EM Question Bank

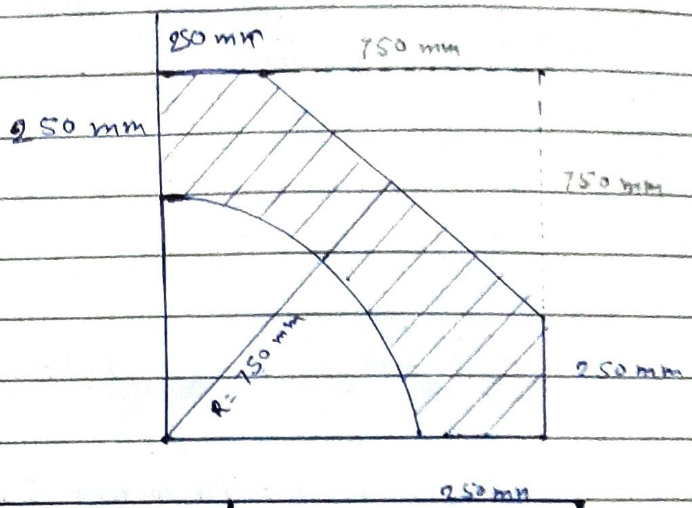
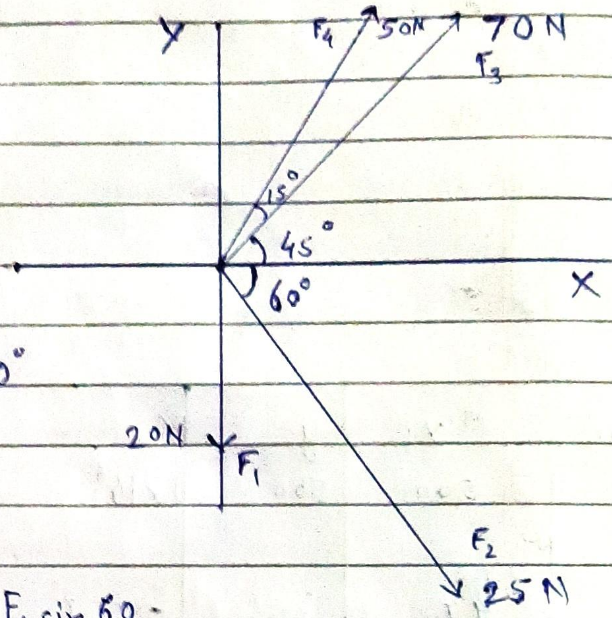


Figure	x_i	y_i	A	$A_i x_i$	$A_i y_i$
	500	500	1×10^6	5×10^8	5×10^8
	$\frac{4r}{3\pi}$	$\frac{4r}{3\pi}$	$-\frac{\pi r^2}{4}$		
	$=\frac{4\times750}{3\pi}$	$=\frac{4\times750}{3\pi}$	$=-\frac{\pi(750)^2}{4}$	-1.406×10^8	-1.406×10^8
	$\frac{2b+250}{3}$	$\frac{2b+250}{3}$	$-\frac{1}{2}750^2$	-2.109×10^8	-2.109×10^8
	750	750	$=-281250$		
			276983.5331	~~218.8×10^6~~ 148.5×10^6	~~218.8×10^6~~ 148.5×10^6

$$\bar{x} = \frac{\sum A_i x_i}{\sum A_i} = \cancel{789.996\ mm}\ 536.1717\ mm$$

$$\bar{y} = \frac{\sum A_i y_i}{\sum A_i} = \cancel{789.996\ mm}\ 536.1717\ mm$$

Q2 Determine the resultant force acting as given. Find the angle which the resultant makes with positive x-axis.



Let us assume ↑ +ve, ↓ -ve
→ +ve & ← -ve

$\Sigma F_x = +F_2 \cos\theta + F_3 \cos\theta + F_4 \cos\theta$

$= +25 \cos 60^\circ + 70 \cos 45^\circ + 50 \cos 60^\circ$

$= 86.997 \text{ N}$

$\Sigma F_y = -F_1 - F_2 \sin 60 + F_3 \sin 45^\circ + F_4 \sin 60$

$= -20 - 25 \sin 60 + 70 \sin 45^\circ + 50 \sin 60$

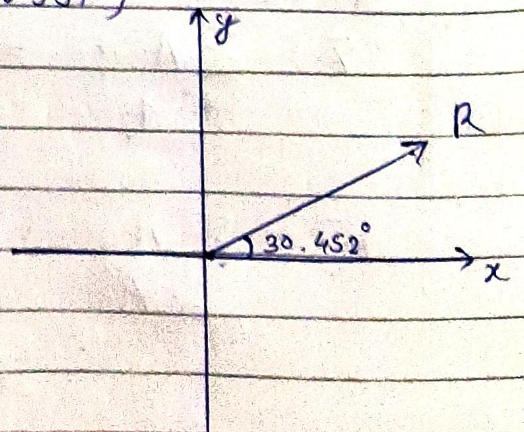
$= 51.148 \text{ N}$

$\text{Resultant} = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$

$= \sqrt{86.997^2 + 51.148^2}$

$R = 100.9188 \text{ N}$

$\theta = \tan^{-1}\left(\left|\frac{\Sigma F_y}{\Sigma F_x}\right|\right) = \tan^{-1}\left(\frac{51.148}{86.997}\right) = 30.452^\circ$



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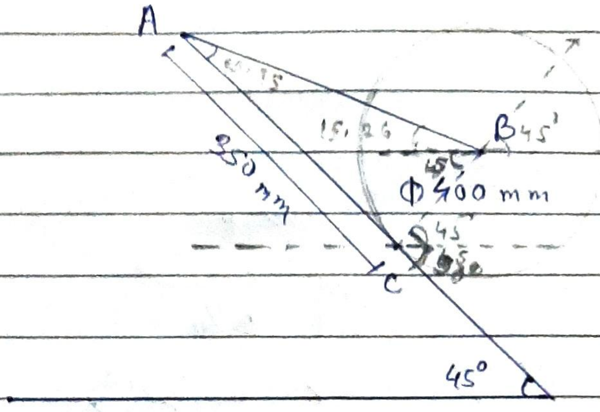
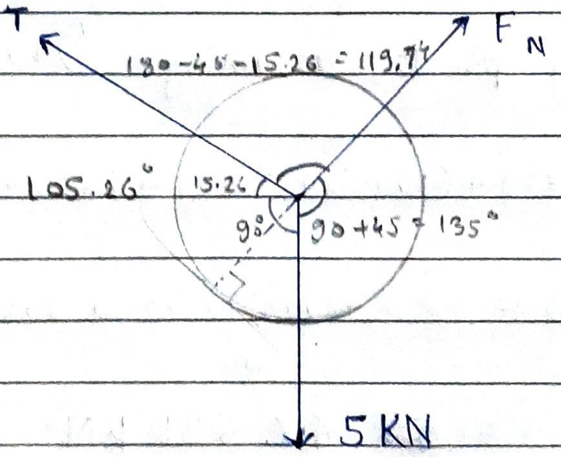
Q3 The cylinder B diameter 400 mm and weight 5 KN, is held in position as shown with the help of cable AB. Find the tension in the cable and the reaction developed at contact C.



FBD



Using Lami's Theorem

$$\frac{T}{\sin(135)} = \frac{F_N}{\sin(105.26)} = \frac{5}{\sin(119.74)}$$

$$\therefore F_N = \frac{5 \times \sin(105.26)}{\sin(119.74)} = 5.54 \text{ KN}$$

$$\therefore T = \frac{5 \times \sin(135)}{\sin(119.74)} = 4.06 \text{ KN}$$

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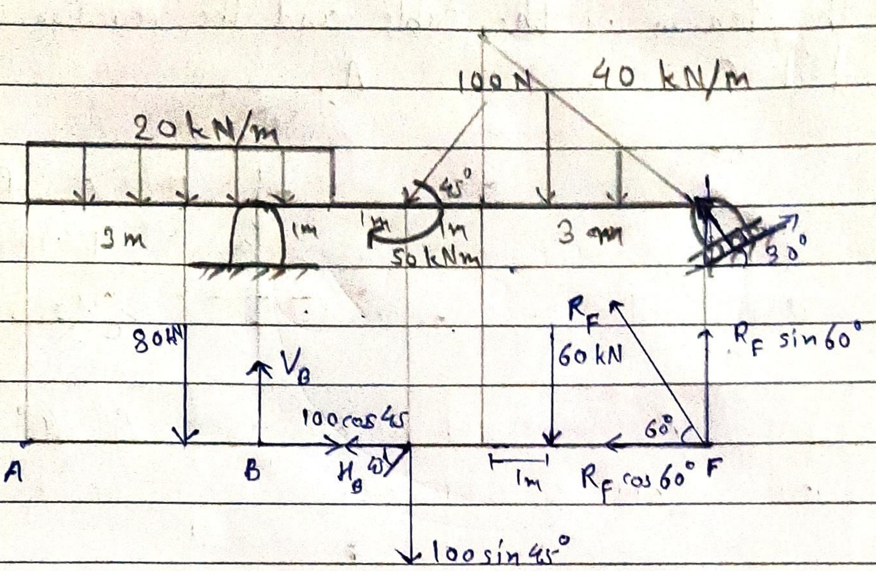
Q4 For a beam shown, calculate the support reaction.



Moment along pt. B assuming ↻ +ve ↺ -ve

$$\Sigma M_B = (80 \times 1) + (-100 \sin 45 \times 2) + (-60 \times 4) + (R_F \sin 60 \times 6) - 50 = 0$$

$$\therefore R_F \sin 60 = \frac{-80 + 100 \sin 45 \times 2 + 60 \times 4 + 50}{6}$$

$$\therefore R_F = \cancel{58}.\ 67.631 \text{ kN}$$

$$\Sigma F_x = -100 \cos 45 + H_B - R_F \cos 60 = 0$$

$$\therefore H_B = 100 \cos 45 + R_F \cos 60 = 104.526 \text{ kN}$$

$$\Sigma F_y = -80 + V_B - 100 \sin 45 - 60 + R_F \sin 60 = 0$$

$$\therefore V_B = 80 + 100 \sin 45 + 60 - R_F \sin 60$$
$$= 152.1405 \text{kN}$$

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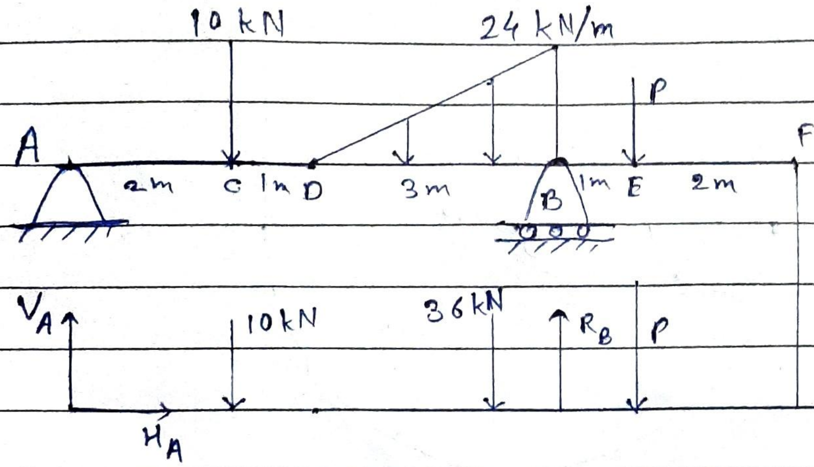
Q5 If the support reaction at A is zero, then find force P and the support reaction at B.



By using condition of equilibrium
Moment along pt. B, assuming ↻ +ve ↺ -ve

$$\Sigma M_B = (-V_A \times 6) + (10 \times 4) + (36 \times 1) - P \cdot 1 = 0$$

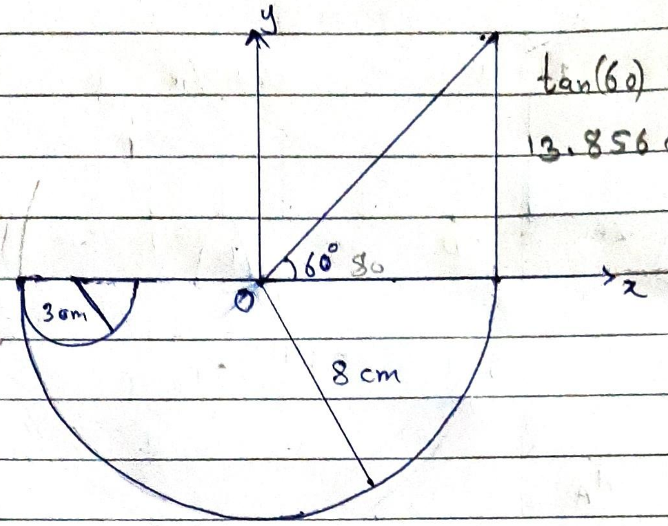
$\therefore P = 40 + 36 - 16$

$P = 60 \text{ kN}$

$$\Sigma F_y = R_B - 10 - 36 - 60 = 0$$

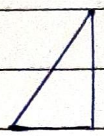
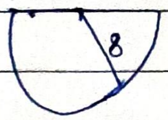
$\therefore R_B = 106 \text{ kN}$

Q 6 Determine the centroid of the shaded region.



$\tan(60) \times 8$

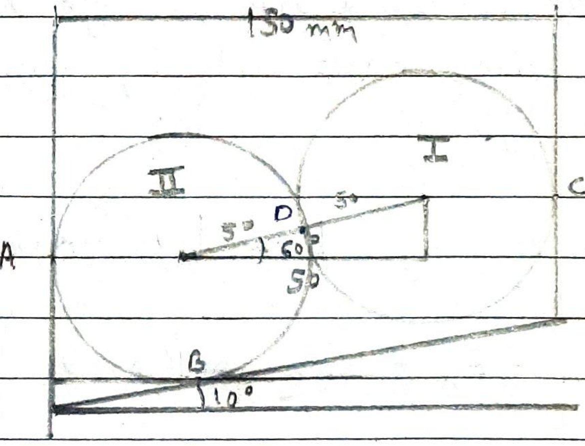
13.856 cm

Figure	x_i	y_i	A_i	$A_i x_i$	$A_i y_i$
	$\frac{2b}{3} = 5.\overline{3}$	4.619	55.426	295.605	256.011
	0	-3.395	100.531	0	$-341.\overline{3}$
	-5	-1.273	-14.137	70.686	17.997
			$\Sigma A_i = 141.82$	$\Sigma A_i x_i = 366.291$	$\Sigma A_i y_i = \cancel{-58.325}$ -67.325

$$\therefore \bar{x} = \frac{\Sigma A_i x_i}{\Sigma A_i} = 2.583 \text{ cm}$$

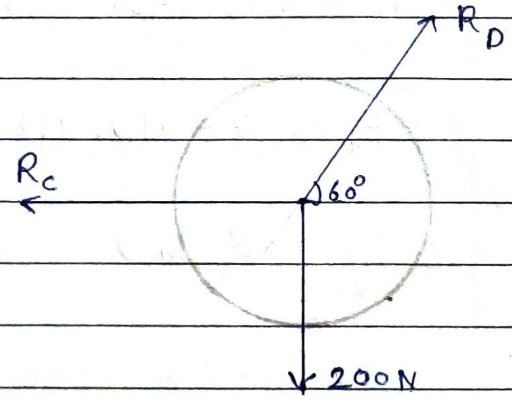
$$\bar{y} = \frac{\Sigma A_i y_i}{\Sigma A_i} = -0.475 \text{ cm}$$

Q7 Two identical cylinders of diameter 100 mm and weight 200 N are placed as shown. All contacts are smooth. Find reaction at A, B and C.



FBD of figure I

By using Lami's Theorem

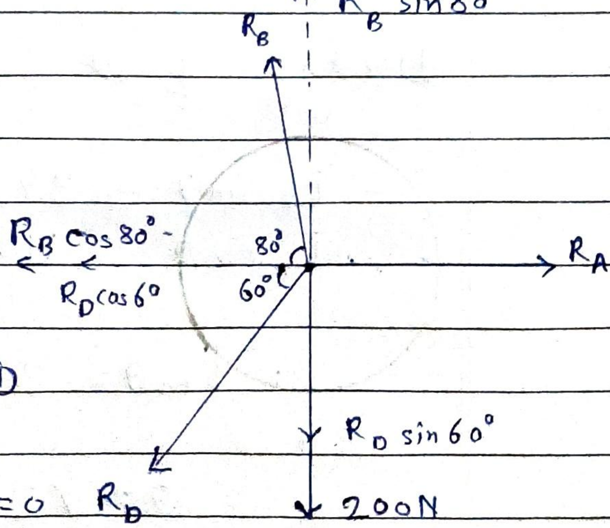


$$\frac{R_D}{\sin 90} = \frac{R_c}{\sin 150°} = \frac{200}{\sin 120°}$$

$\therefore R_D = 230.94\,N$

$R_c = 115.47\,N$

FB.D of figure II



Applying ~~condi~~ COE

$\Sigma F_x = R_A - R_D \cos 60 - R_B \cos 80 = 0$

$\therefore R_A = R_B \cos 80 + 115.47$ —(1)

$\Sigma F_y = R_B \sin 80 - R_D \sin 60 - 200 = 0$

$\therefore R_B = 406.17\,N$

$\therefore R_A = 186.00\,N$ from (eq (1) and R_B)

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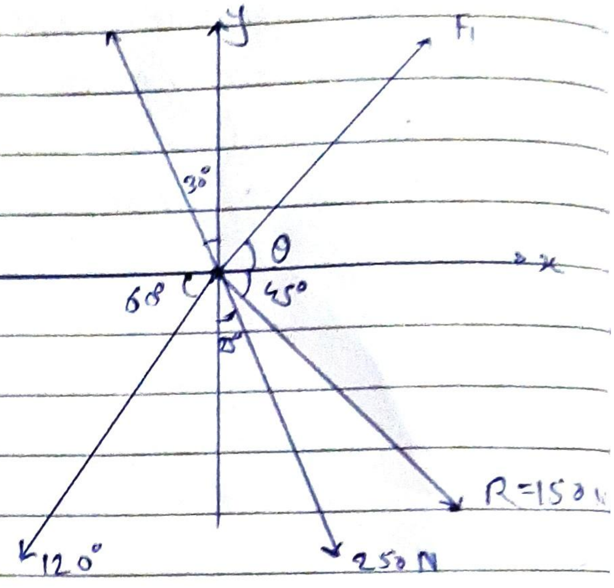
Q8 Find fourth force F_4 completly so as to give the resultant of the system of forces



Let us assume an angle θ with x-axis made by force F_4

Assuming ↑+ve, ↓-ve →+ve ←-ve

$\Sigma F_x = R\cos\phi$

$\therefore 150\cos 45 = -100\sin 30 - 120\cos 60 + 250\sin 25 + F_4\cos\theta$

$\therefore F_4\cos\theta = 110.411$ N —(I)

$\Sigma F_y = R\sin\phi$

$-150\sin 45 = -250\cos 25 - 120\sin 60 + 100\cos 30 + F_4\sin\theta$.

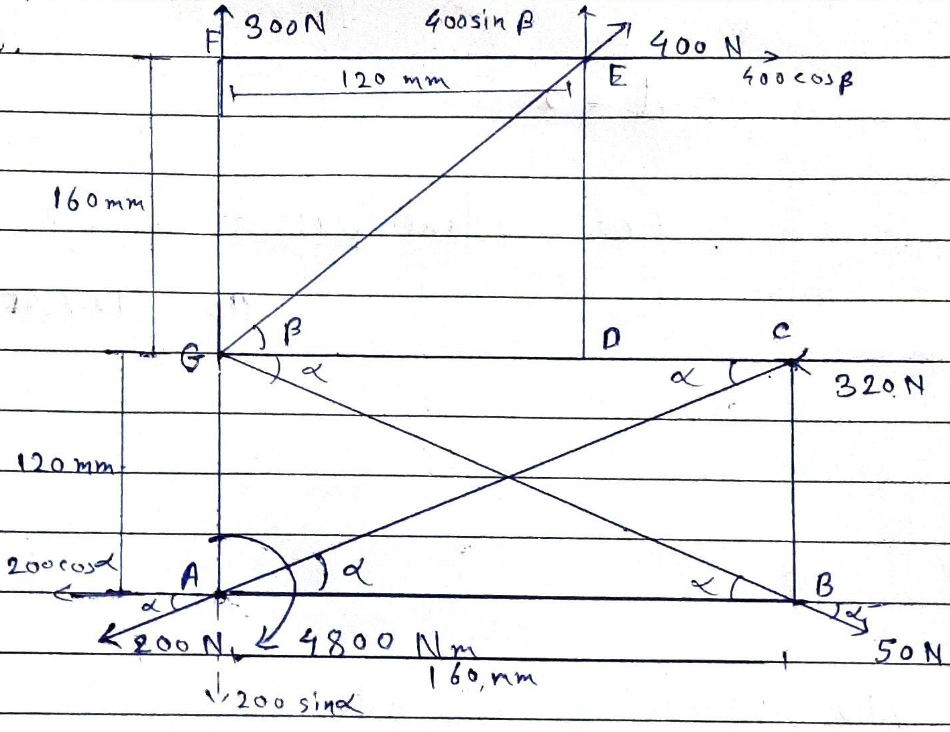
$\therefore F_4\sin\theta = 137.831$ N —(II)

Dividing eq (II) by (I)

$\frac{F_4\sin\theta}{F_4\cos\theta} = \frac{137.831}{110.411} = \tan\theta$ $\therefore \theta = 51.303°$

$\therefore F_4 = \frac{110.411}{\cos(51.303)} = 176.601$ N —(from eq (I))

Q9 Find the resultant of coplanar force system and locate the same on AB with due consideration to the applied moment.



$\alpha = \tan^{-1}\left(\frac{120}{160}\right)$

$\alpha = 36.87^\circ$

$\beta = \tan^{-1}\left(\frac{160}{120}\right)$

$= 53.13^\circ$

$\Sigma F_x = 400\cos\beta - 320 - 200\cos\alpha + 50\cos\alpha$

$= -200\ N$

$\Sigma F_y = 300 + 400\sin\beta - 200\sin\alpha - 50\sin\alpha$

$= 470\ N$

$\therefore R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$

$= 510.78\ N$

$\theta = \tan^{-1}\left(\left|\frac{\Sigma F_y}{\Sigma F_x}\right|\right) = 66.95^\circ$

To find position. consider p.t A.

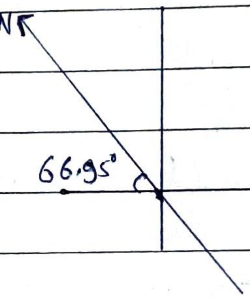
$\Sigma M_A = M_A$ By Varignon's principle.

$d \cdot 510.78 = -4800 - 50\sin\alpha \times 0.16 + 320 \times 0.12 - 400\cos\beta\,(0.12)$

$= -0.0004 \approx 0$

$\therefore d = 0$

$\therefore$ The resultant passes through origin. A.



Q10 Write a Short note on

i) Condition of Equilibrium

If resultant of force system happens to be zero the system is said to be in state of equilibrium.

Conditions of equilibrium.

a) For concurrent system.

i) $\Sigma F_x = 0$ ii) $\Sigma F_y = 0$ iii) $\Sigma M_A = 0$

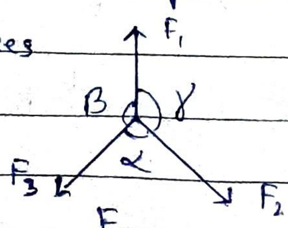
b) For non-concurrent parallel system.

i) $\Sigma F = 0$

ii) $\Sigma M_{\text{any pt}} = 0$

ii) Lami's Theorem.

If three concurrent forces are acting at a pt. are in equilibrium then the ratio of any of the forces is equal to the sine of the angle b/w the remaining two forces.



$$\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}$$

iii) Varignon's Theorem.

The algebric sum of the moment of a system of coplanar forces about any pt. in the place is equal to the moment of the resultant force of the system about the same point.