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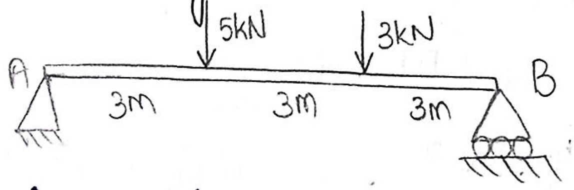
BASIC ENGINEERING MECHANICS CSE-A

ASSIGNMENT-1

3. Find the reactions at support A and B for the beam as shown in figure.



Moment about A = $\Sigma M_A = 0$

$5 \times 3 + 3 \times 6 - r_B \times 9 = 0$

$15 + 18 = 9 r_B$

$r_B = \frac{33}{9} = \frac{11}{3}$

$\boxed{r_B = 3.66N}$

$\Sigma M_B = 0$

$-3 \times 3 - 6 \times 5 + 9 r_A = 0$

$9 r_A = 39$

$r_A = \frac{13}{3}$

$\boxed{r_A = 4.33N}$

5. State the principle of transmissibility.

Ans: A force 'F' acting on a rigid body; the point of application of 'F' replaced along the line of action of force within the rigid body; the net effect will not change.

6. State the conditions of equilibrium.

Ans: Summation of forces along different axes is equated to zero.

$\Sigma F_x = 0$; $\Sigma F_z = 0$

$\Sigma F_y = 0$

Summation of moments of forces along 3 different directions is equated to zero.

$\Sigma M_x = 0$

$\Sigma M_y = 0$

$\Sigma M_z = 0$

7. A 100N force is directed along the line drawn from the points A(2,0,4) to the point B(5,1,1). What is the moment of this force about the origin?

Ans: A(2,0,4) B(5,1,1) F=100N

$S^2 = (3)^2 + 1^2 + (-3)^2 = 19$

$S^2 = 19 \Rightarrow S = \sqrt{19}\, m = \underline{4.35m}$

$F_x = \frac{F(\Delta x)}{S} = \frac{100 \times 3}{4.35} = 68.96N \simeq 69N$

$F_y = \frac{F(\Delta y)}{S} = \frac{100 \times 1}{4.35} = 22.98N \simeq 23N$

$F_z = \frac{F(\Delta z)}{S} = \frac{100 \times (-3)}{4.35} = -68.96N \simeq -69N.$

$F = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$ $\bar{r} = 2\hat{i} + 4\hat{k}$

$\bar{F} = 69\hat{i} + 23\hat{j} - 69\hat{k}$

$M = \bar{r} \times \bar{F}$

$= 23\begin{vmatrix} i & j & k \\ 2 & 0 & 4 \\ 3 & 1 & -3 \end{vmatrix} = 23[-4\hat{i} + 18\hat{j} + 2\hat{k}]$

$= -92\hat{i} + 414\hat{j} + 46\hat{k}$

9. State Varignon's theorem:

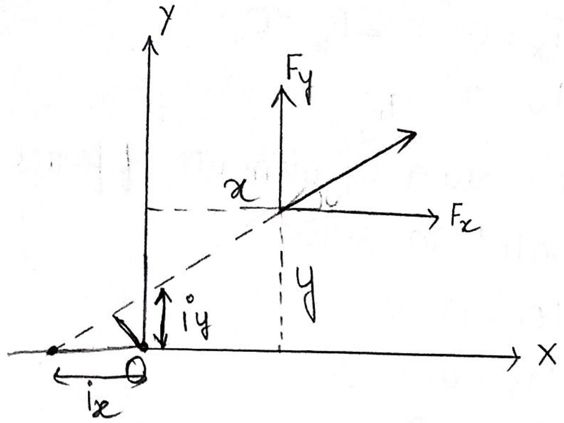
Ans: Varignon's theorem states moment of force is equal to moment sum of its components.

$(+M_0^F = F \times d$

$= -F\sin\theta \times x + F\cos\theta \times y.$

$= F\cos\theta \times i_y$

$= F\sin\theta \times i_x$



Two forces are acting at a point. When they are at right angles to each other their resultant is 10N. When they are at 60° with each other; their resultant is 12.24 N; find the 2 forces.

Ans: Let the 2 forces be F_1 & F_2

When $\theta_1 = 90°$

$$R_1 = 10N = \sqrt{F_1^2 + F_2^2}$$

$$\Rightarrow F_1^2 + F_2^2 = 100 \quad \text{—(1)}$$

When $\theta_2 = 60°$

$$R_2 = 12.24N = \sqrt{F_1^2 + F_2^2 + 2F_1F_2 \cdot \cos 60°}$$

$$F_1^2 + F_2^2 + F_1F_2 = (12.24)^2$$

$$100 + F_1F_2 = 149.81$$

$$F_1F_2 = 49.81$$

$$F_2 = \frac{49.81}{F_1}$$

$$F_1^2 + \frac{2481}{F_1^2} = 100$$

$$F_1^4 - 100F_1^2 + 2481 = 0$$

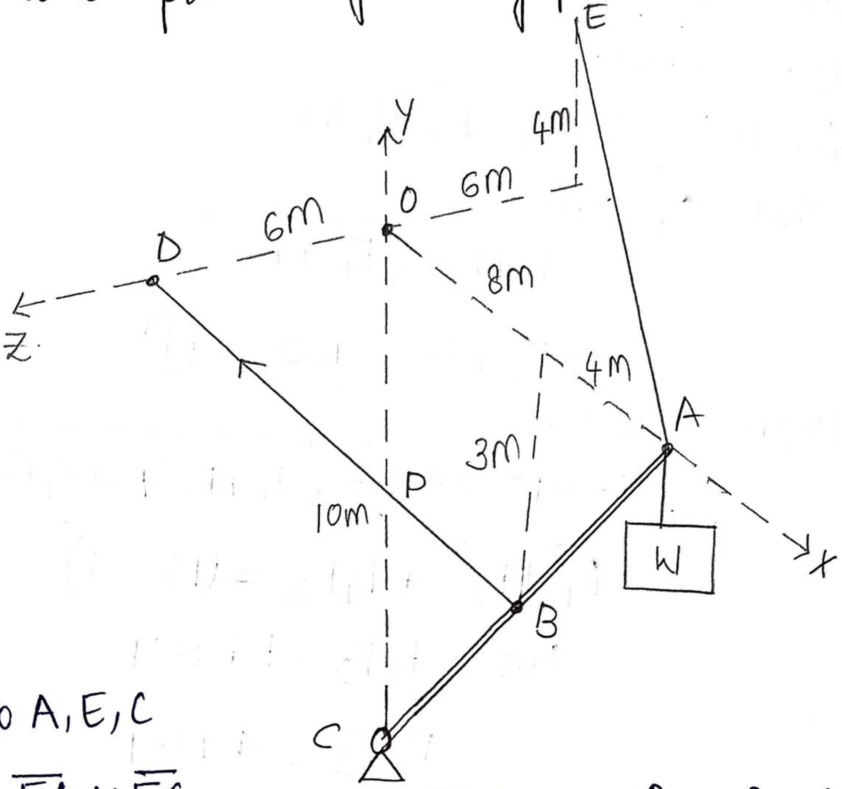
$$F_1^2 = \frac{100 \pm \sqrt{10000 - 9924}}{2 \times 1}$$

$$= \frac{100 \pm 8.71}{2} = 54.35,\ 45.645$$

$$\boxed{\begin{aligned} F_1 &= 7.37,\ 6.75 \\ F_2 &= 6.75,\ 7.37 \end{aligned}}$$

Therefore the 2 forces are $F_1 = 7.37N$ and $F_2 = 6.75N$

18. In the figure; if the force multiplier of force 'P' acting from B to D is $P_m = 20\,N/m$. Determine the component of P that is perpendicular to the plane defined by points E, A & C.



$P_m = 20\,N/m$

A (12, 0, 0)

B (8, −3, 0)

C (0, −10, 0)

D (0, 0, 6)

E (0, +4, −6)

P → B to D

$\bar{P} = 20(-8\hat{i} + 3\hat{j} + 6\hat{k})$

Plane perpendicular to A, E, C is ~~XY plane~~ given by $\overline{EA} \times \overline{EC}$

$\overline{EA} = -12\hat{i} + 4\hat{j} - 6\hat{k}$

$\overline{EC} = 0\hat{i} + 14\hat{j} - 6\hat{k}$

$$\overline{EA} \times \overline{EC} = \begin{vmatrix} -12 & 4 & -6 \\ 0 & 14 & -6 \\ \hat{i} & \hat{j} & \hat{k} \end{vmatrix}$$

$$\begin{array}{r} 14 \\ \times 12 \\ \hline 28 \\ 14 \\ \hline 168 \end{array}$$

$$= \hat{i}(-24 + 84) - \hat{j}(72) + \hat{k}(-168)$$

$$= 60\hat{i} - 72\hat{j} - 168\hat{k}$$

$$|\overline{EA} \times \overline{EC}| = \sqrt{3600 + 5184 + 28224} = \sqrt{37008} = \underline{\underline{192.4}}$$

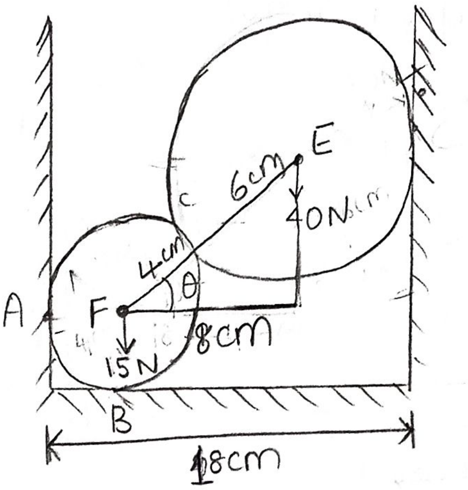
Component of P i.e. ⊥ar to the plane defined by E, A & C

$$= \frac{(-160\hat{i} + 60\hat{j} + 120\hat{k})(60\hat{i} - 72\hat{j} - 168\hat{k})}{192.4}$$

$$= \frac{-9600 - 4320 - 20160}{192.4} = \underline{\underline{-177.13}}$$

1. Two cylinders are piled in a rectangular ditch as shown in figure. Neglecting friction; determine the reactions at various contact points.

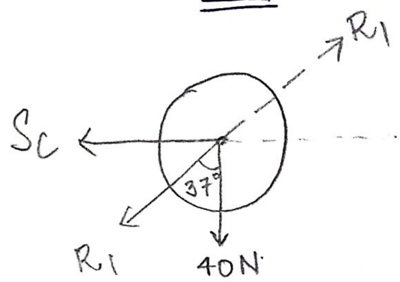
At 'E'



$$\cos\theta = \frac{8}{10} = \frac{4}{5}$$

$$\theta = \cos^{-1}(0.8)$$

$$\theta = \underline{\underline{37^\circ}}$$



At 'F'

$\Sigma F_x = 0 \Rightarrow -R_1\cos 53^\circ + S_C = 0 \Rightarrow S_C = R_1 \cos 53^\circ$

$= 50 \times \frac{3}{5}$

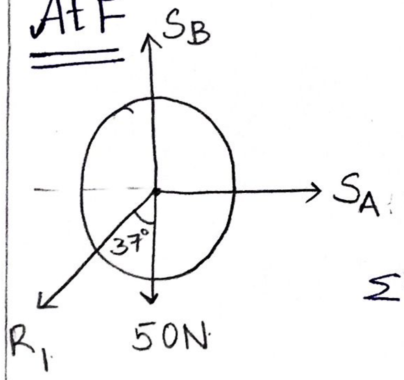
$\boxed{S_C = 30N}$

$\Sigma F_y = 0: -40 - R_1 \sin 53^\circ = 0$

$R_1 = -\frac{\cancel{40}^{10} \times 5}{\cancel{4}}$

$\boxed{R_1 = -50N}$

At 'F'



$\Sigma F_x = 0$

$S_A - R_1 \cos 53^\circ = 0$

$\boxed{S_A = 30N}$

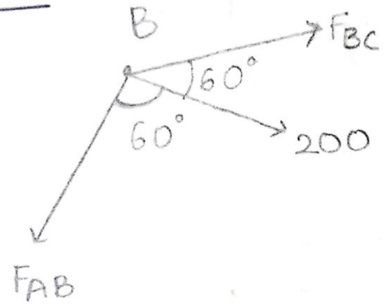
$\Sigma F_y = 0; S_B - 50 - R_1 \sin 53^\circ = 0$

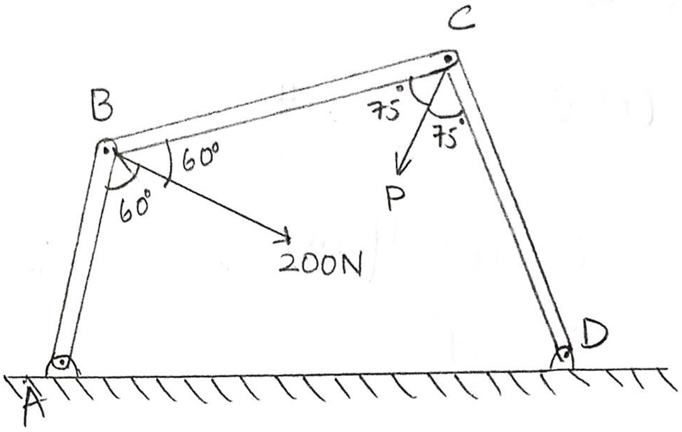
$S_B = 50 + \cancel{50}^{10} \times \frac{4}{\cancel{5}}$

$\boxed{S_B = 90N}$

23. Three bars, pinned together at B and C and supported by hinges at A and D as shown; form a four link mechanism. Determine the value of P that will prevent motion. Angles ABC & BCD are known to be 120° and 150° & forces bisect the given angles.

Ans: FBD for 'B':



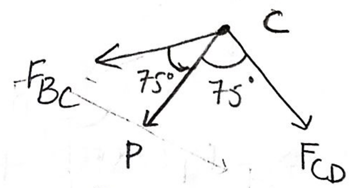


$$\frac{F_{BC}}{\sin 60^\circ} = \frac{200}{\sin 60^\circ}$$

$F_{BC} = 200N$

$\Rightarrow \boxed{P = 200N}$

FBD for 'C':



$$\frac{F_{BC}}{\sin 75^\circ} = \frac{P}{\sin 75^\circ}$$