \quad \text{— (2)}$$

$$\mu T d\theta = dT.$$

$$\Rightarrow \int_{T_1}^{T_2} \frac{dT}{T} = \int_0^\theta \mu \, d\theta.$$

$$\rightarrow \quad \ln\frac{T_2}{T_1} = \mu\theta.$$

$$\boxed{T_2 = T_1 e^{\mu\theta}}.$$

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$$\Rightarrow N = \frac{\cancel{2}T\,d\theta}{\cancel{2}} \Rightarrow \boxed{N = T\,d\theta} \longrightarrow (1).$$

$\Sigma F_y = 0 \Rightarrow$

$$T\cos\frac{d\theta}{2} + \mu N - (T+dT)\cos\frac{d\theta}{2} = 0.$$

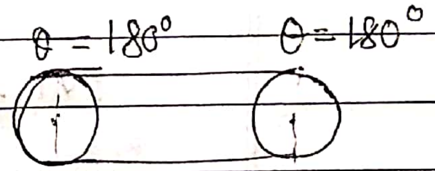
$$\boxed{\mu N = dT} \longrightarrow (2)$$

$$\mu T\,d\theta = dT.$$

$$\Rightarrow \int_{T_1}^{T_2} \frac{dT}{T} = \int_0^{\theta} \mu\,d\theta.$$

$$\rightarrow \ln\frac{T_2}{T_1} = \mu\theta.$$

$$\boxed{T_2 = T_1 e^{\mu\theta}}.$$



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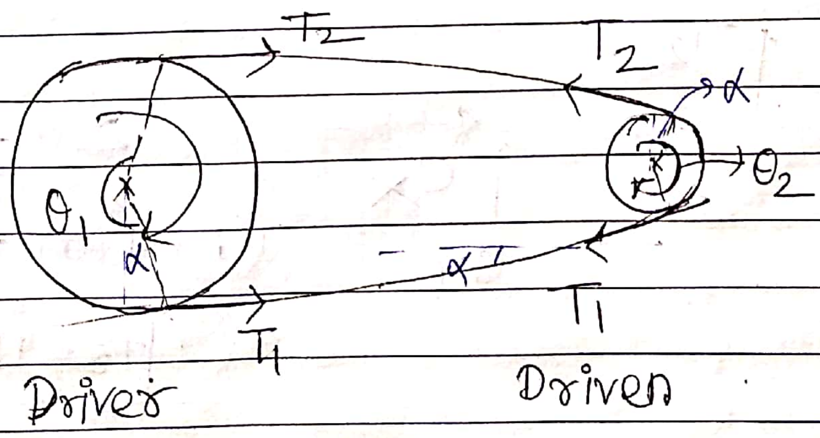


$T_1 > T_2$

$\theta_1 = \pi + 2\alpha$

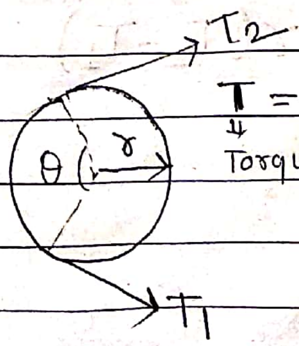
$\theta_2 = \pi - 2\alpha.$

~~IDEALER~~ IDLER PULLEY.

$T_2 = T_1 e^{\mu\theta}$

θ = Angle of Bite.

★



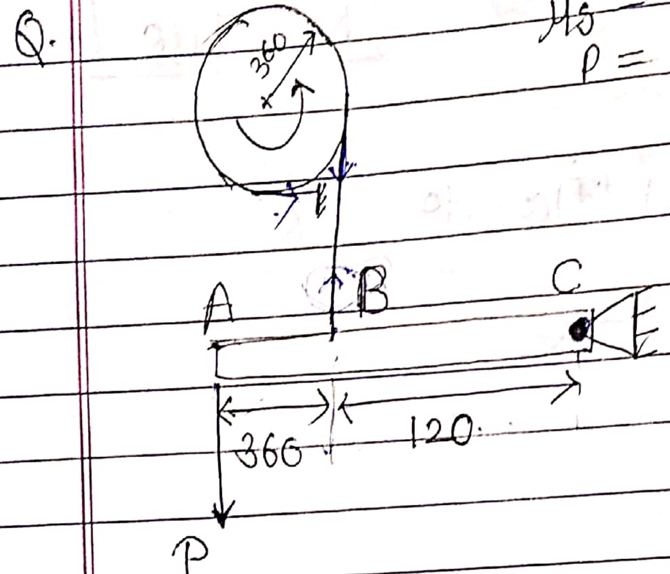
$T = M = -T_2 r + T_1 r = (T_1 - T_2) r.$

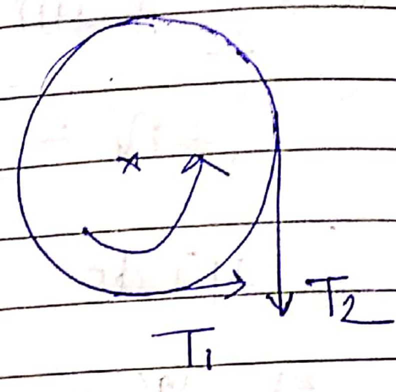
Torque

$P = T\omega.$

$\theta = 270^\circ$ T_2

Q. $\mu_s = 0.3$; $\mu_k = 0.25$.
$P = 45N.$; $M = ?$

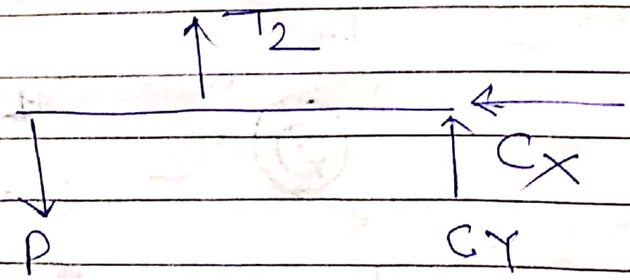




$T_2 > T_1$

⇒ $T_2 = T_1 e^{\mu\theta}$
$T_2 = T_1 e^{\mu 3\pi/2}$

$M = (T_2 - T_1) r$
$= (T_1 e^{\mu 3\pi/2} - T_1) r$.
$M = T_1 (e^{\mu 3\pi/2} - 1) r$



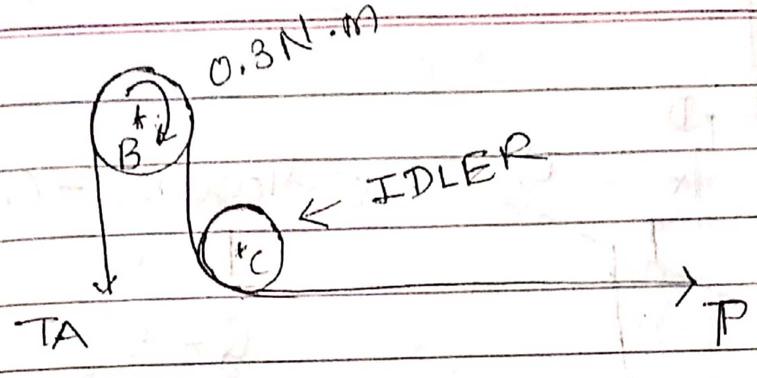
$\Sigma M_C = 0$
$(P \times 480) = T_2 \times 120$
$\boxed{T_2 = 180N}$

$M =$

$\boxed{\mu = \mu_k}$

$\frac{T_2}{T_1} = e^{\mu\theta}$; $M = r(T_2 - T_1)$

Q



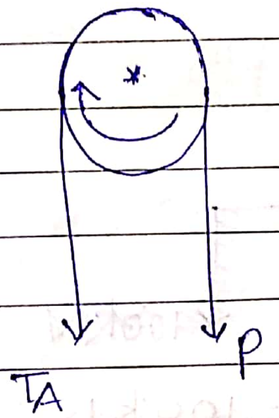
$r_b = 20\,mm$

$\mu_s = 0.4$

$P = ?$

s.t. there is no slip betn pulley B & rope.

⇒



$$T_A = P e^{\mu\pi} \qquad M = r(T_A - P).$$

$$P = \frac{T_A}{e^{\mu\pi}} \qquad \therefore M = r(P)(e^{\mu\pi} - 1)$$

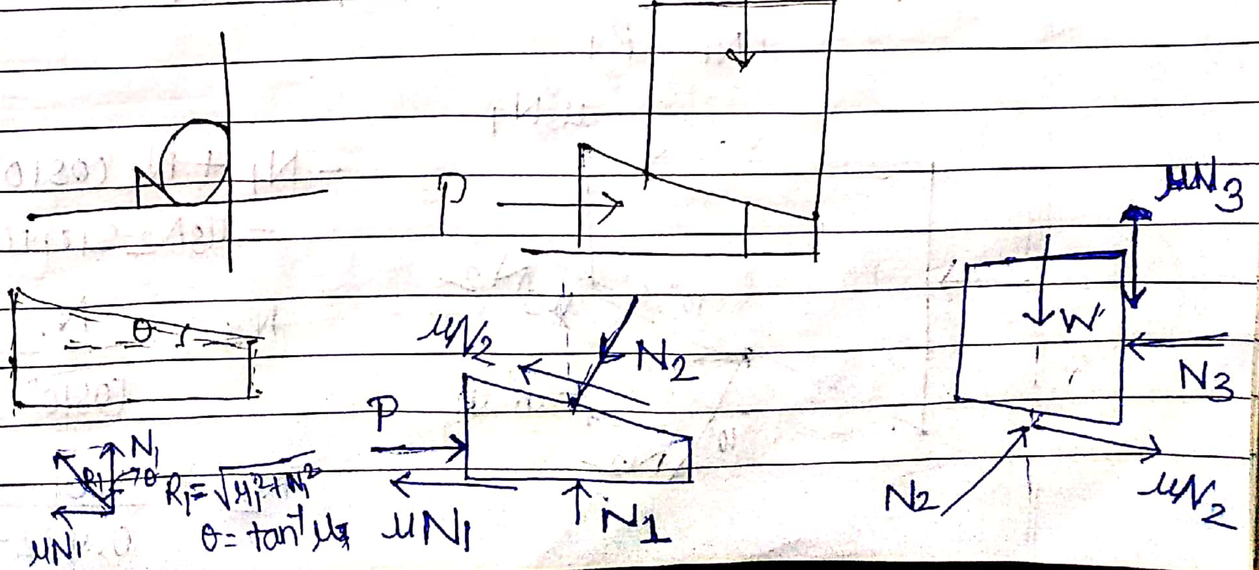
$$\Rightarrow P = \frac{M}{r(e^{\mu\pi} - 1)}$$

$T_A > P$.

$$\Rightarrow P = \frac{0.3}{20\times10^{-3}(e^{(0.4)\pi} - 1)}$$

$$\Rightarrow P = \frac{15}{e^{2\pi/5} - 1} = \frac{15}{2.5135} = 5.967\,N.$$

★ WEDGE :-



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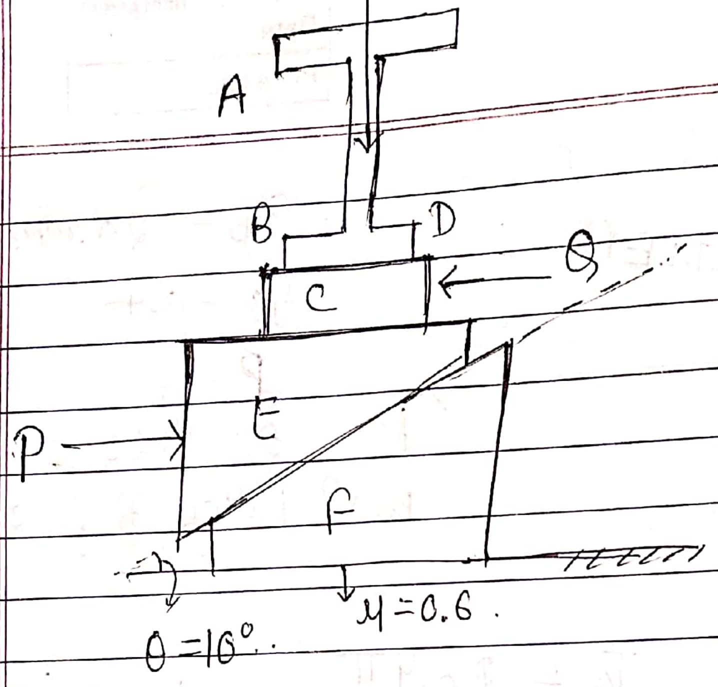
Q.

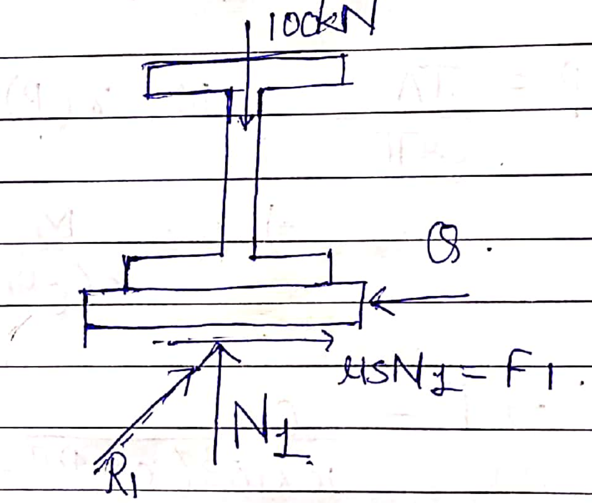


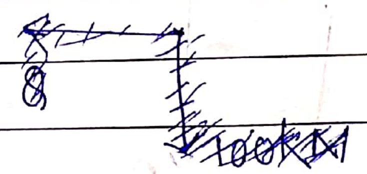
$\mu_s = \mu$ elsewhere $= 0.3$

$P = ?$

$Q = ?$

Ans ⇒





$N_1 = 100\ \text{kN}$

$Q = \mu_s N_1$

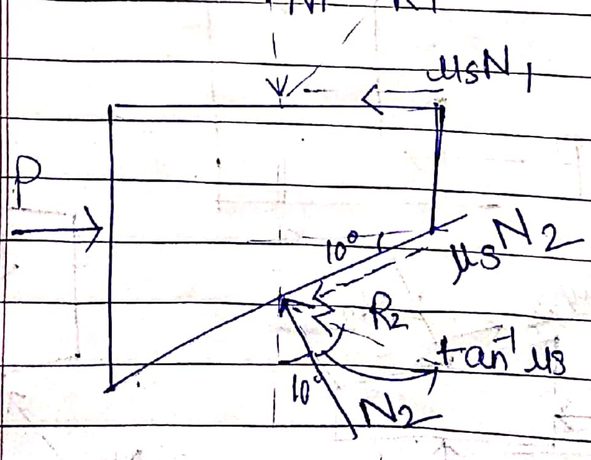
$= (0.3)(100)\ \text{kN}$

$\boxed{Q = 30\ \text{kN}}$

$R_1 = \cancel{\dfrac{100}{\cos(\tan^{-1}\mu)}}$

$= N_1\sqrt{1+(\mu_s)^2} = 100\sqrt{1+0.09}$

$R_1 = 100\sqrt{1.09} = 104.40\ \text{kN}$



$-N_1 + N_2\cos 10^\circ - \mu_s N_2 \sin 10^\circ = 0$

$N_2 = \dfrac{N_1}{\cos 10^\circ - \mu_s \sin 10^\circ}$

$N_2 = \dfrac{100}{0.9327} = 107.2\ \text{kN}$

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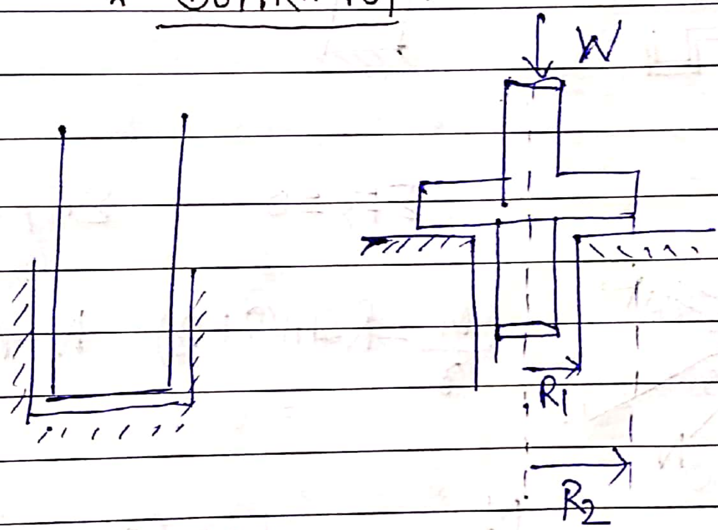
$$P - \mu_s N_1 - \mu_s N_2 \cos 10^\circ + N_2 \sin 10^\circ = 0$$

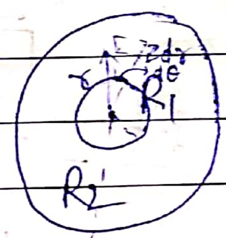
$$P = \mu_s (N_1 + N_2 \cos 10^\circ) - N_2 \sin 10^\circ$$

$$= (0.3)(205.58) - 18.61$$

$$\boxed{P = 43.064\ KN}$$

★ BEARING.





$$P = \frac{W}{\pi(R_2^2 - R_1^2)}$$

$$dA = r\,d\theta\,dr$$

$$dN = P\,dA$$

$$\Rightarrow \quad dF = \mu P\,dA$$

$$dF = \frac{\mu W}{\pi(R_2^2 - R_1^2)} r\,d\theta\,dr$$

$$\Rightarrow \quad F = \int \mu P\,dA$$

$$dT = dF\,r$$

$$= \int_{R_1}^{R_2}\int_0^{2\pi} \mu \frac{W\,r\,d\theta\,dr}{\pi(R_2^2 - R_1^2)} \qquad T = \int_{R_1}^{R_2}\int_0^{2\pi} \frac{\mu W r^2\,d\theta\,dr}{\pi(R_2^2 - R_1^2)}$$

$$= \frac{2\mu W}{(R_2^2 - R_1^2)} \int_{R_1}^{R_2} r\,dr \qquad T = \frac{2\mu W}{(R_2^2 - R_1^2)}\left(\frac{R_2^3 - R_1^3}{3}\right)$$

$$= \frac{2\mu W}{\cancel{(R_2^2 - R_1^2)}}\left(\frac{\cancel{R_2^2 - R_1^2}}{\cancel{2}}\right)$$

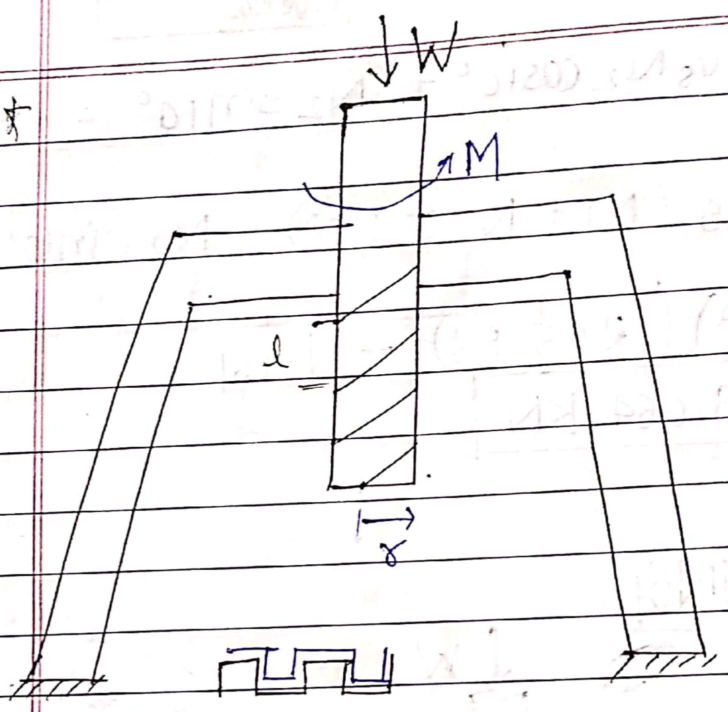
$$= \mu W$$

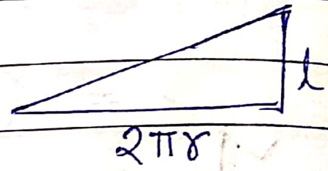
KN

Page No.

SCREW JACK.

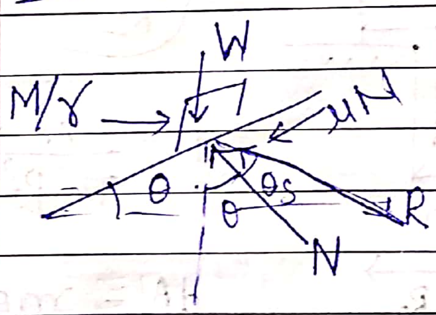
*





$\tan\theta = \dfrac{l}{2\pi r}$

Torque to lift up.



$\Sigma F_x = 0 \qquad \Sigma F_y = 0$

$\dfrac{M}{r} - R\sin(\theta+\theta_s) \qquad W - R\cos(\theta+\theta_s)$

$= 0$.

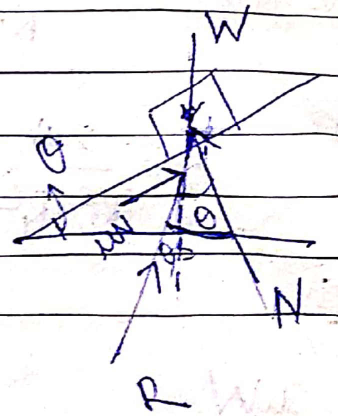
$$\frac{M}{r(W)} = \tan(\theta+\theta_s)$$

$\Rightarrow M = Wr\tan(\theta+\theta_s)$. $M \propto W, r, l$

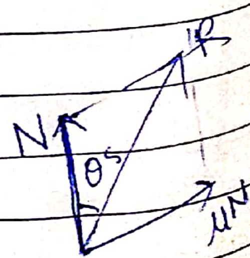
$\tan\theta = l/2\pi r \quad ; \quad \tan\theta_s = \mu$.

* SELFLOCKING. Condⁿ

No Axial force $\Rightarrow M = 0$.



$\boxed{\theta = \theta_s}$



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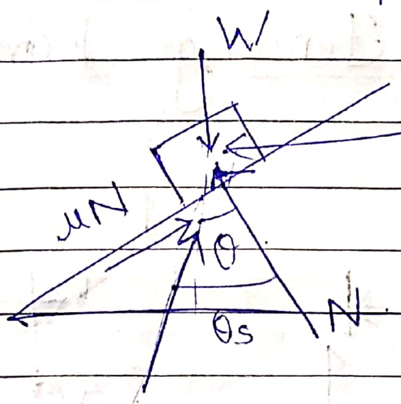
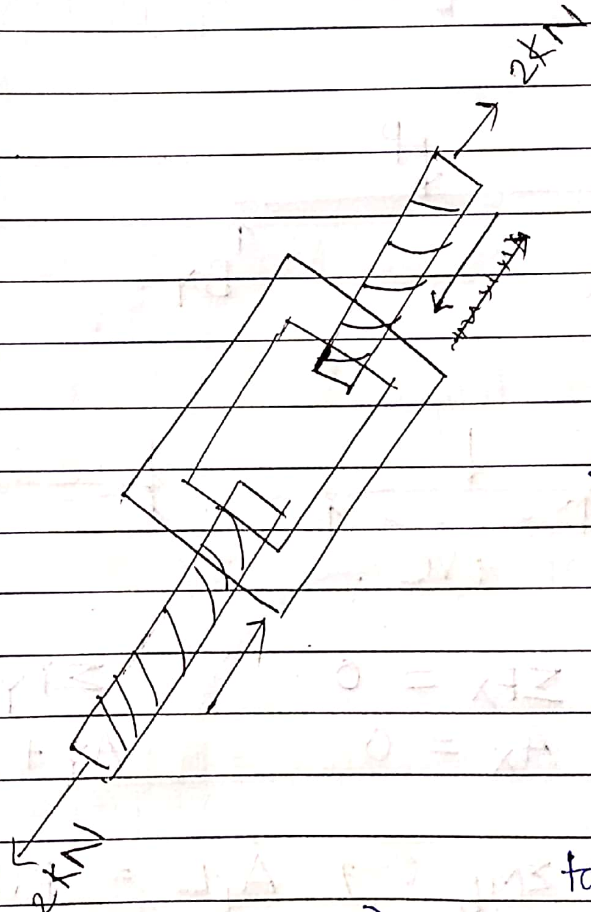
Minimum torque to bring down

☆



$M_1 = Wr\tan(\theta_s - \theta)$

☆ TURNBUCKLE



$r = 5mm$

$l = 2mm$

$\mu = 0.25$

$M = ?$

$\tan\theta = \frac{l}{2\pi r}$

$= \frac{2mm}{2\pi(5)mm}$

$= \frac{1}{5\pi}$

$\tan\theta_s = \mu$

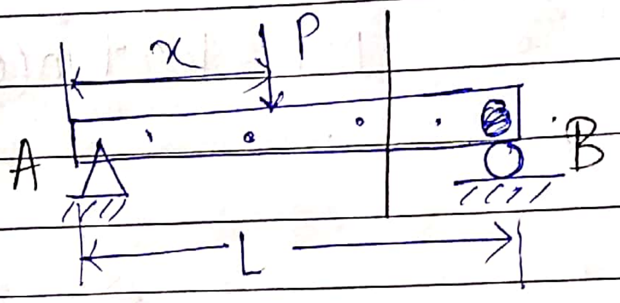
$= \frac{1}{4}$

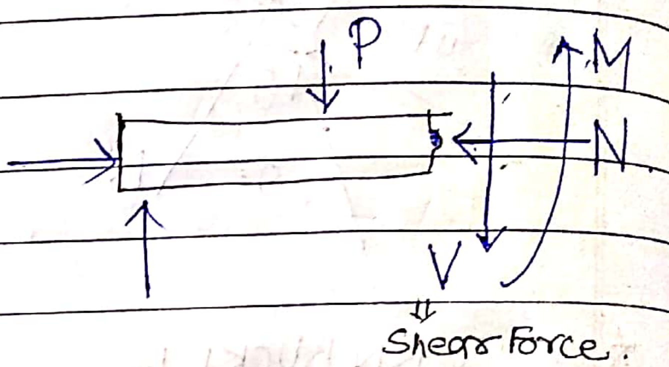
$\Rightarrow \quad M = 2Wr\tan(\theta + \theta_s)$

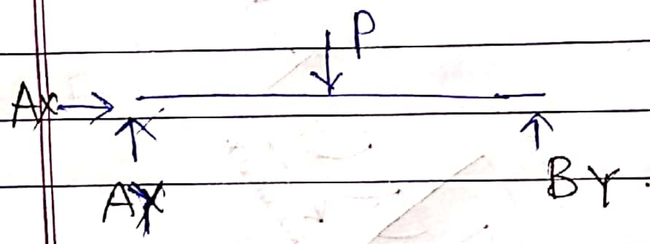
$= 2 \times (2KN)(5mm) \frac{1/5\pi + 1/4}{1 - \frac{1}{20\pi}}$

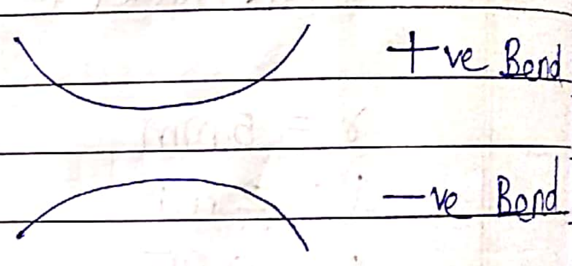
$= 20 \times \left(\frac{4 + 5\pi}{20\pi - 1}\right)$

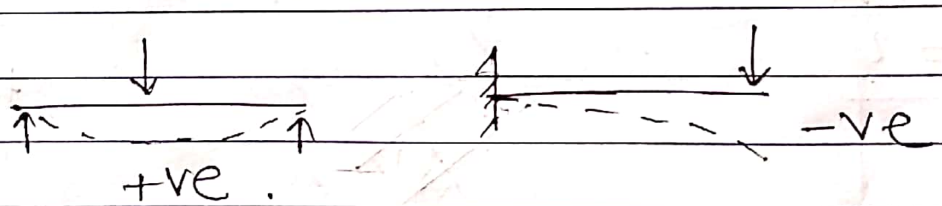
★ Shearing Force and Bending Moment :-











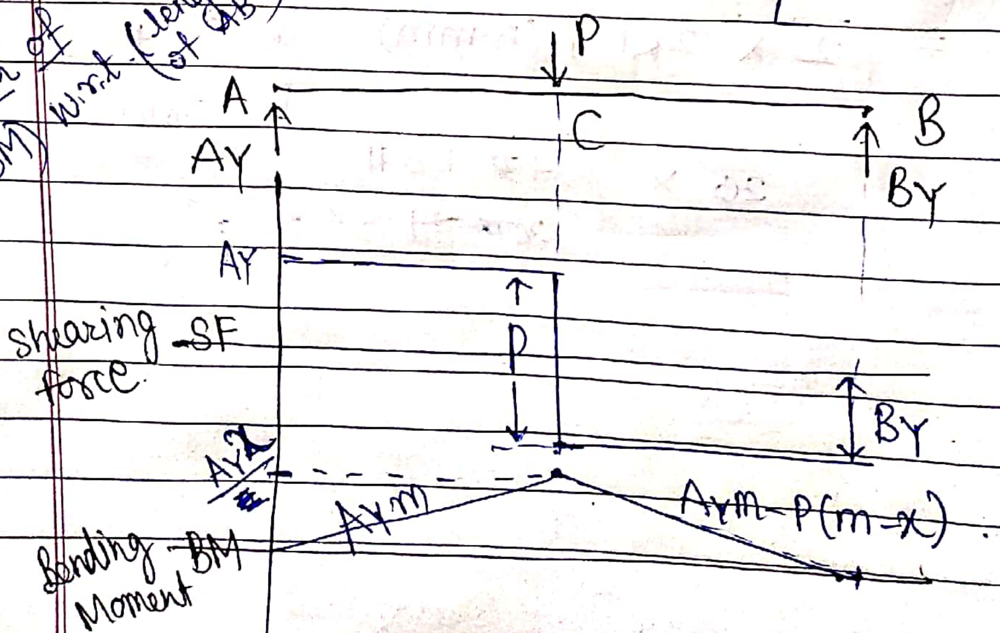
$\Sigma F_x = 0.$ $\qquad$ $\Sigma F_y = 0.$

$A_x = 0$ $\qquad$ $A_y + B_y = P.$

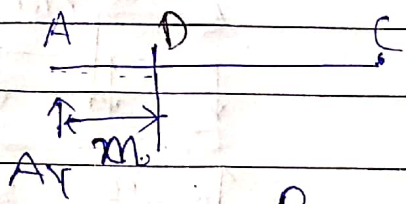
$$\Sigma M_B = 0 \circlearrowleft \quad A_y L = P(L-x)$$

$$A_y = \frac{P(L-x)}{L}$$

★ Graph of variation of (SF or BM) w.r.t. (length of AB)

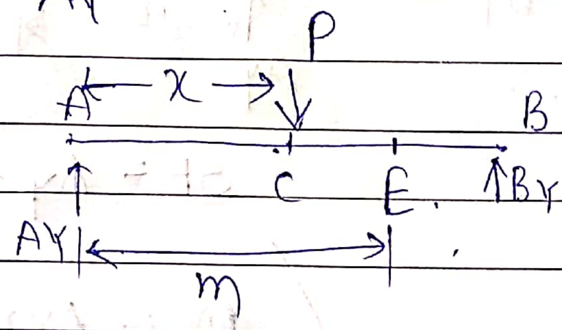


AC



$\Sigma M_D = A_Y m$.

CB



ΣM_E

$= A_Y m - P(m - x)$.

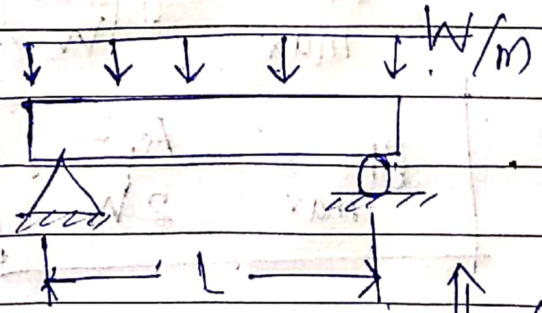
☆ Bending Moment at the end is equal to zero.

☆ Shearing Force at the end is equal to normal reaction at that point

(if no other moments and forces are acting at that point).

☆ When $SF = 0$; $BM = max$.

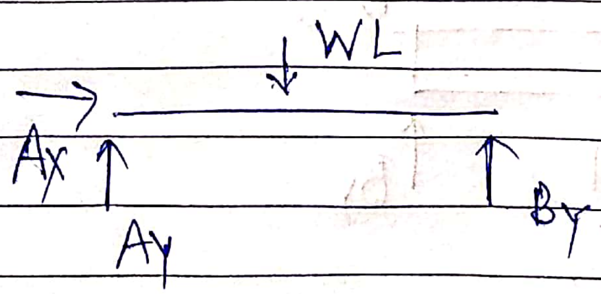
☆ Distributed load.



Total Load

$= W.L$.

⇕ can be considered and solved like the previous one



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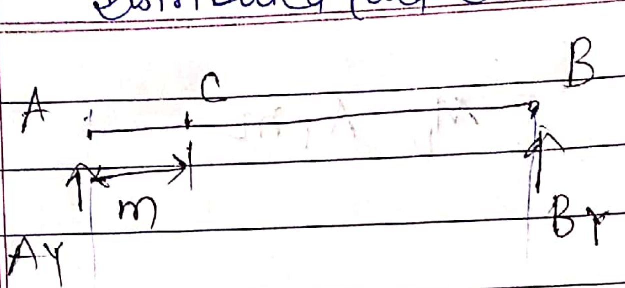
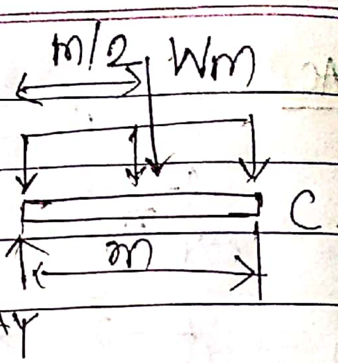
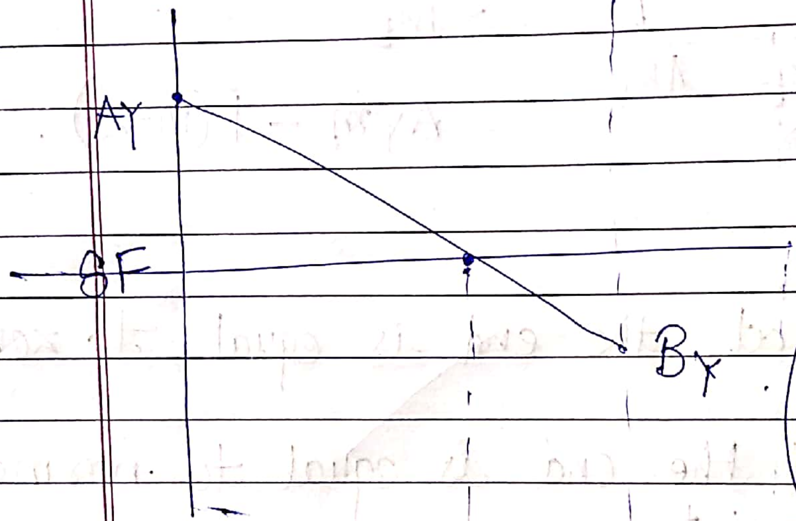
Distributed load calculations







$$SF = A_y - Wm$$

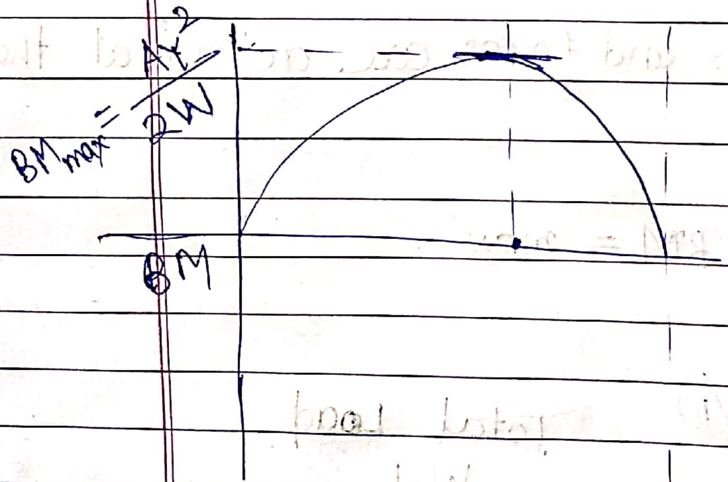
$$BM = A_y m - (Wm)\frac{m}{2}$$

$$BM = A_y m - \frac{Wm^2}{2}$$

$SF = 0$ for max BM

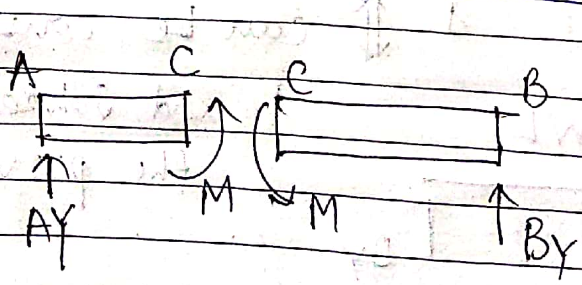
$$0 = A_y - Wm$$

$$\Rightarrow \quad m = \frac{A_y}{W}$$



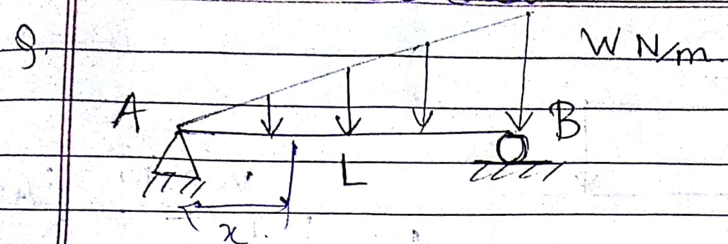
$$BM_{max} = A_y\left(\frac{A_y}{W}\right) - W\left(\frac{A_y^2}{W^2}\right)\frac{1}{2}$$

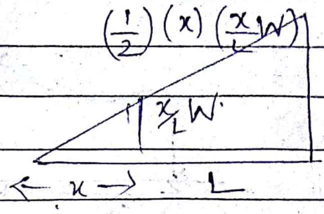
$$\boxed{BM_{max} = \frac{A_y^2}{2W}}$$



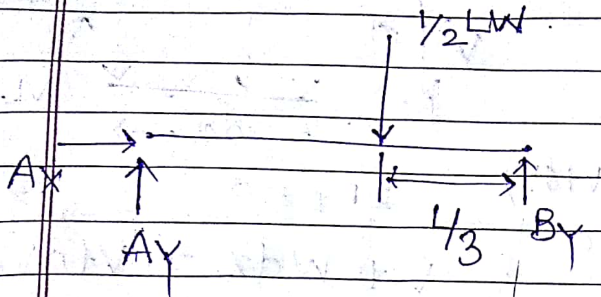
★ ~~Non~~ Uniformly Varying Distributed load

Q.

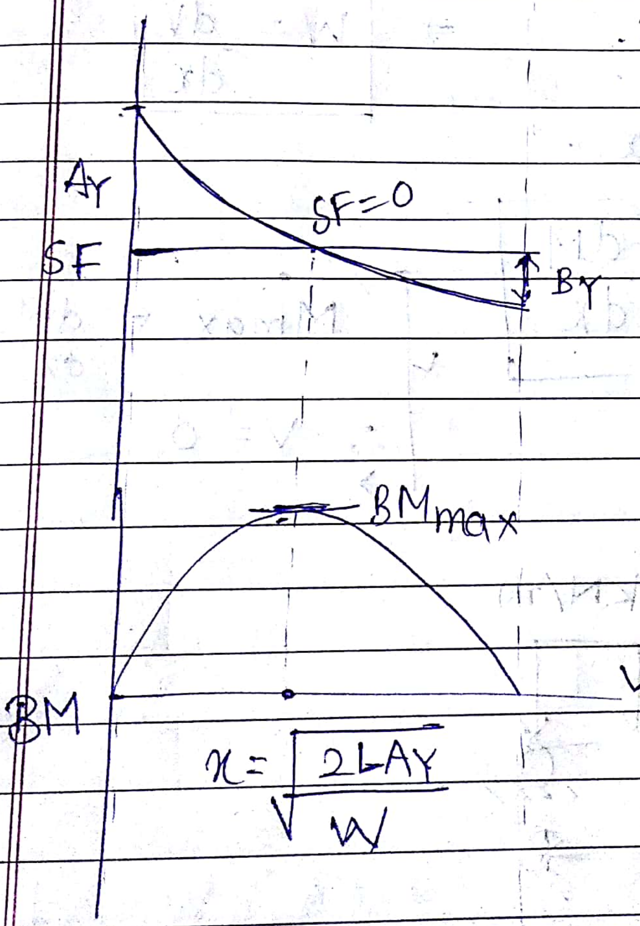




$= \frac{1}{2}LW$.



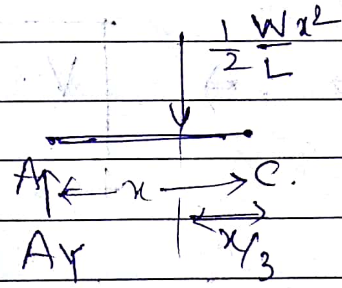
~~Area of distributed load will be total amount of load.~~



$$x = \sqrt{\frac{2LA_Y}{W}}$$

$\therefore$ load at x from A

$$= \frac{1}{2}\frac{W}{L}x^2.$$



(Consider a part of length x.)

$$\Sigma M_C = A_Y x - \left(\frac{1}{2}\frac{W}{L}x^2\right)\left(\frac{x}{3}\right).$$

$$\boxed{BM_x = A_Y x - \frac{1}{6}\frac{W}{L}x^3}$$

$$\boxed{SF_{at\ x} = A_Y - \frac{Wx^2}{2L}}$$

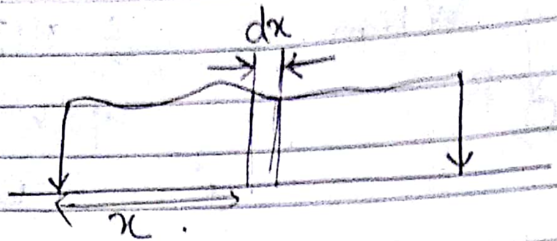
for max BM;

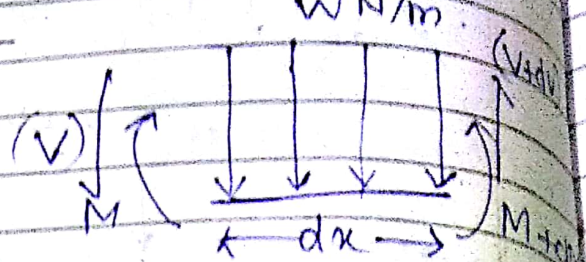
$$0 = A_Y - \frac{Wx^2}{2L}$$

$$\Rightarrow x^2 = \frac{2LA_Y}{W}$$

$$\Rightarrow \boxed{x = \sqrt{2LA_Y/W}}$$

Q.





Ans

$\Sigma M = 0$

$\Rightarrow -M + (M+dM) + dx(V+dV) + W dx \cdot \frac{dx}{2} = 0$

$\left(\frac{dV}{dx}\right)$

$\Rightarrow dM + dxV + \underline{dx\,dV} = 0$

$+ \frac{dV\,dx}{2} \approx 0 \qquad \approx 0$

$\Rightarrow dM = -V dx$

$\Rightarrow \boxed{V = -\frac{dM}{dx}}$

$\Sigma F_Y = 0$

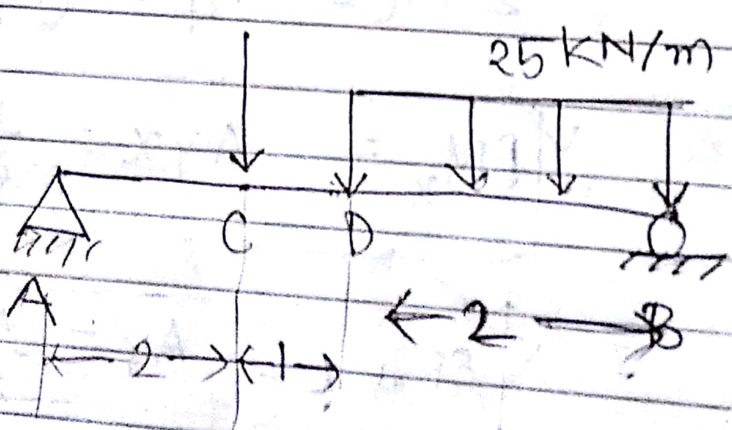
$V + W dx - (V+dV) = 0$

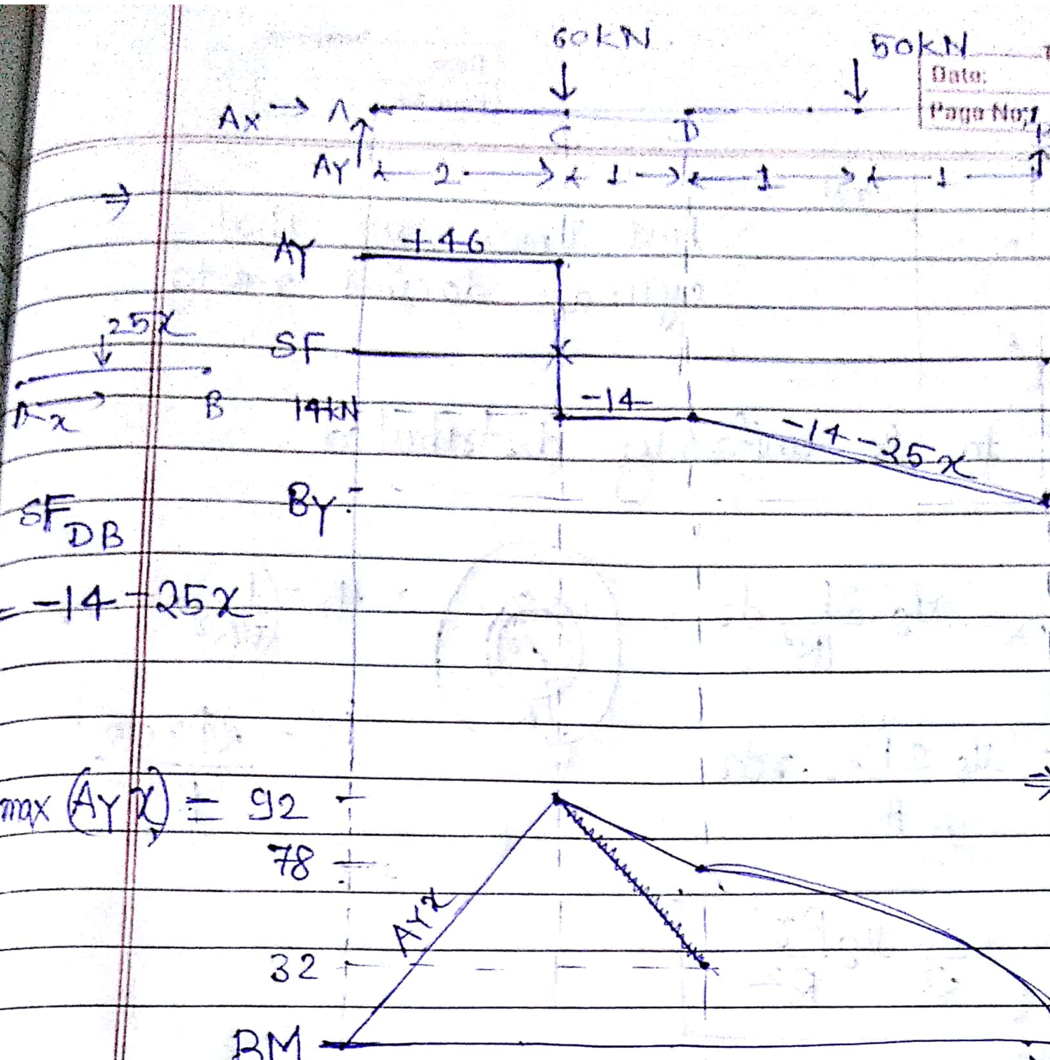
$\Rightarrow \boxed{W = \frac{dV}{dx}}$

$M_{max} \Leftrightarrow \frac{dM}{dx} = 0$

$\therefore V = 0$

Q.





$\Sigma F_x = 0$

$A_x = 0$

$\Sigma F_Y = 0$

$A_Y + B_Y = 110$

$\Sigma M_A = 0$

$(60)(2) + 4(50)$

$= B_Y(5)$

$\Rightarrow B_Y = \frac{320}{5}$

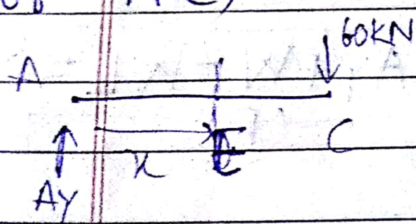
$\Rightarrow B_Y = 64$ kN

$A_Y = 110 - 64$

$\Rightarrow A_Y = 46$ kN

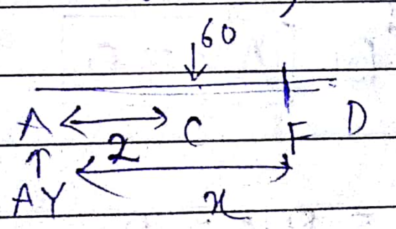
BM calculations.

For AC,



$M_E = A_Y x$.

For CD,

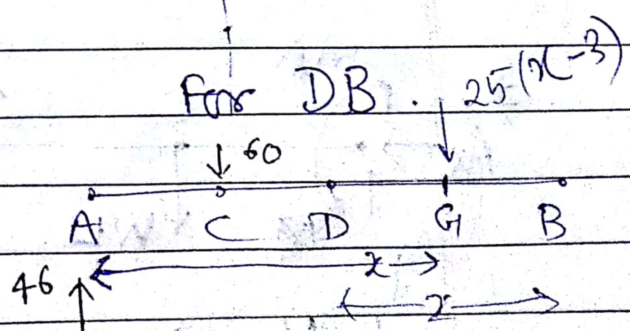


$M_F = \underline{A_Y x - 60(x-2)}$

$= 120 - 14x$

$= 78$

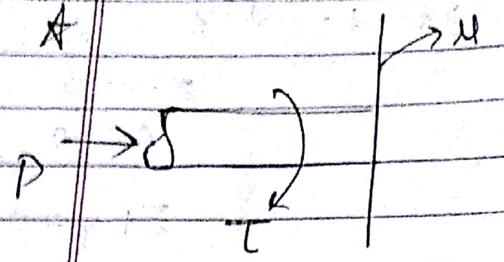
For DB.



$M_G = \cancel{A_Y x - 60(x-2)}$

$\cancel{= B_Y(5-x)}$.

$-25(x-3)\left(\frac{x-3}{2}\right)$



Find τ_{max} such that cylinder doesnot rotate

Soln :- P to be uniformly distributed.

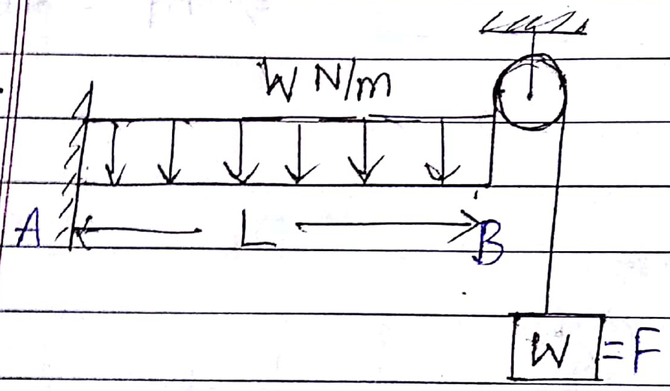
$$d\tau_{max} = \mu_s \frac{2Pr}{R^2} dr$$

$$\rightarrow dN = \left(\frac{P}{\pi R^2}\right) 2\pi r dr$$

$$= \frac{2Pr dr}{R^2}$$

$$d\tau = \mu_s \frac{2Pr}{R^2} \cdot r dr$$

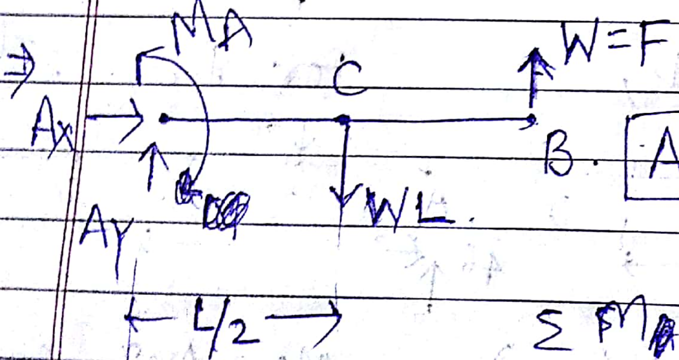
$$\boxed{\tau_{max} = \frac{2}{3} \mu_s \frac{Pr^3}{R^2}}.$$

Q. 

Find SF, BM.

1) M_{max} = ?

2) W is Removed



$\Sigma F_x = 0$ $\quad$ $\Sigma F_Y = 0$

$\boxed{A_x = 0}$ $\quad$ $\boxed{A_Y + \underset{(F)}{W} - WL = 0}$

$$\Sigma M_A = 0$$

$$\Rightarrow +M_A - WL\left(\frac{L}{2}\right) + L\underset{(F)}{(W)} = 0$$

$$\Rightarrow \boxed{M_A = -\underset{(F)}{WL} + \frac{WL^2}{2}} = \frac{WL^2}{2} - FL$$

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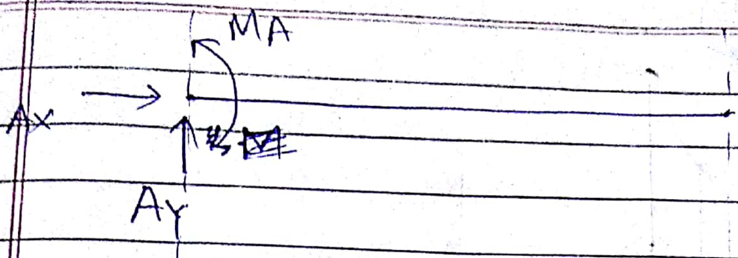

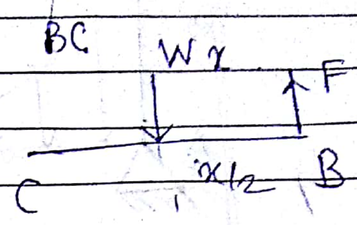

BC

$$M_C = F.x - Wx.\frac{x}{2}$$

$$(BM) = Fx - \frac{Wx^2}{2}$$

$$(BM)_A = FL - \frac{WL^2}{2}$$

$$\frac{d(BM)}{dx} = 0$$

$$F - Wx = 0$$

$$\boxed{x = F/W}$$

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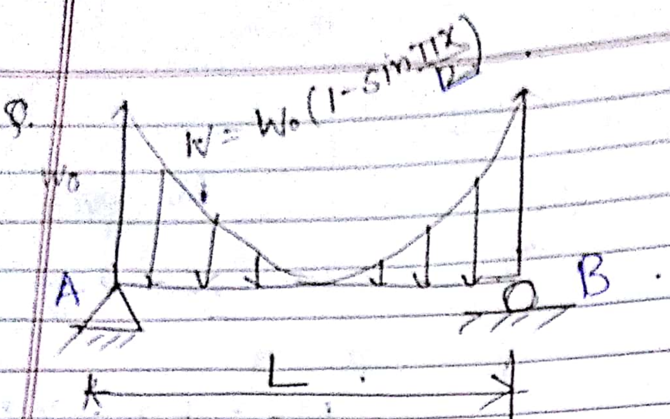
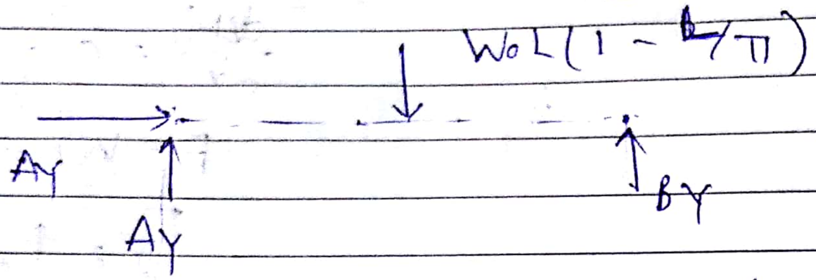
Q.



$$F = \int_0^L w\,dx = \int_0^L W_0\left(1-\sin\frac{\pi x}{L}\right).dx$$

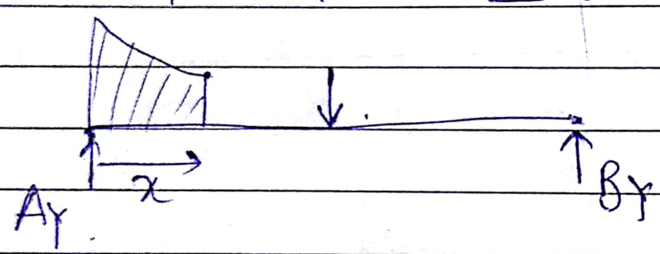
$$= W_0\left(x + \frac{\cos\frac{\pi x}{L}}{\pi/L}\right)_0^L = W_0 L\left(1-\frac{2}{\pi}\right)$$



$A_x = 0$

$A_Y + B_Y = W_0 L\left(1-\frac{2}{\pi}\right)$

$$\Rightarrow A_Y = B_Y = \frac{W_0 L}{2}\left(1-\frac{2}{\pi}\right).$$



$$V = SF = A_Y - \int w\,dx$$

$$= \frac{W_0 L}{2}\left(1-\frac{2}{\pi}\right) - W_0\left(x + \frac{\cos\frac{\pi x}{L}}{\pi/L} - \frac{L}{\pi}\right)$$

$$V = SF = W_0\left(\frac{L}{2} - x - \cancel{\frac{L}{\pi}} - \frac{L}{\pi}\cos\frac{\pi x}{L} + \cancel{\frac{L}{\pi}}\right)$$

$$V = SF = W_0\left(\frac{L}{2} - x - \frac{L}{\pi}\cos\frac{\pi x}{L}\right)$$

$$\Rightarrow \quad M = \int V\,dx$$

$$\Rightarrow \quad M = \int W_0 \left(\frac{L}{2} - x - \frac{L}{\pi} - \frac{2}{\pi}\cos\frac{\pi x}{2} + \frac{2}{\pi} \right) dx$$

$$= \frac{1}{2} W_0 \left(Lx - x^2 - \frac{2Lx}{\pi} - \right.$$

$$\frac{dM}{dx} = V \quad \Rightarrow \quad dM = V\,dx$$

$$\Rightarrow \quad M = \int V\,dx$$

$$= \int W_0 \left(\frac{L}{2} - x - \frac{L}{\pi}\cos\frac{\pi x}{L} \right) dx$$

$$M = W_0 \left(\frac{Lx}{2} - \frac{x^2}{2} - \frac{L^2}{\pi^2}\sin\frac{\pi x}{L} \right)$$

For M_{max} ; $\frac{dM}{dx} = 0$; $V = 0$

$$\Rightarrow \quad W_0 \left(\frac{L}{2} - x - \frac{L}{2}\cos\frac{\pi x}{L} \right) = 0$$

$\Rightarrow$

$$\Rightarrow \quad \frac{L}{2} = x + \frac{L}{2}\cos\frac{\pi x}{L}$$

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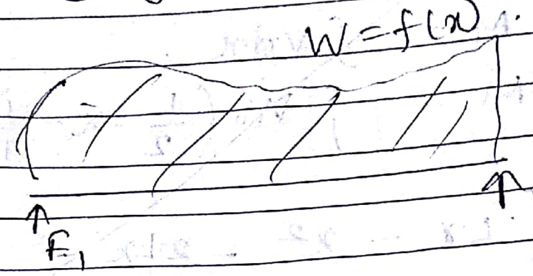
For any general [illegible]



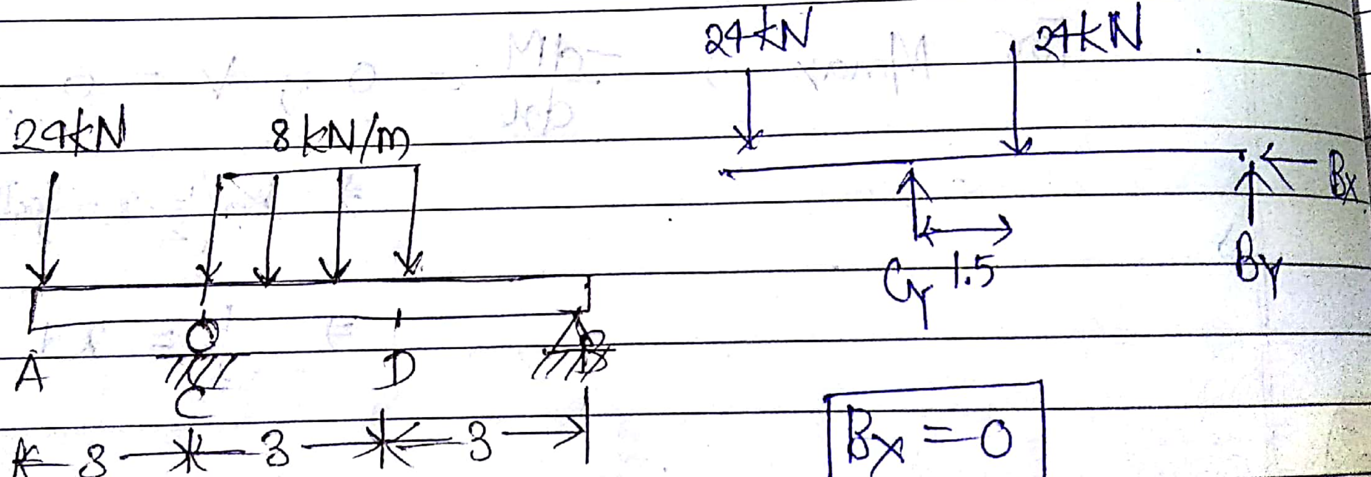
$F_1 = \int W dx$

$V = F_1 - \int W dx \quad ; \quad \frac{dM}{dx} = V$

$\Rightarrow \quad dM = V dx \quad \Rightarrow \quad M = \int V dx$

$M_{max} = \quad \frac{dM}{dx} = 0 \Rightarrow \underset{=0}{V}$ (corresponding SF)

Q



$\boxed{B_x = 0}$

$\Rightarrow \boxed{C_Y + B_Y = 48 \text{ kN}}$

$\Sigma M_B = 0 \Rightarrow \left(\frac{\cancel{24} \times \cancel{9}}{2}\right) + (\cancel{24} \times 9) = C_Y \times 8$

$\Rightarrow \boxed{C_Y = 54 \text{ kN}} \quad \boxed{B_Y = -6 \text{ kN}}$

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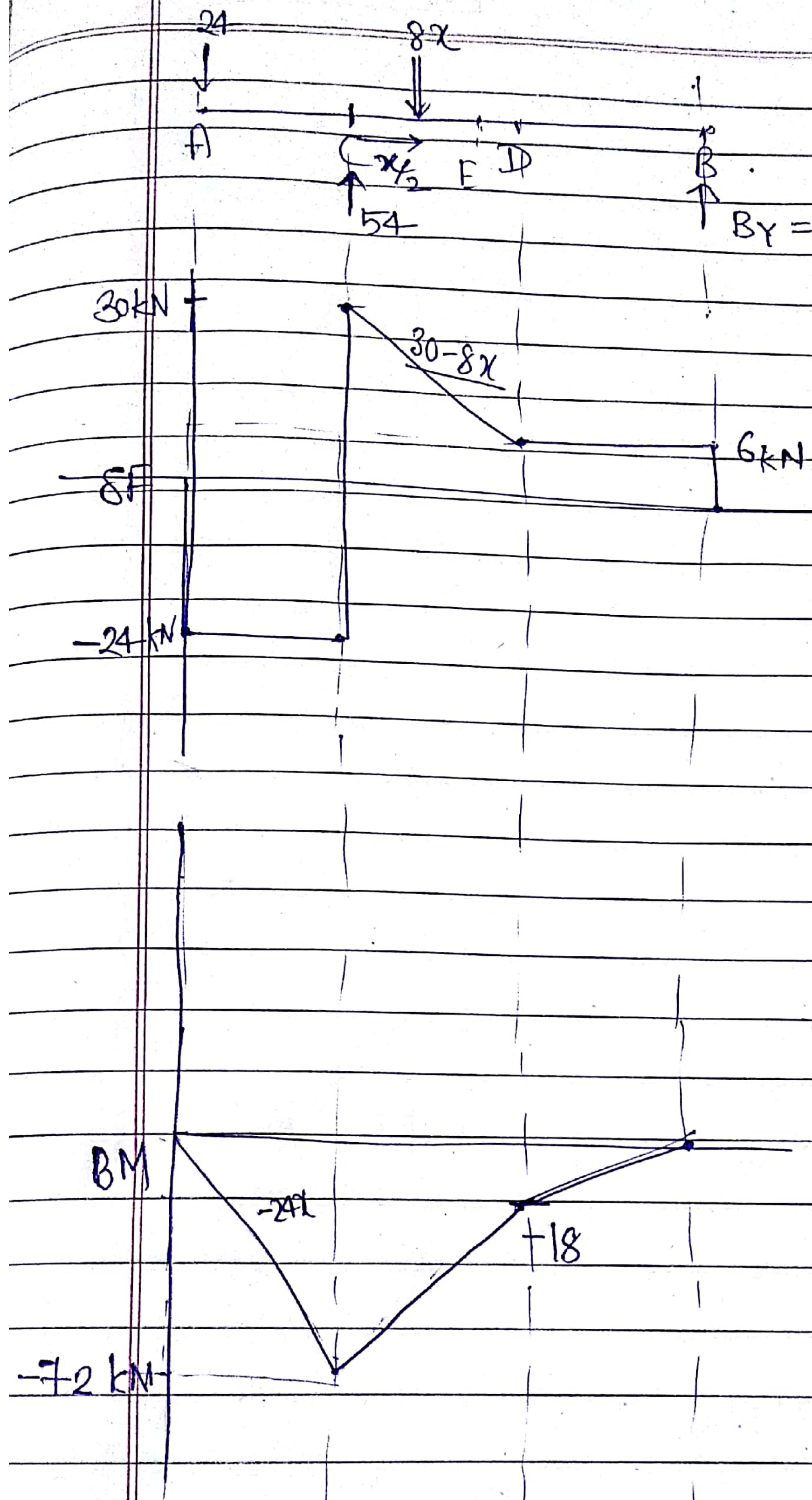
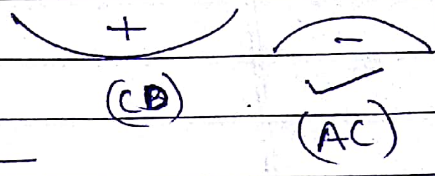
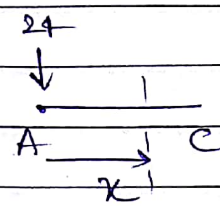


Calculations

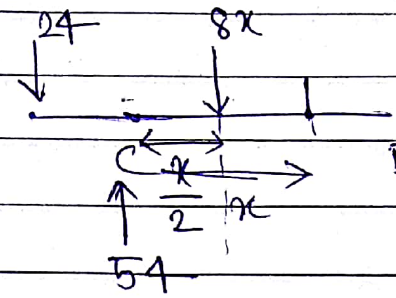
$SF_E = 30 - 8x$

$SF_D \; (x = 3) = 30 - 8 \times 3 = 6\,kN$





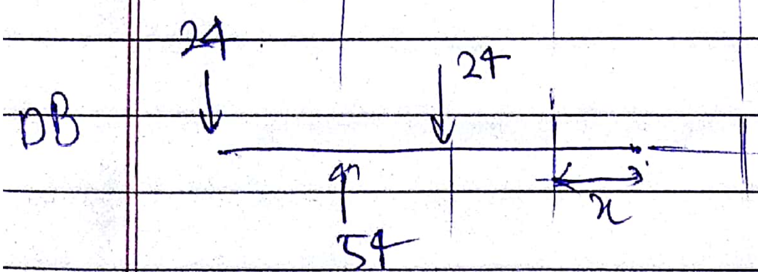
$BM_{AC} = -24x$



$$BM_{CD} = -24(x+3) + 54(x) - 8x\left(\frac{x}{2}\right)$$

$$BM_D = -24(6) + 54(3) - 8(3)\left(\frac{3}{2}\right) = -18$$

DB



$$BM_{DB} = -24(x+6) + 54(x+3) - 24\left(x + \frac{3}{2}\right)$$

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