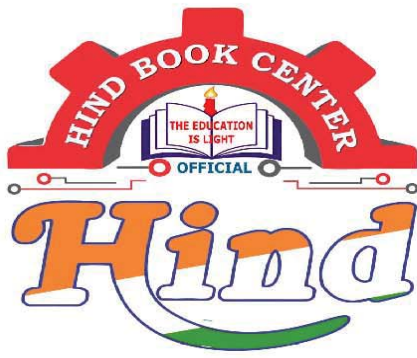




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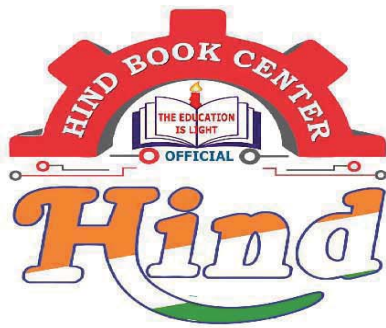
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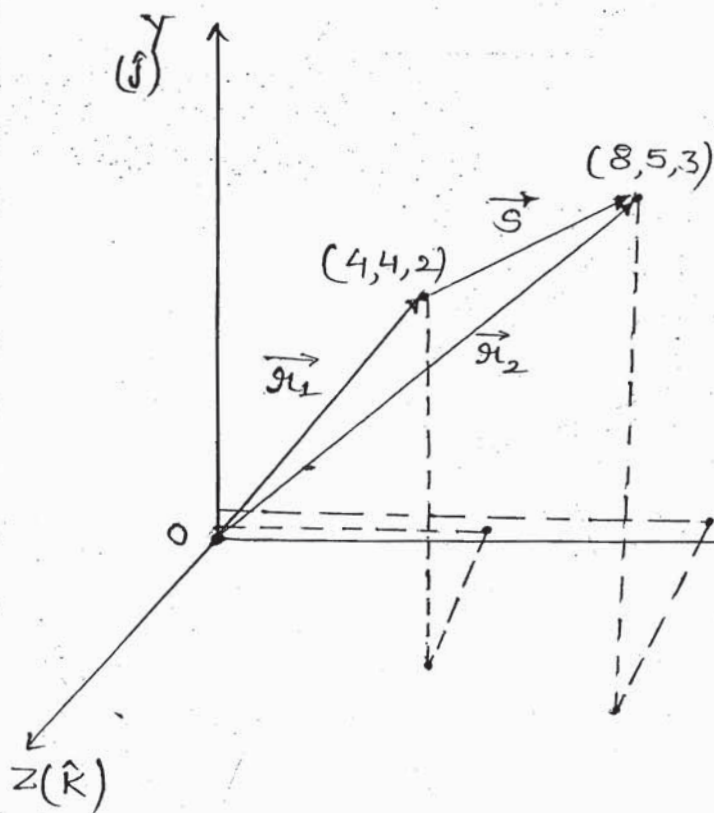
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(1)

VECTOR CALCULUS

origin pt.: Pt. wch is fix in space.

 $\vec{r}$: Position Vector.Vector: Only when it should follow Δ^{th} law of addⁿ. r : Magnitude $\vec{s}$: Displacement Vector
or
change in position vector

$$\vec{r}_1 = x_1 \hat{i} + y_1 \hat{j} + z_1 \hat{k}$$

$$\vec{r}_1 = (4\hat{i} + 4\hat{j} + 2\hat{k})$$

$$r_1 = \sqrt{4^2 + 4^2 + 2^2}$$

$$\vec{r}_2 = (8\hat{i} + 5\hat{j} + 3\hat{k})$$

From Δ Law:

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

(tail to head) (head to head)
add resultant

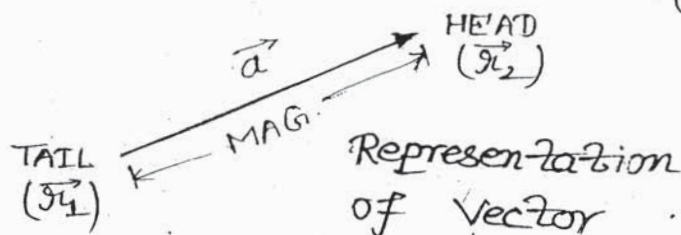
$$\vec{s} = \vec{r}_2 - \vec{r}_1 = 4\hat{i} + \hat{j} + \hat{k}$$

$$\frac{d\vec{s}}{dt} = \frac{dx}{dt} \hat{i} + \frac{dy}{dt} \hat{j} + \frac{dz}{dt} \hat{k}$$

$$\vec{v} = u\hat{i} + v\hat{j} + w\hat{k}$$

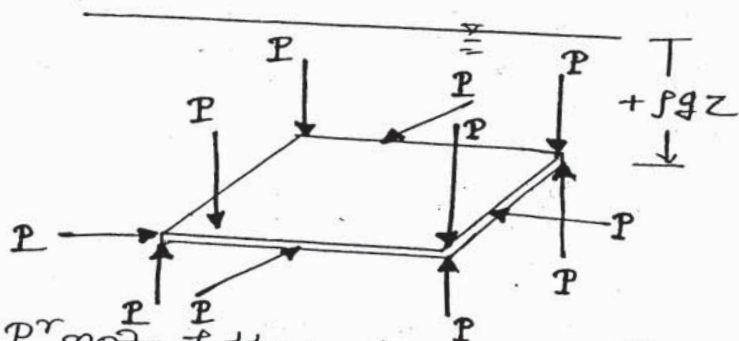
Vector is the physical quantity wch is having both Magnitude as well as dirⁿ & it should obeys Δ^{th} law of vector addition.

NOTE: Some physical quantity have both magnitude as well as dirⁿ but they are not obeying Δ^{th} law of vector addition (Ex: Pressure, Current)



EX' PRESSURE

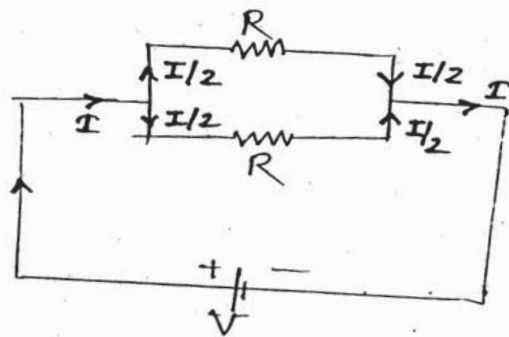
- Scalar Quantity
- External



P not follow Δ law so it is not cancel each other components, so on the surface always acts P (P).

* STRESS → Tensor Quantity
→ Internal

CURRENT

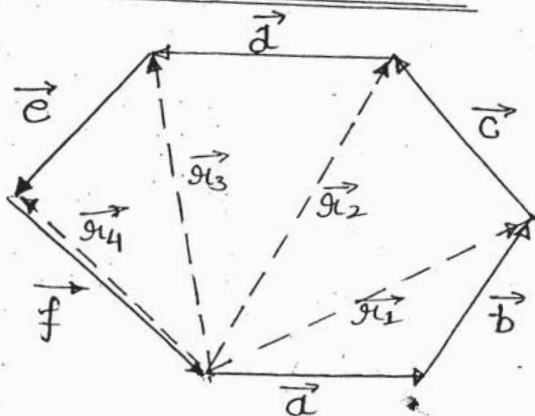


Current also not a vector quantity.

∴ $I/2$ & $I/2$ not cancel each other & they make by add current (I)

LAWS OF VECTOR

1) POLYGON LAW



$$\vec{R}_1 = \vec{a}_1 + \vec{b}_1$$

$$\vec{R}_2 = \vec{R}_1 + \vec{c} = (\vec{a} + \vec{b}) + \vec{c}$$

$$\vec{R}_3 = \vec{a} + \vec{b} + \vec{c} + \vec{d}$$

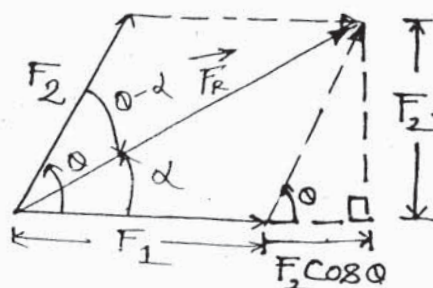
$$\vec{R}_4 = \vec{a} + \vec{b} + \vec{c} + \vec{d} + \vec{e} \quad \text{--- (1)}$$

$$0 = \vec{a} + \vec{b} + \vec{c} + \vec{d} + \vec{e} + \vec{f} \quad \text{--- (2)}$$

$$\vec{R}_4 = -\vec{f}$$

"Negative Vector"

2) PARALLOGRAM LAW



$$F_R = \sqrt{(F_1 + F_2 \cos \theta)^2 + (F_2 \sin \theta)^2}$$

Magnitude:

$$F_R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2 \cos \theta}$$

Direction:

$$\tan \alpha = \frac{F_2 \sin \theta}{(F_1 + F_2 \cos \theta)}$$

c.s. 2006

Q.1 When 2 forces F_1 & F_2 mutually at right angle then their resultant is 10 KN. When they incline at 60° , the " " $5\sqrt{6}$ KN. Then determine the magnitude of the individual forces!

A) 4 KN, 6 KN B) 6 KN, 8 KN

C) $\sqrt{50}$ KN, $\sqrt{50}$ KN D) $\sqrt{25}$ KN, $\sqrt{75}$ KN

Sol^m: $\theta = 90^\circ$, $F_R = 10$ KN

$\theta = 60^\circ$, $F_R = 5\sqrt{6}$ KN.

$$(10)^2 = F_1^2 + F_2^2$$

$$F_1^2 + F_2^2 = 100 \quad (1)$$

Put F_2

$$F_1^2 + \left(\frac{50}{F_1}\right)^2 = 100$$

$$F_1^4 + 2500 = 100 F_1^2$$

$$F_1^4 - 100 F_1^2 + 2500 = 0$$

$$F_1^2 = \frac{100 \pm \sqrt{(100)^2 - 4(2500)}}{2}$$

$$F_1^2 = \frac{100}{2} = 50$$

$$F_1 = \sqrt{50} \text{ KN} \quad \text{Ans.}$$

$$(5\sqrt{6})^2 = F_1^2 + F_2^2 + \left(\frac{1}{2}\right) F_1 F_2 \times 2 \cos 60^\circ$$

$$150 = 100 + \frac{1}{2} F_1 F_2$$

$$F_1 F_2 = 100 \quad (2)$$

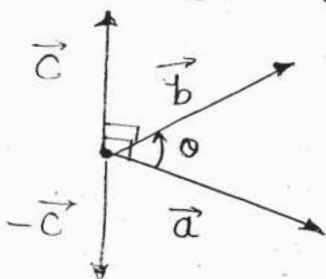
$$F_2 = \frac{50}{F_1}$$

$$\left\{ \begin{array}{l} \text{Let } F_1^2 = x \\ \therefore x^2 - 100x + (50)^2 \\ \text{(or)} (x - 50)^2 = 0 \end{array} \right\} \therefore$$

$$F_2 = \frac{50}{\sqrt{50}} = \sqrt{50} \text{ KN} \quad \text{Ans}$$

CROSS PRODUCT

The dirⁿ of the cross product is always $\perp$ to the plane wch contains vector $\vec{a}$ & $\vec{b}$ & its dirⁿ is given by "Right Hand Thumb Rule (RHTR)".



$$\vec{c} = \vec{a} \times \vec{b} = ab \sin \theta \cdot \hat{n}$$

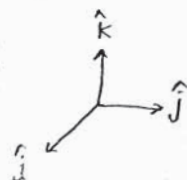
Unit Vector $\rightarrow$

$\rightarrow$ R.H.T.R.

$$\hat{i} \times \hat{i} = 1 \times 1 \times \sin 0 = 0 = \hat{j} \times \hat{j} = \hat{k} \times \hat{k}$$

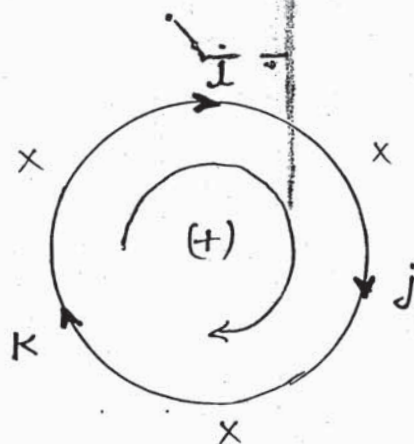
$$\hat{i} \times \hat{j} = 1 \times 1 \times \sin 90^\circ \cdot \hat{k} = \hat{k}$$

$$\hat{j} \times \hat{i} = 1 \times 1 \times \sin 90^\circ (-\hat{k}) = -\hat{k}$$



$$\hat{j} \times \hat{k} = 1 \times 1 \sin 90^\circ \cdot \hat{i} = \hat{i}$$

$$\begin{aligned} * \quad & \vec{a} \times \vec{b} \neq \vec{b} \times \vec{a} \\ & |\vec{a} \times \vec{b}| = |\vec{b} \times \vec{a}| \end{aligned}$$



$$\begin{aligned} \text{Ex: } \vec{a} &= 2\hat{i} + 3\hat{j} + 4\hat{k} \\ \vec{b} &= 3\hat{i} - 4\hat{j} + 2\hat{k} \end{aligned}$$

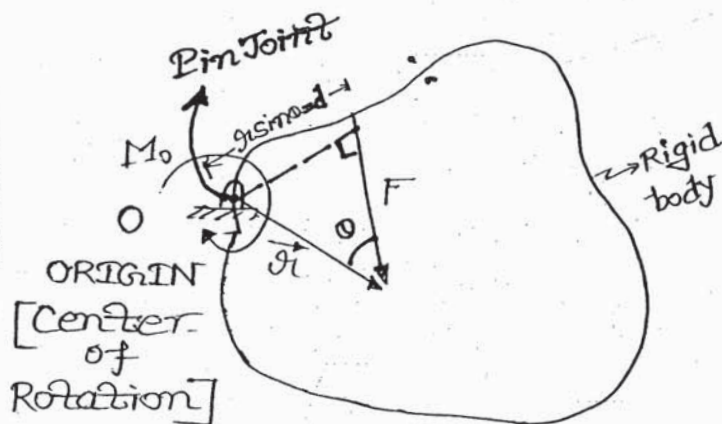
$$\begin{aligned} \vec{c} = \vec{a} \times \vec{b} &= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 3 & 4 \\ 3 & -4 & 2 \end{vmatrix} = \hat{i}(6+16) + \hat{j}(12-4) + \hat{k}(-8-9) \\ &= 22\hat{i} + 8\hat{j} - 17\hat{k} \end{aligned}$$

{ i.e. $\vec{c}$ is $\perp$ to $\vec{a}$ & $\vec{b}$ }

Force Vector Position Vector

TORQUE (or) MOMENT

$$\vec{M}_0 = \vec{r} \times \vec{F} = r F \sin \theta \cdot \hat{n} = Fd$$



$$\begin{cases} \sin \theta = \frac{\text{For}}{\text{Projection}} \\ \cos \theta = \text{Projection} \end{cases}$$

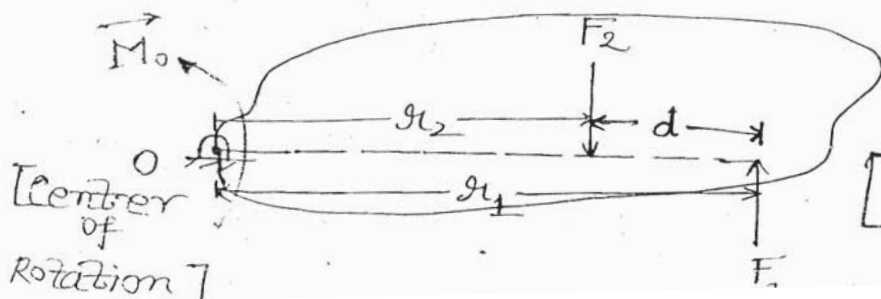
COUPLE

Couple is an arrangement of 2 equal & opp. forces acting $\perp$ to each other & its moment remain uniform throughout the body.

$$M_0 = r_1 F_1 - r_2 F_2$$

$$\text{if } F_1 = F_2 = F$$

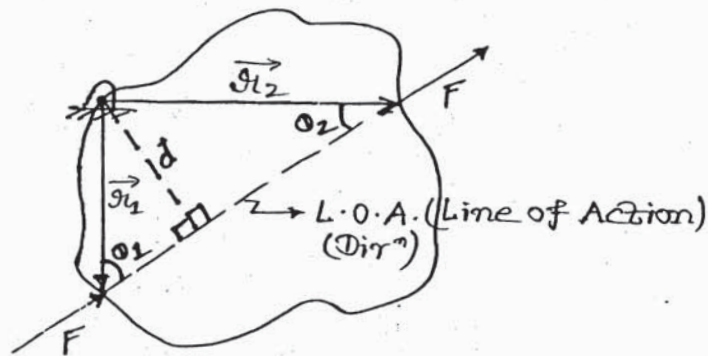
$$M_0 = F(r_1 - r_2)$$



$$\vec{C} = \vec{F}d$$

Anti clock Wise Couple

LAW OF TRANSMISSIBILITY



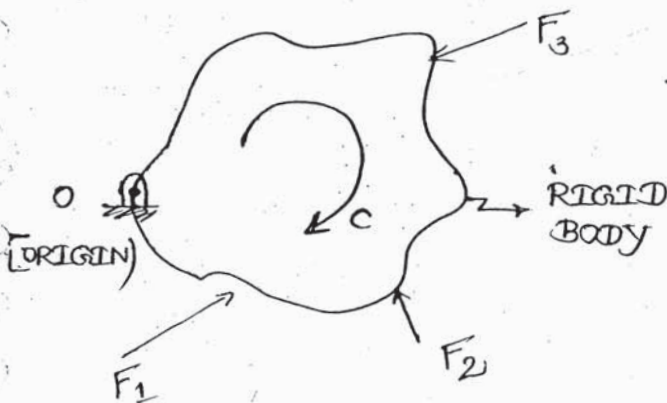
* Truss always at static eqm.

STATIC EQUILIBRIUM

If a body is in static eqm then all d forces & the moment abt any pt. is zero.

Free Body Diagram [F.B.D.] →

It is the Diagram of an Isolated body by showing all the external as well as internal forces & support rxn by removing support.

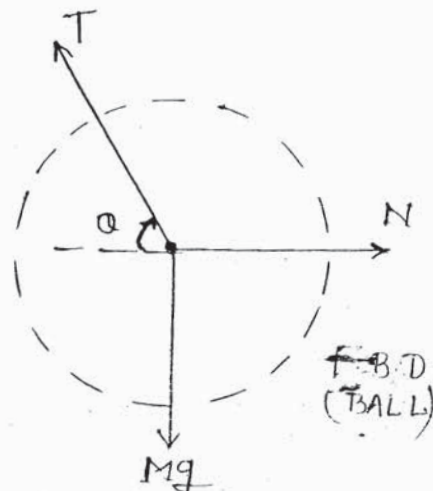
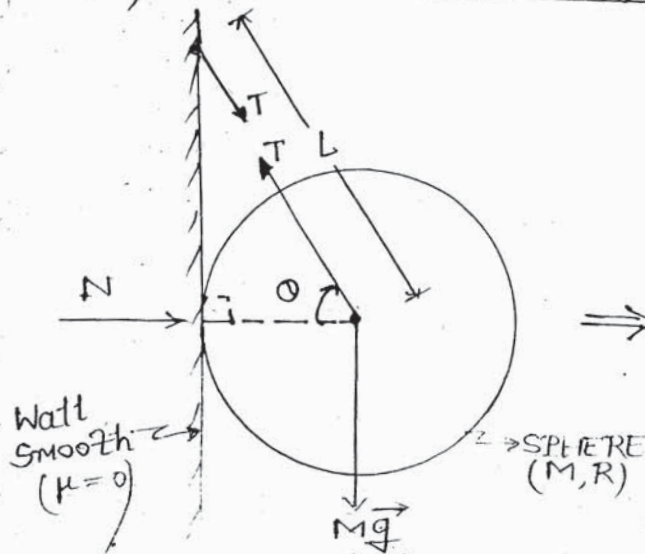


Static - Equilibrium

$$\sum \vec{F} = 0 \Rightarrow \begin{cases} \sum F_x = 0 \\ \sum F_y = 0 \\ \sum F_z = 0 \end{cases}$$

$$\sum \vec{M}_O = 0$$

Ex. 1) 'CONCURRENT' FORCE ANALYSIS



$$\sum F_x = 0$$

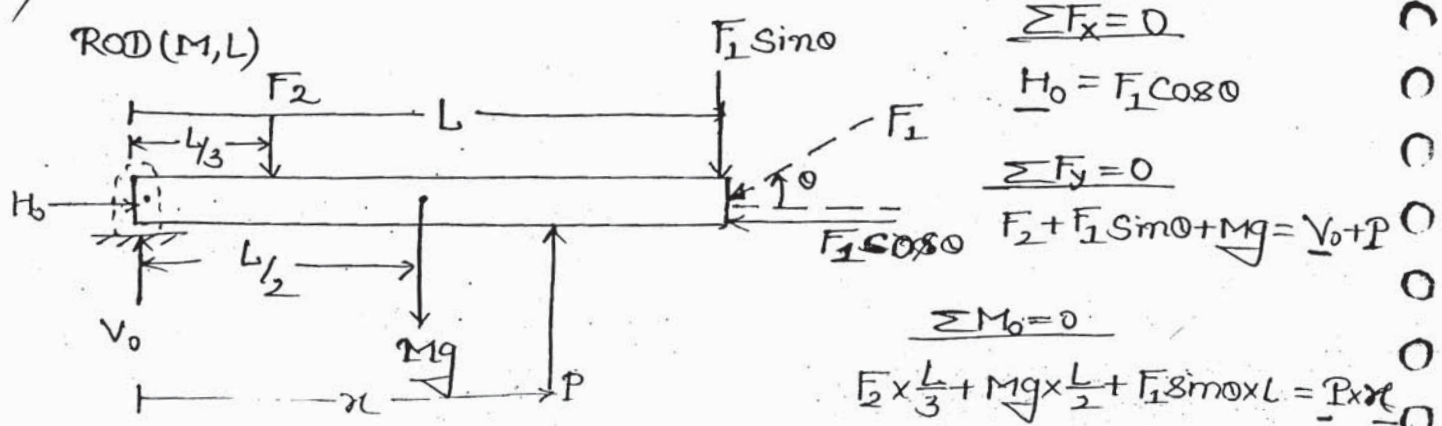
$$T \cos \theta = N \quad (1)$$

$$\sum F_y = 0$$

$$T \sin \theta = Mg \quad (2)$$

$$\left\{ \begin{array}{l} \cos \theta = \frac{R}{L} \\ \sin \theta = \frac{H}{L} \end{array} \right\} \text{ i.e. find}$$

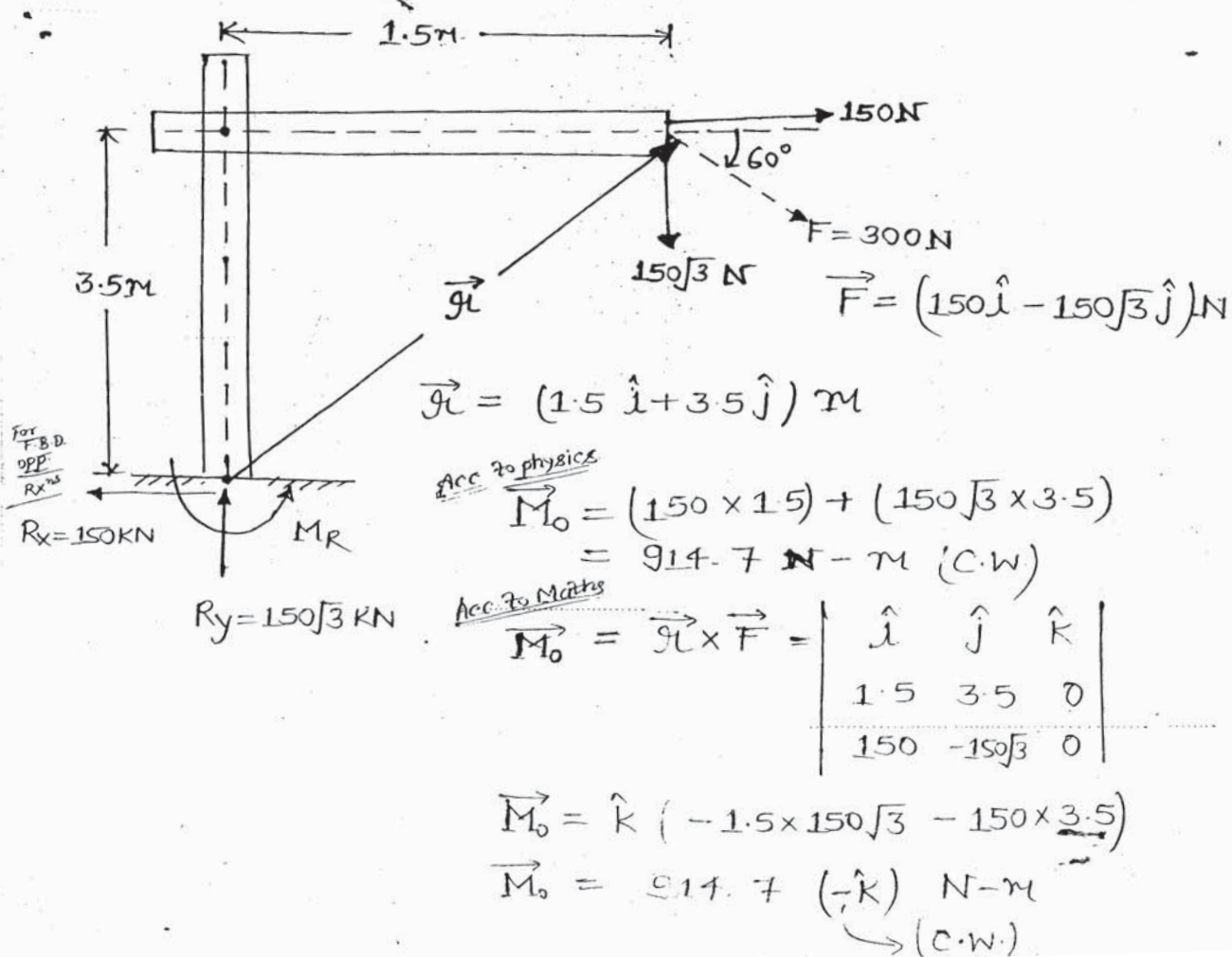
2) 'NON-CONCURRENT' FORCE ANALYSIS



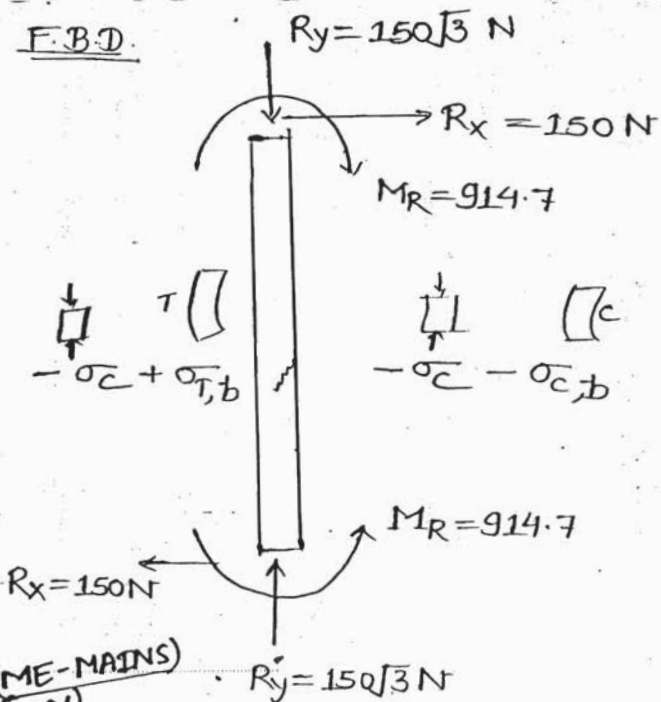
IAS (C.E.)

(2M)

Q.1 Determine the moment abt. at pt. 'o' due to a force acting at the end of a railway sign board post as shown in fig. below -



F.B.D.



$\sigma_{T,b}$ = Tension due to bending

$\sigma_{c,b}$ = Compressive " "

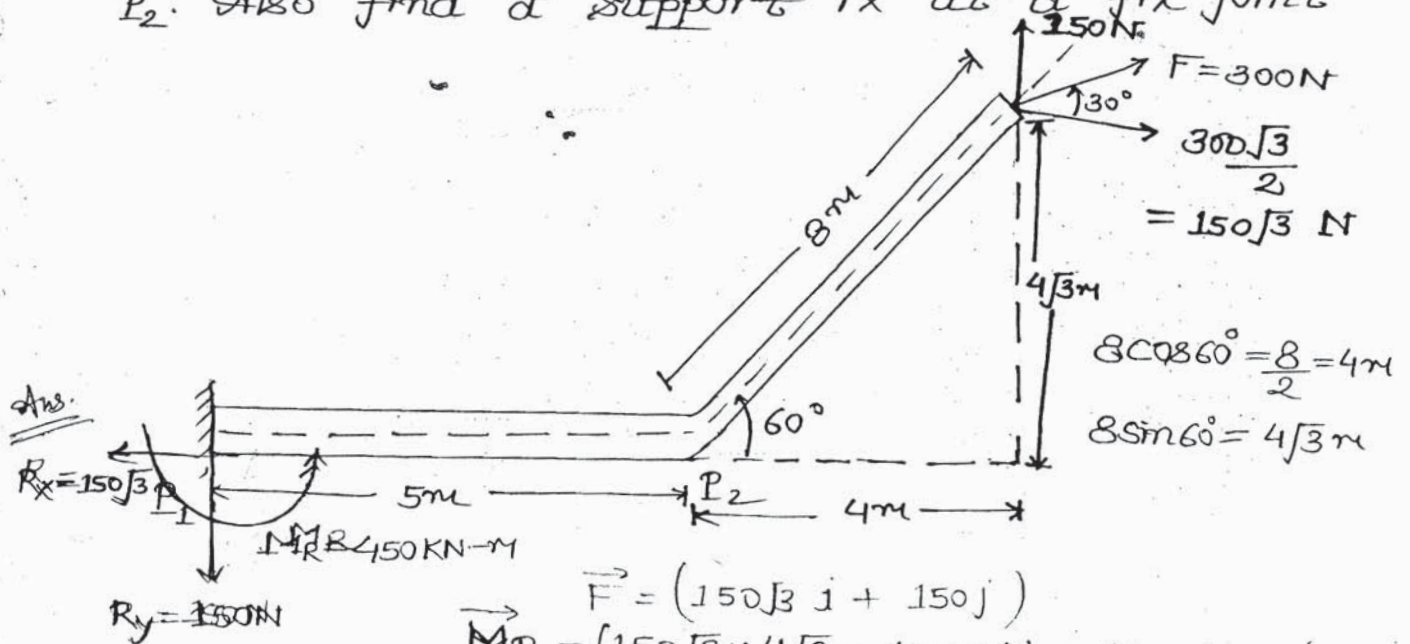
(ME-MAINS)

(12M)

ESE 2018

Q.2

[Bracket] A Rigid body has been loaded as shown in the fig. below determine the moment abt. of Pt. P_1 & P_2 . Also find a support rxⁿ at a fix joint



$$8 \cos 60^\circ = \frac{8}{2} = 4m$$

$$8 \sin 60^\circ = 4\sqrt{3}m$$

$R_y = 150N$

$$\vec{F} = (150\sqrt{3} \hat{i} + 150 \hat{j})$$

$$\vec{M}_{P_2} = (150\sqrt{3} \times 4\sqrt{3} - 150 \times 4) = 1200 N-m (C.W)$$

$$\vec{M}_{P_1} = (150\sqrt{3} \times 4\sqrt{3} - 150 \times 9) = 450 N-m (C.W)$$

$$\vec{r}_{P_1} = 9 \hat{i} + 4\sqrt{3} \hat{j}$$

$$\vec{r}_{P_2} = 4 \hat{i} + 4\sqrt{3} \hat{j}$$

$$\vec{F} = (150\sqrt{3} \hat{i} + 150 \hat{j})$$

ESE-18
(CE-MAINS)
(12M)

