Unit : 4

4. Analysis of Trusses

★ **Truss:-**

Truss is the structure which is formed by connecting various two force members to each other by using pin joint.

★ **Plane truss:**

When all members of truss lies in one plane, then truss is known as plane truss

★ **Rigid truss:** A truss which do not collapse when external load is applied on it.

★ **Simple truss:** The structure formed by basic triangle made by connecting various members are called simple truss.

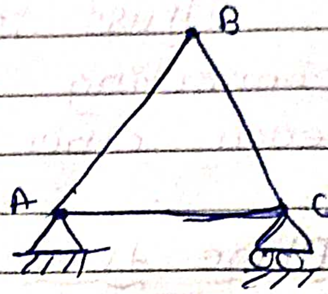
★ Classification of Truss

- Perfect truss (Stable) ($n = 2j - R$)
- Imperfect truss (unstable) ($n \neq 2j - R$)
  - Overstable (Redundant) Truss ($n > 2j - R$)
  - Defficient Truss ($n < 2j - R$)

> **Perfect truss :** A truss which ~~not~~ does not collapse under the action of load is called...

Condition : $n = 2j - R$

n = no. of members
j = no. of joints
R = no. of Reaction



In truss ABC, $n = 3$ & $2j - R = 3$
$\therefore$ Perfect truss.

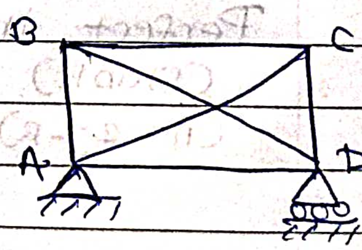
$n = 3$
$j = 3$
$R = 3$

* **Imperfect Truss:** A truss which collapse under the action of load is called imperfect truss

Condition : $n = 2j - R$ — Here, $n \neq 2j - R$
n = no. of members
j = no. of joints
R = no. of Reaction

* Over stable (Redundant Truss)

A truss in which $n > 2j - R$, then it is overstable truss

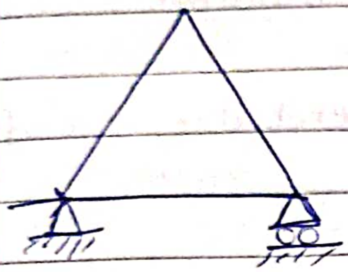


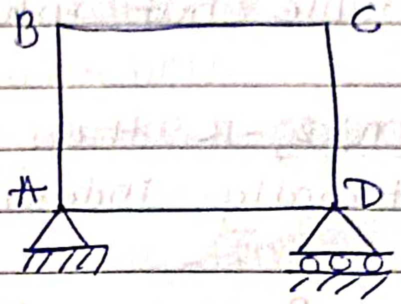
A> redundant truss is composed no. of members more than req. to keep the truss stable

* Defficient Truss:

It is composed of no. of members less than that req. to keep the truss stable.

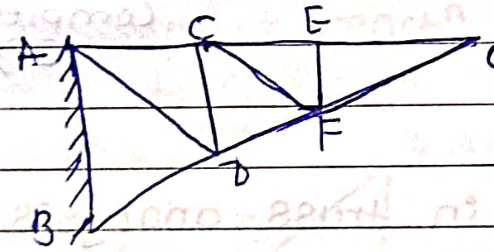
$n < 2j - R$





* Cantilever Truss;

A truss which is fixed on one side & force at other end is called as cantilever truss.



Here
$R = 4$

* Determinancy of truss:-

i) Ext support

Support reacth of truss can be found out using three condition of equllibrium

Conditions :- $\Sigma fx = 0$; $\Sigma fy = 0$; $\Sigma M = 0$

ii) Int force members

If all the axial forces in the truss member can be found out using eqn of equillibrium , $\Sigma fx = 0$; $\Sigma fy = 0$

- If $n = 2j - R$ then truss structure is perfect, stable and internally determinant.
- If $n < 2j - R$, then truss structure is imperfect unstable but internally determinant.
- If $n > 2j - R$ then truss is overstable and internally indeterminant.

* Two force members

Members of truss must be two force members and forces must be axial acting at ends can be compressive or tensile

Tensile (+) Compressive (−)

* Assumptions made in truss analysis:-

i Truss is a perfect truss
ii Truss can be internally determinant and stable
iii All members of truss are connected by pin joints only
iv) All memebers of truss are two force member
v Self weight of members are neglected
v All ext ~~fex~~ loads are acting at joints only.

* Determination of axial force in the member of truss

1) Joint method:

i) Use equilibrium equations i.e $\Sigma f_x = \Sigma f_y = \Sigma M = 0$ ~~to~~ find support reactions.

ii) Identify zero force members

iii) Draw FBD of a joint where, unknown is minimum

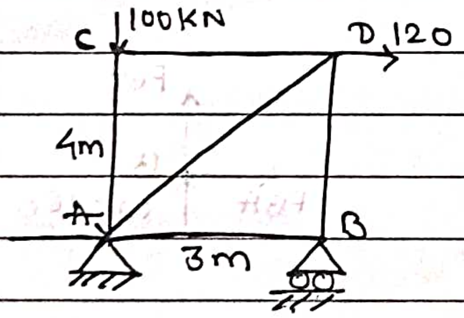
iv) Use $\Sigma f_x = 0$ and $\Sigma f_y = 0$ to find unknown Force

v) Processed to next joint, where unknown is minimum

vi) At last joint verify $\Sigma f_x = 0$ & $\Sigma f_y = 0$

(*) Numericals:

Q1) Find support reactⁿ and member forces of the truss as show in fig.



Soln To find support Reaction

$\Sigma f_x = 0$

$H_A + 120 = 0$

$H_A = -120\,KN$

$\Sigma f_y = 0$

$V_A + V_B = 100 \quad \ldots (1)$

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$\Sigma M_A = 0$

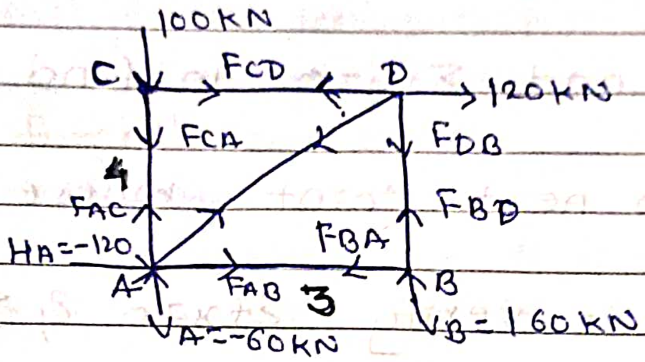
$-(V_B \times 3) + (120 \times 4) = 0$

$\boxed{V_B = 160\ kN}$

from ①

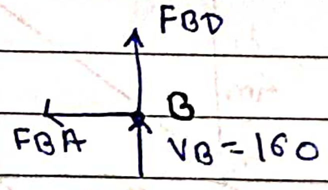
$\boxed{V_A = -60\ kN}$

To find member forces :-



(Start from pt B less unknown forces) (B is at base)

i) At point B



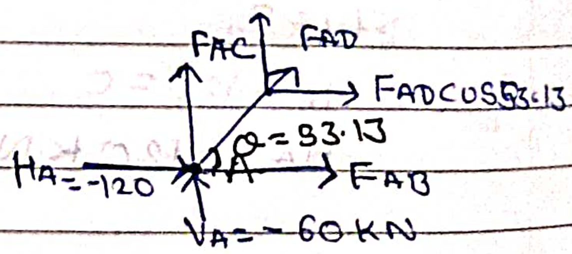
$\Sigma f_x = 0$

$F_{AB} = 0$

$\Sigma f_y = 0$

$F_{BD} = -160\ kN$

ii) At joint A



$\Sigma f_x = 0$

$-120 + \cancel{F_{AB}}^{\,0} + F_{AD}\cos 53.13 = 0$

$\boxed{F_{AD} = 200}$

$\theta \Rightarrow \tan\theta = \frac{4}{3}$ $\quad \theta = \tan^{-1}\left(\frac{4}{3}\right)$

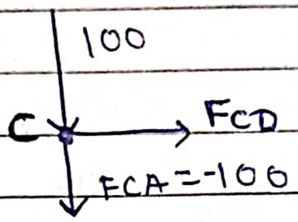
$\boxed{\theta = 53.13}$

$\Sigma f_y = 0$

$-60 + F_{AC} + 200 \sin 53.13 = 0$

$[F_{AC} = -100]$

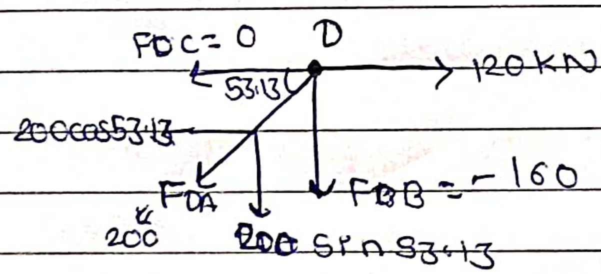
iii) At joint C



$\Sigma f_x = 0$

$F_{CD} = 0$

iv) At joint D



$\Sigma f_x = 0$

$-0 + 120 - 200 \cos 53.13 = 0$

$0 = 0$

$\Sigma f_y = 0$

$+160 - 200 \sin 53.13 = 0$

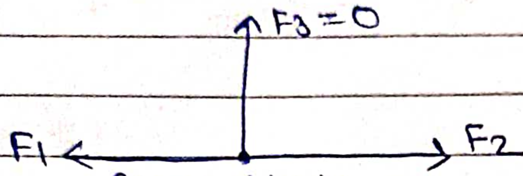
$0 = 0$

★ Table :-

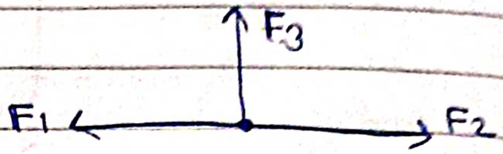
Member	Force	Nature
AB	0	–
AC	100	C
AD	200	T
BD	160	C
CD	0	–

★ Zero Force Members:-

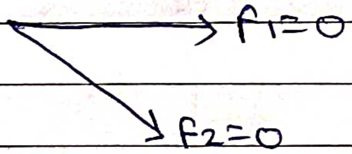
i) If there are three members at a joint out of which two are collinear and no external force acts on that joint third member is zero force member.

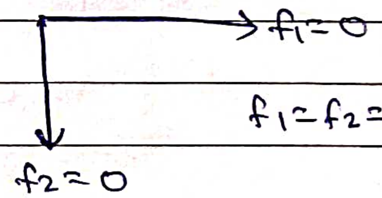


(magnitude same direction opposite)



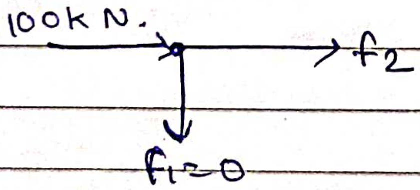
ii) If there are only two members at a joint and there is no external force at that joint, than both member are zero force members.



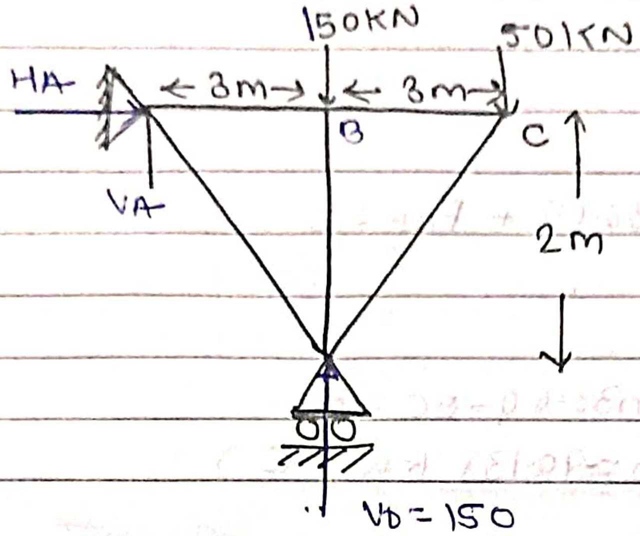


$f_1 = f_2 = 0$

iii) If there are only two members at a joint and external force is acting along one member than other is zero force member.



Q) Determine each member of truss as shown in fig and tabulate the result.



Soln $\Sigma f_x = 0$

$H_A = 0$

2) $\Sigma f_y = 0$

$V_A + V_D = 200$ KN ... ①

3) $M_A = 0$

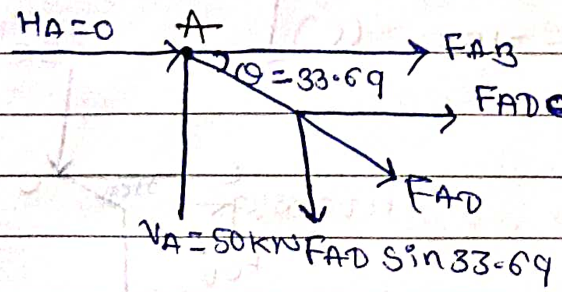
$-(V_D \times 3) + (150 \times 3) + (50 \times 6) = 0$

$\boxed{V_D = 250}$

from eqn ①

$\boxed{V_A = -50KN}$

At joint A



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

$\theta = 33.69°$

$\Sigma f_x = 0$

$0 + F_{AD}\cos 33.69° + F_{AB} = 0$

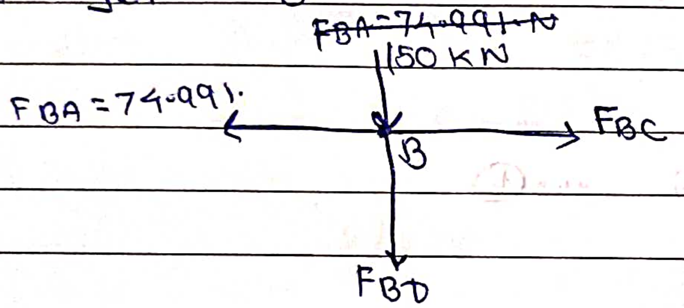
$\Sigma f_y = 0$

$-F_{AD}\sin 33.69 - 50 = 0$

$F_{AD} = -90.138 \text{ kN} \quad (C)$

$F_{AB} = 74.99 \text{ kN}$

ii) At joint B



$\Sigma f_x = 0$

$F_{BC} - F_{BA} = 0$

$F_{BC} = F_{BA}$

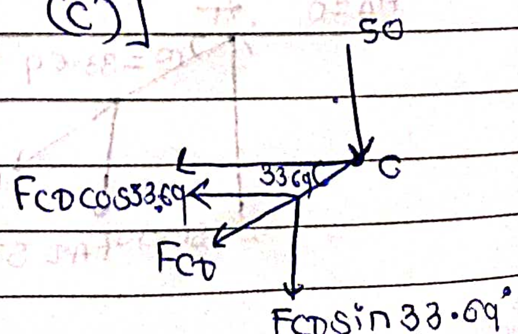
$F_{BC} = 74.99$

$\Sigma f_y = 0$

$-F_{BD} - 150 = 0$

$\boxed{F_{BD} = -150 \quad (C)}$

At joint C

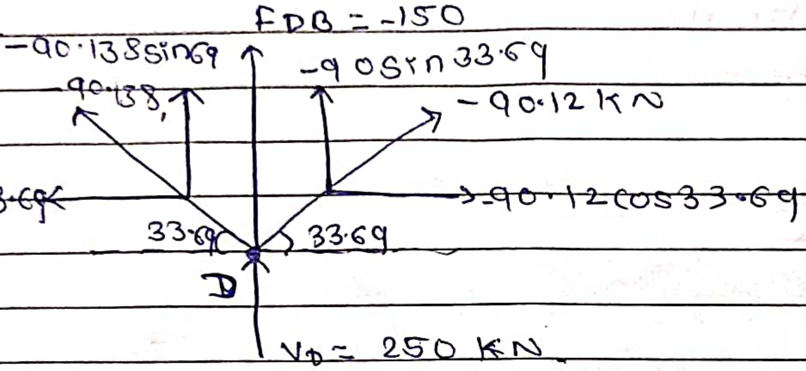


$\Sigma f_x = 0$

$-74.99 - F_{CD}\cos 33.69 = 0$

$F_{CD} = -90.12$ kN (C)

At joint D (last).



$\Sigma f_x = 0$

$-90.12\cos 33.69 + 90.13\cos 33.69 = 0$

$0 = 0$

$\Sigma f_y = 0$

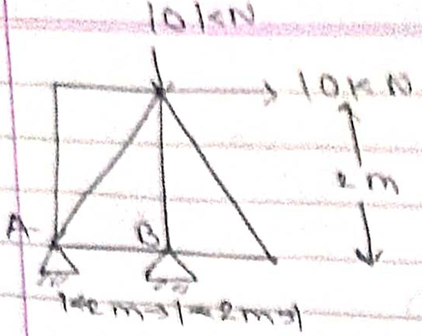
$-90.138\cos 33.69 - 90.12\sin 33.69 - 150 - 250 = 0$

$0 = 0$

⊖ Table :-

Member	Force	Nature
FAD	90.138	C
FAB	74.99	T
FBC	74.99	T
FCD	90.12	C
FDB	150	C

Q) Identify Zero force members and determine forces ?



Here two members
are present with no
external load.

$F_{DE} = 0$
$F_{DA} = 0$

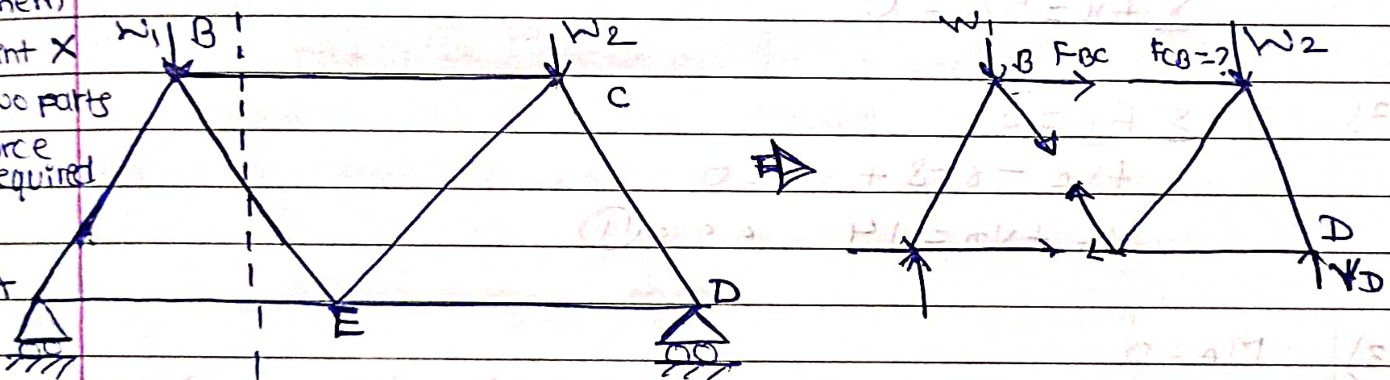
* Section Method:

1) Find the support reactions using three equations of equillibrium.

2) Draw forces in the required members

3) Cut this members by an imaginary sections i.e laying or curve such that truss structure divides into two separate parts.
Note:-
(a) Line or curve do not cut more than three members
(b) Line and curve should be passed through members only not through joint.

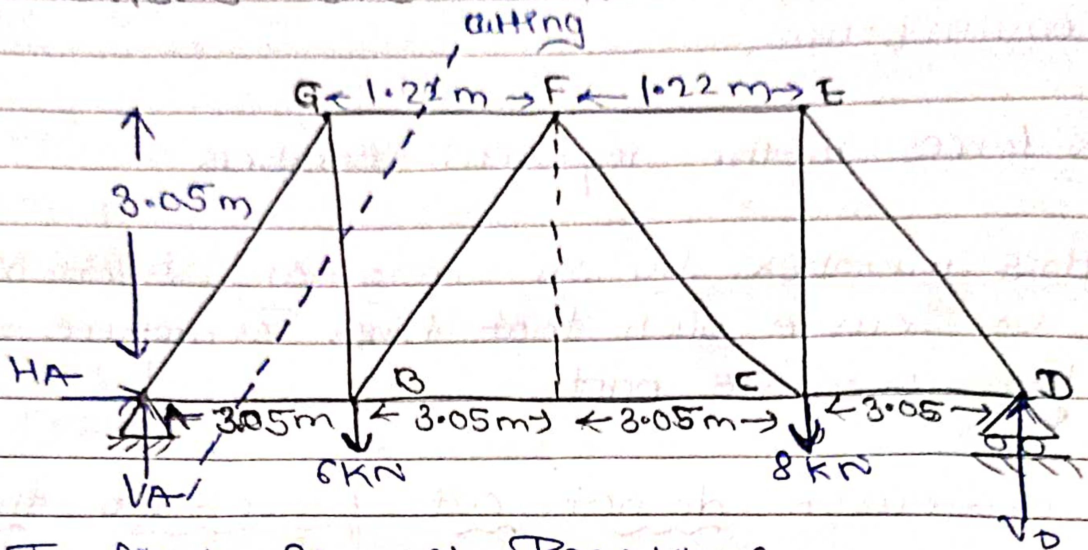
① 3 mem
② Joint X
③ Two parts
④ Force required



4) Consider only one part fore analysis i.e called as configuration diagram.

5) Again apply static equillibrium equation i.e $\Sigma fx=0$; $\Sigma fy=0$ & Moment about any point $=0$ in dconfiguration diagram.
Note:-
In $\Sigma fx=0$, $\Sigma f=0$ & $M@=0$ only those forces must be considered whic are involve in the configuration diagram.

Q) Determine force develop in members GB and GF of the truss and State if this members are in tension or compression.



Soln To find Support Reactions

1) $\Sigma fx = 0$

$\Sigma fx = HA = 0$

2) $\Sigma Fy = 0$

$+VA - 6 - 8 + VD = 0$

$VA + VD = 14 \quad \ldots (1)$

3) $MA = 0$

$MA = +(6 \times 3.05) + (8 \times 9.15) - (VD \times 12.2) = 0$

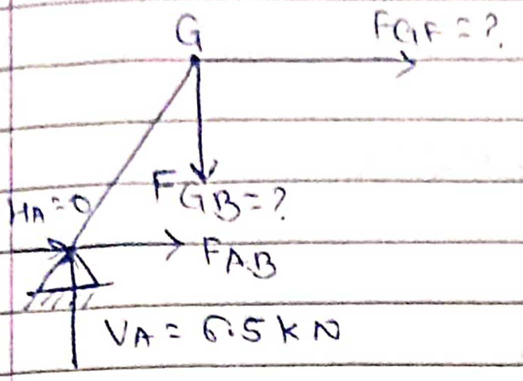
$VD = \frac{(6 \times 3.05) + (8 \times 9.15)}{12.12} \Rightarrow 7.5 \text{ kN}$

$\boxed{VD = 7.5 \text{ KN}}$

from (1)

$\boxed{VA = 6.5 \text{ KN}}$

VF → HD
HF → VD



$\Sigma fy=0$

$-FGB+6.5KN=0$

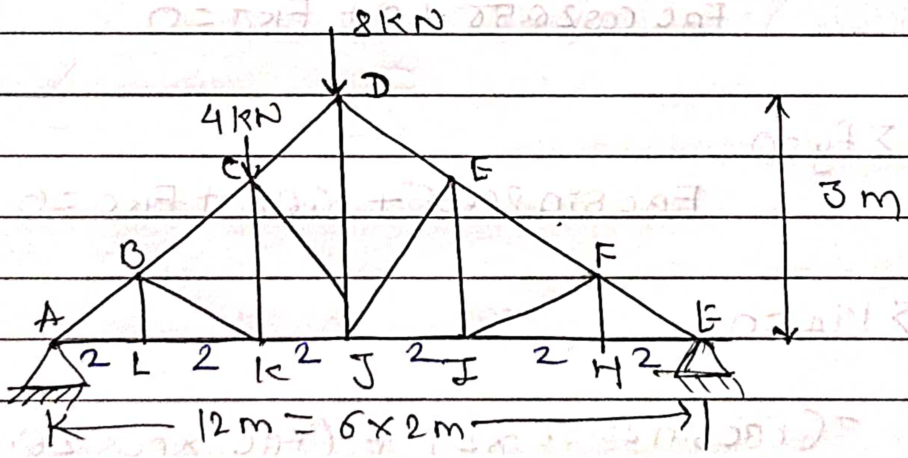
$\boxed{FGB=6.65\ KN}$ (T)

3) $MA=0$

$+(F_{GF}\times3.05)+(6.5\times3.05)=0$

$\boxed{FGF=-6.5\ KN}$ (C)

Q2) Determine the force in members BC, ek and KJ and state if these members are in tension or compression



1) $\Sigma fx=0$

$\boxed{HA=0}$

2) $\Sigma fy=0$

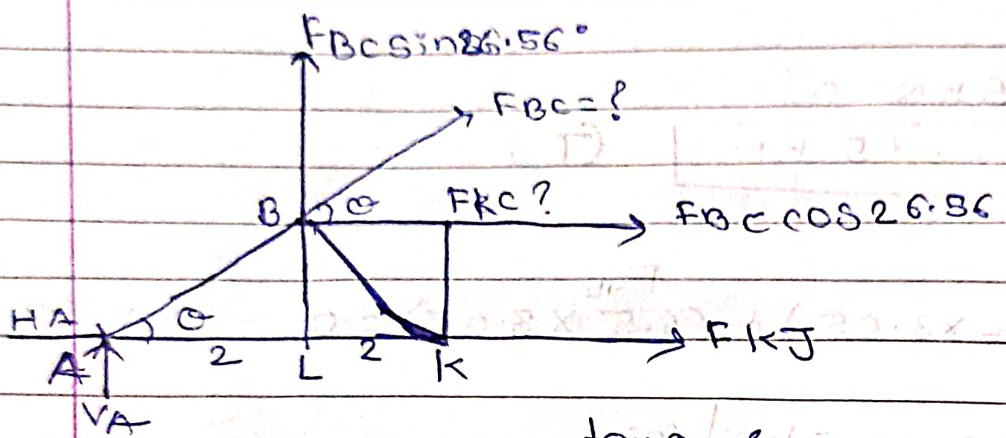
$VA+VG=12$ ... (1)

3) $\Sigma M_A = 0$

$+(4\times4) + (8\times6) - (V_G \times 12) = 0$

$V_G = 5.33\,kN$

$V_A = 6.67\,kN$



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

$\boxed{\theta = 26.56°}$

1) $\Sigma f_x = 0$

$F_{BC}\cos 26.56 + 0 + F_{KJ} = 0$

2) $\Sigma f_y = 0$

$F_{BC}\sin 26.56° + 6.67 + F_{KC} = 0$

3) $\Sigma M_A = 0$

$-(F_{BC}\sin 26.56 \times 2) + (F_{BC} \times \cos 26.56 \times 1) - (F_{KC}$

$-0.89\,F_{BC} + 0.89\,F_{BC} - F_{KC} \times 4 = 0$

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

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$F_{BC} \sin 26.56^{\circ} = -6.67$

$$F_{BC} = \frac{-6.67}{0.447} = -14.92 \text{ kN (C)}$$

$$\boxed{F_{BC} = -14.92 \text{ kN}} \text{(C)}$$

$F_{KJ} = 14.92 \cos 26.56$

$$\boxed{F_{KJ} = 13.34}$$

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* Cables:-

Cables are used in engineering structures to support different types of loads,

> They are commonly used in cranes transmission lines suspention bridges etc.

Normally cables are subjected to point load

* Assumption in cables:-

1) The material of cable is flexible but inextensible in nature
2) self weight of cables is neglacted
3) Cables are
4) All loads acting are verticle
5) Vertical as-well-as horizontal distance of one the external load is known from one support
6) Cable carries only tension.

* Steps for analysis of cable;

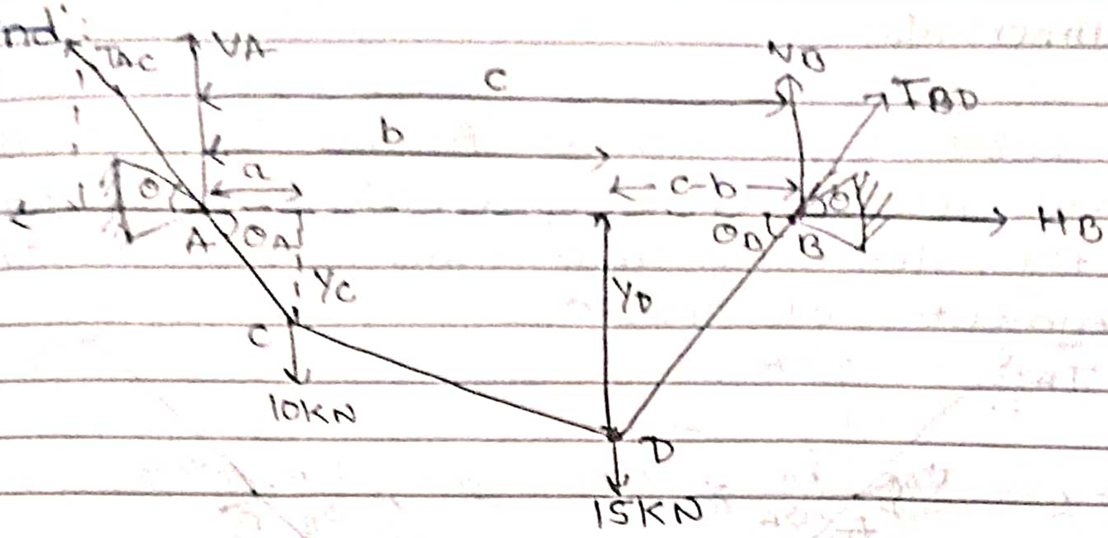
1) Draw FBD of complete cable and find support reactions
2) Support Reactions can be found out by using 3 equillibrium equations.

$$\Sigma f_x = 0 \; ; \; \Sigma f_y = 0 \; \& \; M_O = 0$$

3) For Fourth unknown consider -section bet^n any two points & take moment about that point is equal to zero (Take Moment either from left or right part).

4) Find Reactions at ends and it will equal to tension at that point

Q) Find:



1) $\Sigma fx = 0$

$\Sigma fy = 0$

$\Sigma MA = 0$

$\Sigma MB = 0$ OR

By Pythagoras theorm.

$$T_{BD} = R_B = \sqrt{H_A^2 + V_B^2}$$

$$T_{AC} = R_A = \sqrt{H_A^2 + V_A^2}$$

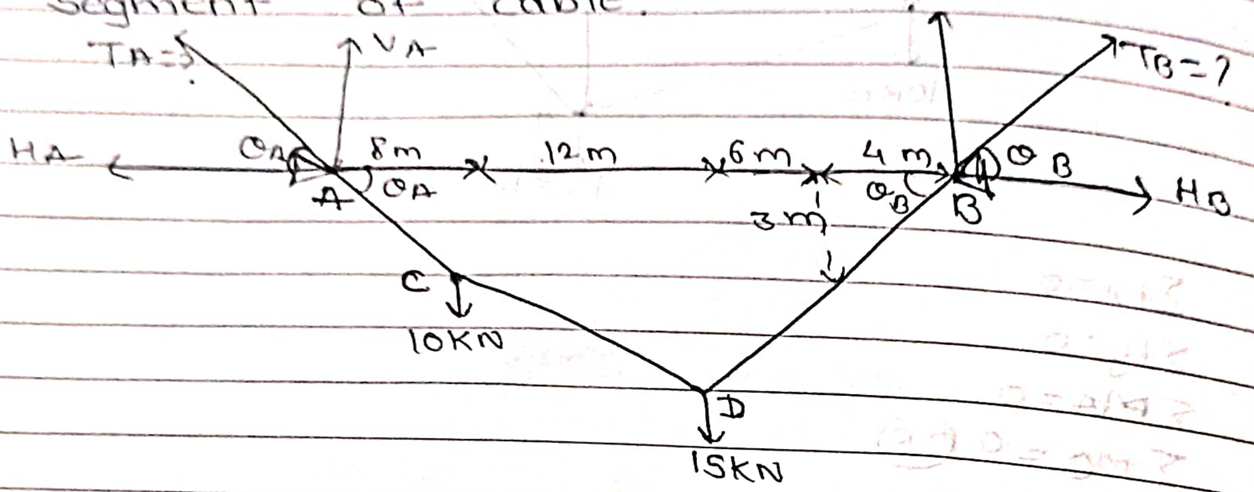
$\tan\theta_B = \frac{V_B}{H_B}$ $\qquad$ $\tan\theta_A = \frac{V_A}{H_A}$

$\tan\theta_B = \frac{Y_D}{c-b}$ $\qquad$ $\tan\theta_A = \frac{Y_C}{a}$

$\therefore \tan\theta_B = \frac{Y_D}{c-b} = \frac{V_B}{H_B}$ $\qquad$ $\therefore \tan\theta_A = \frac{V_A}{H_A} = \frac{Y_C}{a}$

* Numericals:

Q) A cable supported at A and B at the same level over a span of 30m as shown in fig. determine maximum tension in the segment of cable.



Soln Using equillibrium equations,

1) $\Sigma fx = 0$

$HA = HB$

2) $\Sigma fy = 0$

$VA + VB = 25\,KN \quad \dots (1)$

3) $\Sigma MA = 0$

$-(VB \times 30) + (10 \times 8) + (15 \times 20) = 0$

$\boxed{VB = 12.67\,KN}$

eqn (1)

$\boxed{VA = 12.33\,KN}$

4) $\Sigma M_B = 0$ OR

$\tan\theta_B = \frac{V_B}{H_B} = \frac{12.67}{H_B}$

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

$\frac{12.67}{H_B} = \frac{3}{4}$ $\quad H_B = 16.89$ KN

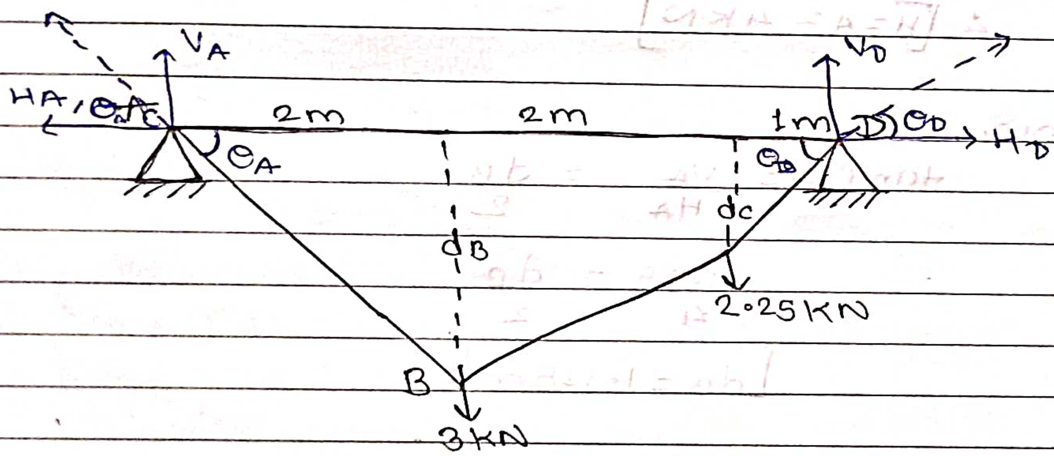
$H_A = 16.89$ KN

$T_B = R_B = \sqrt{(H_B)^2 + V_B^2}$

$\boxed{T_B = 21.11 \text{ KN}}$

$T_A = R_A = \sqrt{(H_A)^2 + V_A^2}$

$\boxed{T_A = 20.91 \text{ KN}}$



Q. Sol^n Using equillibrium equation.

$\Sigma f_x = 0$

$\boxed{H_D = H_A}$

2) $\Sigma f_y = 0$

$V_A + V_D = 5.25\ kN$

3) $\Sigma M_A = 0$

$-(V_D \times 5) + (2.25 \times 4) + (3 \times 2) = 0$

$\boxed{V_D = 3\ kN}$

from eqn ①

$\boxed{V_A = 2.25\ kN}$

$\tan\theta_D = \frac{V_D}{H_D} = \frac{0.75}{1}$

$\boxed{H_D = 4\ kN}$

$\therefore \boxed{H = A = 4\ kN}$

Now,

$\tan\theta_A = \frac{V_A}{H_A} = \frac{d_B}{2}$

$\frac{2.25}{4} = \frac{d_B}{2}$

$\boxed{d_B = 1.125\ m}$

Also,

$T_D = \sqrt{H_D^2 + V_D^2} = 5\ kN$

and

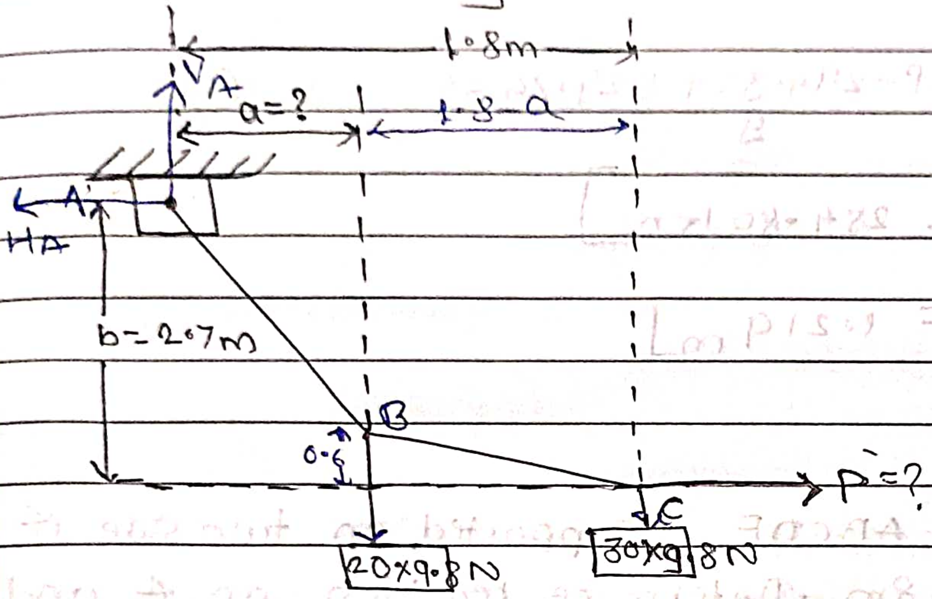
$T_A = \sqrt{H_A^2 + V_A^2} = 4.589\ kN$

Hence Tension is max at cable CD.

* Horizontal force → vertical distance

Cable :- Type 2

Q1 Cable ABC supports two boxes as shown in fig knowing that ~~b~~ = v = 2.7 m, determine the required magnitude of the horizontal force P and corresponding distance a



Soln

1) $\Sigma f_x = 0$

$$\boxed{H_A = P}$$

2) $\Sigma f_y = 0$

$$V_A = (20\times9.81) + (30\times9.81)$$

$$\boxed{V_A = 490.51 KN}$$

3) $\Sigma M_A = 0$

$$-(P\times2.7) + (20\times9.81\times a) + (30\times9.81\times1.8) = 0$$

$$-\underset{x}{2.7P} + \underset{y}{196.2a} + 529.74 = 0 \quad \ldots (1)$$

$\Sigma M_B = 0$

$+[30 \times 9.81 \times (1.8 - a)] - P \times 0.6 = 0$

$529.74 - 294.3a - 0.6P = 0$

$-0.6P - 294.3a + 529.74 = 0$ ... (2)

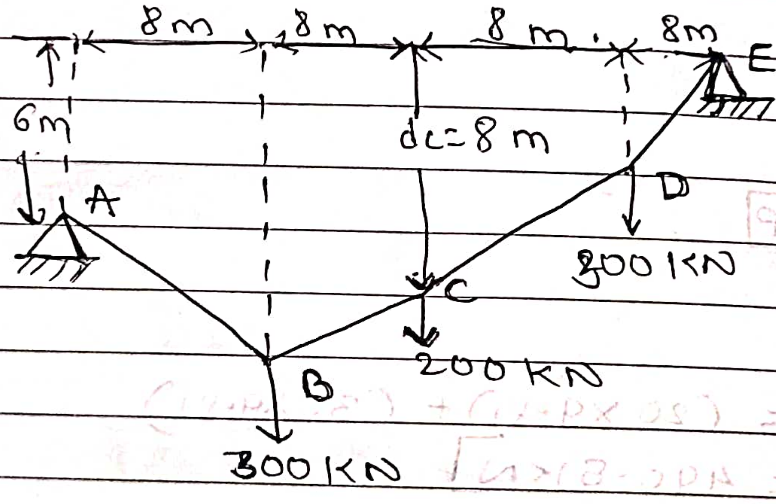
x y

Solving eq^n (1) & (2) in calc,

$\boxed{P = 284.80 \text{ kN}}$

$\boxed{a = 1.219 \text{ m}}$

Q2) Given ABCDE supported on two side if DC is equal to 8m. Determine reaction on A and



D

* FRAMES:-

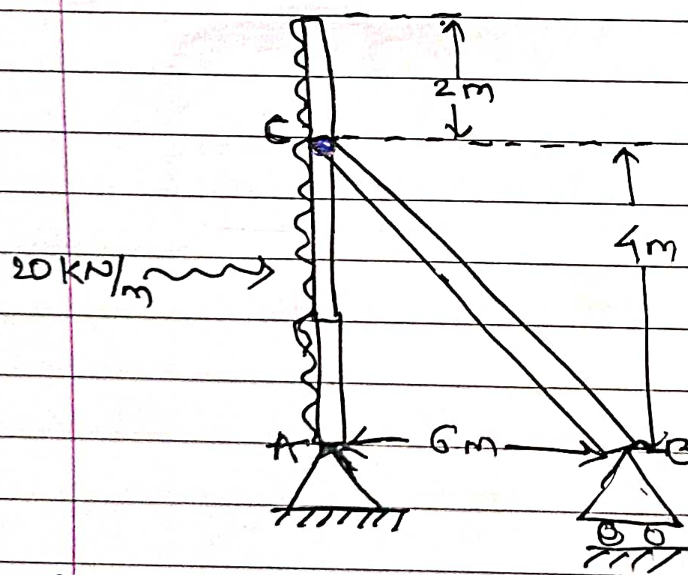
Frames are structures consisting of severlar members connected to each other out of which at least one member is multiforce member that means member having non co-axial force.

> A member which is subjected to two equal opposite and collinear forces are called as two force members

> Analysis of frame is done by using equation of equillibrium.

* Numerical

Q) Determine components of Reactions pin joint at point C for the frame as shown in figure



Sol^n

UDL to point load

= Load x length

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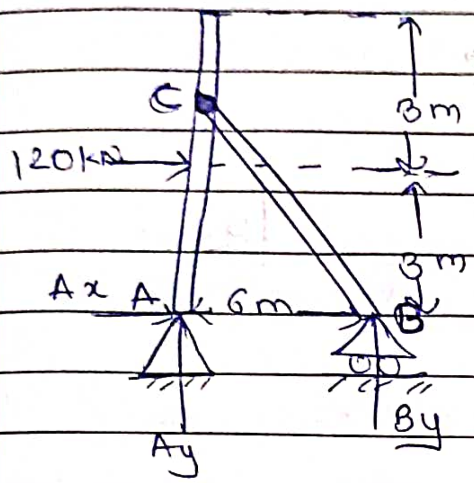
$= 20 \frac{kN}{m} \times 6 m$

$= 120$ kN (it will act at center of length)



1) $\Sigma f_x = 0$

$A_x + 120 = 0$

$\boxed{A_x = -120 kN}$

2) $\Sigma f_y = 0$

$A_y + B_y = 0$ ... (1)

3) $\Sigma M_A = 0$

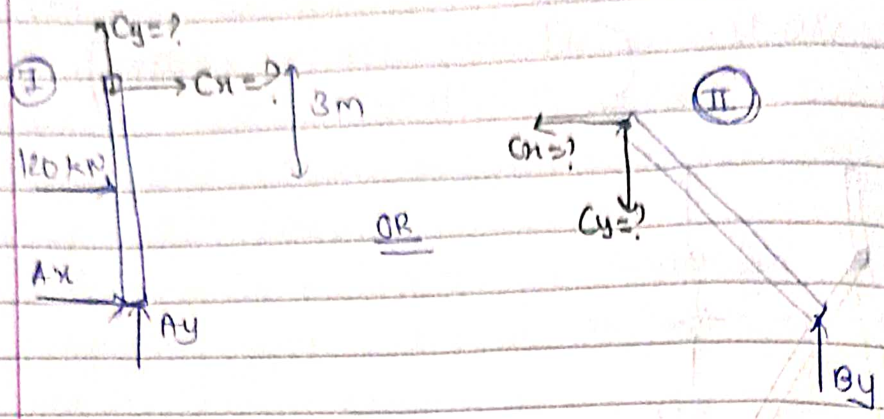
$(-B_y \times 6) + (120 \times 3) = 0$

$\boxed{B_y = 60 kN}$

from (1)

$\therefore \boxed{A_y = -60 kN}$

* Isolating both bars



From part (I)

$\Sigma f_x = 0$

$120 + A_x + C_x = 0$

$120 - 120 + C_x = 0$

$\boxed{C_x = 0}$

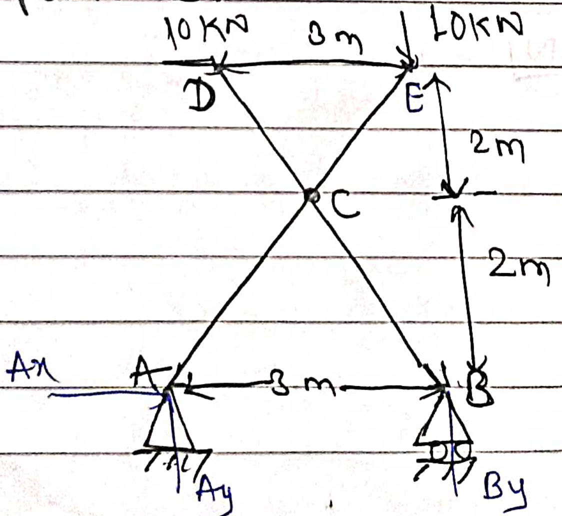
$\Sigma f_y = 0$

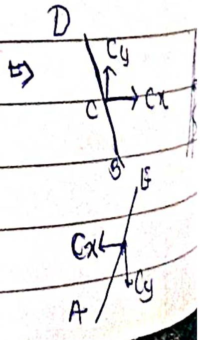
$C_y + \overset{-60}{A_y} = 0$

$C_y - 60 = 0$

$\boxed{C_y = 60\,kN}$

Q) Find reactions at A and B and Forces at pin point C.





Soln 1) $\Sigma fx = 0$

$Ax + 10 = 0$

$\boxed{Ax = 10 \text{ kN}}$

2) $\Sigma fy = 0$

$Ay + By - 10 \text{ kN} = 0$

$Ay + By = 10 \text{ kN} \quad \dots \text{ (1)}$

3) $\Sigma MA = 0$

$-(By \times 3) + (10 \times 4) - (10 \times 3) = 0$

$-By \times 3 + 40 - 30 = 0$

$-By \times 3 + 10 = 0$

$By = \frac{10}{3}$

$\boxed{By = 3.33} \text{ kN}$

From (1)

$Ay = 10 - 3.33$

$Ay = 6.67 \text{ kN}$

Unit

3.

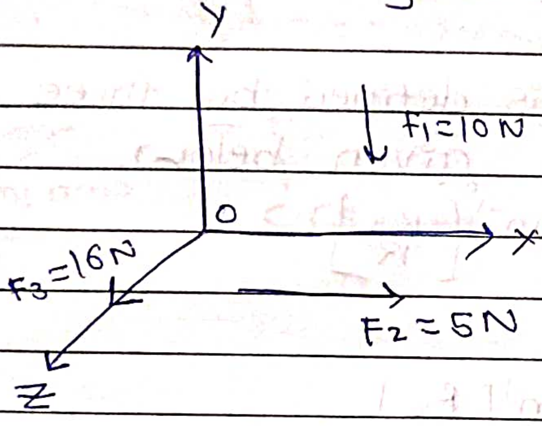
* ~~Space:-~~

~~Forces as vecto~~

* Forces as vector in 3D

For expressing force in terms of unit vectors i, j, k along $x, y,$ and z axis are given below.

i) Forces parallel to x, y and z axis



$\hat{i}$ $\hat{j}$ $\hat{k}$
↓ ↓ ↓
x y z

$F_1 = (-10\hat{j})N$

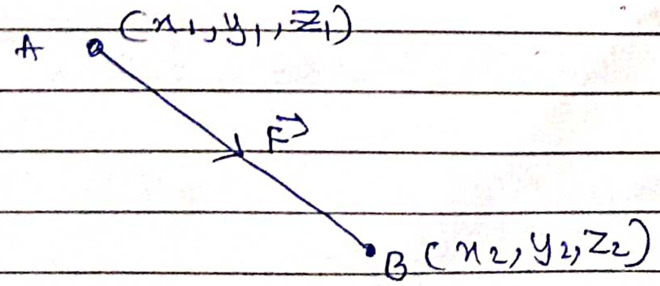
$\vec{F_2} = (+5\hat{i})\ N$

$\vec{F_3} = +(15\hat{k})N$

ii) Two points on the line of action when know

~~Consider a force F~~

Consider a force F is directed from A to B then unit vector from A to B is



$$\vec{F} = F_{mag} \times \hat{e}_{AB}$$

mag direcⁿ

$$= F \times \left[\frac{(x_2-x_1)i+(y_2-y_1)j+(z_2-z_1)k}{\sqrt{(x_2-x_1)^2+(y_2-y_1)^2+(z_2-z_1)^2}}\right]$$

★ Concurrent Force System :-

> Resultant of Concurrent force system can be found out by using

$$R_x = \Sigma f_x$$

$$R_y = \Sigma f_y$$

$$R_z = \Sigma f_z$$

$$\left[\therefore R = \sqrt{R_x^2 + R_y^2 + R_z^2}\right]$$

> Direction of R is defined by three angles with co-ordinate axis given below.

$$\theta x = \tan^{-1}\left[\frac{R_x}{R}\right]$$

Similarly

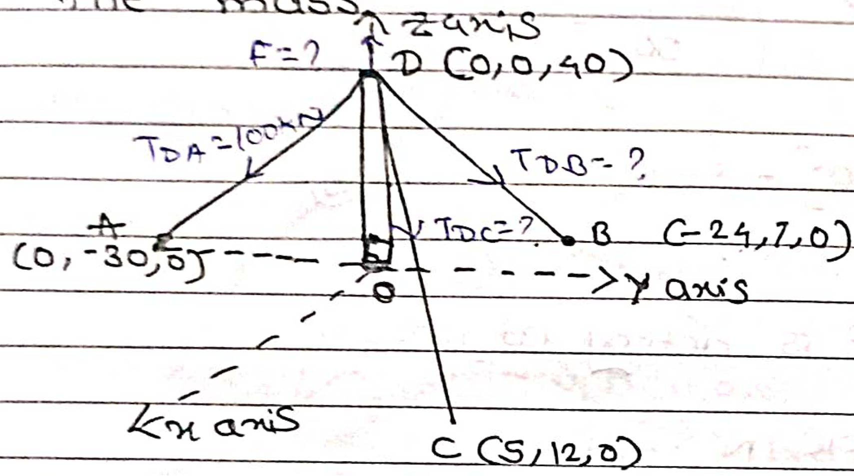
$$\theta y = \tan^{-1}\left[\frac{R_y}{R}\right]$$

$$\theta z = \tan^{-1}\left[\frac{R_z}{R}\right]$$

> Equation of equillibrium for concurent force system $\Sigma f_x = 0$, $\Sigma f_y = 0$, $\Sigma f_z = 0$.

* Type-1 Numerical; To find forces in Concurrent force system:-

Q1) A vertical mass OD is having base O. Three cables DA, DB & DC kept the mass in equillibrium, tension in cable DA is 100 kN Find Tension in cable DC and DB and Force in the mass.



Soln ~~F~~ Given

$T_{DA} = 100 kN$

$F = ?$

$T_{DB} = ?$ $T_{DC} = ?$

Step (I) :- $\vec{T}_{DB} = T_{DB} \times \hat{e}_{DB}$

$$\vec{T}_{DB} = T_{DB} \times \left[\frac{(-24-0)\hat{i} + (7-0)\hat{j} + (0-40)\hat{k}}{\sqrt{(-24-0)^2 + (7-0)^2 + (0-40)^2}} \right]$$

$$\vec{T}_{DB} = T_{DB} \times \frac{-24\hat{i} + 7\hat{j} - 40\hat{k}}{47.17} \quad \text{—} (1)$$

$$\vec{T}_{DC} = T_{DC} \times \hat{e}_{DC}$$

$$T_{DC} = T_{DC} \times \left[\frac{(5-0)\hat{i} + (12-0)\hat{j} + (0-40)\hat{k}}{\sqrt{(5-0)^2 + (12-0)^2 + (0-40)^2}} \right]$$

$$\vec{T_{DC}} = T_{DC} \times \frac{5\hat{i} + 12\hat{j} - 40\hat{k}}{42.05} \quad -(2)$$

$$\vec{T_{DA}} = T_{DA} \times \left[\frac{(0-0)\hat{i} + (-30-0)\hat{j} + (0-40)\hat{k}}{\sqrt{(0-0)^2 + (-30-0)^2 + (0-0)^2}} \right]$$

$$\vec{T_{DA}} = 100 \times \left[\frac{0\hat{i} - 30\hat{j} - 40\hat{k}}{50} \right]$$

$$T_{DA} = -60\hat{j} - 80\hat{k} \text{ KN} \quad \ldots (3)$$

Let force 'F' is acting at mass k.

$$\vec{F} = (F\hat{k}) \text{ N} \quad \ldots (4)$$

Step II :- (1) $\Sigma f_x^{\hat{i}} = 0$

$$\frac{-24 T_{DB}}{47.17} + \frac{5 T_{DC}}{42.06} = 0 \quad -(5)$$

(2) $\Sigma f_y^{\hat{j}} = 0$

$$-60 + \frac{7 T_{DB}}{47.17} + \frac{12 T_{DC}}{42.06} = 0 \quad -(6)$$

(3) $\Sigma f_z^{\hat{k}} = 0$

$$-80 - \frac{40 T_{DB}}{47.17} - \frac{40 T_{DC}}{42.06} + F = 0 \quad -(7)$$

By Calculator.

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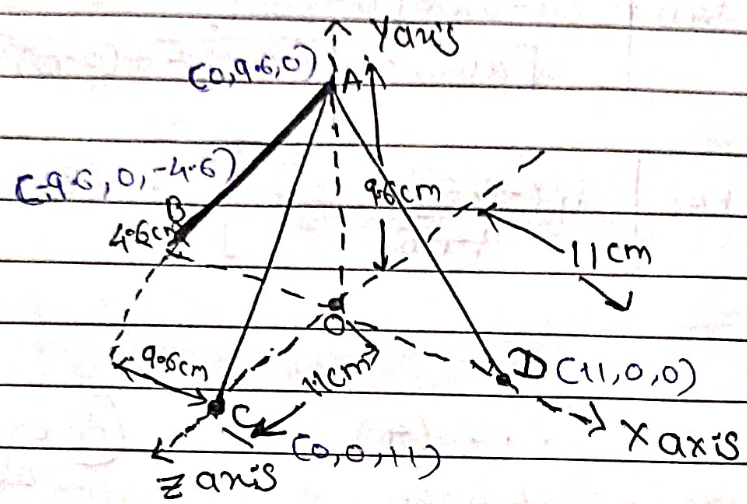
$$\boxed{\begin{aligned} T_{DB} &= 48.81 \\ T_{DC} &= 187.512 \end{aligned}}$$

Q) Support Asembly shown in fig is bolted at point B, C and D. Supporting downward force of 45 N at A. Determine forces in member AB, AC and AD.



Sol^n

x y z

A (0, 9.6cm, 0)

B (-9.6cm, 0, -4.6 cm)

C (0, 0, +11)

D (+11, 0, 0)

Step I :-

$$\vec{F}_{AB} = F_{AB}\left[\frac{(-9.6-0)\hat{i} + (0-9.6)\hat{j} + (-4.6-0)\hat{k}}{\sqrt{(-9.6-0)^2 + (0-9.6)^2 + (-4.6-0)^2}}\right]$$

$$= F_{AB}\left(\frac{-9.6\hat{i} - 9.6\hat{j} - 4.6\hat{k}}{14.33}\right) \quad \cdots (1)$$

$$= \frac{-9.6\hat{i}\,F_{AB}}{14.33} - \frac{9.6\hat{j}\,F_{AB}}{14.33} - \frac{4.6\hat{k}\,F_{AB}}{14.33}$$

$$\vec{F}_{AC} = F_{AC}\left[\frac{(0-0)\hat{i}+(0-9.6)\hat{j}+(11-0)\hat{k}}{\sqrt{0^2+(0-9.6)^2+(11-0)^2}}\right]$$

$$= F_{AC}\left[\frac{0\hat{i}-9.6\hat{j}+11\hat{k}}{14.6}\right] \quad \ldots (1)$$

$$\vec{F}_{AD} = F_{AD}\left[\frac{(11-0)\hat{i}+(0-9.6)\hat{j}+(0-0)^2\hat{k}}{\sqrt{(11-0)^2+(0-9.6)^2+(0-0)^2}}\right]$$

$$\vec{F}_{AD} = F_{AD}\left[\frac{4\hat{i}-9.6\hat{j}+0\hat{k}}{14.6}\right] \quad \ldots (3)$$

Now

$$F = -45\hat{j}\ N \quad \ldots (4)$$

(downward along z)

Step (II) :-

1) $\Sigma f_x = 0$

$$-\frac{9.61 F_{AB}}{14.33} + \frac{11 F_{AD}}{14.6} = 0 \quad -(5)$$

2) $\Sigma f_y = 0$

$$-\frac{9.61 F_{AB}}{14.33} - \frac{9.6 F_{AC}}{14.6} - \frac{9.6 F_{AD}}{14.6} - 45 = 0 \quad -(6)$$

3) $\Sigma f_z = 0$

$$-\frac{4.6 F_{AB}}{14.33} + \frac{11 F_{AC}}{14.6} = 0 \quad -(7)$$

F_{AB}

By Solving equation ⑤, ⑥ & ⑦

$F_{AB} = -29.03$ N

$F_{AD} = -25.81$ N

$F_{AC} = -12.37$ N

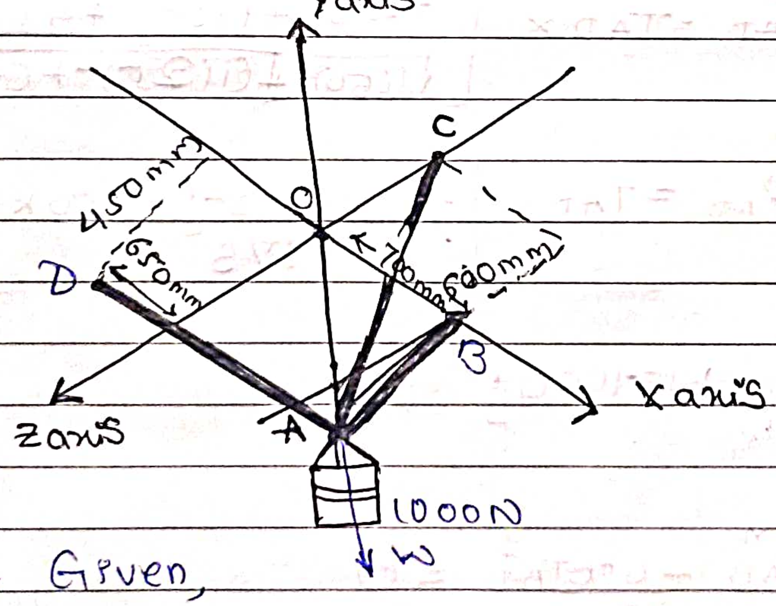
Since ans are coming in "-ve" assumed direction can be reversed

$F_{BA} = 29.3$ N

$F_{DA} = 26.07$ N

$F_{AC} = 12.49$ N

Three cables are used to support a containe as shown in fig determine Tension force in each cable if weight of controller is 1000 N



Soln ~~AC~~ Given,

$l(OA) = 1125$ mm

$l(OC) = 600$ mm

A (0, -1125, 0)
B (700, 0, 0)
C (00, 0, -600)
D (-650, 0, 450)
W = 1000 j

Step I :-

$$\vec{T}_{AB} = T_{AB} \times \left[\frac{(700-0)\hat{i} + (0+1125)j + (0-0)k}{\sqrt{(700-0)^2 + (0+1125)^2 + (0)^2}}\right]$$

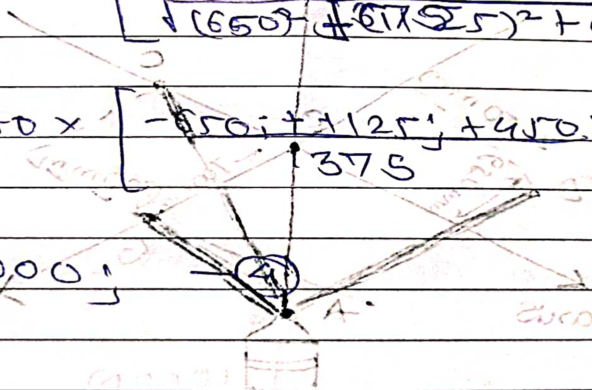
$$T_{AB} \times \left[\frac{700i + 1125j + 0k}{1325}\right] \quad \text{--- (1)}$$

$$\vec{T}_{AC} = T_{AC} \times \left[\frac{(0-0)i + (0+1125)j + (-600-0)k}{\sqrt{0^2 + (+1125)^2 (-600-0)^2}}\right]$$

$$\vec{T}_{AC} = T_{AC} \times \left[\frac{0i + 1125j - 600k}{1275}\right] \quad \text{--- (2)}$$

$$\vec{T}_{AD} = T_{AD} \times \left[\frac{-650i + 1125j + 450k}{\sqrt{(650)^2 + (1125)^2 + (450)^2}}\right]$$

$$\vec{T}_{AD} = T_{AD} \times \left[\frac{-650i + 1125j + 450k}{1375}\right] \quad \text{--- (3)}$$



W = -1000 j (4)

1) $\Sigma F_x = 0$

$$\frac{700 T_{AB}}{1325} - \frac{650 T_{AD}}{1375} = 0$$

$\Sigma f_y = 0$

2) $\frac{1125\,T_{AB}}{1325} + \frac{1125\,T_{AC}}{1275} + \frac{1125\,T_{AD}}{1375} - 1000 = 0$

3) $\Sigma f_z = 0$

$\frac{-600\,T_{AC}}{1275} + \frac{450\,T_{AD}}{1375} = 0$

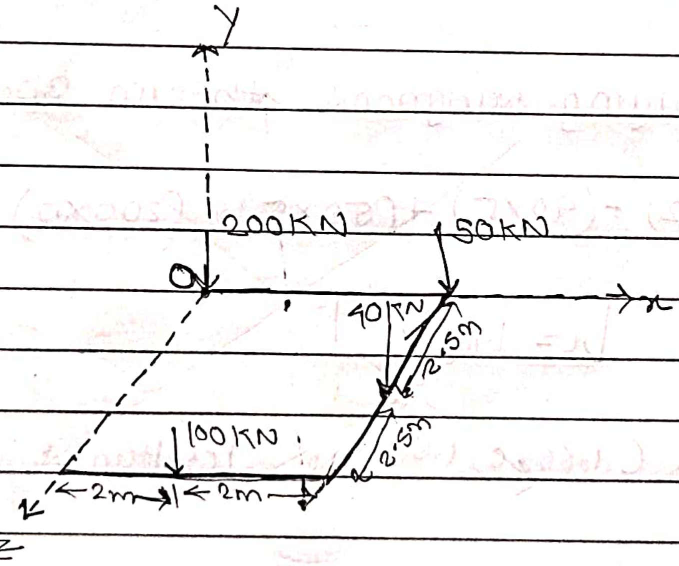
$T_{AB} = 408.29$

$T_{AD} = 456.29$

$T_{AC} = 317.33$

* Type - 2 Parallel Force System:

Q1) Square mat foundation supports four ~~colon~~ columns as shown in fig. Determine magnitude and position of resultant force w.r.t origin.

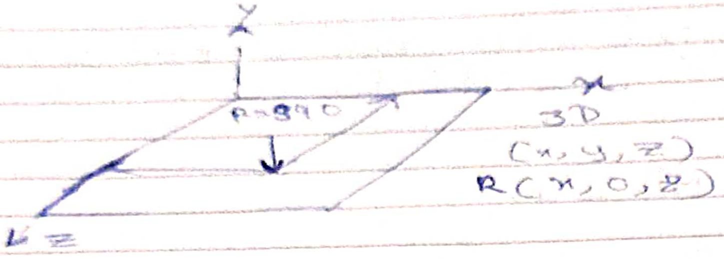


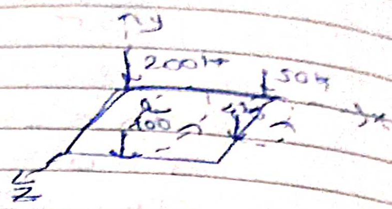
Sol^n

$R_y = \Sigma f_y = -200 - 50 - 40 - 100 = -390$ KN $(\downarrow)$

$\therefore (R_x = R_z = 0)$

R → mag
→ position





Now applying varignon's theorm about z axis

ACLK $-(40\times 2.5)-(100\times 5)+(200\times 0)+(80\times 0)=-390\times z$

$$-600=-390\times z$$

$$\boxed{z=1.53}$$

Now applying varignon's theorm about z axis

$$(100\times 2)+(40\times 5)+(50\times 5)+(200\times 0)=390\times x$$

$$\boxed{x=1.667\,m}$$

$R(1.66, 0, 1.53)$ resultan co-ordinat

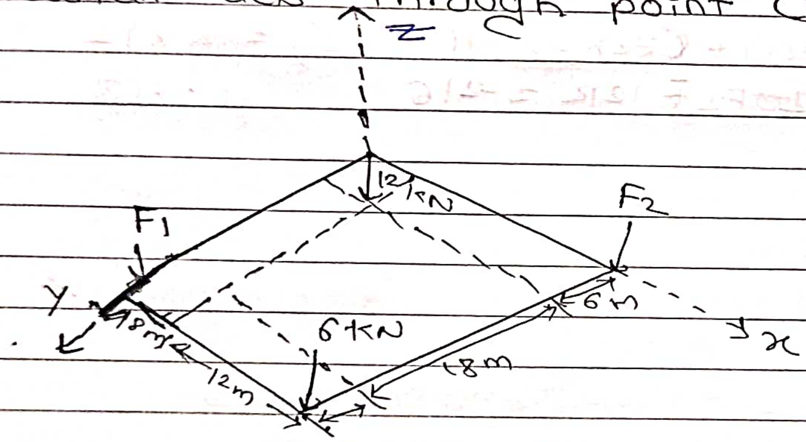
* Note:-

1. Axis in which all forces are given then resultant will act in that axis only
2. Resultant need three coordinates to locate if it acts on y axis then y coordinate will be zero

if it acts in z axis then z co-ordinate will be zero, & for x-axis x co-ordinate will be zero.

3. Moment about z axis gives x co-ordinate
Moment about x axis gives z co-ordinate
in x-z plane.
Similarly in x-y plane wit Moment about y-axis will give x-co-ordinate & vice vera.

Q) Builing slap is subjected to four parallel colum as shown in fig determine force F_1 & F_2 if resultant acts through point (12m, 10m)



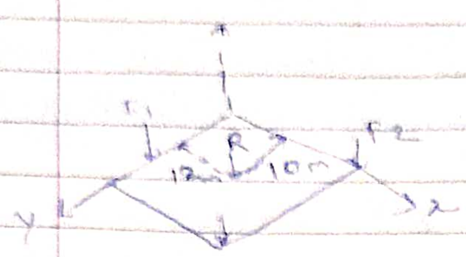
Soln Given,

R (12m, 10m)
R = ?
$F_1, F_2 = ?$

$R_z = \Sigma F_z = -F_1 - F_2 - 6 - 12$ —— (1)

$R + F_1 + F_2 = 28$

$\therefore (R_x = R_y = 0)$



Plane is x-y

Applying V.T about x-axis.

$-(12\times6)-(F_1\times24)-(6\times28) = -R\times10$

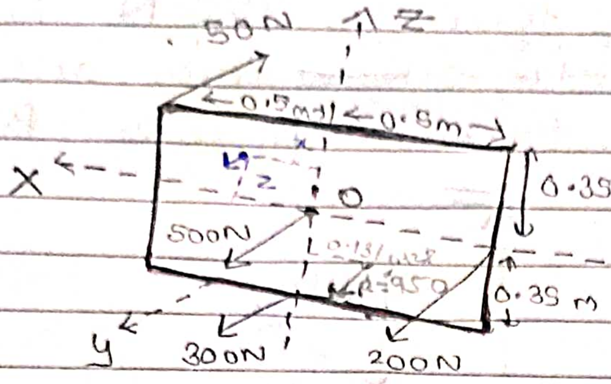
$\Rightarrow -24f_1+10R=240 \quad \ldots (2)$

Applying V.T about y-axis.

$+(6\times20)+(F_2\times20)+(12\times8) = R\times12$

$20F_2 \mp 12R = -216 \quad \ldots (3)$

Q) Determine resultant of parallel force ~~dif~~ system which acts on the plate as shown in figure



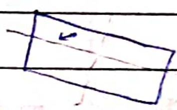
Solⁿ

~~Rest~~ $R_y = \Sigma f_y = 500 + 300 + 200 - 50 =$

$R = 950N$

Now

$R(x, 0, z)$



Varignon's Theorm about x-axis :-

$+(50 \times 0.35) + (300 \times 0.35) = -R \times z$

$122.5/950 = -z$

$\boxed{z = -0.128m}$

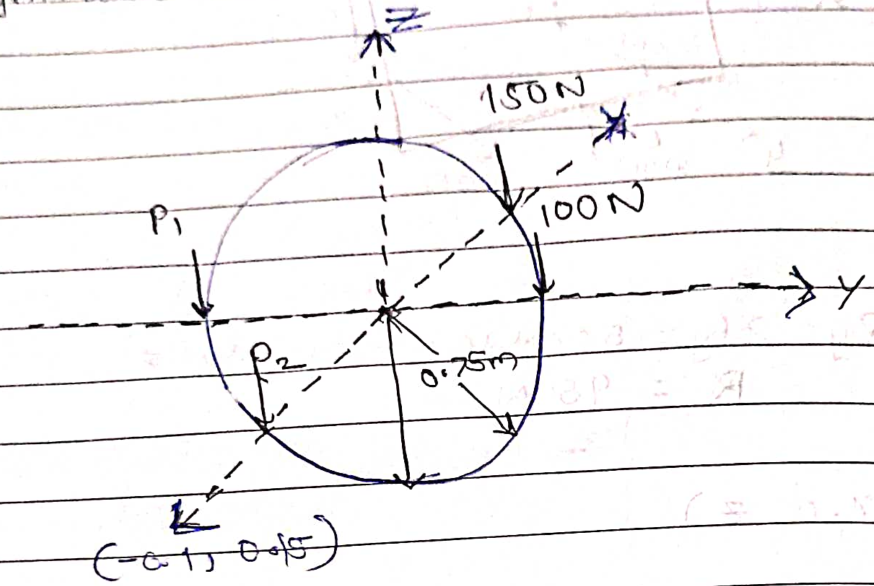
Varignon's Theorm about z axis.

$+(50 \times 0.5) + (200 \times 0.85) = -R \times x$

$\therefore \frac{125}{950} = x$

$\boxed{x = -0.131\,m}$

Q) Four parallel volting forces act on the rim of circular corner plate as shown in figure. If resultantat force is 750 N is passing through ~~(0.1 m, 0.15m)~~ (0.15, 0.1m) from origin O determine magnitude of force of ~~P_1 & P_2~~ P_1 & P_2



Soln Given,

$R = 750 N$

$R (0.1 m, 0.15 m, 0)$

$R_z = \Sigma f_z = -150 - 100 - P_1 - P_2$

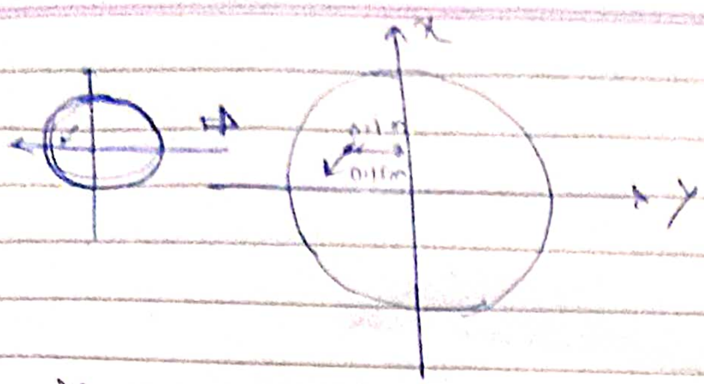
$P_1 - P_2 - 350 = -750$

$P_1 + P_2 = 500$ ... (1)

~~Varignon's theorm about X-X plane -~~

~~$-(P_1 \times 0.75) + (100 \times 0.75) + (150 \times 0) - (P_2 \times 0)$~~

~~$P_1 = -250$~~



Varignon's Theorem about x–x–axis.

$$-(P_1 \times 0.75) + (100 \times 0.75) = -\cancel{R}^{750} \times 0.1$$

$$\boxed{P_1 = 200 N}$$

$$\therefore \boxed{P_2 = 300 N}$$