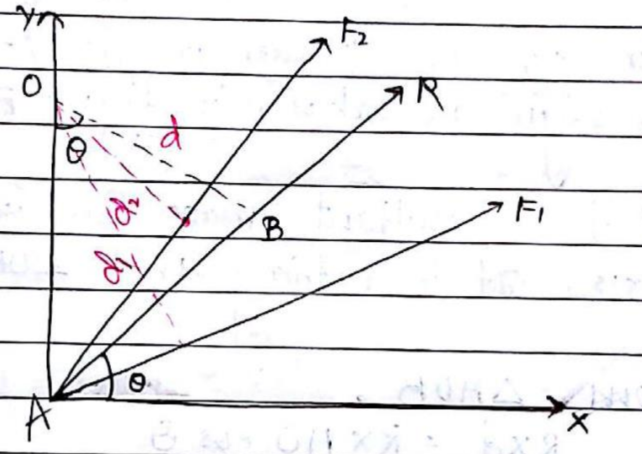
MODULE 3

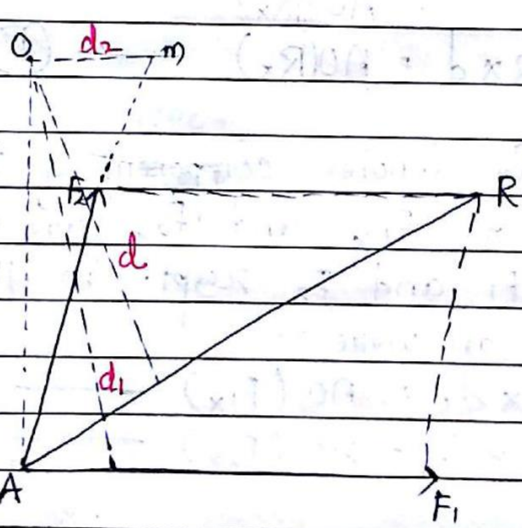
22/4

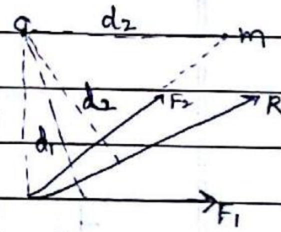
ANALYSIS OF NON-CONCURRENT FORCE SYSTEM

Imp • State and prove Varignon's theorem of moment :-

Statement : It states that the algebraic sum of moments of a system co-planar forces about a moment centre is equal to the moment of their resultant forces about the same moment centre.







Correct Diagram

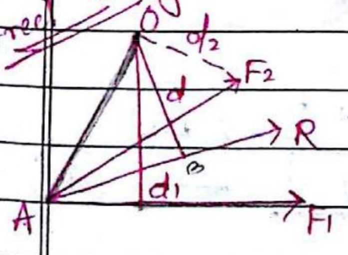


figure (a)

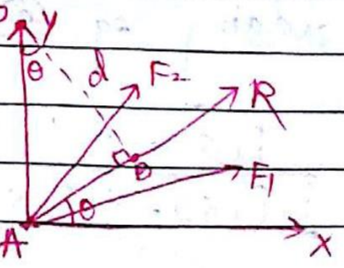


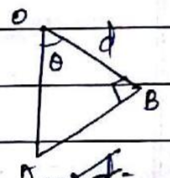
figure (b)

Refering to fig (a), Let R be the resultant of 2 forces F_1 and F_2 and O be the moment centre. Let D, D_1 and D_2 are the moment arms of the force R, F_1 and F_2 respt. Then according to the theorem, we have to prove

$$\boxed{R \times d = F_1 \times d_1 + F_2 \times d_2}$$

Join OA and Consider it as Y-axis being A as origin as shown in figure B.

Let the resultant make an angle θ wrt x-axis. It is nothing that $\angle AOB = \theta$.



~~cos d~~ =

$\cos\theta = \frac{d}{OA}$

From ΔAOB,

$$R \times d = R \times AO \cos\theta$$
$$= R \times \cos\theta \times AO.$$
$$= AO \times (R_x)$$
$$R \times d = AO(R_x) \quad \text{—— (1)}$$

If R_x denotes component of R in x-direction. Similarly if F_{1x} and F_{2x} are the component of F_1 and F_2 respt. in the x-direction then we can write :-

$$F_1 \times d_1 = AO(F_{1x}) \quad \text{—— (2)}$$
$$F_2 \times d_2 = AO(F_{2x}) \quad \text{—— (3)}$$

Adding eq (2) and (3) :-

$$F_1 \times d_1 + F_2 \times d_2 = (F_{1x} + F_{2x})\, AO$$
$$\boxed{F_1 \times d_1 + F_2 \times d_2 = R_x AO} \quad \text{—— (4)}$$

Since $F_{1x} + F_{2x} = R_x$

Comparing eq (1) and (4) :-

$$\boxed{R \times d = F_1 \times d_1 + F_2 \times d_2}$$

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(1) Locate the moment centre. (Given in ques.)

(2) Find the moment of all the forces about the moment centre.

$$\Sigma H \neq 0$$
$$\Sigma V \neq 0$$

$$R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2} \quad , \theta = \tan^{-1}\left(\frac{\Sigma V}{\Sigma H}\right)$$

From Varignon's Theorem * $\boxed{d = \frac{|m_c|}{R}}$

(3) Find the distance of the point

$$d = \frac{|m_c|}{R}$$

(4) x-intercept $= \frac{|m_c|}{\Sigma V}$

(5) Y-intercept $= \frac{|m_c|}{\Sigma H}$

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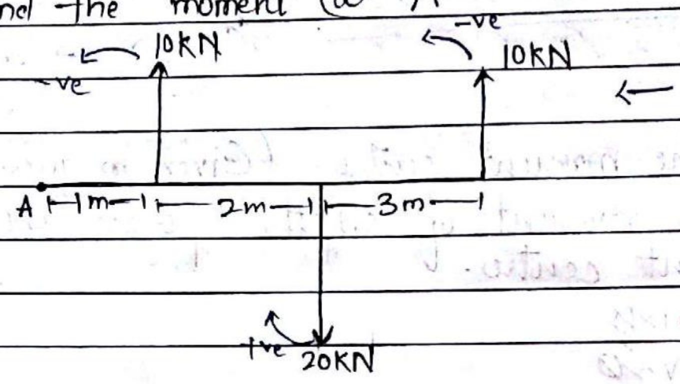
Q.1- Find the moment @ A

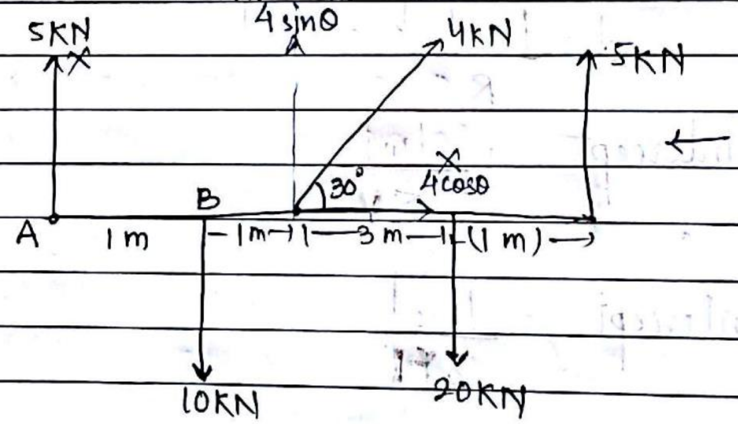
Ans-



$M_A = (-10)\times 6 + (20)(3) - (10)(1)$

$= \cancel{-60} + \cancel{60} - 10 = -10$ KNm

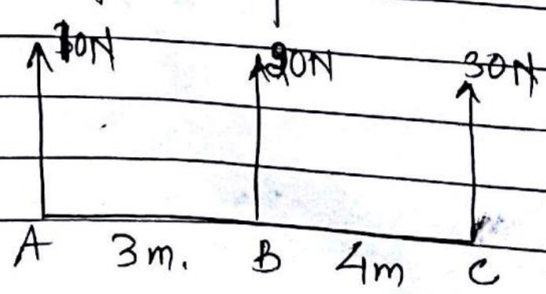
Q.2- Find the moment at A :-



Ans- $M_A = (-5)(6) + (20)(5) - (4\sin 30)(2) + (10)(1)$

$M_A = 76$ KN-m

Q.3- 3 like parallel forces 10, 20 and 30 N are acting on line ABC respectively. Find the magnitude, direction and distance of resultant from the point A. AB = 3m BC = 4m.



Ans- $\Sigma H = 0$

$\Sigma V = 10 + 20 + 30 = 60.$

$R = \sqrt{\Sigma H^2 + \Sigma V^2} = \sqrt{(60)^2} = 60N$ //

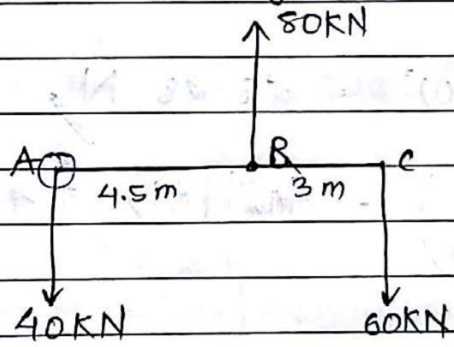
$d = \frac{|m_A|}{R}$

$\Sigma m_A = -(30 \times 7) - (20 \times 3)$
$= -210 - 60 = -270.$

$\therefore d = \frac{|-270|}{60} = \frac{27\cancel{0}}{6\cancel{0}} = 4.5\ m$ //

Q.4- A coplanar parallel force system consists of 3 forces acting on a rigid bar as shown in fig. Determine the single force (resultant) and its location from the point A.

Ans-



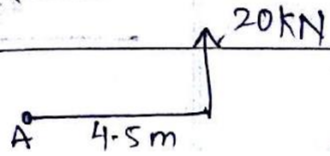
$\Sigma H = 0$

$\Sigma V = 80 - 40 - 60 = 80 - 100 = -20\ KN$

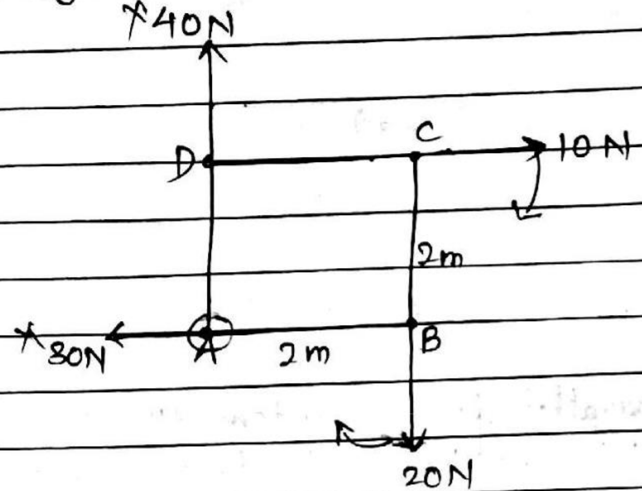
$R = \sqrt{0^2 + (-20)^2} = 20KN$ //

$M_A = (60 \times \overset{7.5}{\cancel{48}}) - (80)(4.5) + 0$
$= 90\ Nm$ //

$\therefore d = \frac{|M_A|}{R} = \frac{9\cancel{0}}{2\cancel{0}} = 4.5\ m.$



Q.5- IMP 4 forces are simultaneously acting of magnitude 10 N, 20N, 30N & 40 N along the 4 sides of the square of size (2×2) as shown in fig. Determine the magnitude and direction and its distance from A.



$\Sigma H = 10 - 30 = -20\ N.$

$\Sigma V = 40 - 20 = 20\ N.$

$R = \sqrt{(-20)^2 + (20)^2} = 28.28\ N$

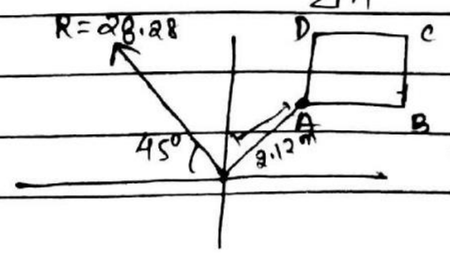
$\theta = \tan^{-1}\left(\frac{20}{-20}\right) = \tan^{-1}(+1) = 45°$

$m_A = 10 \times 2 + 20 \times 2 = 20 + 40 = 60\ Nm$

$d = \frac{|m_A|}{R} = \frac{60}{28.28} = 2.1216\ m$

$x\text{-intercept} = \frac{|m_A|}{\Sigma V} = \frac{60}{20} = 3\ m$

$y\text{-intercept} = \frac{|m_A|}{\Sigma H} = \frac{60}{-20} = 3m$



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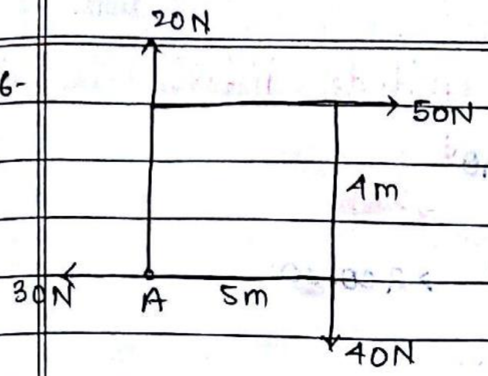
Q.6-



$\Sigma H = 50 - 30 = 20\ N.$

$\Sigma V = 20 - 40 = -20\ N$

$R = \sqrt{(20)^2 + (-20)^2} = 28.28\ N.$

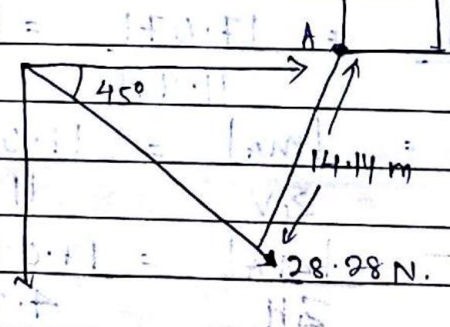
$\theta = \tan^{-1}\left(\frac{20}{20}\right) = 45°$

$m_A = (50 \times 4) + (40) \times 5$
$= 200 + 200 = 400\ Nm$

$d = \frac{|m_A|}{R} = \frac{400}{28.28} = 14.144\ m$

$x\text{-intercept} = \frac{|m_A|}{\Sigma V} = \frac{400}{-20} = 20\ m$

$y\text{-intercept} = \frac{|m_A|}{\Sigma H} = \frac{400}{20} = 20\ m$



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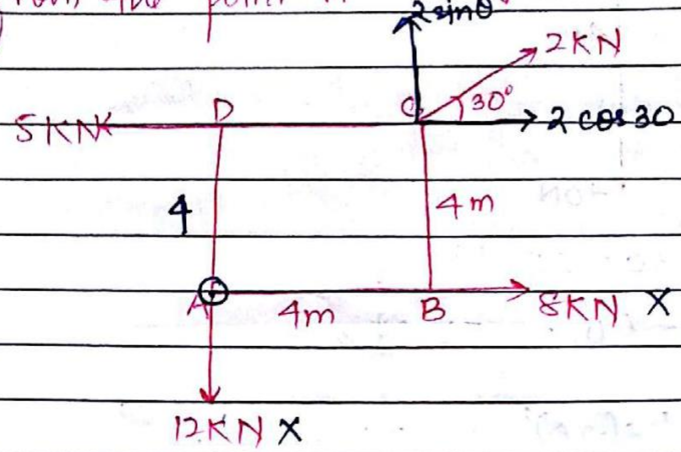
Q.7. Find the resultant magnitude, distance and direction from the point A



Ans-

$M_A = ?$

$\Sigma H = 8 - 5 + 2\cos 30° = 4.732$ kN.

$\Sigma V = -12 + 2\sin 30 = -11$ kN

$R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2} = 11.974$ kN

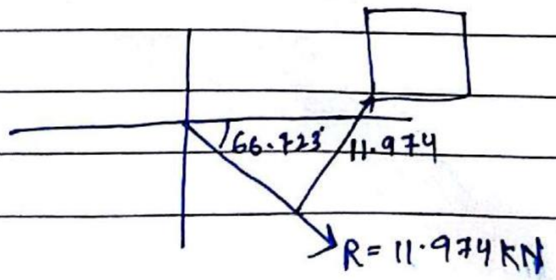
$\theta = \tan^{-1}\left(\frac{\Sigma V}{\Sigma H}\right) = 66.723°$

$M_A = -2\sin 30 \times 4 + 2\cos 30 \times 4 - 5\times 4$
$= -17.071$ Nm

$d = \frac{|m_A|}{R} = \frac{17.071}{11.974} = 1.425$ m

x - intercept $= \frac{|m_A|}{\Sigma V} = \frac{17.071}{11} = 1.551$ m

y - intercept $= \frac{|m_A|}{\Sigma H} = \frac{17.071}{4.732} = 3.607$ m



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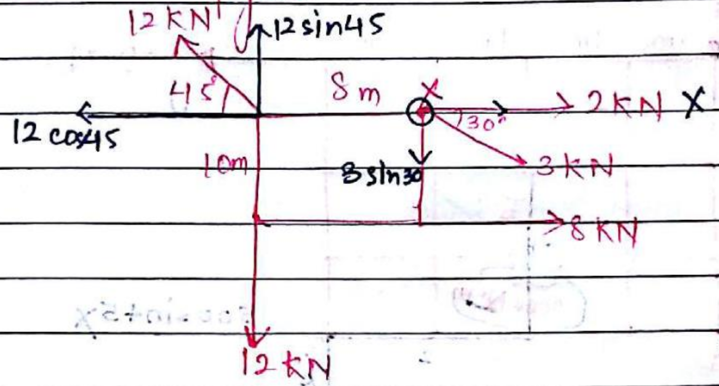
Q.8. Find the resultant magnitude and direction & the distance from x of the force system shown in figure :-

Ans-



$\Sigma H = 2 - 12\cos 45 + 8 + 3\cos 30 = 4.112$ KN

$\Sigma V = 12\sin 45 - 12 - 3\sin 30$
$= -5.014$ KN

$R = \sqrt{\Sigma V^2 + \Sigma H^2} = 6.4832$ KN.

$\theta = \tan^{-1}\left(\frac{\Sigma V}{\Sigma H}\right) = \tan^{-1}\left(\frac{5.014}{4.112}\right) = 50.64°$

$m_A = (12\sin 45 \times 8) - (12 \times 8) - (8 \times 10)$
$= -108.117$ KN-m.

$d = \frac{|m_A|}{R} = \frac{108.117}{6.4832} = 16.67$ m

x-intercept $= \frac{108.117}{5.014} = 21.56$ m

y-intercept $= \frac{108.117}{4.112} = 26.293$ m

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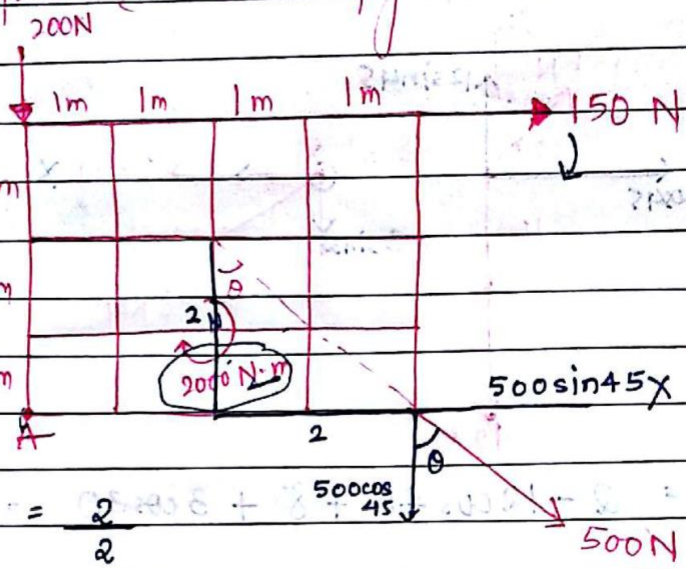
Imp. Find the equilibrium wrt A as origin of system of forces shown in figure :-



Ans- $\tan\theta = \frac{2}{2}$

$\theta = \tan^{-1}(1) = 45°$

$\Sigma H = 150 + 500\sin 45 = 503.55\ N$

$\Sigma V = -200 - 500\cos 45 = -553.55\ N$

$R = \sqrt{\Sigma V^2 + \Sigma H^2} = 748.31\ N$

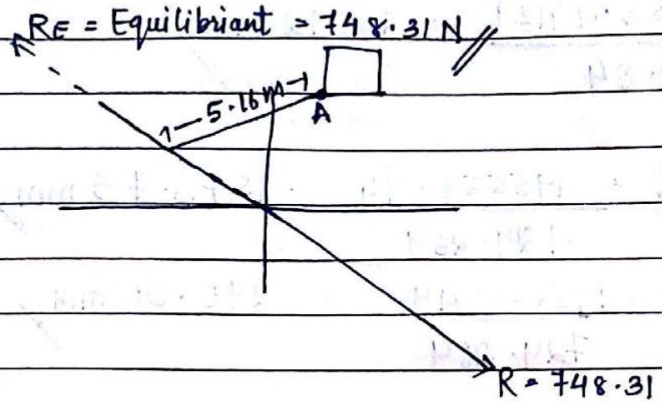
$\theta = \tan^{-1}\left(\frac{553.55}{503.55}\right) = 47.708°$

$M_A = 2000 + 500\cos 45 \times 4 + 150 \times 3$
$= 3864.21\ N\text{-}m$

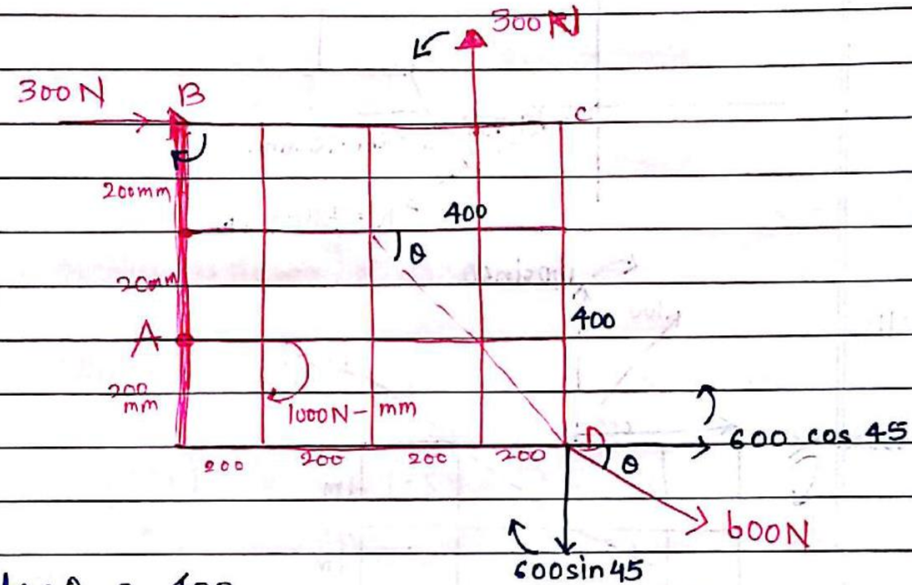
$d = \frac{|3864.21|}{748.31} = 5.16\ m$

$x\text{-intercept} = \frac{3864.21}{553.55} = 6.98\ m$

$y\text{-intercept} = \frac{3864.21}{503.55} = 7.67\ m$



Q.10.



$\tan\theta = \frac{400}{400}$

$\theta = \tan^{-1}(1) = 45^\circ$

$\Sigma H = 300 + 600\cos 45 = 724.264\ N$

$\Sigma V = 300 - 600\sin 45 = -124.264\ N$

$R = \sqrt{(724.264)^2 + (124.264)^2} = 734.84\ N$

$\theta = \tan^{-1}\left(\frac{124.264}{724.264}\right) = 9.735^\circ$

$M_A = (300 \times 400) - 300(600) - (600\cos 45)200 + (600\sin 45)(800)$

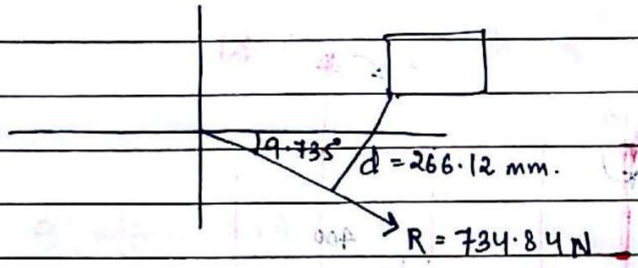
$= 194558.4412\ N\text{-}mm + 1000$

$= 195558.4412\ N\text{-}mm$

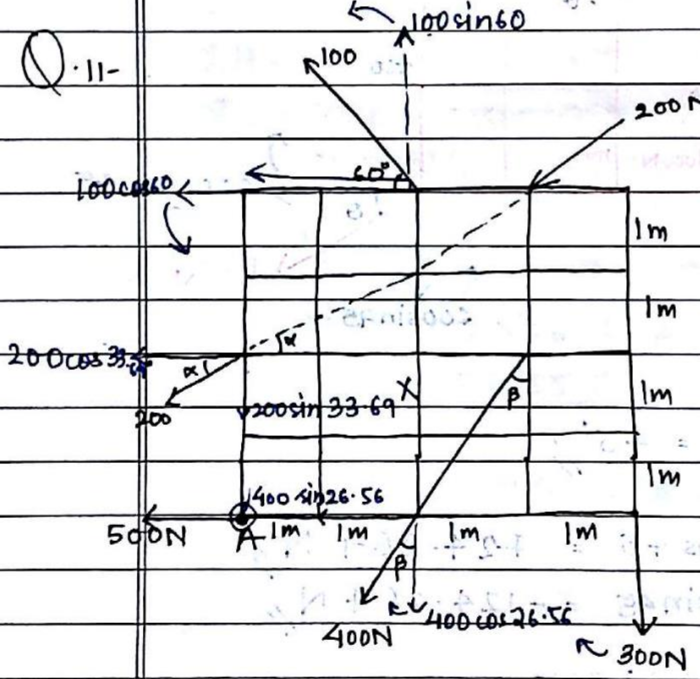
$$d = \frac{|195558.4412|}{734.84} = 266.12\ mm$$

$$x\text{-intercept} = \frac{195558.44}{124.264} = 1573.73\ mm$$

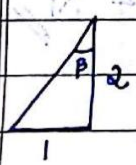
$$y\text{-intercept} = \frac{195558.44}{724.264} = 270.00\ mm$$



Q.11-

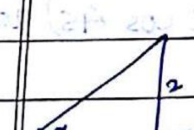


Ans-



$$\tan\beta = \frac{1}{2}$$

$$\beta = \tan^{-1}(1/2) = 26.56°$$



$$\tan\alpha = \frac{2}{3}$$

$$\alpha = \tan^{-1}\left(\frac{2}{3}\right) = 33.69°$$

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$\Sigma H = -500 - 200\cos 33.69 - 100\cos 60 -$
$400\sin 26.56$
$\cancel{-850.76\ N} = -895.26\ N$

$\Sigma V = 100\sin 60 - 200\sin 33.69 - 400\cos 26.56 - 300$
$= -682.12\ N$

$R = \sqrt{\Sigma H^2 + \Sigma V^2} = 1125.5124\ N$

$\theta = \tan^{-1}\left(\frac{\Sigma V}{\Sigma H}\right) = 37.30^\circ$

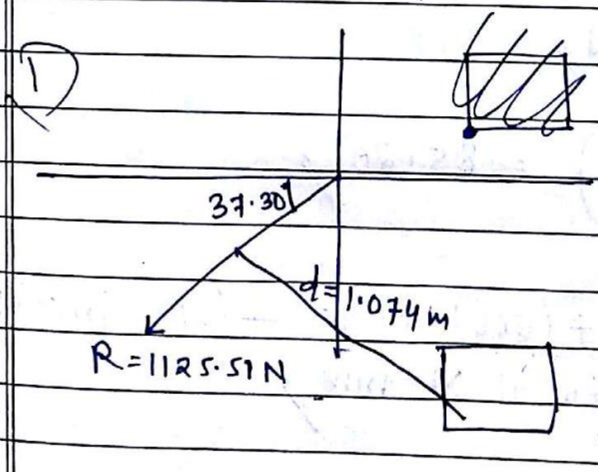
$m_A = (-100\sin 60)2 - (100\cos 60)4 - (200\cos 33.69)2$
$+ (400\cos 26.56)2 + (300)4$

$= 1209.54\ Nm$

$d = \frac{|m_A|}{R} = \frac{1209.54}{1125.5124} = 1.074\ m$

$x\text{-intercept} = \frac{|m_A|}{\Sigma V} = \frac{1209.54}{682.12} = 1.773\ m$

$Y\text{-intercept} = \frac{|m_A|}{\Sigma H} = 1.3510\ m$



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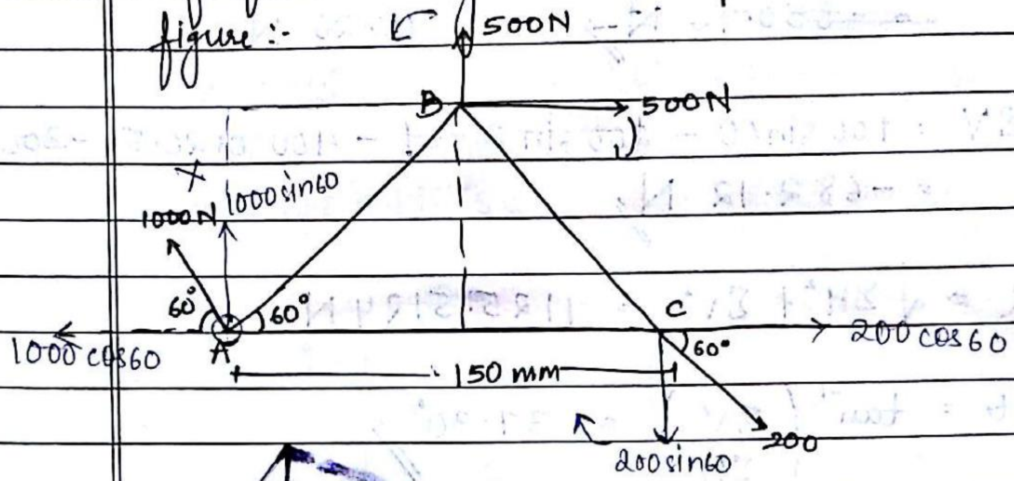
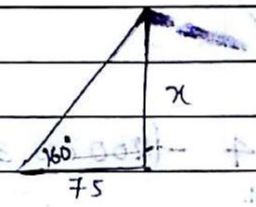
Q- Determine the resultant @ equilibrium for a system of forces acting on an equilateral Δ as shown in figure :-





$$\tan 60^\circ = \frac{x}{75}$$

$$x = 75 \times \sqrt{3} = 129.90 \text{ mm}$$

$$\Sigma H = 500 + 200\cos 60 - 1000\cos 60$$
$$= 100 \text{ N}$$

$$\Sigma V = 500 - 200\sin 60 + 1000\sin 60$$
$$= 1192.82 \text{ N}$$

$$R = \sqrt{\Sigma H^2 + \Sigma V^2}$$

$$= 1197.00 \text{ N}$$

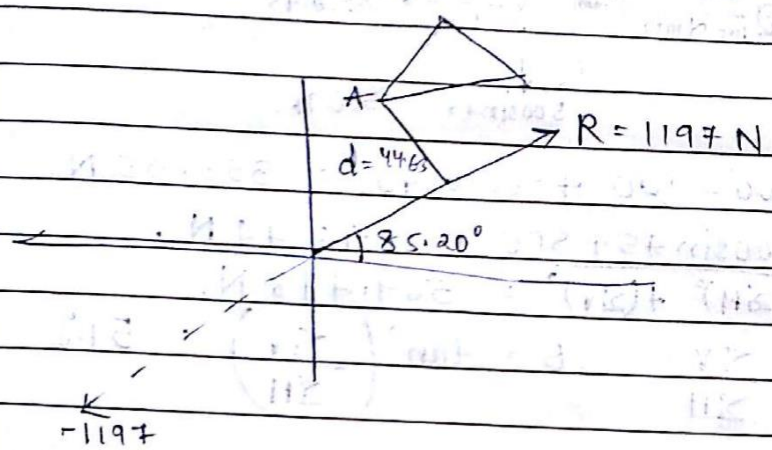
$$\theta = \tan^{-1}\left(\frac{\Sigma V}{\Sigma H}\right) = 85.20^\circ$$

$$M_A = -(500)\,75 + (500)\,129.90 + (200 \sin 60)\,150$$
$$= 53430.76211 \text{ N-mm}$$

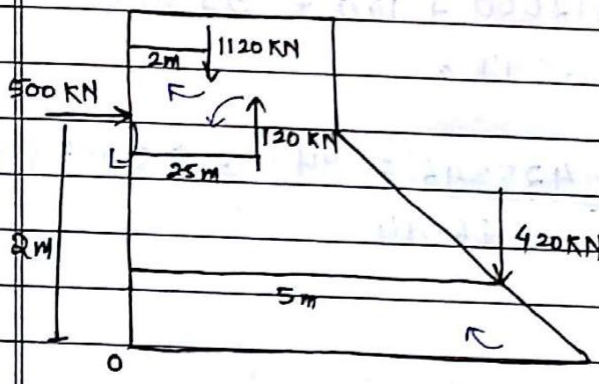
$$d = \frac{53430.76211}{1197.0} = 44.63 \text{ mm}$$

x - intercept $= \frac{|m_A|}{\Sigma V} = \frac{5340.76211}{1192.82} = 44.79$ mm.

y - intercept $= \frac{|m_A|}{\Sigma H} = 534.3076$ mm



Q-

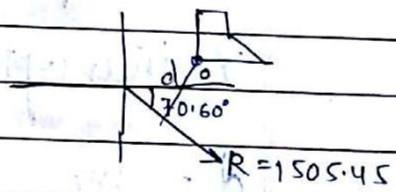


x - intercept $= \frac{|m_A|}{\Sigma V}$

$= 3.54$ m

y - intercept $= \frac{|m_A|}{\Sigma H}$

$= 10.08$ m.



$\Sigma H = 500$ KN

$\Sigma V = -1120 + 120 - 420$

$= -1420$ KN

$R = \sqrt{\Sigma H^2 + \Sigma V^2} = 1505.45$ KN

$\theta = \tan^{-1}\left(\frac{\Sigma V}{\Sigma H}\right) = 70.60°$

$m_A = (1120) \times 2 - (120)\,2.5 + (420) \times 5 + (500)\,2$

$= 5040$ KN - m

$d = \frac{|m_A|}{R} = \frac{5040}{1505.45} = 3.347$ m

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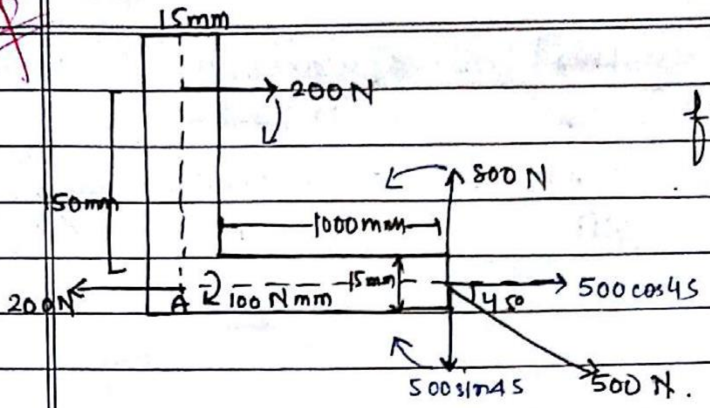


find moment @ 'A'

Ans-

$\Sigma H = \cancel{200} - \cancel{200} + 500\cos 45 = 353.55\ N.$

$\Sigma V = -500\sin 45 + 800 = 446.44\ N.$

$R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2} = 569.478\ N.$

$\tan\theta = \dfrac{\Sigma V}{\Sigma H} \qquad \theta = \tan^{-1}\left(\dfrac{\Sigma V}{\Sigma H}\right) = 51.6^\circ$

$M_A = 200 \times \cancel{150}^{(150+15)} - 800 \times (1000+15) + 100 + (500\sin 45)\,1000$

$= 33000 - 812000 + 100 + 353553.3906.$

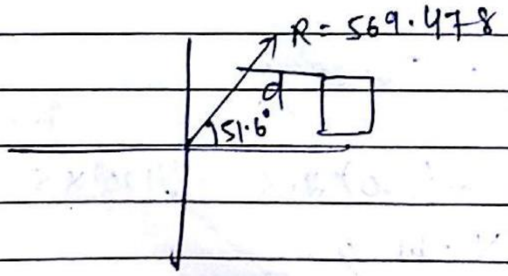
$= -425346.6094$ //

$d = \dfrac{M_A}{\Sigma V} = \dfrac{-425346.6094}{446.44} = 952.75\ mm.$

X - intercept =

Y - intercept $= \dfrac{-425346.6094}{353.55} = +1203.073\ mm$

$d = \dfrac{M_A}{R} = \dfrac{+425346.6094}{569.478} = 746.906\ mm$ //.



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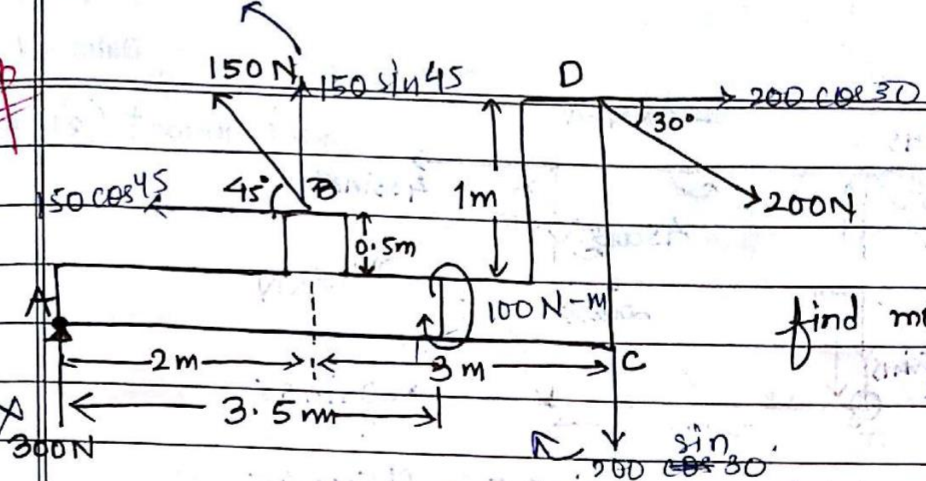


find moment @ A.

Ans–

$\Sigma H = -150\cos 45 + 200\cos 30 = 67.13\ N.$

$\Sigma V = 300 + 150\sin 45 + 200\sin 30 = 306.06\ N$

$R = \sqrt{\Sigma V^2 + \Sigma H^2} = 313.335\ N$

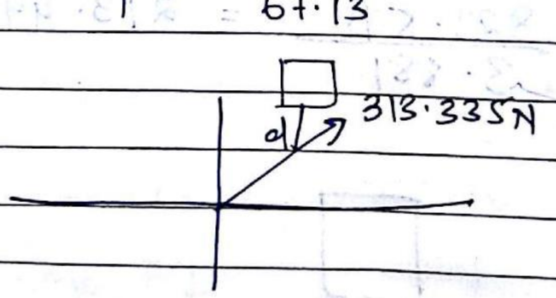
$\theta = \tan^{-1}\left(\frac{\Sigma V}{\Sigma H}\right) = 77.62°$

$M_A = -(150\sin 45)(2) + (200\sin 30)(3+2) - (150)\cos 45 \times 0.5 + 100 + 200\cos 30 \times (1 \cancel{+0.5})$
$= 508.040\ Nm$

$d = \frac{508.04}{313.335} = 1.621\ m$

$x\text{-intercept} = \frac{508.04}{306.06} = 1.660\ m$

$y\text{-intercept} = \frac{508.40}{67.13} = 7.573\ m$



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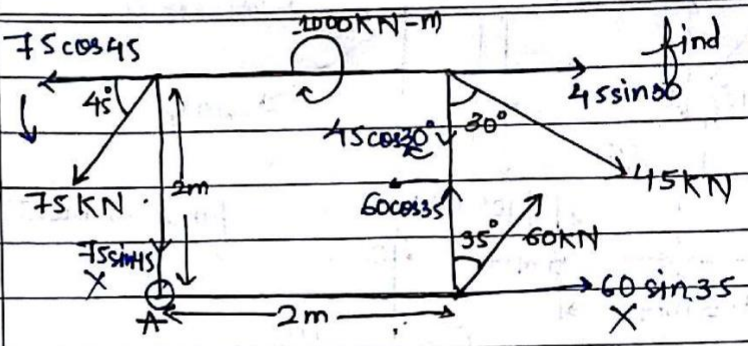
Q - find moment @ 'A'.



Ans -

$\Sigma H = 45\sin 30 + 60\sin 35 - 75\cos 45$

$= 3.881$ KN.

$\Sigma V = -75\sin 45 + 60\cos 35 - 45\cos 30 = -42.855$ KN

$R = \sqrt{\Sigma H^2 + \Sigma V^2} = \sqrt{(42.85)^2 + (3.88)^2} = 43.030$ KN

$\theta = \tan^{-1}\left(\frac{\Sigma V}{\Sigma H}\right) = \tan^{-1}\left(\frac{42.855}{3.881}\right) = 84.82^\circ$

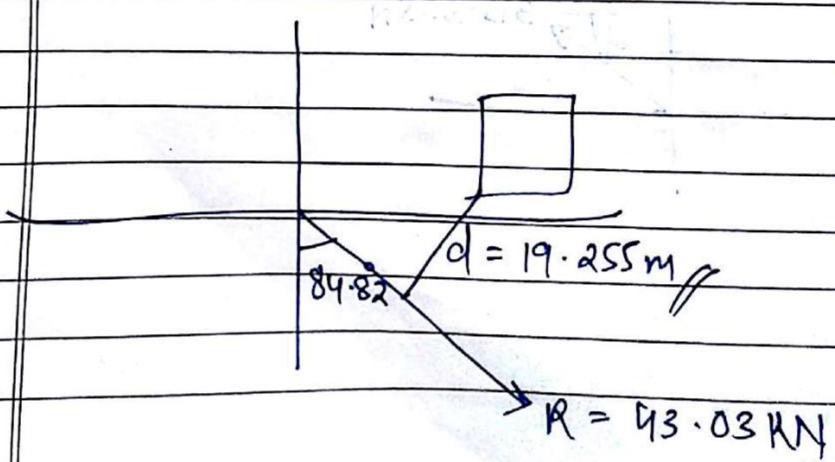
$M_A = -(75\cos 45)2 - (60\cos 35)2 + (45\cos 30)2 - (45\sin 30)2 + 1000$

$\Rightarrow 828.578$ Nm

$d = \frac{828.578}{43.03} = 19.255$ m

x-intercept $= \frac{828.578}{42.855} = 19.3344$ m

y-intercept $= \frac{828.578}{3.881} = 213.496$ m



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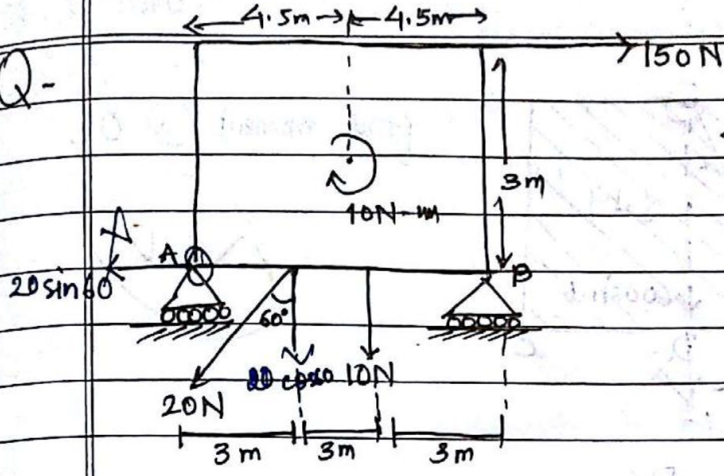
Q- find moment at 'A'.



$\Sigma H = 150 - 20\sin 60 = 132.679$ N

$\Sigma V = -10 - 20\cos 60 = -20$ N

$R = \sqrt{\Sigma V^2 + \Sigma H^2} = 134.1779$ N

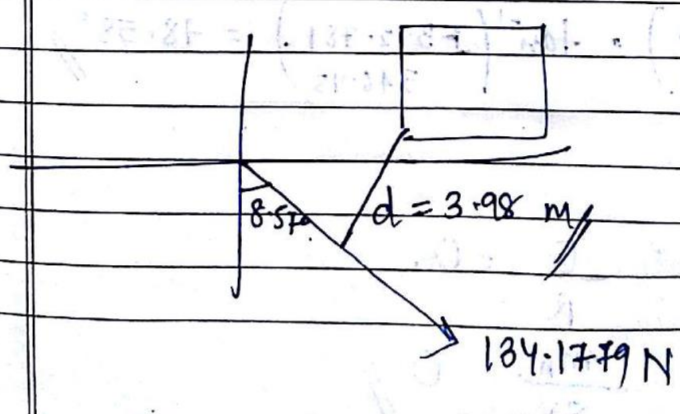
$\theta = \tan^{-1}\left(\frac{20}{132.679}\right) = 8.57°$

$m_A = 150 \times 3 + (10 \times 4.5) + 10 + (20\cos 60)3$
$= 535$ Nm

$d = \frac{535}{134.17} = 3.98$ m

x-intercept $= \frac{535}{20} = 26.75$ m

y-intercept $= \frac{535}{132.679} = 4.032$ m



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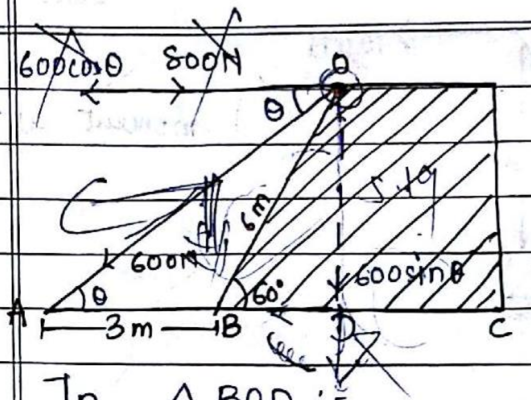
Q- 

find moment @ O.

Ans- In ΔBOD :-

$\sin 60 = \frac{DO}{6}$

$OD = 5.196\ m$

$\cos 60 = \frac{BD}{6}$

$BD = 3\ m$

In ΔADO :-

$\tan\theta = \frac{OD}{AD} = \frac{5.196}{3+3} = \frac{5.196}{6}$

$\theta = 40.892°$

$\Sigma H = 800 - 600\cos(40.892)$
$= 346.43\ N$

$\Sigma V = -600\sin(40.892) = -392.781\ N$

$R = \sqrt{\Sigma H^2 + \Sigma V^2} = 523.727\ N$

$\theta = \tan^{-1}\left(\frac{\Sigma V}{\Sigma H}\right) = \tan^{-1}\left(\frac{-392.781}{346.43}\right) = 48.58°$

$m_O = 0$

$d = \frac{m_A}{R} = \frac{0}{R} = 0.$

$x\text{-intercept} = \frac{m_A}{\Sigma V} = 0$

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Y - intercept $\Rightarrow \dfrac{M_A}{\Sigma H} = 0$

MODULE 3.

Support And Support Reaction

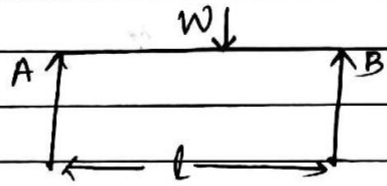
2/5/17

- **Define beam on an horizontal member and what are the different types of beam.**

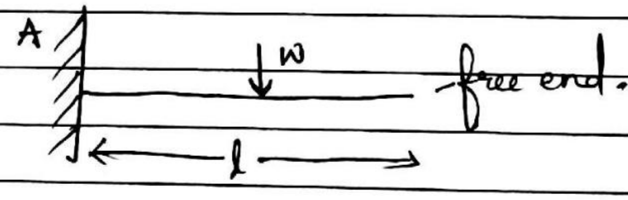
A beam is a structural member which is having longer length compared to its width & depth. It is also called as horizontal member.

Different Types of Beam :-

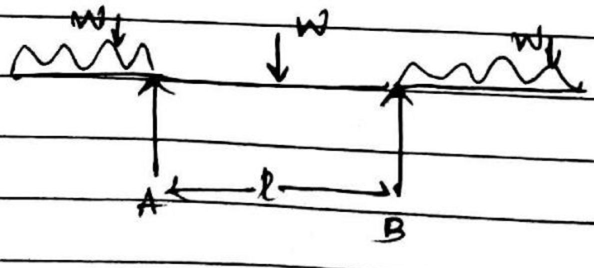
(1) Simply Supported Beam : In this beam both ends of the beam are simply supported



(2) Cantilever Beam :- In this beam, one end of the beam is supported and the other end is left free.



(3) Over hanging Beam :- In this beam, a part of the beam overhangs at one end or both the ends.



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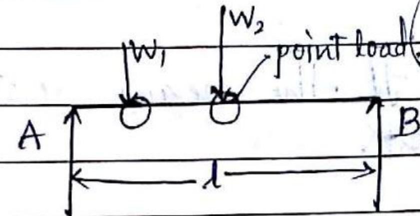
• DIFFERENT TYPES OF LOADINGS :-

(1) Point load
(2) Uniformly Distributed load.
(3) Uniformly Varying Load.

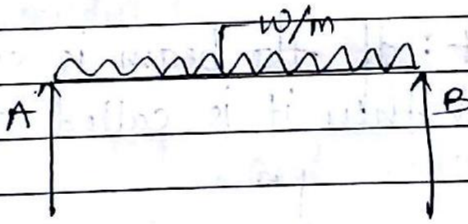
POINT LOAD :- Load is acting at a point on a beam.



Example :- two person standing on the beam.

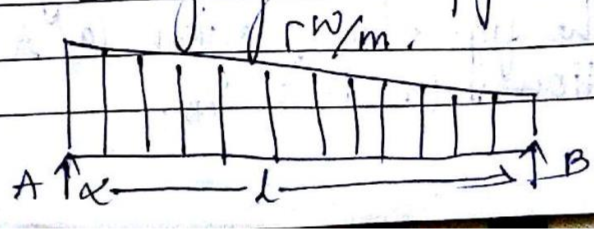
UNIFORMLY DISTRIBUTED LOAD :- Load which has got same intensity over a considerable length is called as uniformly distributed load. (UDL).

Example :- Brick wall constructed on a beam.



UNIFORMLY VARYING LOAD :- Intensity of the load increases lineare along the length is called as uniformly varying load. (UVL).

Example :- Brick Wall constructed on a beam carrying a slopy roof.



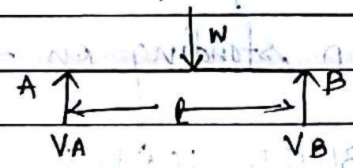
- SUPPORTS :-

The diff types of supports are :-

(1) Simply Support (2) Roller Support (3) Hinged Support

(4) Fixed Support (5) Continous Support.

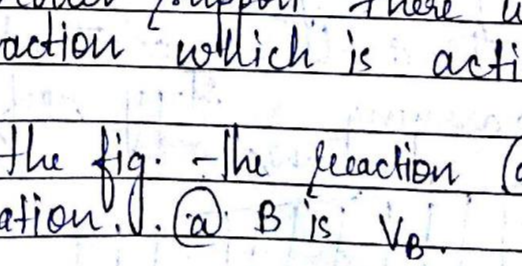
(1) Simply Support : If the beam rest simply on a support.



For a simply supported there will be only one reaction which is acting vertically upwards

From the fig. the reaction @ A is V_A and reaction @ B is V_B.

(2) Roller Support : If the beam is supported on the roller, then it is called as roller support



For roller support there will be only one reaction which is acting vertically upward

From the fig. the reaction @ A is V_A and reation @ B is V_B.

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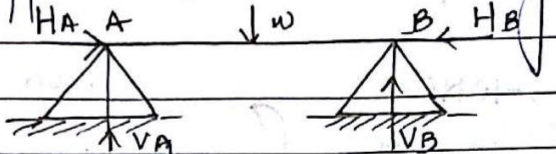
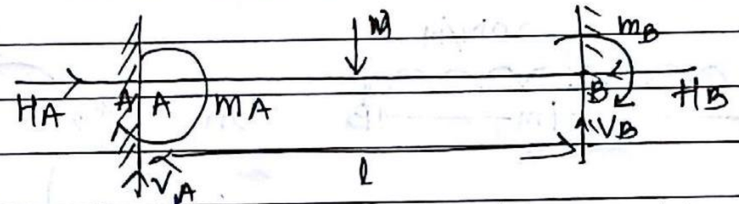
(3) Hinged Support :- If the beam is supported on the hinge or a pin then that type of support is called as hinged support.



For the hinged support there will be 2 reaction ie vertically upwards and horizontally inwards

From the fig. the reaction @ A is VA and HA and reaction @ B is VB or HB.

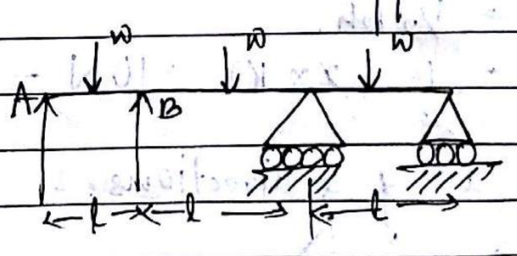
(4) Fixed Support :- If the beam is supported on one end or both the ends.



For the fixed support, there will be 3 reaction ie vertically upwards and horizontally inwards. and moment.

From the fig. the reaction @ A are VA, HA and mA and reactions @ B are VB, HB and mB.

(5) CONTINOUS SUPPORT :- If the beam is having 3 or more support.



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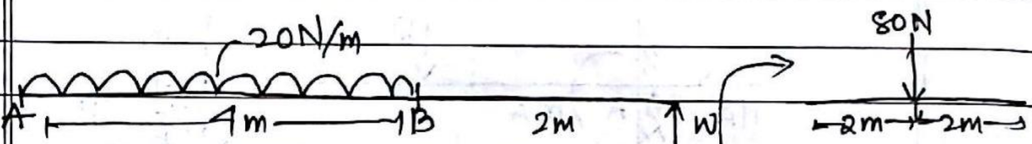
• NOTE:

(1) CONVERTING UDL TO POINT LOAD :-

$10\,N/\cancel{m} \times 3\,\cancel{m}$

$\Rightarrow$ 30N
Point Load.

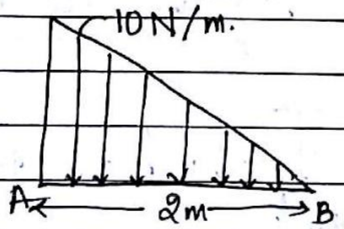


$20\,N/\cancel{m} \times 4\,\cancel{m}$

80N - Point Load.

(2) CONVERTING UVL TO POINT LOAD:-

(I)

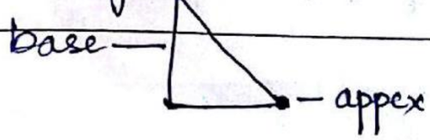


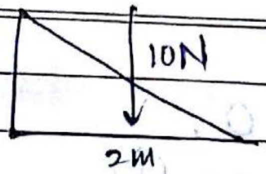
Area of $\Delta = \frac{1}{2}bh$.

$= \frac{1}{\cancel{2}} \times \cancel{2} \times 10 = 10N$ - Point Load.

It will act along 2 directions:-

(i) from base





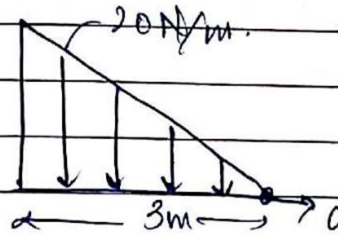
from base $= \frac{1}{3} d$

$= \frac{1}{3} \times 2 = 0.66m$

from appex $= \frac{2}{3} d$

$= \frac{2}{3} \times 2 = \frac{4}{3} = 1.33\ m$

(II)



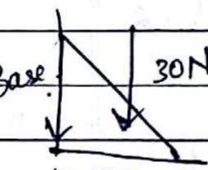
Area $= \frac{1}{2} bh$

$= \frac{1}{2} \times 3 \times \cancel{20}10 = 30\ N$

Point Load.

from base :- $\frac{1}{3} d$

$\Rightarrow \frac{1}{3} \times 3 = 1\ m$

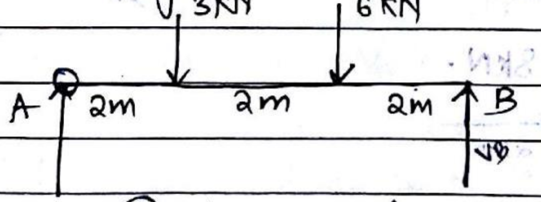


from appex :- $\frac{2}{3} d \Rightarrow \frac{2}{\cancel{3}} \times \cancel{3} = 2m.$

$\boxed{\text{distance from base + distance from appex = span}}$

Q- Find the support and support reaction for the beam shown in figure :-

Ans -



Support @ A - simply support → vertically ↑wards. $= V_A$
@ B - simply support → vertically ↑wards V_B.

$\Sigma V = 0$

$V_A + V_B - 3 - 6 = 0$

$\boxed{V_A + V_B = 9}$ —— (1)

$\Sigma m_A = 0$

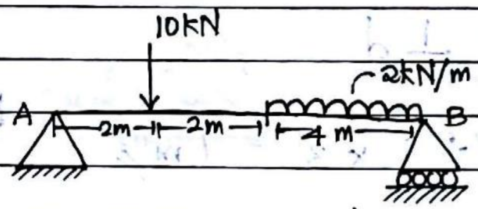
$(-V_B \times 6) + 6 \times 4 + 3 \times 2 = 0$

$6 V_B = 24 + 6$

$V_B = \frac{30}{6} = 5 \text{ kN}$ //

$V_A = 9 - 5 = 4 \text{ kN}$ //

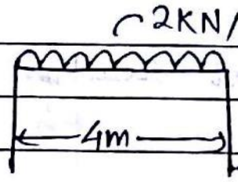
Q2.



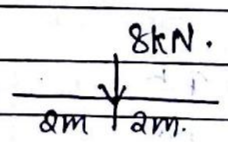
Ans- Support @ A - hinged support → $\uparrow V_A$, $\rightarrow H_A$

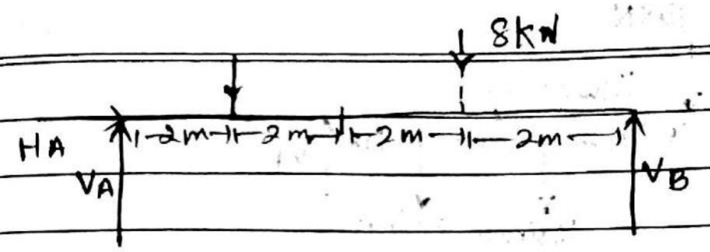
@ B - roller support → $V_B \uparrow$

$H_A = ?$ $V_A = ?$ $V_B = ?$



Point Load = $2\text{kN}/\cancel{m} \times 4\cancel{m} = 8 \text{ kN}$ //





$\Sigma H = 0.$

$\boxed{H_A = 0 \text{ KN.}}$

$\Sigma V = 0.$

$\boxed{V_A + V_B - 10 - 8 = 0}$

$\Rightarrow V_A + V_B = 18 \text{ KN}$

$\Sigma M_A = 0.$

$- V_B \times 8 + 8 \times 6 + 10 \times 2 = 0.$

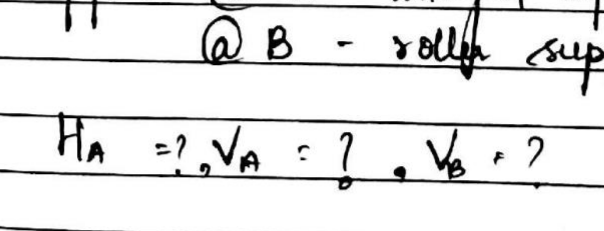
$V_B \times 8 = 68$

$V_B = \frac{68}{8} = 8.5 \text{ KN.}$

Substituting the value.

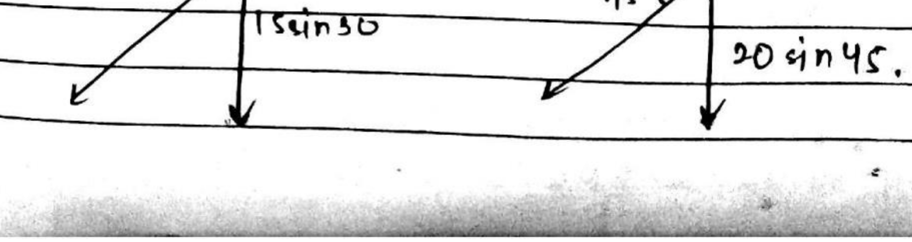
$V_A = 18 - 8.5 = 9.5 \text{ KN} //$

Q.3



Ans. Support @ A - hinged support → ↑V_A , → H_A.
@ B - roller support → V_B ↑.

$H_A = ?, V_A = ?, V_B = ?$



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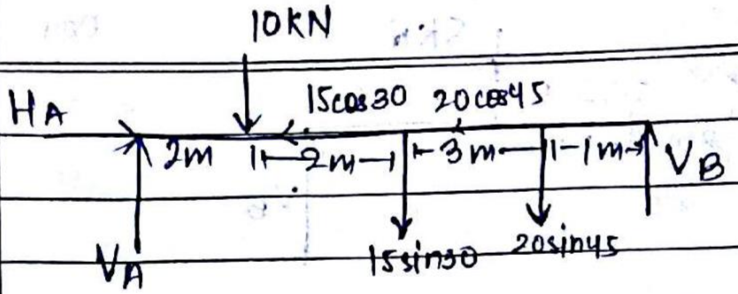


$\Sigma H = 0.$

$H_A - 15\cos 30 - 20\cos 45 = 0$

$H_A = 27.13$ kN

$\Sigma V = 0.$

$\Rightarrow V_B + V_A - 10 - 15\sin 30 - 20\sin 45 = 0$

$\Rightarrow V_A + V_B = +31.64$ kN — (1).

$\Sigma M_A = 0.$

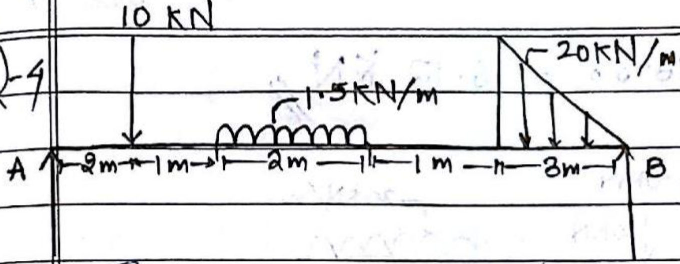
$\Rightarrow -V_B \times 8 + (20\sin 45)7 + (15\sin 30)4 + 10 \times 2 = 0$

$\Rightarrow V_B \times 8 = 148.99$

$\Rightarrow V_B = \frac{148.99}{8} = 18.62$ kN.

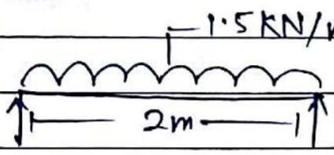
$\therefore V_A = 31.64 - 18.62 = 13.02$ kN

Q-4

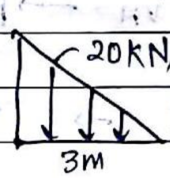


Ans- Support @ A - simply support → $V_A \uparrow$

@ B - simply support → $V_B \uparrow$.



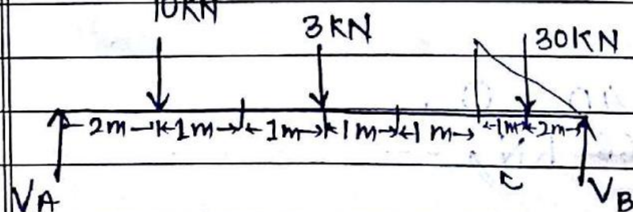
Point Load $= 1.5 \frac{KN}{m} \times 2m = 3\ KN$



Point Load $= \frac{1}{2} \times b \times h = \frac{1}{\cancel{2}} \times 3 \times \cancel{20}^{10} = 30\ KN$

from base $= \frac{1}{3} \times d = \frac{1}{3} \times 3 = 1\ m.$

from apex $= \frac{2}{3} \times d = \frac{2}{3} \times 3 = 2m$



$\Sigma V = V_A + V_B - 10 - 3 - 30$

$\Rightarrow 0 = V_A + V_B - 43.$

$\Rightarrow V_A + V_B = 43\ KN$ —— (1).

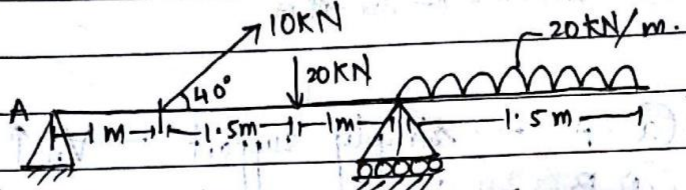
$\Sigma M_A = 0$

$\Rightarrow -V_B \times 9 + 30 \times 7 + 3 \times 4 + 10 \times 2 = 0$

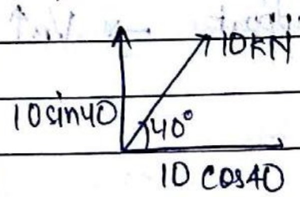
$\Rightarrow V_B \times 9 = 242 \quad \Rightarrow V_B = \frac{242}{9} = 26.88\ KN$

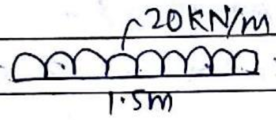
$\therefore \quad V_A = 43 - 26.88 = 16.12 \text{ KN}$ //

Q.5-



Ans-

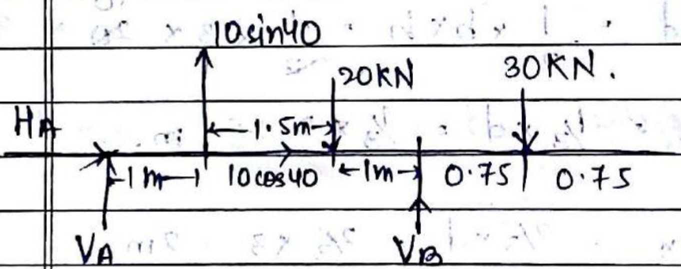




$\rightarrow \frac{20 \text{ KN}}{\cancel{m}} \times 1.5 \cancel{m} = 30 \text{ KN}.$

Support @ A is hinged $\rightarrow \uparrow V_A \quad \longrightarrow H_A$

@B is roller support $\rightarrow V_B \uparrow$.



$\Sigma H = 0.$

$H_A + 10\cos 40 = 0.$

$H_A = -7.66 \text{ KN}$ //

$\Sigma V = 0.$

$\Rightarrow V_A + V_B + 10\sin 40 - 30 - 20 = 0.$

$\Rightarrow V_A + V_B = 43.572 \text{ KN} \longleftarrow (1)$ //

$\Sigma M_A = 0$

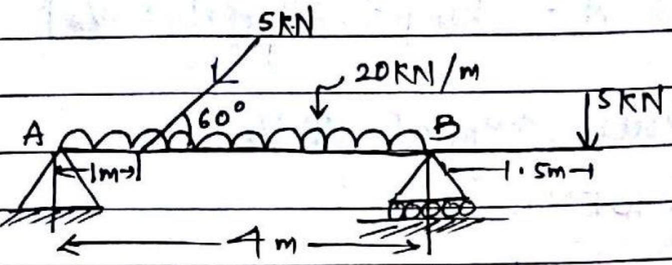
$\Rightarrow \cancel{(30) \times 10.41 - V_B \times 9.66 + 20(10\cos 40 + 1)}$

$\Rightarrow 30 \times 4.25 - V_B \times 3.5 + 20 \times 2.5 - 10 \sin 40 \times 1 = 0$

$\Rightarrow V_B = \dfrac{171.072}{3.5} = 48.87\ KN$

$V_A = 43.57 - 48.87 = -5.3\ KN$

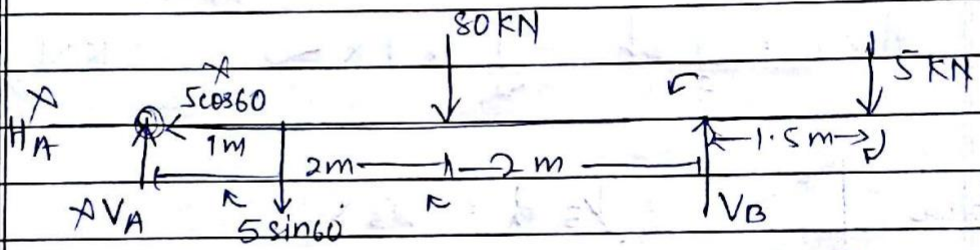
Q.6-



Support @ A is hinged → $V_A \uparrow$ → H_A

@ B is roller support → $V_B \uparrow$

20 kN/m, 4m → $\dfrac{20\,kN}{m} \times 4m = 80\ KN$



$\Sigma H = 0$

$\Rightarrow H_A - 5\cos 60 = 0$

$\Rightarrow H_A = 2.5\ KN$

$\Sigma V = 0$

$\Rightarrow V_A + V_B - 5\sin 60 - 80 - 5 = 0$

$\Rightarrow V_A + V_B = 89.3301$ —— (1)

$\Sigma M_A = 0.$

$\Rightarrow (5\sin 60)1 + (80)2 - (V_B)4 + (5)(5.5) = 0$

$\Rightarrow V_B = 47.957\ KN$

$\therefore V_A = 89.3301 - 47.957 = 41.3731\ KN$

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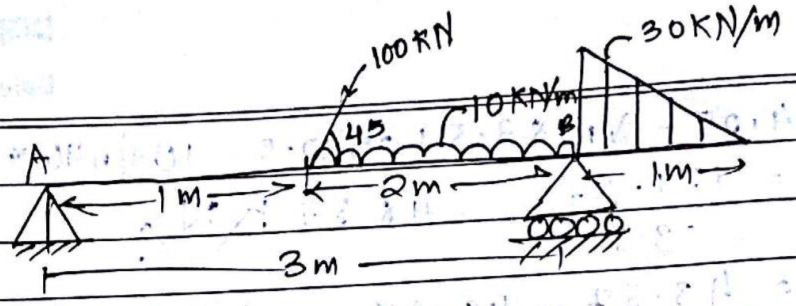
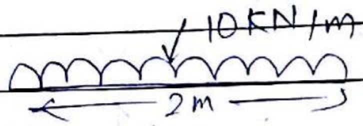
Q:7-



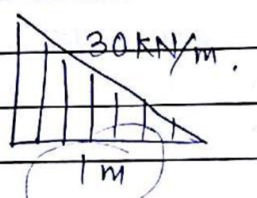
Ans-

Support @ A - hinged support → $V_A \uparrow$ $H_A \rightarrow$

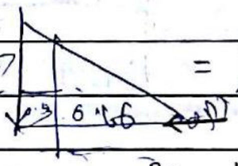
@ B - roller support $\uparrow V_B$.



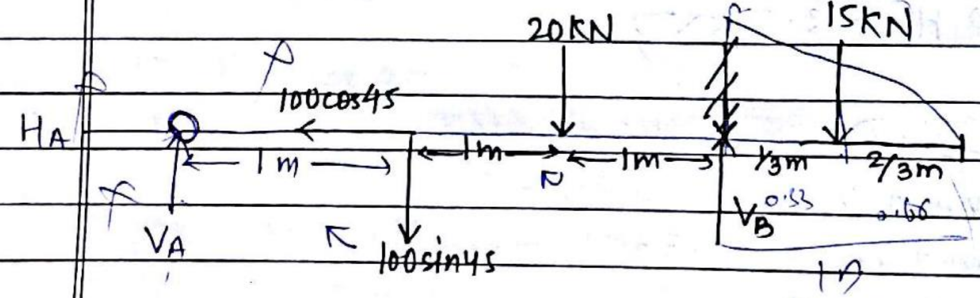
Point Load = $\frac{10KN}{\cancel{m}} \times 2\cancel{m} = 20\ KN$ //



Area = $\frac{1}{2} bh = \frac{1}{2} \times 1 \times \overset{15}{30} = \underline{\underline{15\ KN}}$ //

from base  $= \frac{1}{3} d = \frac{1}{3} \times 1 = 0.33$

from appex $= \frac{2}{3} d = \frac{2}{3} \times 1 = 0.6$



$\Sigma H = 0$

$\Rightarrow H_A - 100 \cos 45 = 0.$

$\Rightarrow H_A = 70.71\ KN$ //

$\Sigma V = 0$

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Date: / /

$\Sigma V = 0$

$\Rightarrow V_A - 100\sin 45 - 20 + V_B - 15 = 0$

$\Rightarrow V_A + V_B = 105.710$ —— (1).

$\Sigma M_A = 0$

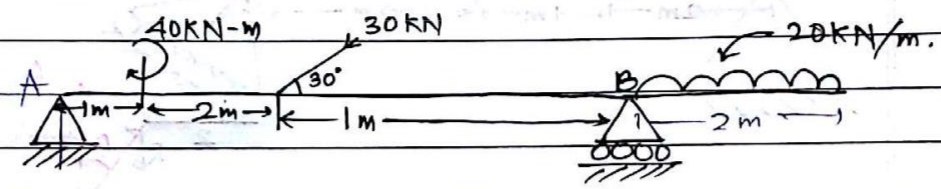
$\Rightarrow (100\sin 45)1 + (20)2 - 3V_B + (15)\cancel{(1/3)}(3.33) = 0$

$\Rightarrow 3V_B = 160.66$

$\Rightarrow V_B = \frac{160.66}{3} = 53.55\ KN.$

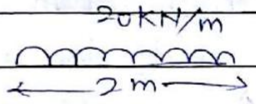
$V_A = 105.710 - 53.55 = 52.16\ KN$

Q.8-



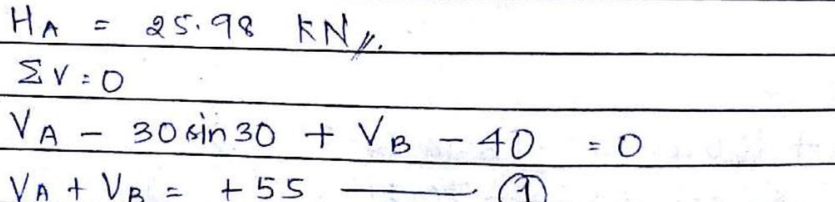
Ans- Support @ A is hinged support $\uparrow V_A$ $\rightarrow H_A$.

@ B is roller support $\uparrow V_B$.



Point Load $\Rightarrow \frac{20\ KN}{m} \times 2m = 40\ KN$

FBD :-



$\Sigma H = H_A - 30\cos 30$

$\Rightarrow 0 = H_A - 25.98$

$\Rightarrow H_A = 25.98\ KN$

$\Sigma V = 0$

$\Rightarrow V_A - 30\sin 30 + V_B - 40 = 0$

$\Rightarrow V_A + V_B = +55$ —— (1).

$\Sigma M_A = 0.$

$\Rightarrow 40 + (30\sin 30)3 - (V_B)4 + (40)5 = 0$

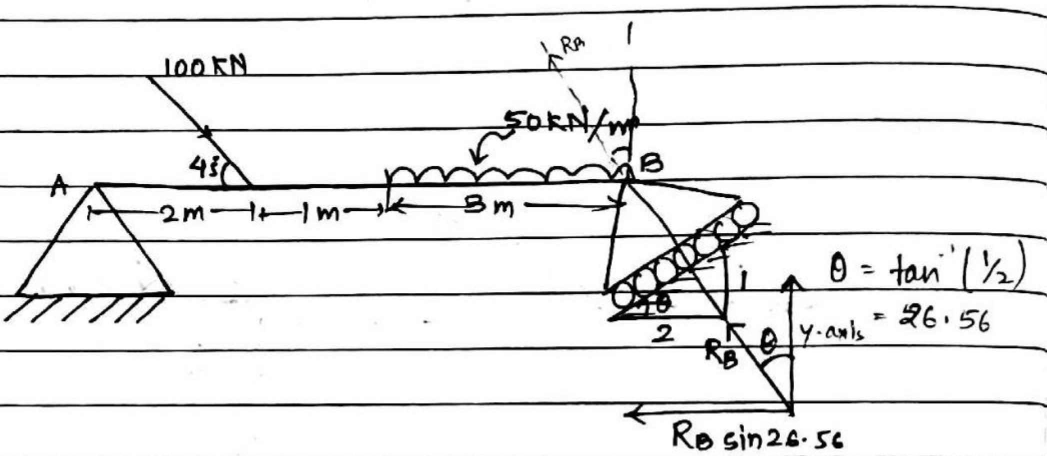
$\Rightarrow 4V_B = 285 \quad \Rightarrow V_B = 71.25\ KN$

$\Rightarrow V_A + V_B = 55$

$\Rightarrow V_A = 55 - V_B = 55 - 71.25 = -16.25$ //

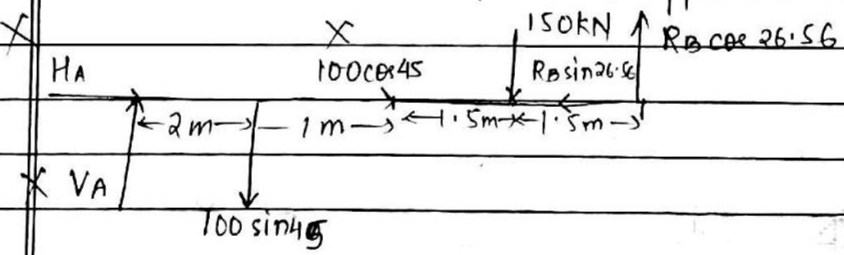
Imp Q-9

Ans.



Support @ A is hinged support $\uparrow V_A$ $H_A \rightarrow$

@ B is roller support R_B inclined @ 26.56 to Y-axis



$\Sigma V = 0$

$\Rightarrow V_A - 100\sin 45 - 150 + R_B \cos 26.56 = 0$

$\Rightarrow V_A + R_B \cos 26.56 = 220.710$ —— (1)

$\Sigma H = 0$

$H_A + 100\cos 45 - R_B \sin 26.56 = 0$

$\Rightarrow H_A - R_B \sin 26.56 = -70.71$ —— (2)

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$\Sigma m_A = (100 \sin 45)2 + (150)(4.5) - (R_B \cos 26.56)6 = 0$

$\Rightarrow (R_B \cos 26.56) \cdot 6 = 816.421$

$\Rightarrow R_B = \dfrac{816.421}{6 \cos 26.56} = 152.124 \text{ KN}$

$\Rightarrow V_A = 220.710 - R_B \cos 26.56$

$= 220.710 - (152.124) \cos 26.56$

$= 84.64 \text{ KN}$

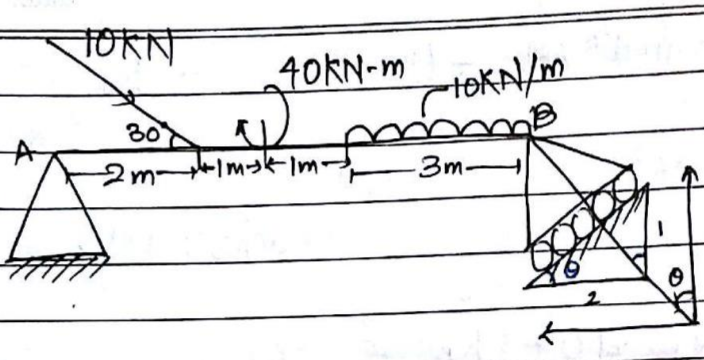
$\Rightarrow H_A = 152.124 \sin 26.56 - 70.71$

$= -2.69 \text{ KN}$

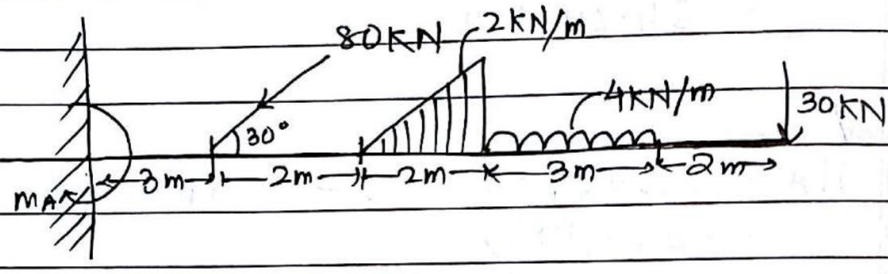
——x——x——

Date: / /

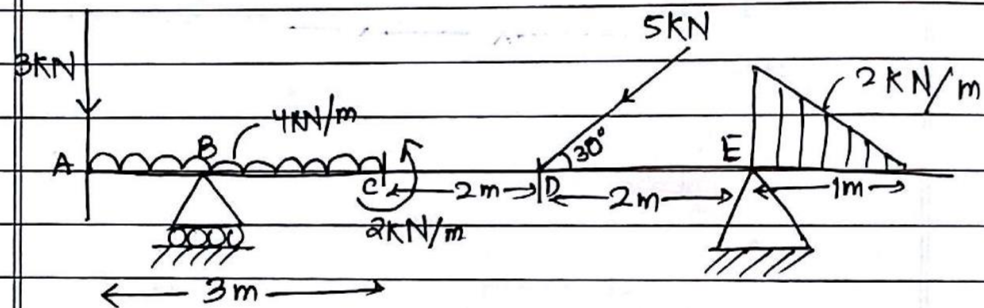
Q.1-



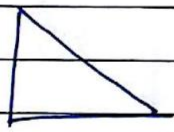
Q.2-



Q.3-



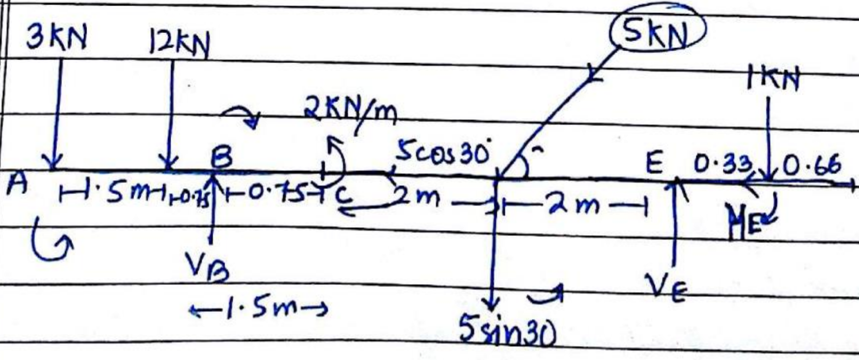
Ans 3 Point Load $= 4 \times 3 = 12$ KN.



$\frac{1}{2} bh = \frac{1}{2} \times 1 \times 2 = 1$ KN

from apex $= \frac{2}{3} d = \frac{2}{3} \times 1 = 0.66$

from base $= \frac{1}{3} d = \frac{1}{3} \times 1 = 0.33$.



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Date: / /

$\Sigma H = 0.$

$\Rightarrow -H_E - 5\cos 30 = 0$

$\Rightarrow H_E = -4.330\ kN$

$\Rightarrow \Sigma V = 0$

$\Rightarrow -3 - 12 + V_B - 5\sin 30 + V_E - 1 = 0$

$\Rightarrow V_B + V_E = 18.5\ kN$

$\Rightarrow \Sigma M_E = 0$

$\Rightarrow -(3)7 - (12)5.5 + (V_B)4.75 - 2 - (5\sin 30)2 + (1)0.33 = 0$

$\Rightarrow -21 - 66 + 4.75 V_B - 2 - 5 + 0.33 = 0$

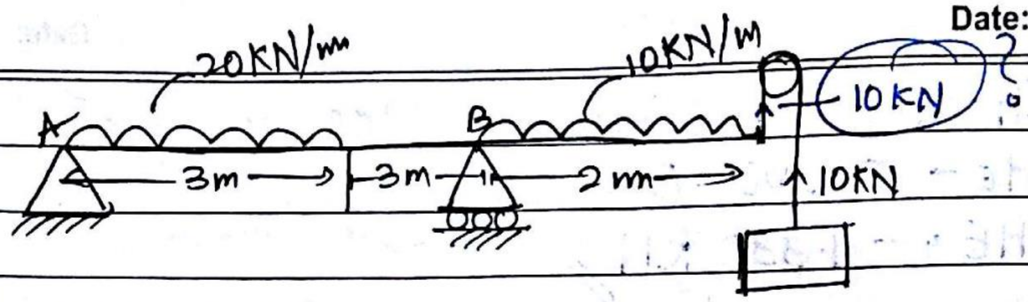
$\Rightarrow V_B = 19.72\ kN$

$\therefore V_E = 18.5 - 19.72 = -1.22\ kN$

papergrid

Date: / /

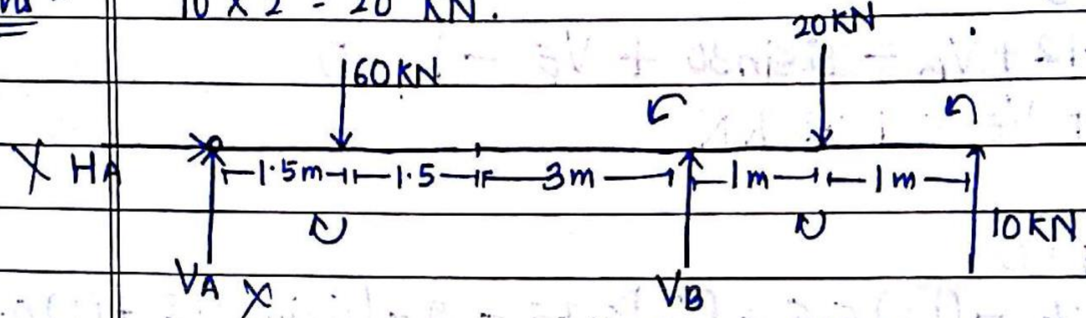
Q.



Ans -

$20 \times 3 = 60$ KN.

$10 \times 2 = 20$ KN.



$\Sigma H = 0.$

$\Rightarrow H_A = 0$

$\Sigma V = 0.$

$\Rightarrow V_A - 60 + V_B - 20 + 10 = 0$

$\Rightarrow V_A + V_B = 60 + 10 \Rightarrow V_A + V_B = 70$ —— (1).

$\Sigma m_A = 0$

$\Rightarrow (60)1.5 - (V_B)(6) + (20)(7) - (10)8 = 0$

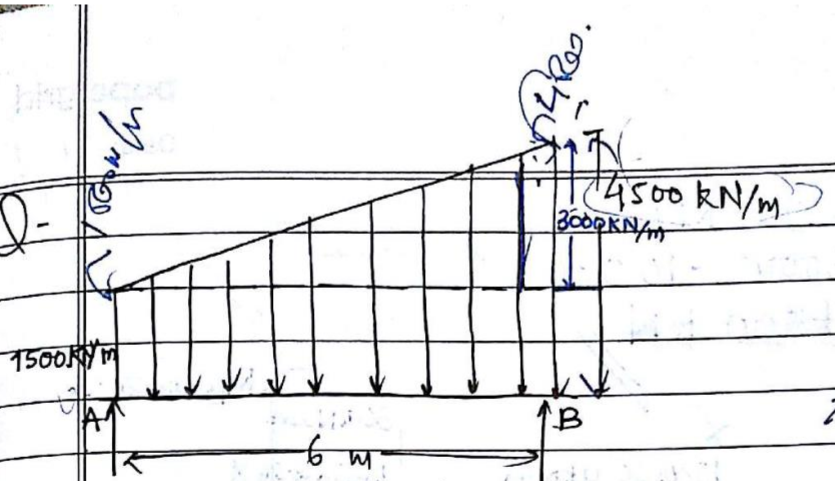
$\Rightarrow \frac{150}{6} = V_B$

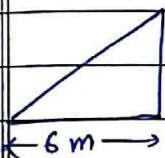
$\Rightarrow V_B = 25$ KN//

$V_A = 70 - 25 = 45$ KN //

Answer

Q-





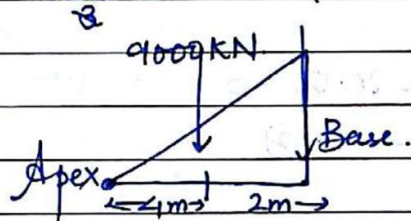
Area of Δ $= \frac{1}{2} bh$

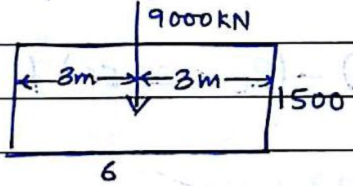
$= \frac{1}{\cancel{2}} \times \cancel{6}^{3} \times 3000 = 9000\ kN$

from base, from apex $= \frac{2}{3} d = \frac{2}{\cancel{3}} \times \cancel{6}^{2}$

$= \frac{1}{3} d$ $= 4m$

$= \frac{1}{\cancel{3}} \times \cancel{6}^{2} = 2m$

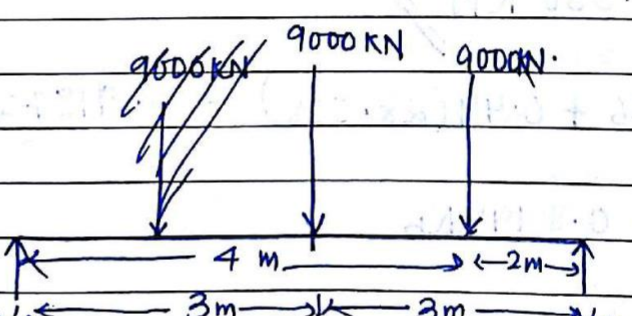




Area of rec. $= bh$

$= 1500 \times 6$

$= 9000\ kN$



$\Sigma V = 0$

$V_A - 9000 - 9000 + V_B = 0$

$V_A + V_B = 18000$ —— (1)

$\Sigma M_A = 0$

$\Rightarrow (9000)3 + (9000)4 - (V_B)6 = 0$

$\Rightarrow V_B = 10500\ kN$

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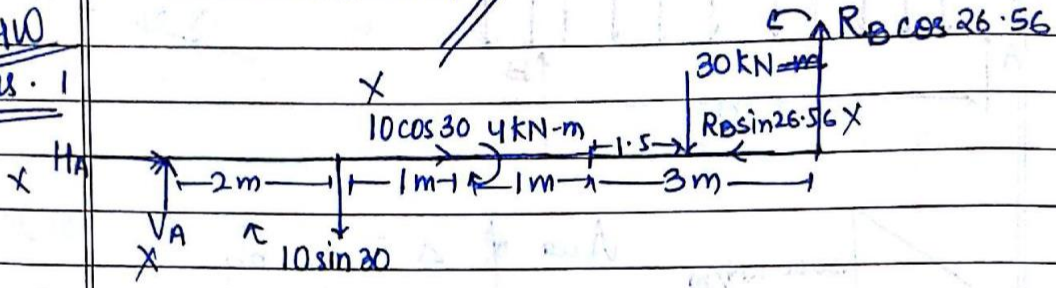
$\therefore V_B = 10500\ KN$

$V_A = 18000 - 10500$

$= 7500\ KN$

H/W

Ans. 1



$\tan\theta = 1/2 \Rightarrow \theta = 26.56$

$\Sigma H = 0$

$\Rightarrow H_A + 10\cos 30 - R_B \sin 26.56 = 0$

$\Rightarrow H_A - 0.44 R_B = -8.66$ —— (1)

$\Sigma V = 0$

$\Rightarrow V_A - 10\sin 30 - 30 + R_B \cos 26.56 = 0$

$\Rightarrow V_A + 0.8944 R_B = 35$ —— (2)

$\Sigma M_A = 0.$

$\Rightarrow (+10\sin 30) 2 + 4 + 30(5.5) - (R_B \cos 26.56) 7 = 0$

$\Rightarrow \frac{179}{7} = R_B \cos 26.56$

$\Rightarrow R_B = 28.588\ KN$

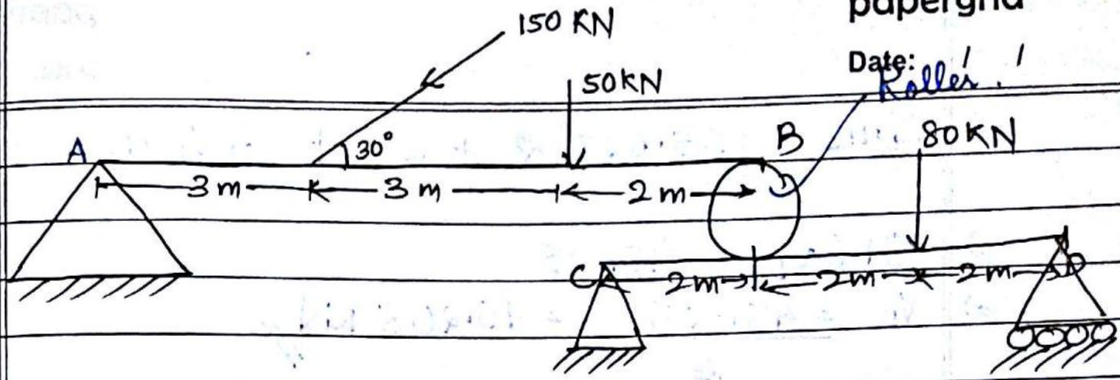
$\Rightarrow H_A = -8.66 + 0.44(28.588) = 3.91872\ KN$

$\Rightarrow V_A = 35 - 0.8944 R_B$

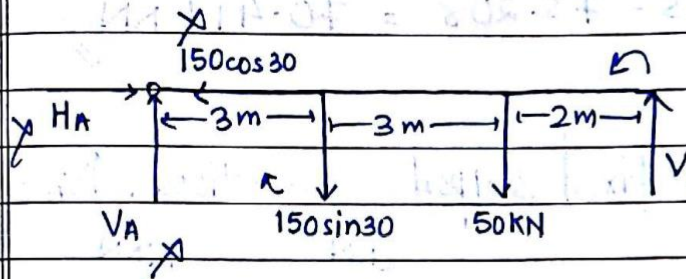
$\Rightarrow V_A = 35 - (0.8944)(28.588)$

$\Rightarrow V_A = 9.43\ KN$

Q.-



Ans- FBD @ AB line :-



$\Sigma H = 0$

$\Rightarrow H_A - 150\cos 30 = 0$

$\Rightarrow H_A = 150\cos 30 = 129.90\ KN$ //

$\Sigma V = 0$

$\Rightarrow V_A - 150\sin 30 - 50 + V_B = 0$

$\Rightarrow V_A + V_B = 125$ ——— ①

$\Sigma m_A = 0$

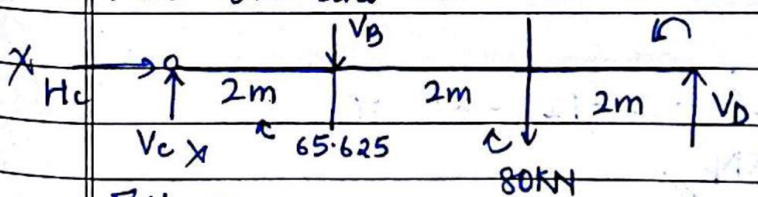
$\Rightarrow (150\sin 30)\,3 + (50)\,6 - (V_B)(8) = 0$

$\Rightarrow 8V_B = 525$

$\Rightarrow V_B = 65.625\ KN$ //

$\therefore V_A + V_B = 125 \Rightarrow V_A = 59.375\ KN$ //

FBD on line CD :-



$\Rightarrow \Sigma H = 0$

$\Rightarrow H_C = 0.$

$\Rightarrow \Sigma V = 0$

$\Rightarrow V_C - 65.625 - 80 + V_D = 0$

$\Rightarrow V_C + V_D = 145.625$ ——— ①

$\Sigma m_c = (65.625)2 + (80)4 - (V_D)6$

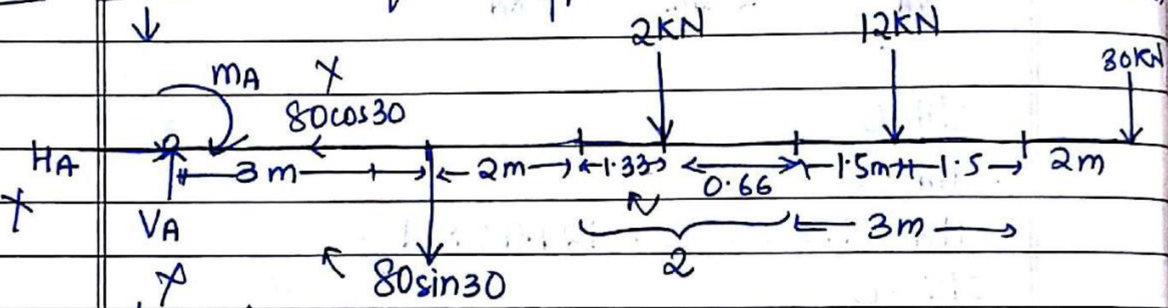
$\Rightarrow 0 + 6V_D = 451.25$

$\Rightarrow V_D = \frac{451.25}{6} = 75.208$ kN //

$V_c = 145.625 - 75.208 = 70.417$ KN //

HW

Ans. 2 FBD @ A → fixed support - 3 reactions. $\uparrow V_A \rightarrow H_A$ m_A



Area of $\Delta = \frac{1}{2}bh = \frac{1}{2} \times 2 \times 2 = 2$ KN.

from apex $= \frac{2}{3}d = \frac{2 \times 2}{3} = \frac{4}{3} = 1.33$ m.

from base $= \frac{1}{3}d = \frac{2}{3} = 0.66$ m.

$\Sigma H = 0$

$\Rightarrow H_A - 80\cos 30 = 0$

$\Rightarrow H_A = 69.282$ KN //

$\Sigma V = 0$

$\Rightarrow V_A - 80\sin 30 - 2 - 12 - 30 = 0$

$\Rightarrow V_A = 84$ KN //

$\Sigma m_A = ?$

$\Rightarrow (80\sin 30)3 + 2(6.33) + 12(8.5) + (30)(12)$

$\Rightarrow 594.66$ // Clockwise