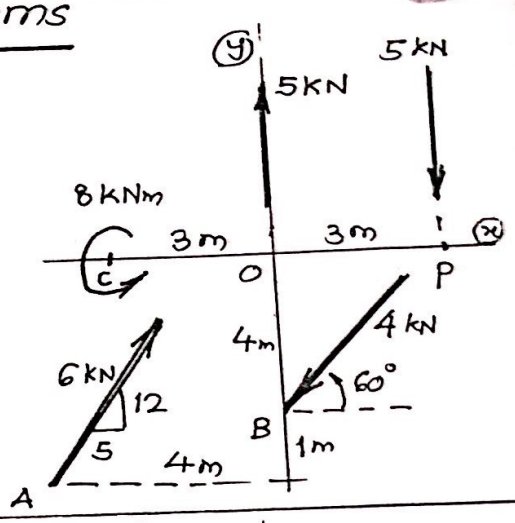
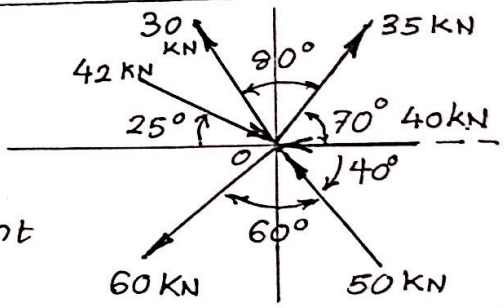
Equivalent Systems, Resultant of concurrent and Parallel Force systems

(1) Replace the force-couple system shown in fig. by an equivalent system at point 'P'.



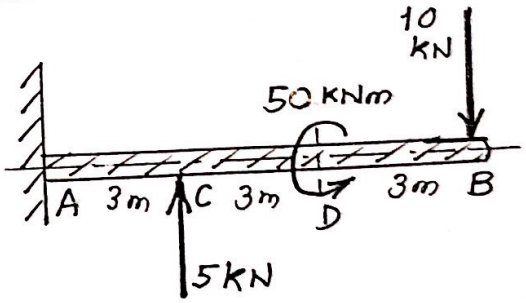
Ans: $R = 2.096$ KN, $\theta = 81.58°$, $M_p = 31.838$ KNm

(2) Find the resultant of the force system, acting at O.



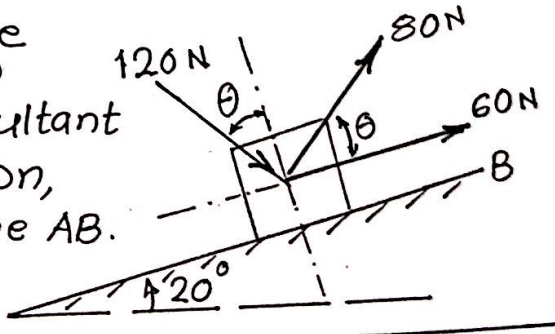
Ans: $R = 64.758$ KN, $\theta = 2.824°$ in 2nd quadrent

(3) Find the resultant of the force system, acting on the cantilever AB.



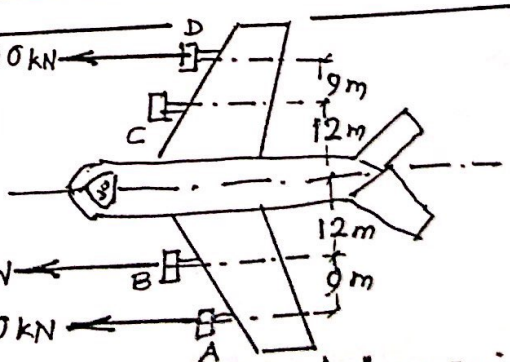
Ans: $R = 5$ KN (↓) at a distance of 5 m to the right of A.

(4) For the block shown in the fig. determine the required value of angle 'θ', if the resultant of the three forces shown, is to be parallel to the plane AB. Also, find the resultant force.



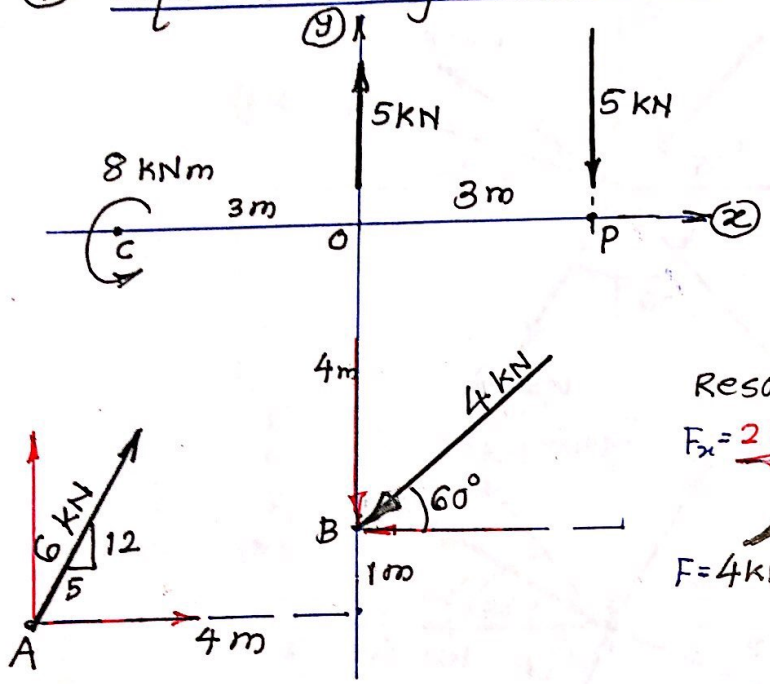
Ans: $\theta = 56.31°$ $R = 204.22$ N

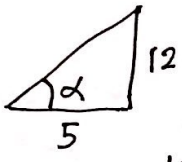
(5) A commercial airliner with four jet enjines, each producing 90 kN of forward thrust is in a steady level cruise, when engine at C suddenly fails. Determine & locate the resultant of the three remaining thrust forces.



Ans: $R = 270$ KN, 4 m below axis

① Equivalent system at P:

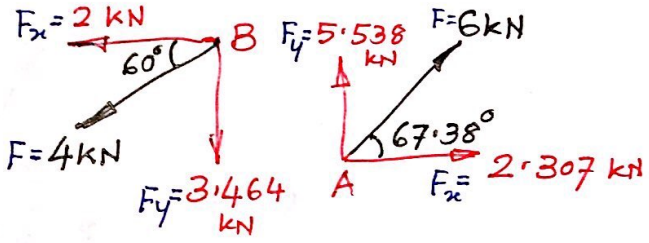




$\tan\alpha = \frac{12}{5}$

$\alpha = 67.38°$

Resolution of forces:



The equivalent system at point 'P' consists of

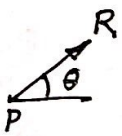
i) The Resultant Force at pt. P and

ii) The Resultant Moment at pt. P

$\therefore R_x = \Sigma F_x = (2.307) - (2.0) = 0.307$ kN (→)

$R_y = \Sigma F_y = (5.538) - (3.464) + 5 - 5 = 2.074$ kN (↑)

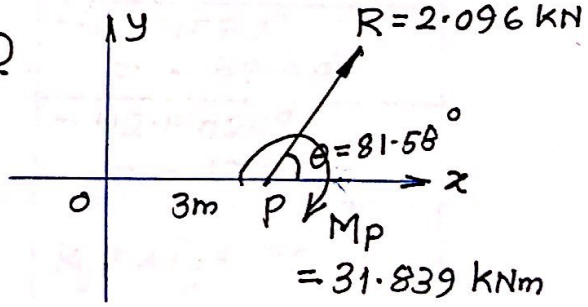
$\therefore$ * $R = \sqrt{R_x^2 + R_y^2} = 2.096$ kN



* $\theta = \tan^{-1}(R_y/R_x) = 81.58°$

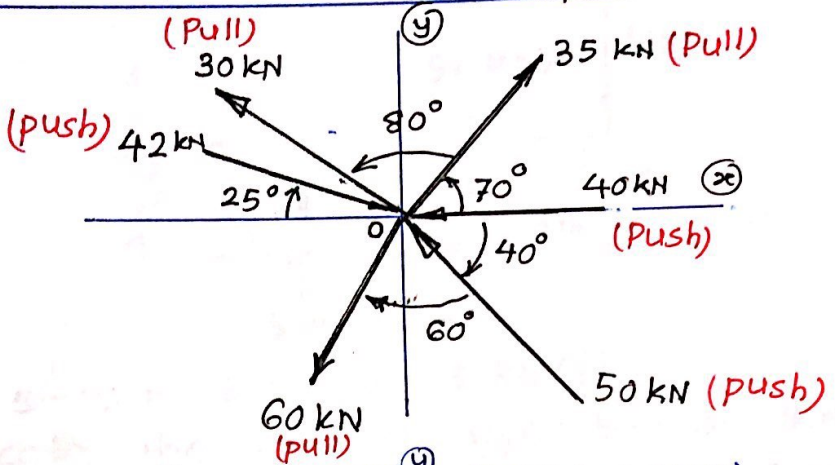
$M_P = +(8.0) - (5\times3) + (2.307\times5) - (5.538\times7) - (2\times4) + (3.464\times3)$

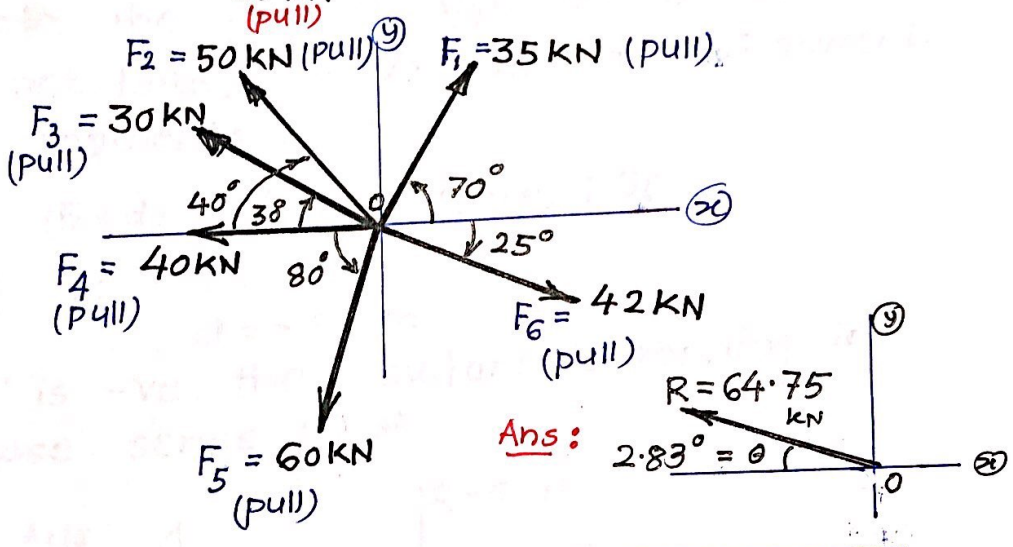
* $M_P = 31.839$ kNm ↻



Equivalent system at P

(2) Resutant of concurrent coplanar force system

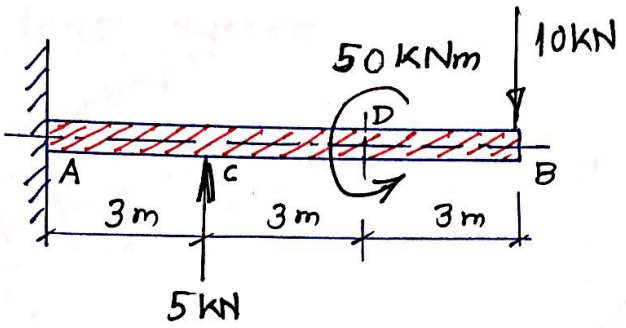




Ans :

Force	x-component	y-component
F_1	$35 \cdot \cos 70^\circ = 11.97$	$35 \cdot \sin 70^\circ = 32.89$
F_2	$-50 \cdot \cos 40^\circ = -38.30$	$50 \cdot \sin 40^\circ = 32.14$
F_3	$-30 \cdot \cos 30^\circ = -25.98$	$30 \cdot \sin 30^\circ = 15.00$
F_4	-40.00	~~~
F_5	$-60 \cdot \cos 80^\circ = -10.42$	$-60 \sin 80^\circ = -59.08$
F_6	$42 \cdot \cos 25^\circ = 38.06$	$-42 \cdot \sin 25^\circ = -17.75$
Resultant R	$R_x = \Sigma F_x = -64.67$ kN	$R_y = \Sigma F_y = 3.2$ kN

(3) Resultant of parallel force system:



$R = 5 - 10 = -5$ KN i.e. 5 KN (↓)

To locate the point of application of the resultant force, use Varignon's thm. of moments.

Take moments @ A,

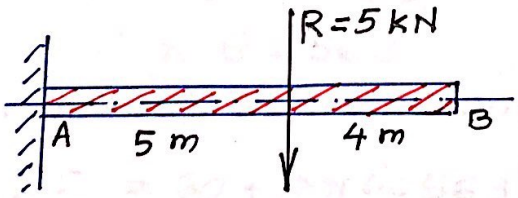
$$(5 \times d) = (5 \times 3) - (10 \times 9) + 50$$

$$\therefore 5d = -25$$

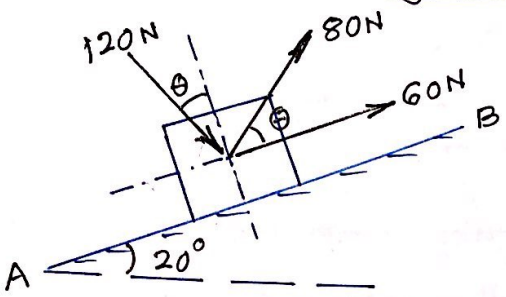
$$d = -5.0 \text{ m}$$

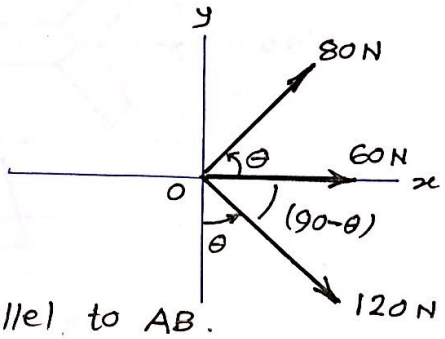
As 'd' is -ve, the resultant is rotating in clockwise sense @ A

Ans:



④ Resultant of concurrent coplanar force system:





Consider 'x' axis, parallel to AB.

As the resultant is parallel to plane AB,

$\therefore \quad R = \Sigma F_x = R_x$ and $R_y = \Sigma F_y = 0$

$\therefore \quad R_y = \Sigma F_y = 80 \cdot \sin\theta - 120 \cdot \sin(90-\theta) = 0$

$\therefore \quad 80 \cdot \sin\theta - 120 \cdot \cos\theta = 0$

$\therefore \quad 80 \cdot \sin\theta = 120 \cdot \cos\theta$

$\therefore \quad \tan\theta = 1.5$

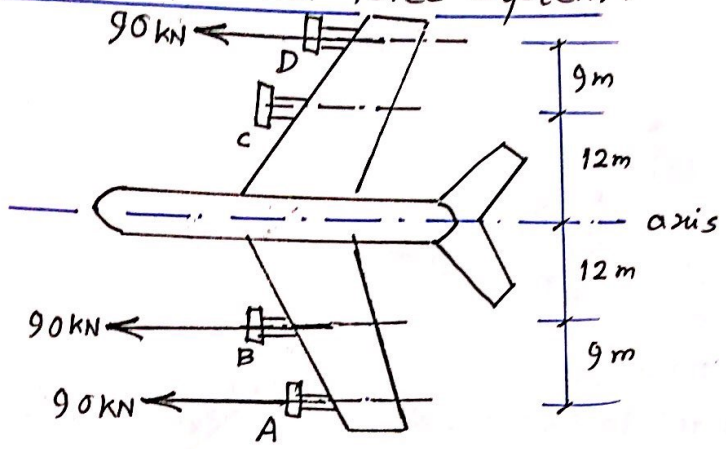
$\therefore \quad * \ \theta = 56.3°$

The magnitude of the resultant is given by,

$R = R_x = \Sigma F_x = 60 + (80)(\cos 56.3°) + (120)(\cos 33.7°)$

$* \ R = 204.22 \text{ N}$ along AB

⑤ Resultant of parallel force system:



$R = 90 + 90 + 90 = 270\ kN\ (\leftarrow)$

Using Varignon's thm. of moments, taking moment @ the axis of the plane,

$$R \cdot d = 270 \cdot d = (90 \times 21) - (90 \times 12) - (90 \times 21)$$

$$d = -4\ m$$

∴ As the distance d is -ve, the resultant is rotating in clockwise sense @ the axis of the plane.

Ans: Resultant thrust = 270 kN acting at a dist. of 4 m below the axis of the plane.