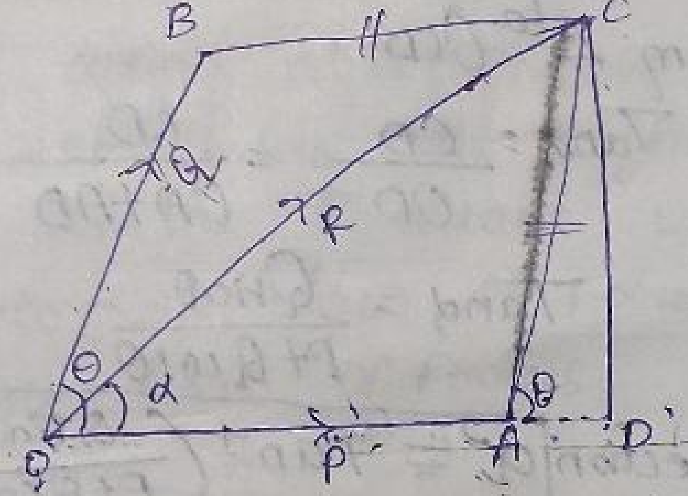
Parallelogram Law of Forces:- Two forces are acting at point O & represents Magnitude and direction by two adjacent Sides of a Parallelogram then the resultant represents in magnitude and direction by the diagonal sides of the parallelogram passing through that point.



Let

P, Q = Two forces acting at point 'O' (AI)

R = Resultant of the forces (AI)

θ = Angle between two forces

α = Angle between resultant (R) to the one of the force (P)

$BC = \overrightarrow{OA} = P$, $\overrightarrow{OB} = Q = AC$, $\overrightarrow{OC} = R =$

From Δ^{le} ACD,

$$\sin\theta = \frac{CD}{AC} = CD = AC\sin\theta$$

$$\cos\theta = \frac{AD}{AC} = CD = Q\sin\theta .$$

$$\Rightarrow AD = AC\cos\theta$$

$$AD = Q\cos\theta$$

From Δ^{le} OCD,

$$OC^2 = OD^2 + CD^2$$

$$OC^2 = (OA + AD)^2 + CD^2$$

$$R^2 = (P + Q\cos\theta)^2 + (Q\sin\theta)^2$$

$$R^2 = P^2 + Q^2\cos^2\theta + 2PQ\cos\theta + Q^2\sin^2\theta$$

$$R^2 = P^2 + Q^2(1) + 2PQ\cos\theta$$

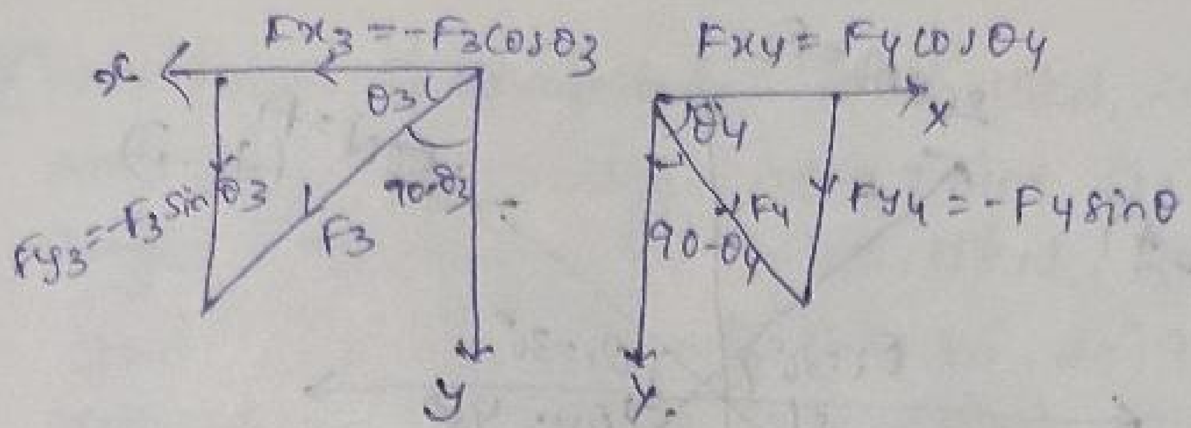
Magnitude $\boxed{R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}}$

From Δ^{le} OCD

$$\tan\alpha = \frac{CD}{OD} = \frac{CD}{OA + AD}$$

$$\tan\alpha = \frac{Q\sin\theta}{P + Q\cos\theta}$$

Direction $\boxed{\alpha = \tan^{-1}\left(\frac{Q\sin\theta}{P + Q\cos\theta}\right)}$



ΣF_x = Sum of all horizontal forces (x-components)

$\Sigma F_x = F_{x1} + F_{x2} + F_{x3} + F_{x4}$

$\Sigma F_x = F_1\cos\theta_1 - F_2\cos\theta_2 - F_3\cos\theta_3 + F_4\cos\theta_4$

ΣF_y = Sum of all Vertical Forces (y-components)

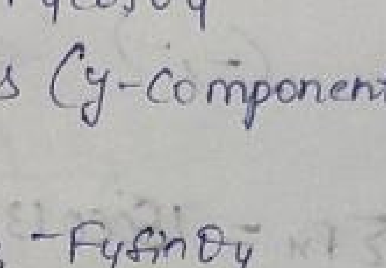
$\Sigma F_y = F_{y1} + F_{y2} + F_{y3} + F_{x4}$

$\Sigma F_y = F_1\sin\theta_1 + F_2\sin\theta_2 - F_3\sin\theta_3 - F_4\sin\theta_4$

Resultant

$R^2 = \Sigma F_x^2 + \Sigma F_y^2$.

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

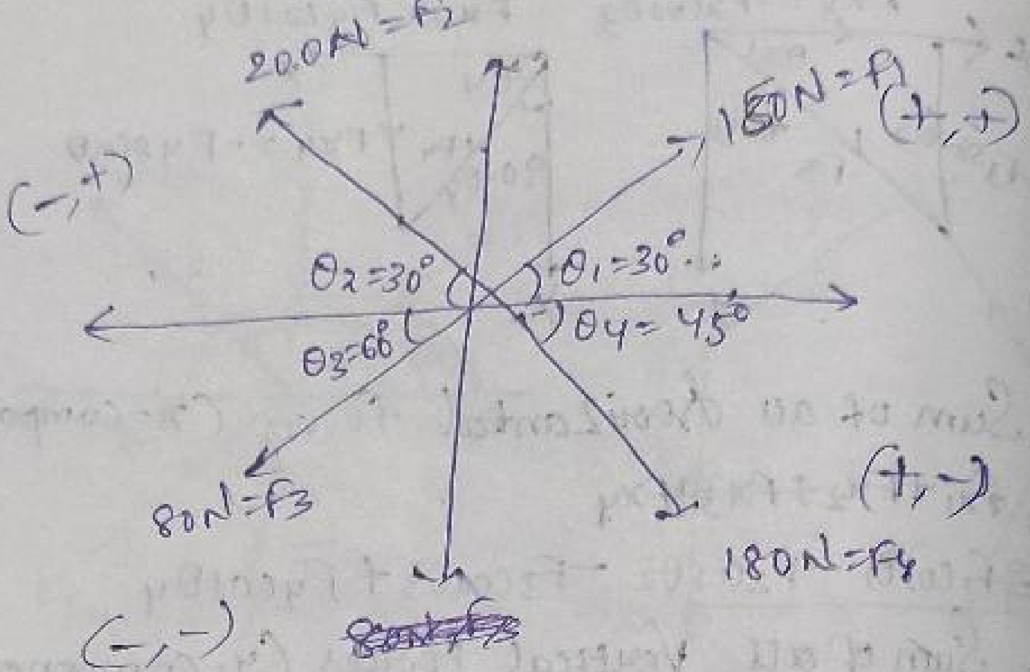


$\tan\alpha = \dfrac{\Sigma F_y}{\Sigma F_x}$.

Angle b/w resultant as the x-axis

$\alpha = \tan^{-1}\left(\dfrac{\Sigma F_y}{\Sigma F_x}\right)$

Ques: Determine the Resultant of the magnitude and direction of the four forces acting on the body as shown in the figure.



$\Sigma F_x = 150\cos 30^\circ - 200\cos 30^\circ - 80\cos 60^\circ + 180\cos$

$\Sigma F_x = \cancel{48.27N}\ 45.97N.$

$\Sigma F_y = 150\sin 30^\circ + 200\sin 30^\circ - 80\sin 60^\circ - 180^\circ\sin 45^\circ$

$\Sigma F_y = -21.561N.$

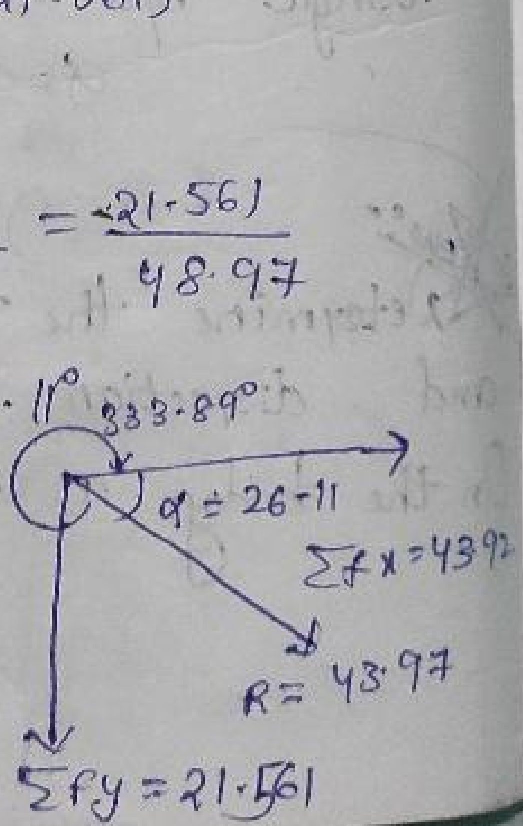
$R = \sqrt{\Sigma F_x^2 + \Sigma F_y^2}$

$\sqrt{(45.97)^2 + (-21.561)^2}$

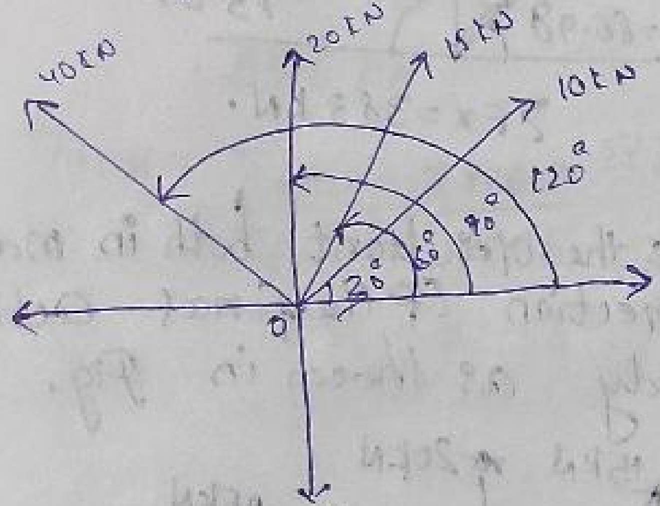
$R = 48.97N$

$\tan\alpha = \dfrac{\Sigma F_y}{\Sigma F_x} = \dfrac{-21.561}{48.97}$

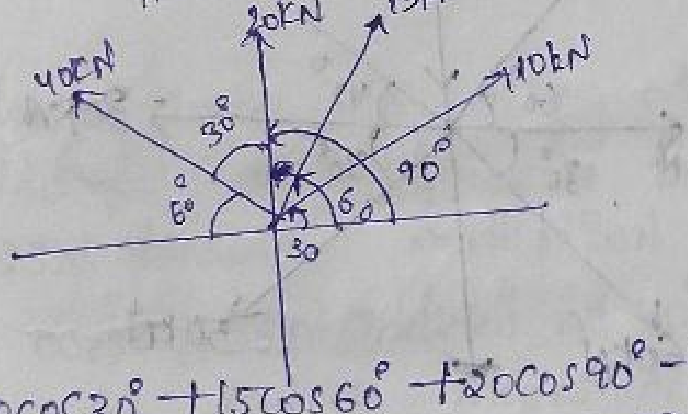
direction $\alpha = 26.11^\circ$



2) Four forces of magnitude 10kN, 15kN, 20kN and 40kN are acting at a point O. The angles made by 10kN, 15kN, 20kN and 40kN with X-axis are $30°$, $60°$, $90°$ & $120°$ respectively. Find the magnitude and direction of resultant force.



$1 kN = 10^3 N$



$\Sigma F_x = 10\cos30° + 15\cos60° + 20\cos90° - 40\cos60° = -3.83 kN.$

$\Sigma F_y = 10\sin30° + 15\sin60° + 20\sin90° + 40\sin60° = 72.63 kN.$

$R = \sqrt{\Sigma F_x^2 + \Sigma F_y^2} = \sqrt{(-3.83)^2 + (72.63)^2}$

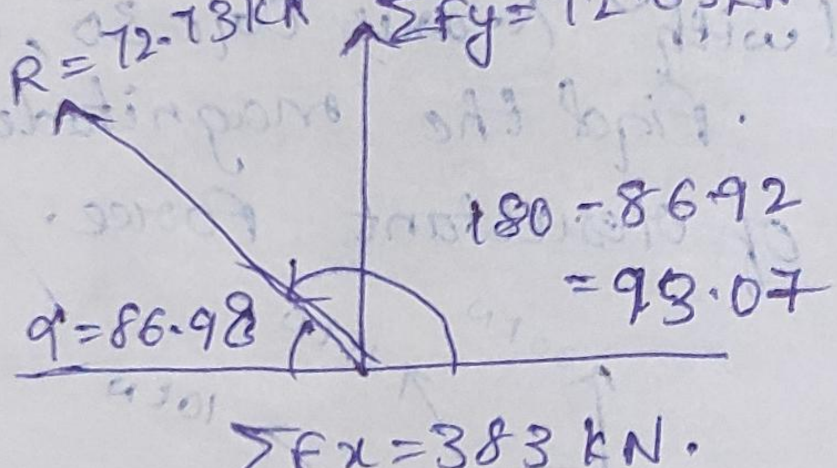
$= 72.73 kN$

$\tan\alpha = \dfrac{\Sigma F_y}{\Sigma F_x} = \dfrac{72.73}{3.83}$

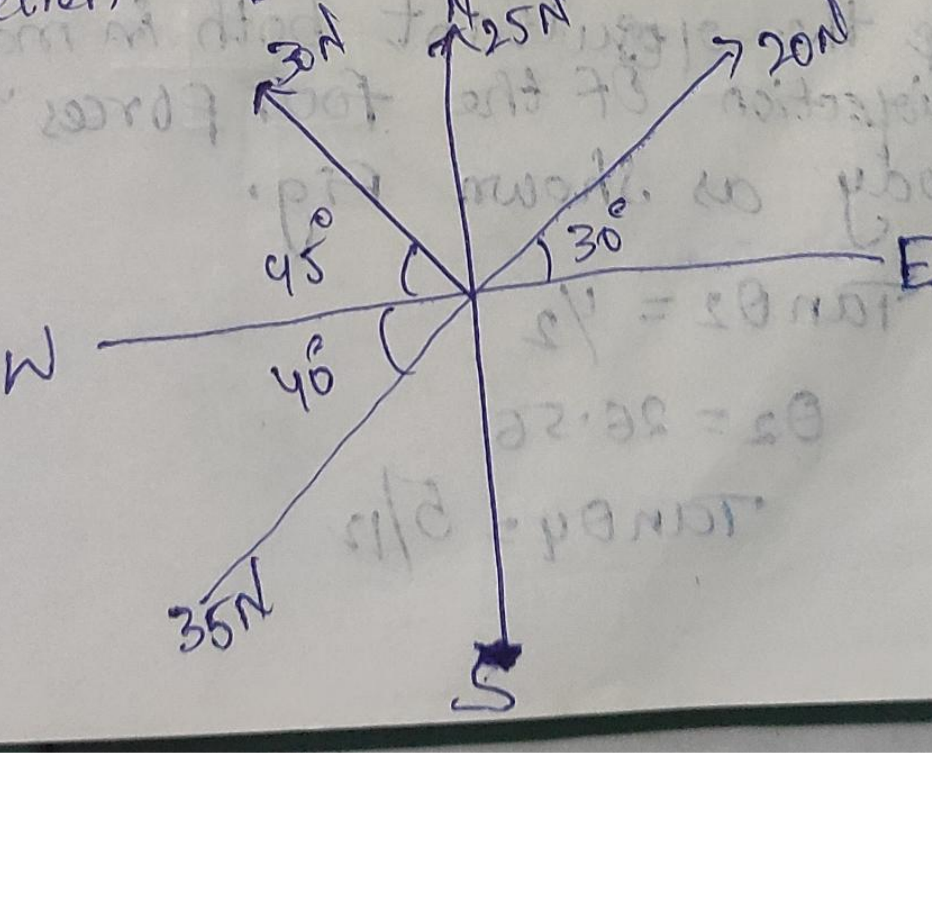
$\tan\alpha = 18.98°$

$$\alpha = \tan^{-1}(18.98^{\circ})$$

$$\alpha = 86.98$$



The following forces are acting at a Point i, 20N inclined at 30° towards the north of east. ii, 25N towards North iii, 30N towards North west iv, 35N inclined at 40° towards South of west find the magnitude and direction of the resultant force.



$$\Sigma F_x = 20\cos 30^\circ - 30\cos 45^\circ - 35\cos 40^\circ$$

$$\Sigma F_x = -30.70\,N$$

$$\Sigma F_y = 20\sin 30^\circ + 25 + 30\sin 45^\circ - 35\sin 40^\circ$$

$$\Sigma F_y = \cancel{-35\sin 40}$$

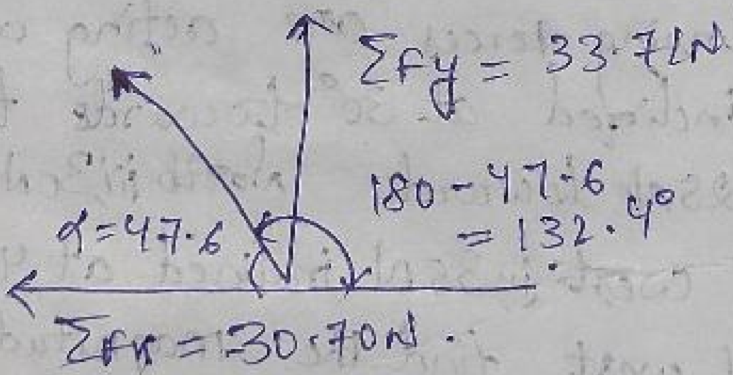
$$\Sigma F_y = 33.71\,N$$

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

$$\sqrt{(-30.70)^2 + (33.71)^2} = 45.59\,N$$

$$\tan\alpha = \frac{\Sigma F_y}{\Sigma F_x}$$

$$\alpha = 47.6^\circ$$



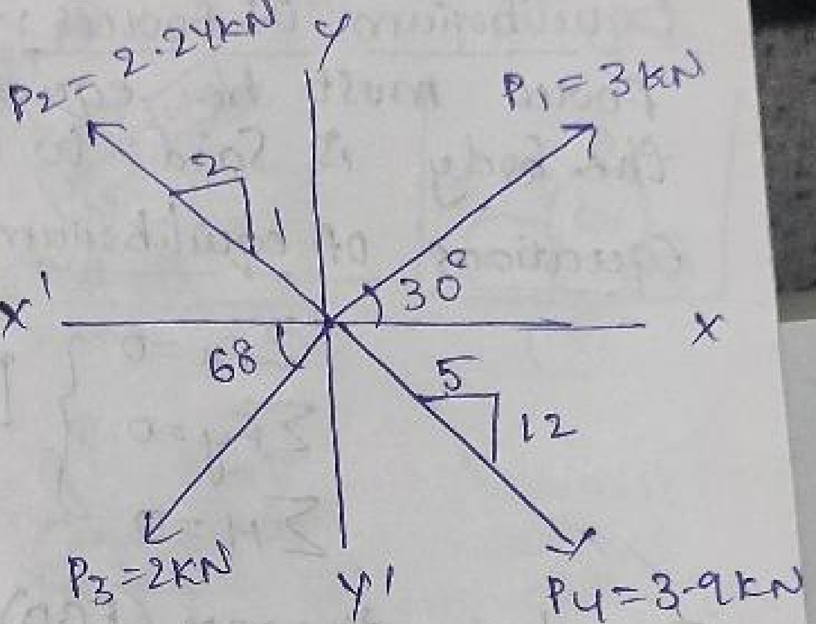
Q. Determine the resultant both in magnitude and direction of the four forces acting on a body as shown fig.

$$\tan\theta_2 = 1/2$$

$$\theta_2 = 26.56$$

$$\tan\theta_4 = 5/12$$

$\theta_y = 22.61$



$\Sigma F_x =$

$3\cos 30 - 2.24\cos(26.56)$
$-2\cos 60 + 3.9\cos(22.61)$
$= 33.19kN$

$\Sigma F_y =$

$3\sin 30 + 2.24\sin 26.56 - 2\sin 60 - 3.9\sin 22.61$
$= -0.429N.$

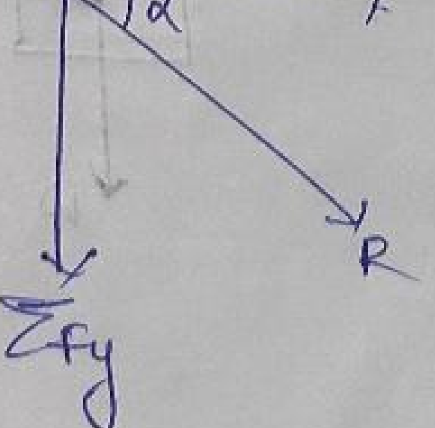
$$R = \sqrt{\Sigma F_x^2 + \Sigma F_y^2} =$$

$$\sqrt{(33.19)^2 + (-0.429)^2}$$

$$= 3.27N$$

$$\alpha = \tan^{-1}\left(\frac{0.429}{3.19}\right)$$

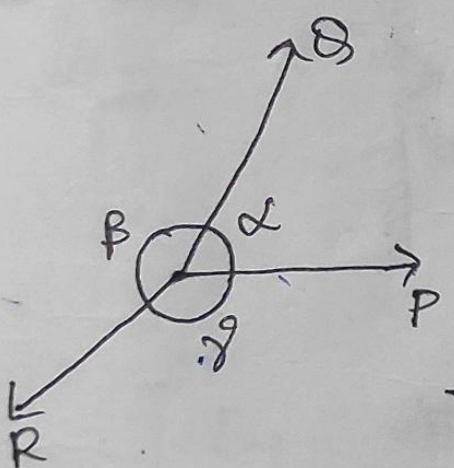
$$\alpha = 12.87$$



Lami's theorem:-

If three forces acting at a point at Equilibrium Each force is proportional to Sine of the angle b/w the other two forces.

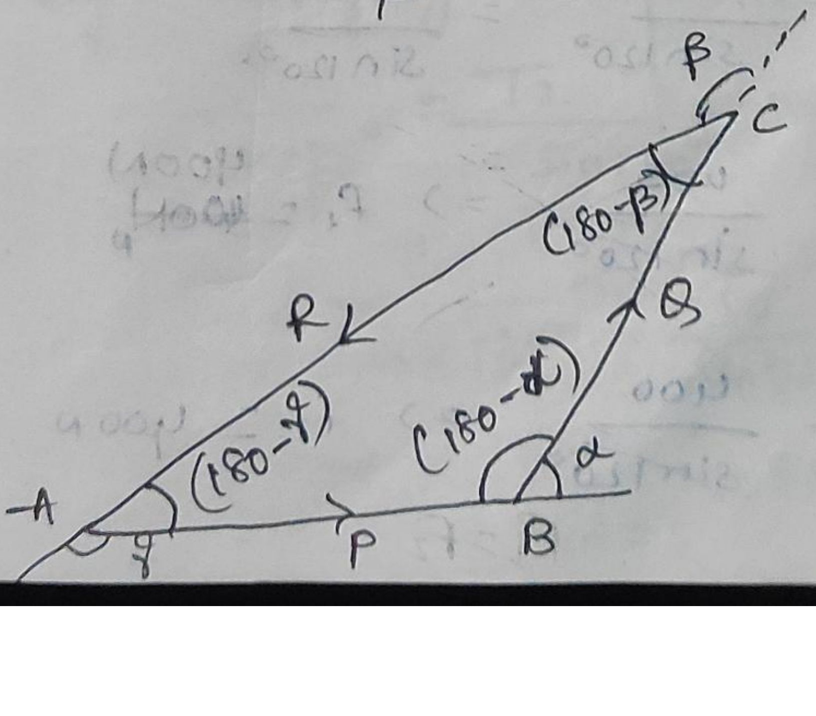
$$P \propto \sin\beta \Rightarrow \frac{P}{\sin\beta} = \text{const}$$



$$Q \propto \sin\gamma \Rightarrow \frac{Q}{\sin\gamma} = \text{Const}$$

$$R \propto \sin\alpha \Rightarrow \frac{R}{\sin\alpha} = \text{const}.$$

$$\frac{P}{\sin\beta} = \frac{Q}{\sin\gamma} = \frac{R}{\sin\alpha}$$

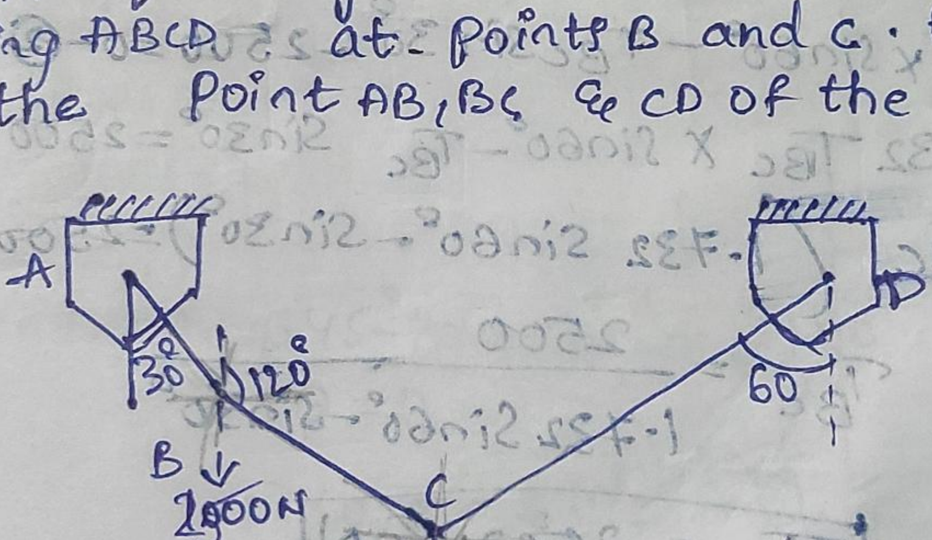


By Apply sine law

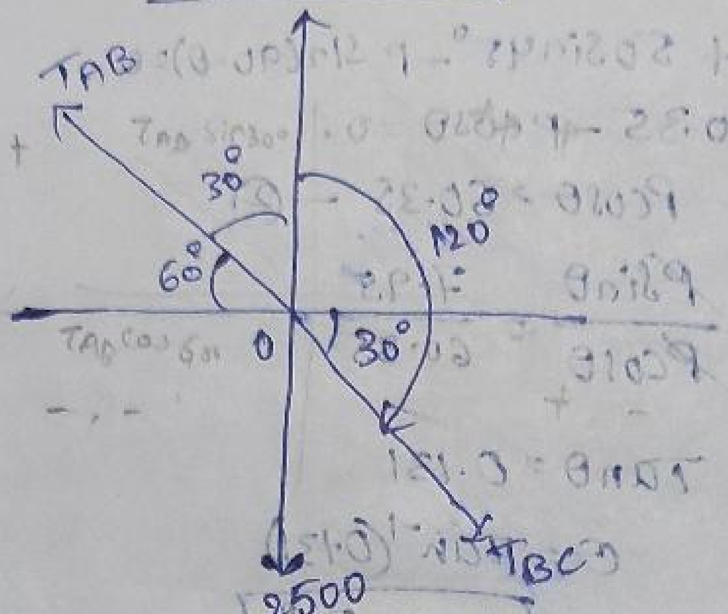
$$\frac{P}{\sin(180-\beta)} = \frac{Q}{\sin(180-\gamma)} = \frac{R}{\sin(180-\alpha)}$$

$$\frac{P}{\sin\beta} = \frac{Q}{\sin\gamma} = \frac{R}{\sin\alpha}$$

Problem 6:- Two equal loads of 2500N are Suppoorted by a Fleniable ~~Sitting flow~~ String ABCD is at points B and C. Find tension in the Point AB, BC & CD of the String.



FBD of point B.



$\Sigma F_x = 0$

$-T_{AB} \cos 60° + T_{BC} \cos 30° = 0$

$T_{AB} \cos 60° = T_{BC} \times \cos 30°$

$$T_{AB} = T_{BC} \times \frac{\cos 30°}{\cos 60°}$$

$$\boxed{T_{AB} = 1.732\, T_{BC}} \quad \text{—} ①$$

$\Sigma F_y = 0$

$T_{AB} \times \sin 60° - T_{BC} \sin 30° - 2500 = 0$ — ②

$1.732\, T_{BC} \times \sin 60° - T_{BC} \sin 30° = 2500$

$T_{BC} (1.732 \sin 60° - \sin 30°) = 2500$

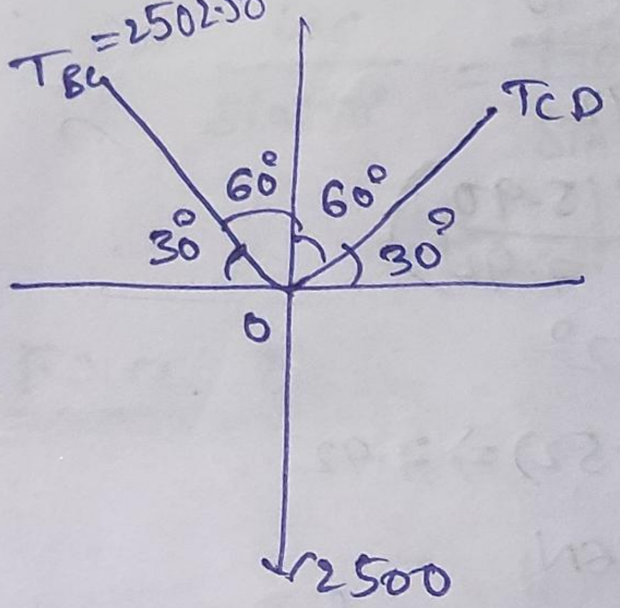
$$T_{BC} = \frac{2500}{1.732 \sin 60° - \sin 30°}$$

$$\boxed{T_{BC} = 2502.50\,N}$$

$T_{AB} = 1.732 \times 2502.50$

$$\boxed{T_{AB} = 4334.55\,N}$$

FBD at Point C



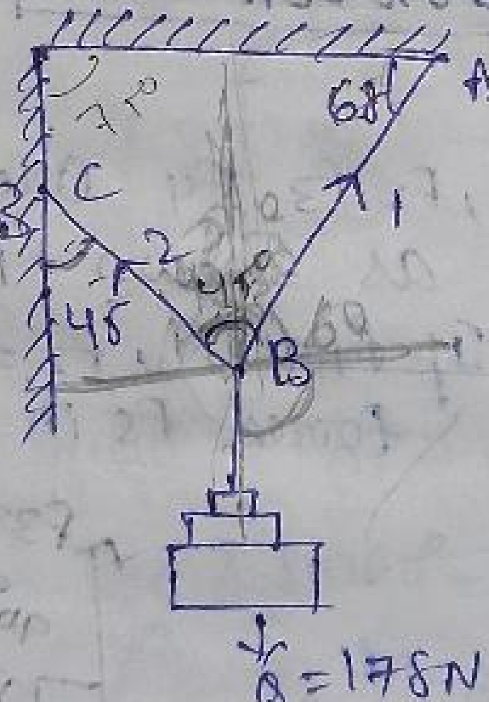
$\sum f_x = 0$

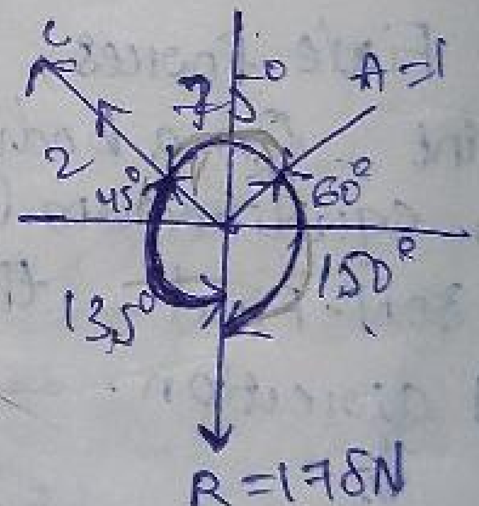
$T_{CD} \cos 30^\circ - 2502.50 \times \cos 30^\circ$

$$T_{CD} = \frac{2502.50 \times \cancel{\cos 30^\circ}}{\cancel{\cos 30^\circ}}$$

$$\boxed{T_{CD} = 2502.50N = T_{BC}}$$

An, ~~Equi~~ electrical light ~~fixture~~ Fixed of weight $Q = 178N$ is supported as shown in the figure. Determine the tension force in the wires BA and BC if their angles of indications are as shown in figure.





Sine law

$$\frac{AB}{\sin 135^\circ} = \frac{BC}{\sin 150^\circ} = \frac{Q}{\sin 75^\circ}$$

$$\frac{AB}{\sin 135^\circ} = \frac{178}{\sin 75}$$

$$AB = \frac{178}{\sin 75} \times \sin 135^\circ$$

$AB = 130.3N$

$$\frac{BC}{\sin 150^\circ} = \frac{178}{\sin 75^\circ}$$

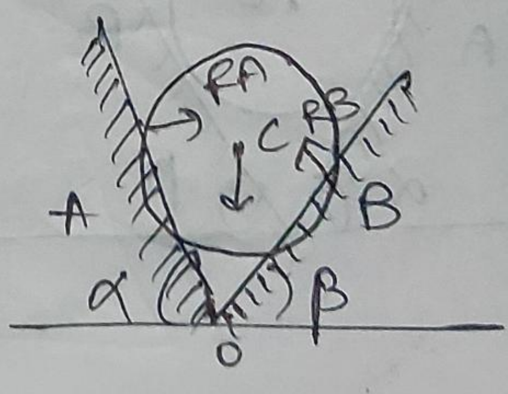
$BC = 92.139N$

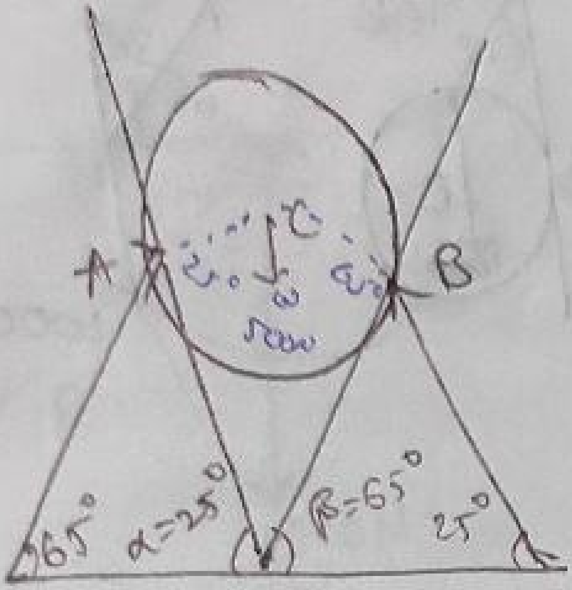
A Smooth Circular cylinder of weight w and radius r rest in a V shaped radial groove whose sides are inclined at angles α and β to the horizantal as shown in the fig. Find the reaction R_A and R_B at the point of contact. Given $\alpha = 25^\circ$ and $w = 500N$.

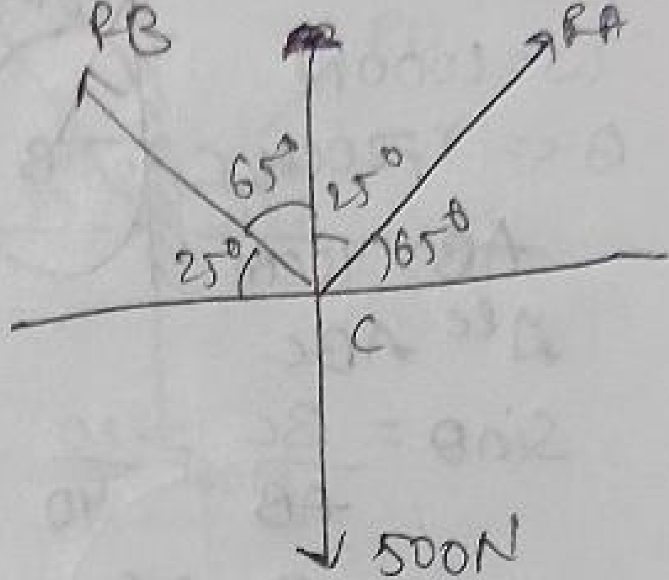
Sol Given that $\alpha = 25^\circ$

$\beta = 65^\circ$, $w = 500N$

$R_A, R_B = ?$







$\Sigma F_x = 0$

$R_A \cos 65^\circ - R_B \cos 25^\circ = 0.$

$$R_A = \frac{R_B \cos 25^\circ}{\cos 65^\circ}$$

$R_A = 2.14\, R_B \quad -①.$

$\Sigma F_y = 0.$

$R_A \sin 65^\circ + R_B \sin 25^\circ = 500$

$2.14\, R_B \sin 65^\circ + R_B \sin 25^\circ = 500$

$(2.14 \sin 65^\circ + \sin 25^\circ) = 500$

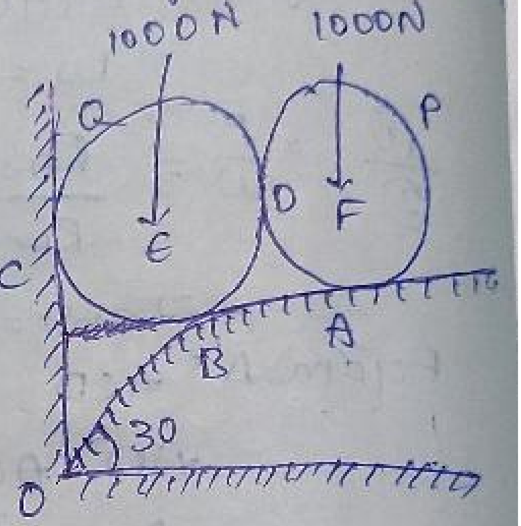
$$R_B = \frac{500}{2.14 \sin 65 + \sin 25^\circ}$$

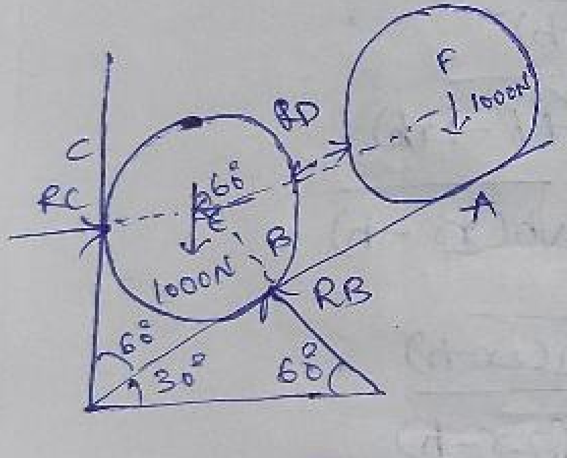
$R_B = 211.36\,N$

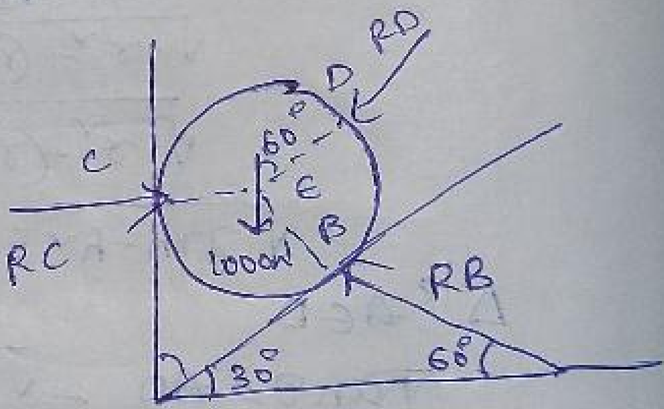
$① \Rightarrow R_A = 2.14\,(211.36)$

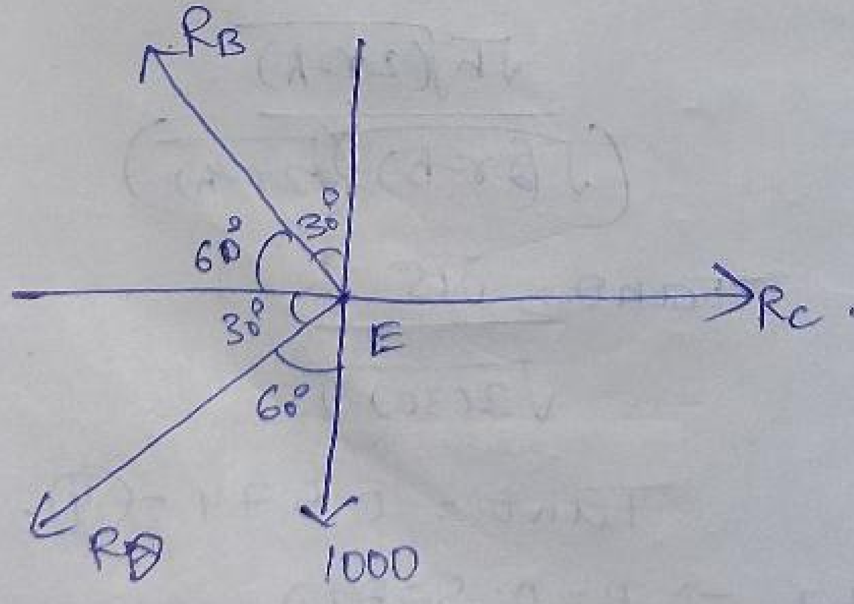
$R_A = 453.36\,N.$

Two identical rollers, each of weight w are supported by an inclined plane and vertical wall as shown figure. Find the reactions at the point of supports A, B and C. Assume all the surfaces to be smooth.







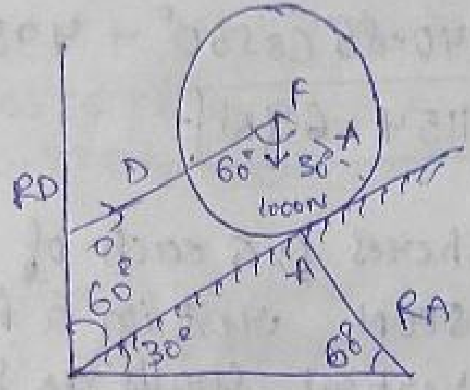


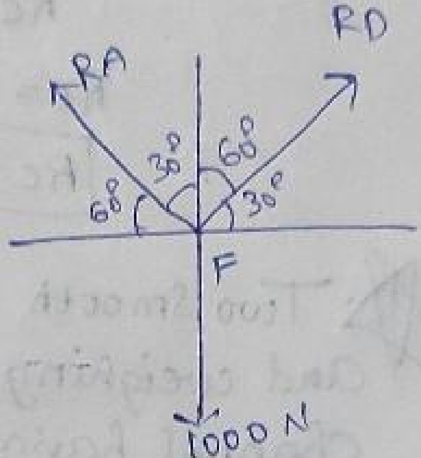
$\Sigma F_x = 0$

$R_C - R_B \cos 60^\circ - R_D \cos 30^\circ = 0$ — ①

$\Sigma F_y = 0$ $R_B \sin 60^\circ - R_D \sin 30^\circ - 1000 = 0$ — ②.

FBD of Roller-2:-





$\Sigma F_x = 0$

$R_D \cos 30^\circ - R_A \cos 60^\circ = 0.$

$R_D = \frac{R_A \cos 60^\circ}{\cos 30^\circ}$ $R_D = R_A [0.577]$

$\Sigma F_y = 0$ $R_D = 0.577 R_A$

$R_D \sin 30^\circ + R_A \sin 60^\circ - 1000 = 0.$

$R_A [0.57] \sin 30^\circ + R_A \sin 60^\circ - 1000 = 0.$

$R_A [0.57 \sin 30^\circ + \sin 60^\circ] = 1000.$

$R_A = \frac{1000}{0.57 \sin 30^\circ + \sin 60^\circ}$

$\boxed{R_A = 866.35 N}$

$R_D = 866.35 (0.57)$

$\boxed{R_D = 499.69 N}.$

From equ ②

$R_B \sin 60 - 499.69 \sin 30^\circ + 1000$

$R_B \sin 60 = 495.64 \sin 30^\circ + 1000$

$$R_B = \frac{495.64\sin 30^\circ + 1000}{\sin 60^\circ}$$

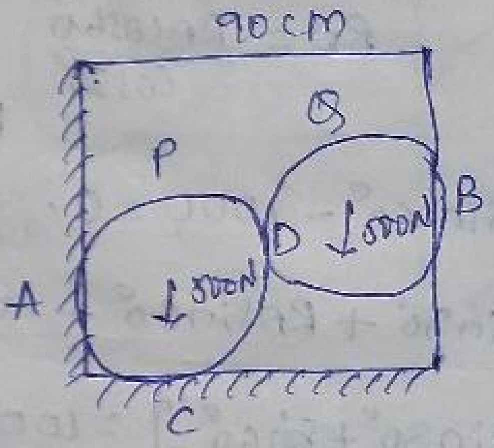
$$\boxed{R_B = 1440.85N}$$

$R_C - 1440.85\cos 60^\circ - 495.64\cos 30^\circ$

$R_C = 1440.85\cos 60^\circ + 495.64\cos 30^\circ$

$$\boxed{R_C = 1154.69N}$$

11. Two smooth spheres P, Q each of radius 25 and weighing 500N, rest in a horizontal channel having vertical walls as shown fig. If the distance between the walls is 90cm, calculate the reactions at point of contact A, B and C.

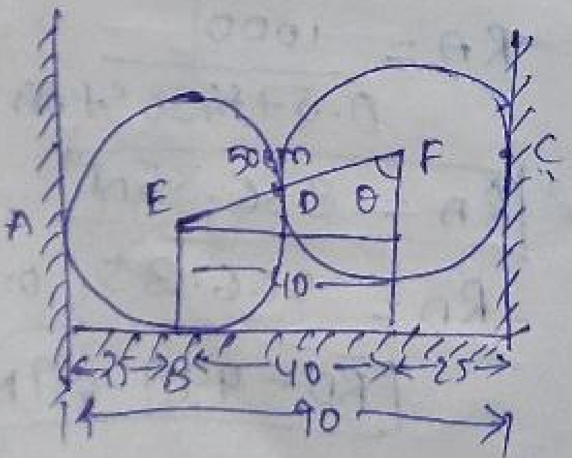


$\sin\theta = 40/50$

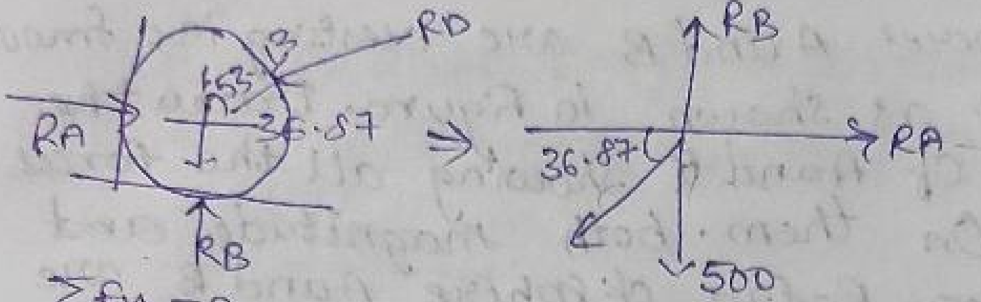
Vertical$(\theta) = 53.13$

horizontal$(\theta) = 90 - 53.13$

$= 36.87$



FBD of Roller ①



$\Sigma F_x = 0$

$R_A - R_D \cos 36.87^\circ = 0$

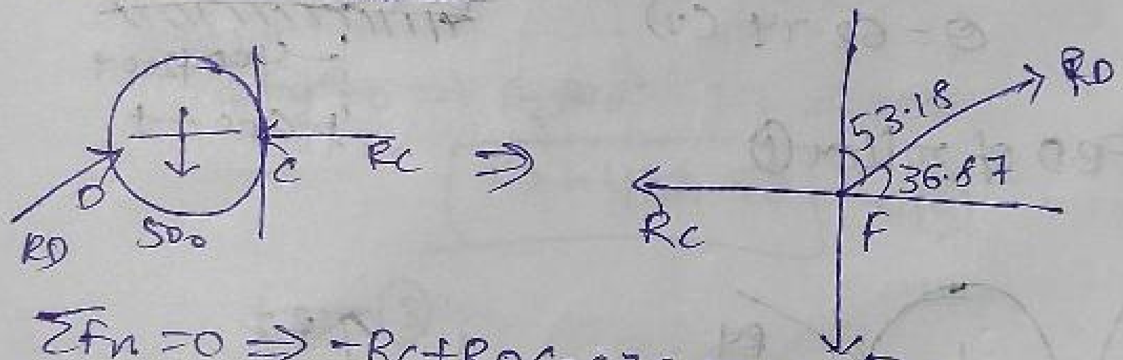
$R_A = 0.799 R_D$ — ①

$\Sigma F_y = 0$

$-R_B - R_D \sin 36.87 - 500 = 0$

$R_B = 0.600 R_D + 500$ — ②

FBD of Roller ②



$\Sigma F_x = 0 \Rightarrow -R_C + R_D \cos 36.87 = 0$ 500

$\Sigma F_y = 0 \Rightarrow R_D \sin 36.87 - 500 = 0$.

$R_D = \dfrac{500}{\sin 36.87} \Rightarrow \boxed{833.33N = R_A}$

$R_C = R_D \cos 36.87$

$\boxed{R_C = 666.66}$

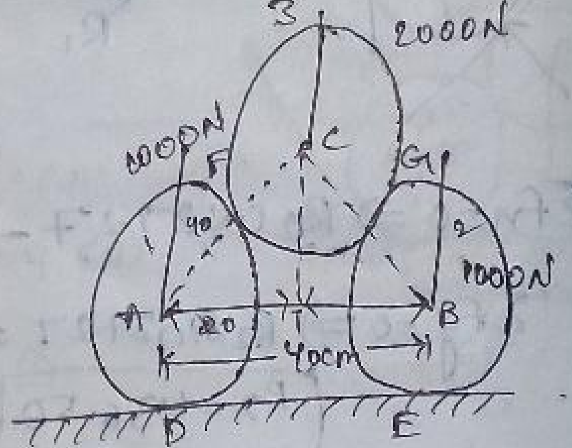
$R_A = 0.799 \times 833.83$

$\boxed{R_A = 665.830}$

$R_B = 0.600(833.33) + 500$

$\boxed{R_B = 999.99}$

Two Smooth circular cylinder, each of weight $= 1000N$ and radius 15cm, are connected at the centres by a string AB of length $= 40$ cm and rest upon a horizontal plane supporting above them a third cylinder of weight 2000N and radius 15cm as shown figure. Find the force T in the string AB and the pressure produced on the floor at the point of contact D and E.



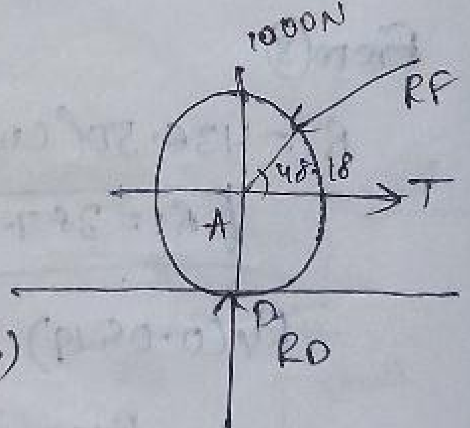
$W_1 = W_2 = 1000N$

$r_1 = r_2 = 15cm$

$AB = 40cm$

$W_3 = 2000N$

$r_3 = 15cm$



$\cos\theta = 20/30$

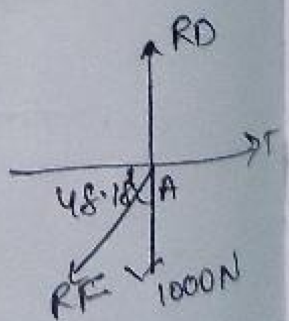
$\theta = 48.18$ (H)

$\theta = 90 - 48.18$

$\theta = 41.81°$ (v)

(a) $T = ?$

(b) $R_D, R_E = ?$



FBD of cylinder:

$\Sigma F_x = 0$

$T - R_F \cos 48.18 = 0$

$T = 0.6 R_E$ — (1)

$\Sigma F_y = 0$

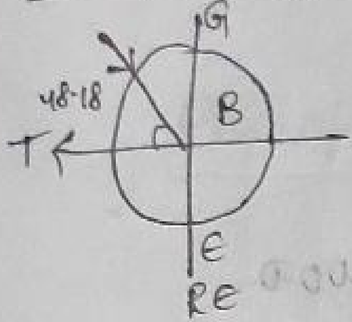
$R_D - R_F \sin 48.18 - 1000 = 0$

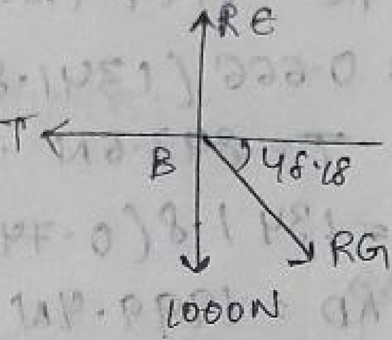
$R_D - R_F \sin 48.18 = -1000$

$R_D = R_F \sin 48.18 + 1000$

$R_D = R_F(0.74) + 1000$ — ②

FBD OF cylinder 2:





$\sum F_x = 0$

$-T + R_G \cos 48.18 = 0$

$T = R_G \cos(48.18)$

$T = 0.666 R_G$ — ③

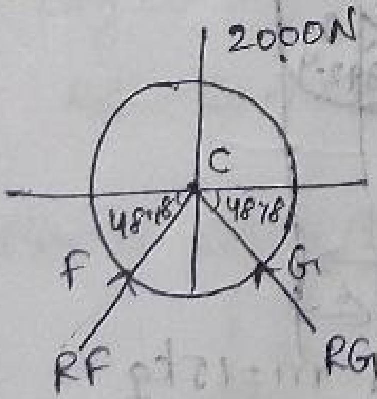
$\sum F_y = 0$

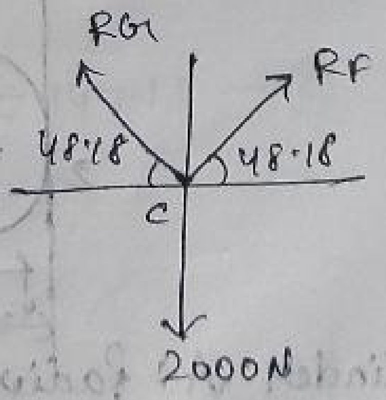
$R_E - 1000 - R_G \sin 48.18 = 0$

$R_E = R_G \sin 48.18 + 1000$

$R_E = R_G(0.74) + 1000$ — ④

FBD OF Cylinder 3:-





$\sum F_x = 0$

$R_F \cos 48.18 - R_G \cos 48.18 = 0$

$R_F = R_G$ — ⑤

$\sum F_y = 0$

$R_F \sin 48.18 + R_G \sin 48.18 - 2000 = 0.$

$R_G = 1341.8$

$R_F = 1341.8$

$R_G = R_F = 1341.84N.$

(4) $\Rightarrow 1341.8\,(0.74) + 1000$

$R_E = 1999.9N$

(3) $\Rightarrow T = 0.666\,(1341.8)$

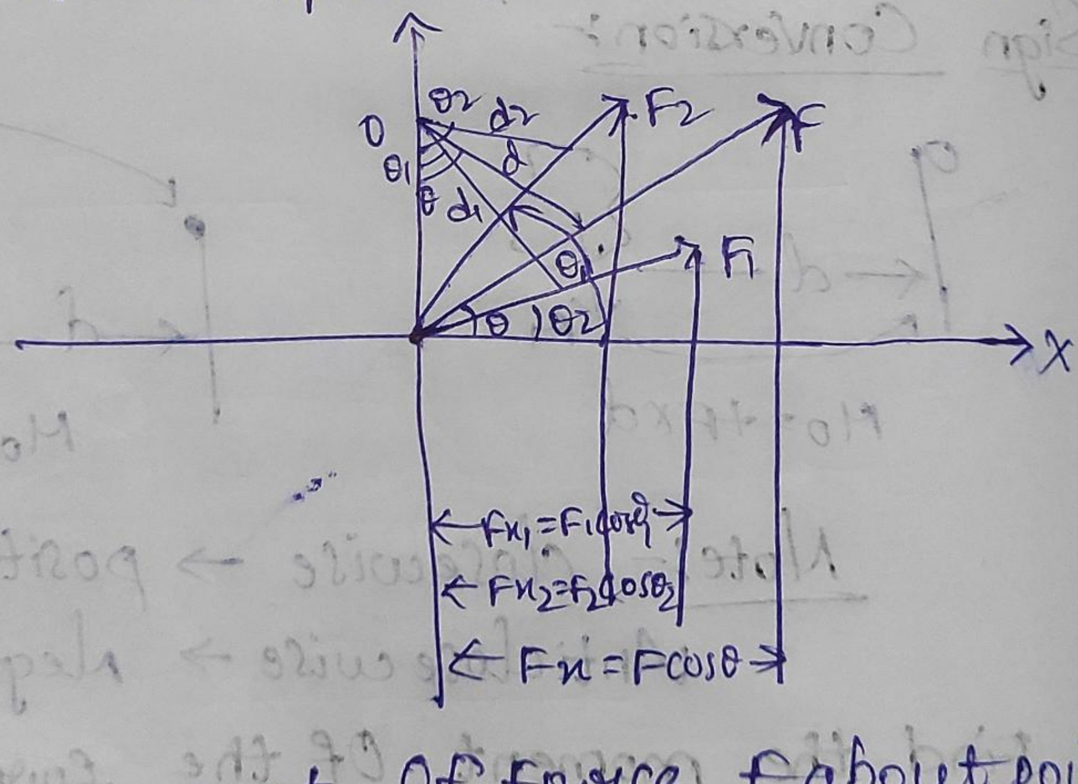
$T = 893.6N$

(2) $\Rightarrow R_D = 1341.8\,(0.74) + 1000$

$R_D = 1999.9N.$

Varignon's Theorem:-

It states that the moment of a Force above any point is equal to the algebric sum of the mom-ents of Components above Same point.



The moment of force F about point O $= F \times d$

$$= F \times OA \cos\theta$$

$$Fd = OA \times F\cos\theta$$

$$Fd = OA \times F_x \quad \text{— ①}$$

The moment of force F_1 above point $O = F_1 d_1$

$F_1 \times OA \cos\theta_1$ $\left\{ \because \cos\theta = d/OA \;\; \therefore d = OA\cos\theta \right\}$

$OA \times F_1 \cos\theta_1$

$F_1 d_1 = OA \times Fx_1$ — (2) $\left\{ \cos\theta_1 = d_1/OA \;\; d_1 = OA\cos\theta_1 \right\}$

The moment of force F_2 about point

$O = F_2 d_2$

$F_2 \times OA \cos\theta_2$

$F_2 \cos\theta_2 \times OA$ $\left\{ \cos\theta_2 = d_2/OA \;\; d_2 = OA\cos\theta_2 \right\}$

$F_2 d_2 = OA \times Fx_2$ — (3)

(2) + (3) $\Rightarrow$

$F_1 d_1 + F_2 d_2 = OA\,Fx_1 + OA\,Fx_2$

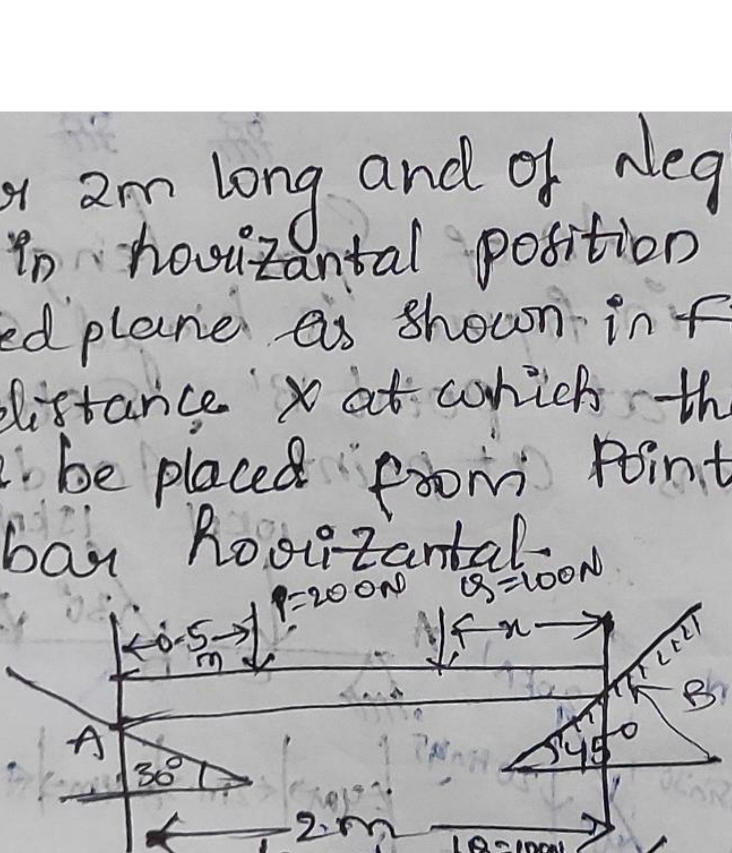
$F_1 d_1 + F_2 d_2 = OA\,[Fx_1 + Fx_2]$.

$F_1 d_1 + F_2 d_2 = OA \cdot Fx$ — (4).

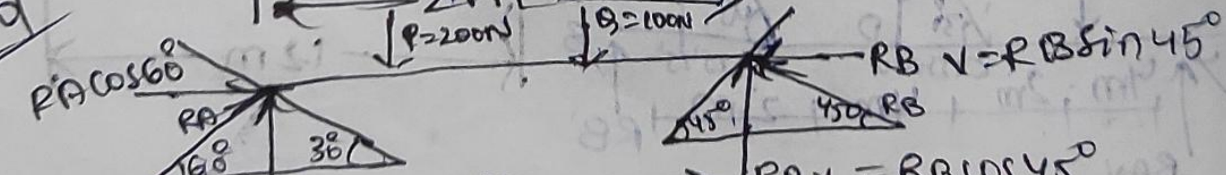
(1) = (4)

$$\boxed{Fd = F_1 d_1 + F_2 d_2}$$

Q. A bar 2m long and of Neglegible weight rests in horizontal position on two smooth inclined plane as shown in fig. Determine the distance x at which the load Q=100N shall be placed from point B to keep the bar horizontal.



Sol



$\Sigma F_x = 0$

$R_A \cos 60^\circ - R_B \cos 45^\circ = 0$

$R_A = \dfrac{R_B \cos 45^\circ}{\cos 60^\circ}$

$R_A = 1.414 R_B$ — (i)

$\Sigma F_y = 0$

$R_A \sin 60^\circ - 200 - 100 + R_B \sin 45^\circ = 0$

$1.414 R_B \sin 60^\circ + R_B \sin 45^\circ = 300$

$R_B = \dfrac{30}{1.414 \sin 60^\circ + \sin 45^\circ}$

$R_B = 155.30 N$

$R_A = 219.60 N$

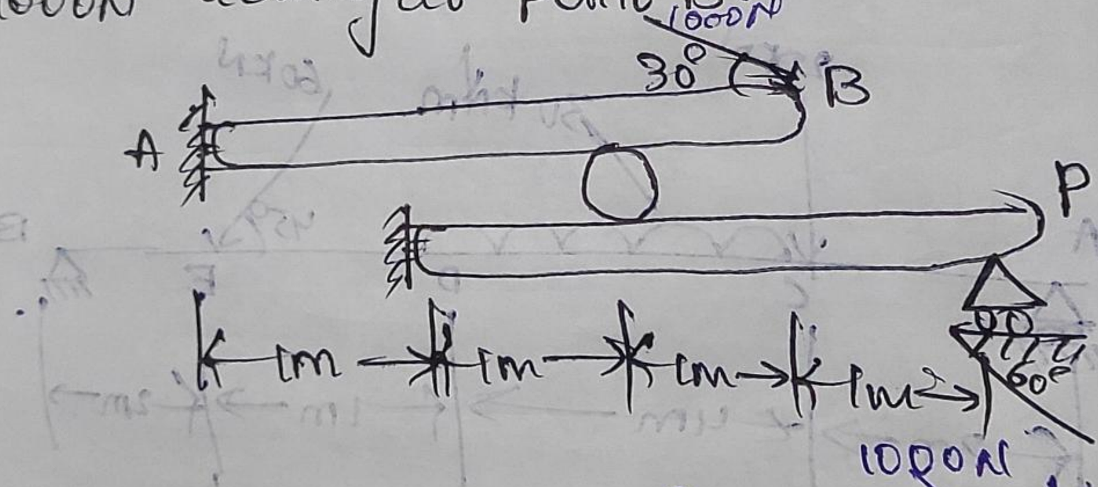
$\Sigma M_B = 0$

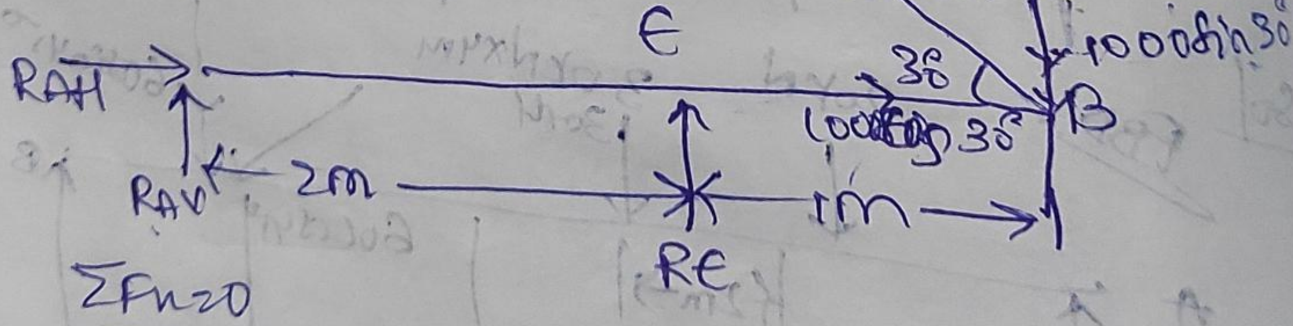
$-100 \times x - 200(2 - 0.5) + R_A \sin 60^\circ \times 2 = 0$

$219.60 \sin 60 \times 2 - 200 \times 1.5 = 100 x$

$\boxed{x = 0.80 m}$

Q. Two beams AB and CD are arranged and supported as shown figure. Find the reaction of D due to the force of 1000N acting at point B.





$\Sigma F_x = 0$

$R_{AH} + 1000\cos 30^\circ = 0$

$R_{AH} = -1000\cos 30^\circ$

$R_{AH} = -866$

$\Sigma F_y = 0$

$R_{AV} + R_E - 1000 \sin 30^\circ = 0$

$R_{AV} + R_E = 500N$ — ②

$\Sigma M_A = 0$

$-R_E \times 2 + 1000 \sin 30 \times 3 = 0$

$R_E = 750N$ — ③

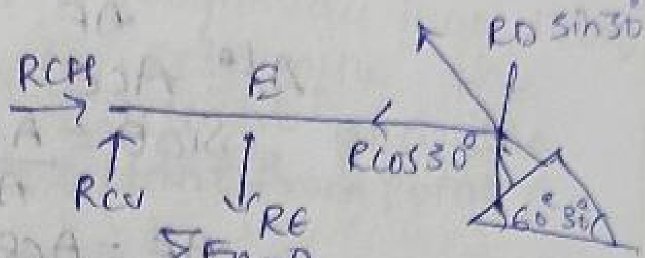
② $\Rightarrow R_{AV} = 500 - 750$

$R_{AV} = -250N$

$R_A = \sqrt{R_{AH}^2 + R_{AV}^2}$

$\sqrt{(866.02)^2 + (-250)^2}$

$= 901.38N$



$\Sigma F_x = 0$

$R_{CH} - R_D \cos 30 = 0$

$R_{CH} = R_D \cos 30^\circ$

$\Sigma F_y = 0$

$R_{CV} - R_E + R_D \sin 30 = 0$

$R_{CV} + R_D \sin 30$

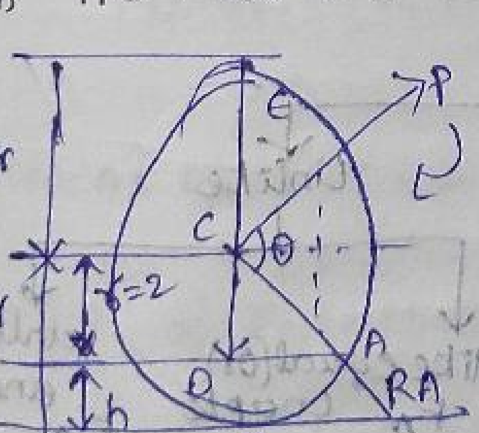
$\Sigma M_C = 0$

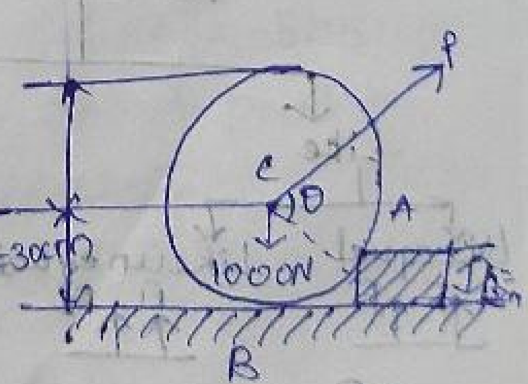
$R_E \times 1 - R_D \sin 30 \times 3 = 0$

$R_E = 3 R_D \sin 30$

$\boxed{R_D = 500N}$

A uniform wheel of 60cm diameter weighing load rests against a rectangular obstacle 15cm high. Find the least force required which when acting through the centre of the wheel will just turns the wheel over the corner of the block. Also find the angle θ which this least force shall make with AC, as shown fig.





$R_B = 0$

$\Sigma M_A = 0$

$-W \times AD + P \times AE = 0.$

$$P = \frac{\omega \times AD}{AE}$$

Δ^{le} ACE

$$\sin\theta = \frac{AE}{AC}$$

$$AE = AC\sin\theta$$

$$AE = r\sin\theta$$

From Δ^{le} ADC

$$AD^2 = AC^2 - CD^2$$

$$AD = \sqrt{AC^2 - CD^2}$$

$$AD = \sqrt{r^2 - (r-h)^2}$$

$$AD = \sqrt{r^2 - (r^2 + h^2 - 2rh)}$$

$$AD = \sqrt{2rh - h^2}$$

If P value is minimum θ should be maximum

$\sin\theta = 1$

$\theta = 90^\circ$

$$P = \frac{\omega \times \sqrt{2rh - h^2}}{r\sin\theta}$$

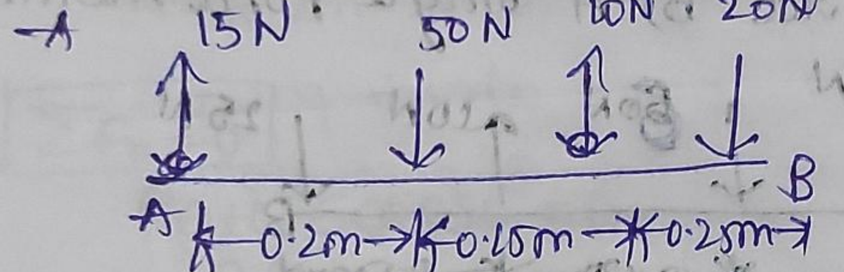
$$P = \frac{1000 \times \sqrt{2 \times 30 \times 15 - 15^2}}{30 \times 1}$$

$$\boxed{P_{min} = 866.02\,N}$$

10. A Rigid bar is subjected to a system of Parallel force as shown in figure. Reduce the system of a) A single force

ii) A single force - moment system of A.

iii) A single force - moment system at B.

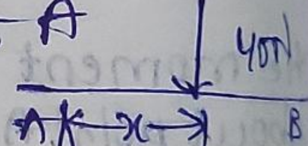


a) Single Force (Resultant)

$R = -15 + 50 - 10 + 20$

$R = -45\ (\downarrow)$ $R = 45N\ (\downarrow)$

$Fd = F_1 d_1 + F_2 d_2 + F_3 d_3 + F_4 d_4$



The moment of 15N about point A

$15 \times 0 = 0$

The moment of 50N about point B

$B = 50 \times 20 = 10N$

The moment of 10N about point C

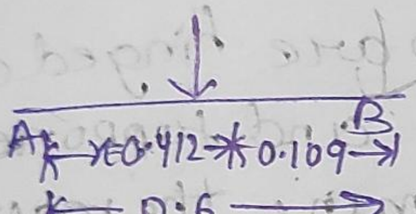
$= -10 \times 0.35 = -3.5N$

The moment of 20N about point D

$= 20 \times 0.6 = 12N.$

The moment of Resultant $= 45 \times x$

b) A Single moment System of at A

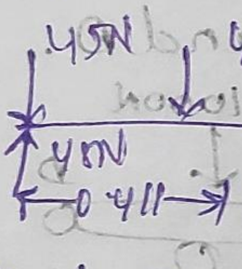


$45 \times x = 18.5$

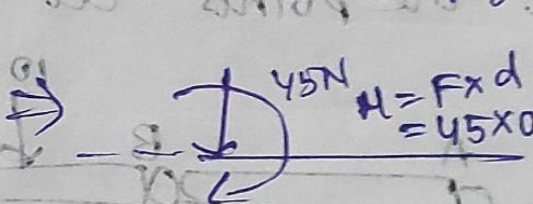
$x = \dfrac{18.5}{4.5}$

$x = 0.411$

⇒

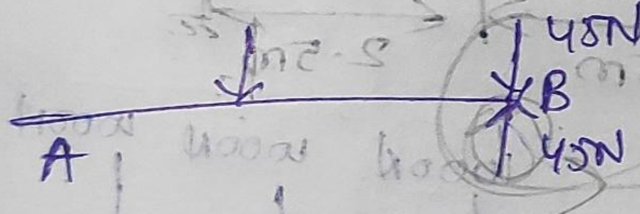


⇒

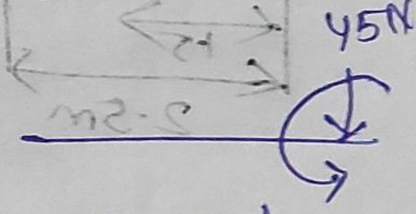


$M = F \times d$
$= 45 \times 0.411 = 18.495m$

c) A single force moment system at B



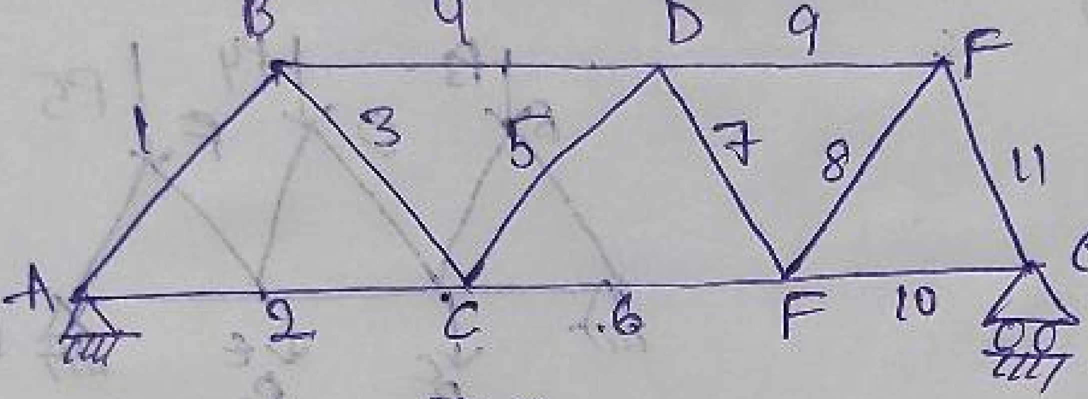
⇒



$F_1 = F \times d$

$M = 45 \times 0.209$
$= 4.905.$

Assumption of Perfect truss:-



$J = 7$

$m = 11$

$m = 2J - 3$ (Perfect truss)

$11 = 11$

* All the members are in One plane.
* The external loads are applied at the joints.
* The weight of members are negligeble.
* The cross section of members are uniform
* The truss is statically determined.

$\Sigma f_x = 0$, $\Sigma F_y = 0$, $\Sigma m = 0$.

* All the joints of a truss ideally hinged (or) Roller.
* The forces in the member are only axial that is either tensile or Compression.

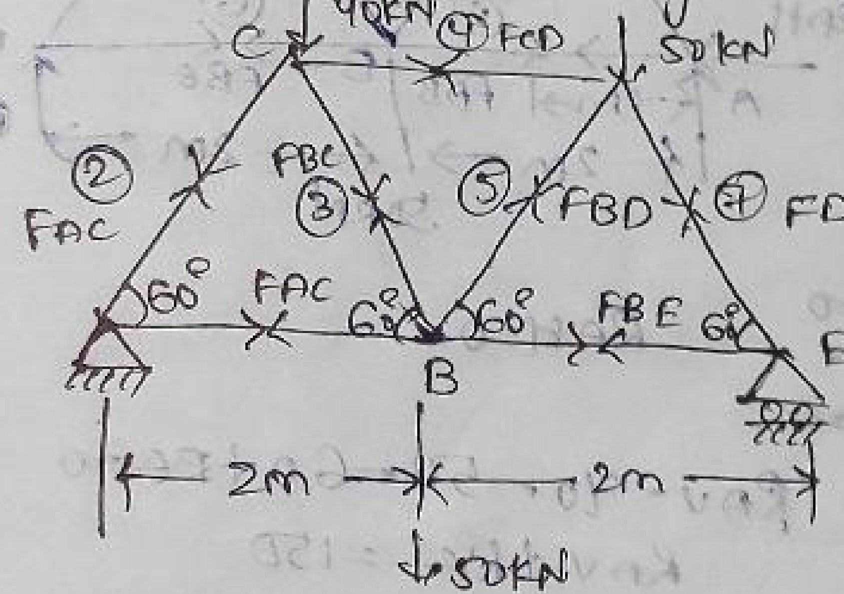
Methods Of Analysis Of trusses:-

i. Method of joints

ii) Method of sections (not in syllabus)

Problem:-

Q. Determine the axial forces included in the members at a truss using method of joints as shown in figure.



Members = 7

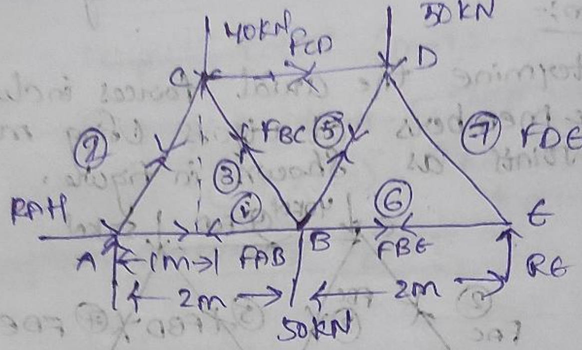
Joints = 5

$m = 2J - 3$

$7 = 2 \times 5 - 3$

$7 = 7$ Perfect truss

SNo	member	Force
1	AB	FAB
2	AC	FAC
3	BC	FBC
4	CD	FCD
5	BD	FBD
6	BE	FBE
7	DE	FDE



$\Sigma Fx = 0$

$RAH = 0$

$\Sigma Fy = 0$

$RAV - 40 - 50 - 60 + RE = 0$

$RAV + RG = 150$

$\Sigma MA = 0$

$40 \times 1 + 60 \times 2 + 50 \times 3 - RE \times 4 = 0$

$RG = 77.5 kN$

$RAV = 72.5 kN$

Joint A

$\Sigma Fx = 0$

$FAB + FBC \cos 60^\circ = 0$ — (1)

$\Sigma Fy = 0$

$72.5 + FAC \sin 60^\circ = 0$

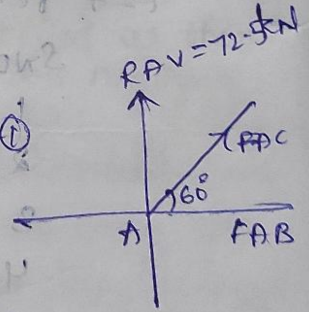
$FAC = \frac{-72.5}{\sin 60}$

$FAC = -83.7 kN$

$FAC = 83.7$ (compression(C))

$FAB = -FAC \cos 60^\circ$

$FAB = 41.85 (T) kN.$



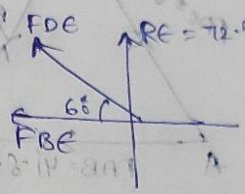
Joint E:-

$\Sigma F_x = 0$

$-F_{BE} - F_{DE}\cos 60^\circ = 0$

$\Sigma F_y = 0$

$72.5 + F_{DE}\sin 60^\circ = 0$



$F_{DE} = \dfrac{72.5}{-\sin 60}$

$F_{DE} = -89.4\,kN$

$F_{DE} = 89.4\,kN\,(C)$

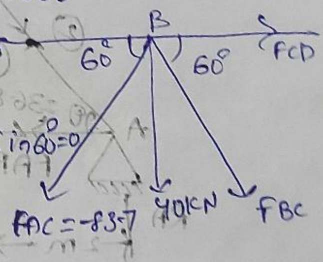
$F_{BE} = 44.74\,kN\,(T)$

Joint C:-

$\Sigma F_x = 0$

$F_{CD} - (-83.7\cos 60^\circ) + F_{BC}\cos 60^\circ$

$F_{CD} + 41.85 + F_{BC}\cos 60^\circ = 0$



$\Sigma F_y = 0$

$-40 - (-83.75\sin 60^\circ) - F_{BC}\sin 60^\circ = 0$

$-40 + 83.7\sin 60^\circ = F_{BC}\sin 60^\circ$

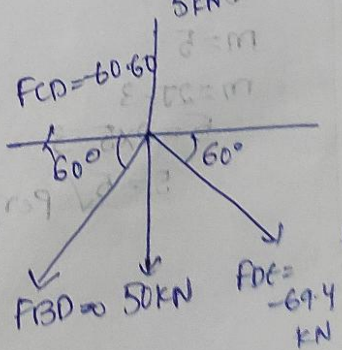
$F_{BC} = 37.51\,kN\,(T)$

$F_{CD} = -41.85 - 37.51\cos 60^\circ$

$F_{CD} = -60.605\,kN$

$F_{CD} = 60.605\,kN\,(C).$

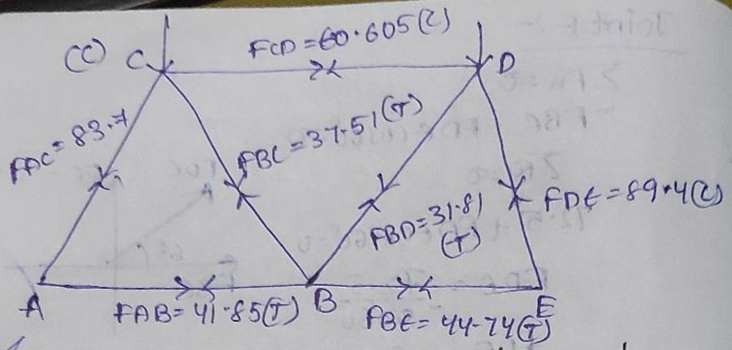
Joint D:-



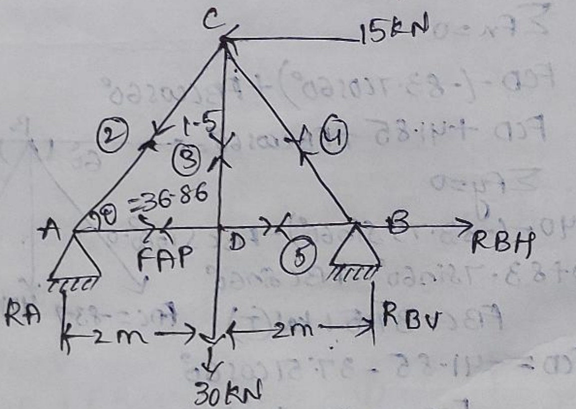
$\Sigma F_x = 0$

$-(-60.605) - F_{BD}\cos 60^\circ + (-89.4\cos 60) = 0.$

$F_{BD} = 31.81\,kN\,(T).$



Determine the magnitude and nature of forces in the various members of the triangular trusts loaded and supported as shown figure



$J = 4$

$m = 5$

$m = 2J - 3$

$5 = 2 \times 5 - 3$

$5 = 5 \checkmark$ Perfect

S.No	member	Force
1	AD	F_{AD}
2	AC	F_{AC}
3	CD	F_{CD}
4	BC	F_{BC}
5	BD	F_{BD}

$\tan\theta = \frac{1.5}{2}$

$\theta = 36.86^\circ$

$\Sigma F_x = 0$

$R_{BH} - 15 = 0$

$R_{BH} = \boxed{15}$

$\Sigma F_y = 0$

$R_A - 30 + R_{BV} = 0$

$\Sigma M_A = 0$

$30 \times 2 - 15 \times 1.5 - R_{BV} \times 4 = 0$

$R_{BV} = 9.375\ kN$

$R_A = 20.625\ kN$

Joint A :-

$\Sigma F_x = 0$

$F_{AD} + F_{AC} \cos 36.86 = 0$

$\Sigma F_y = 0$

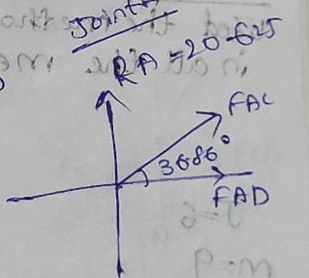
$20.625 + F_{AC} \sin 36.86 = 0$

$F_{AC} = \frac{-20.625}{\sin 36.86}$

$F_{AC} = -34.38$

$F_{AC} = 34.38\ (C)$

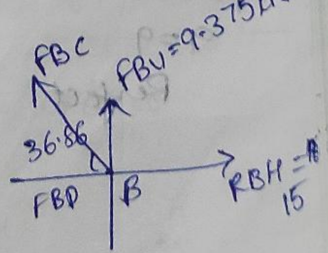
$F_{AD} = 27.50\ kN\ (T)$



Joint B :-

$\Sigma F_x = 0$

$15 - F_{BD} - F_{BC} \cos 36.86 = 0$



$\Sigma F_y = 0$

$9.375 + F_{BC} \sin 36.86 = 0$

$F_{BC} = -15.62$

$F_{BC} = 15.62\ (C)$

$F_{BD} = -F_{BC} \cos 36.86 + 15$

$F_{BD} = 15.62 \cos 36.86 + 15$

$F_{BD} = 27.49\ \text{kN}\ (T)$

Joint D:-

$\Sigma F_x = 0$

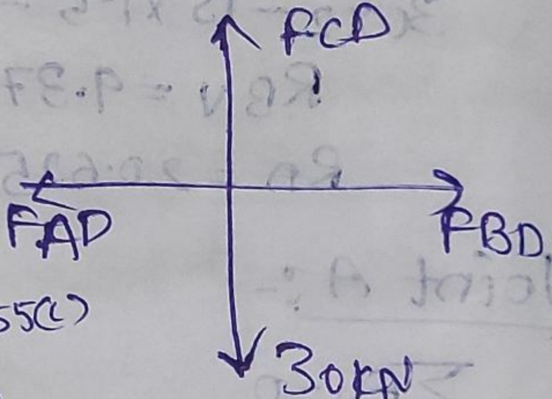
$F_{BD} - F_{AD} = 0$

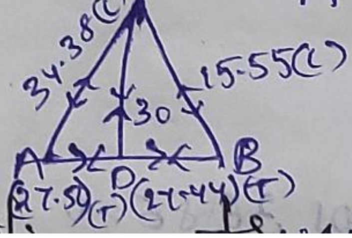
$27.49 - 27.50 = -0.01$

$\Sigma F_y = 0$

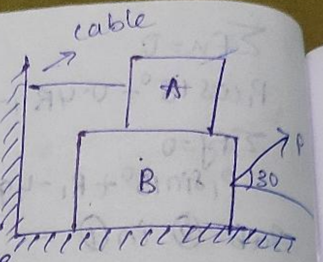
$F_{CD} - 30 = 0$

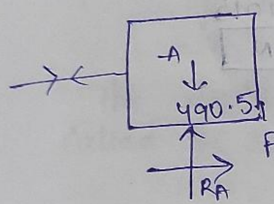
$\boxed{F_{CD} = 30T}$





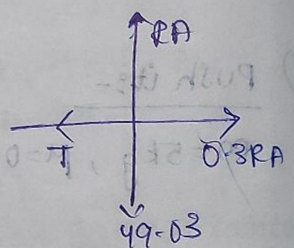
Q. Two blocks A and B of masses 50 kg and 80 kg respectively are in equilibrium as shown in figure. Determine the force P required to move the lower block B and the tension in the cable A. Assume the coefficient of friction between two surfaces can be taken as 0.3

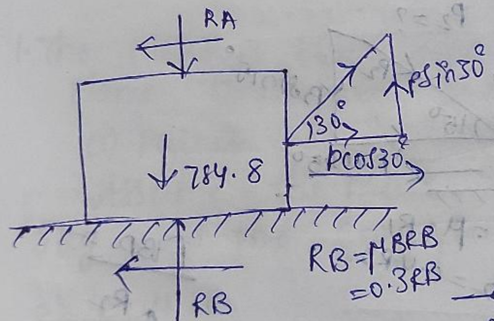




$F_A = \mu_A R_A$
$= 0.3 R_A$

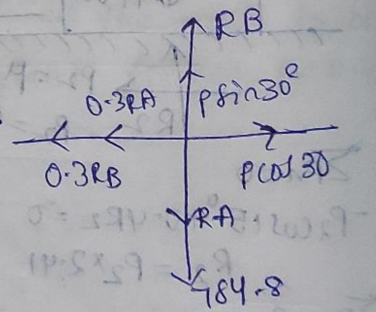
FBD of Block A





$R_B = \mu_B R_B$
$= 0.3 R_B$

FBD of Block B



$\Sigma F_x = 0$

$0.3 R_A - T = 0$

$T = 0.3 R_A$.

$\Sigma F_y = 0$

$R_A - 490.5 = 0$

$R_A = 490.5 N$

$T = 0.3 R_A \Rightarrow 0.3 \times 49.05$

$\boxed{T = 147.15 N}$

POCO
SHOT ON POCO X2

$\Sigma F_x = 0$

$P\cos 30 - 0.3(R_A + R_B) = 0$

$$P = \frac{0.3(490.5 + R_B)}{\cos 30}$$

$$P = \frac{147.15 + 0.3R_B}{\cos 30^\circ}$$

$$R_B = \frac{P\cos 30 - 147.15}{0.3}$$

$\Sigma F_y = 0$, $0.3R_B = P\cos 30 - 0.3(490.5)$

$-0.3R_B - 0.3 \times 490.5 + P\cos 30 = 0$ — (1)

$\Sigma F_y = 0$

$R_B - 490.5 - 784.8 + P\sin 30 = 0$.

$R_B = 1275.3 - P\sin 30$ — (2).

$-0.3(1275.3 - P\sin 30) - 0.3 \times 490.5 + P\cos 30^\circ = 0$.

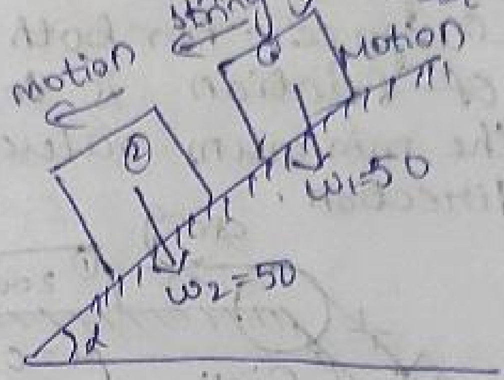
$P(0.3\sin 30 + \cos 30) = 0.3 \times 1257.3 + 0.3 \times 490.5$.

$P(1.0160) = 524.34$

$\boxed{P = 527.419N}$.

Two blocks of weight $W_1 = 50N$ and $W_2 = 50N$ rest on a rough incline plane or connected by string as shown in Fig. The coefficient of

Friction b/w the inclined plane and the weight w_1 and w_2 are 0.3 and 0.2 respectively. Determine the inclination of the plane for which sliping will in impent.



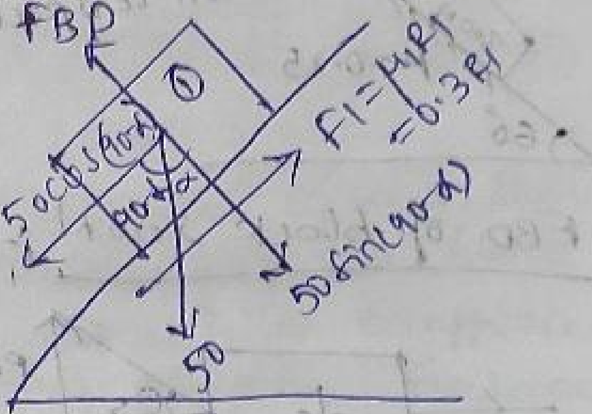
$\Sigma F_x = 0$

$-T + w_1 \sin\alpha - \mu_1 R_1 = 0$ — ①

$\Sigma F_y = 0$

$R_1 - w_1 \cos\alpha = 0$

$R_1 = w_1 \cos\alpha$ — ②



$\Sigma F_x = 0$

$-T + w_2 \sin\alpha - \mu_2 R_2 = 0$ — ③

$\Sigma F_y = 0$

$R_2 - w_2 \cos\alpha = 0$

$R_2 = w_2 \cos\alpha$ — ④

① + ③

$\Rightarrow T + w_1 \sin\alpha - \mu_1 R_1 - T + w_2 \sin\alpha - \mu_2 R_2 = 0$

$(w_1 + w_2)\sin\alpha - \mu_1 w_1 \cos\alpha - \mu_2 w_2 \cos\alpha = 0$

$100 \sin\alpha = (0.3 \times 50 + 0.2 \times 50)\cos\alpha$

$$\frac{\sin\alpha}{\cos\alpha} = \frac{15+10}{100} = \frac{25}{100} = 1/4$$

$\alpha = \tan^{-1}\left(\frac{1}{4}\right)$

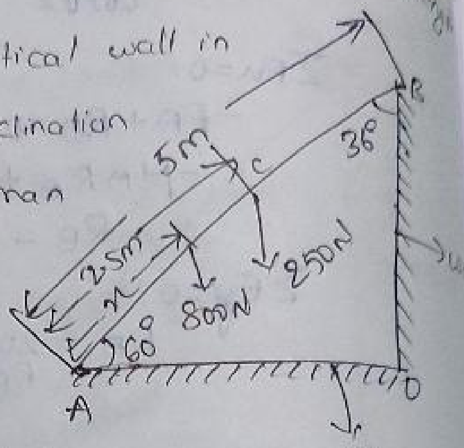
$\alpha = 14.03$

① $\Rightarrow T = \mu_1 R_1 - w_1 \sin\alpha$

$= 0.3 \times 50 \cos(14.03) - 50 \sin(14.03)$

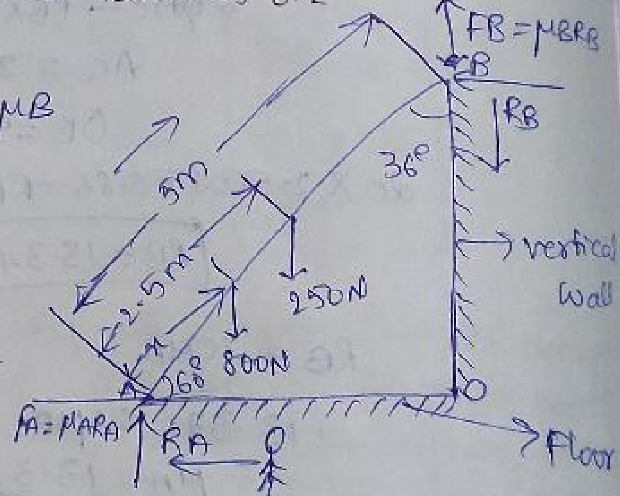
$\boxed{T = 2.43\,N}$

A uniform ladder of weight 250N and length 5m is placed on a vertical wall in the position where its inclination to the vertical is 30°. A man weight 800N climbs the ladder. At what position will be induced slipping? Assume the coefficient of friction at both of the ladder can be taken as 0.2



$\mu = 0.2 = \mu A = \mu B$

$\boxed{x = ?}$



$\Sigma F_x = 0$

$\mu A = \mu B = 0.2$

$-FA + RB = 0$

$-0.2\,\mu A + RB = 0$

$RB = 0.2AB$ — (1)

$\Sigma F_y = 0$

$RA + RB - 250 - 800 = 0$

$RA + 0.2RB - 1050 = 0$

$RA + 0.2 \times 0.2RA = 1050$

$RA(1 + 0.4) = 1050$

$RA = 1009.61N$

$RB = 201.92N$

$\Sigma M_A = 0$

$\Rightarrow 250 \times AE + 800 \times AF - R_B \times OB - F_B \times OA = 0$

$\Rightarrow 250 \times 2.5 \cos 60^\circ + 800 \times \cos 60 - 201.92 \times 5 \sin 60^\circ -$

$0.2 \times 201.92 \times 5 \cos 60^\circ = 0$

$\Rightarrow 312.5 + 800 \times x \cos 60^\circ - 874.3 - 100.96 = 0.$

$\Rightarrow 800 \times x \cos 60^\circ = 975.26 - 312.5$

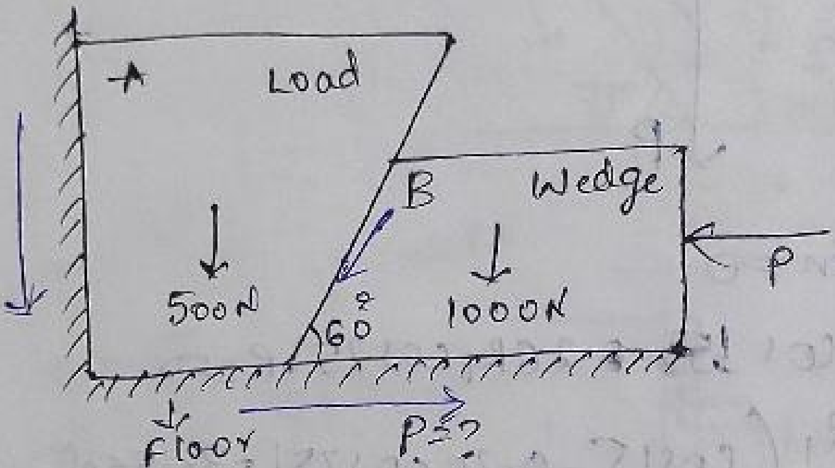
$\Rightarrow 800 \times x \cos 60^\circ = 662.76$

$x \cos 60^\circ = 0.8284.$

$x = \dfrac{0.828}{\cos 60^\circ}$

$\boxed{x = 1.656 \text{ mt}}.$

Q. Two blocks A & B rusting aganist a wall and floor as shown in Fig. Determine the value of horizantal force P applied to the lower block that will be hold the system in equilibrium. The coefficient of friction is 0.25 at the floor, 0.3 at the wall and 0.2 between the blocks.

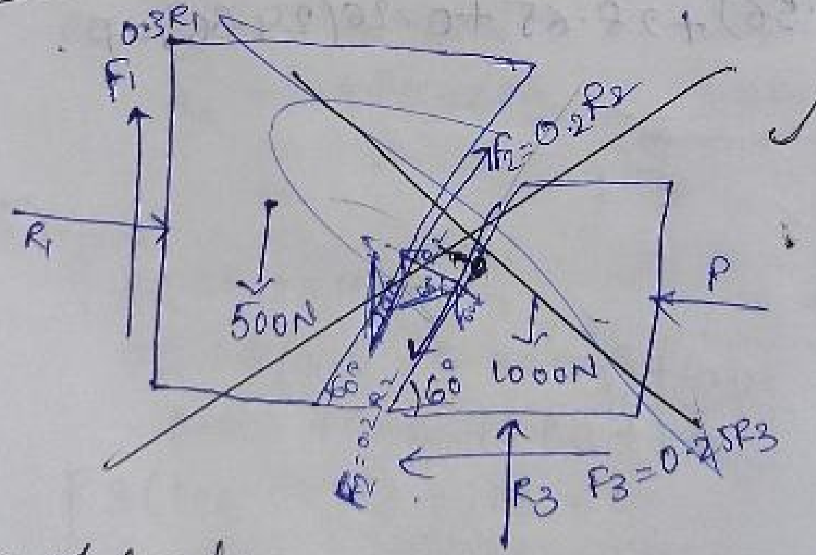


$\mu_3 = (\mu)_{floor} = 0.25$

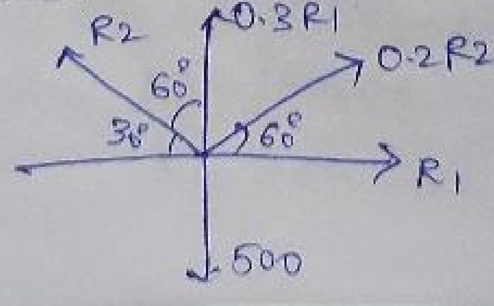
$\mu_1 = (\mu)_{wall} = 0.3$

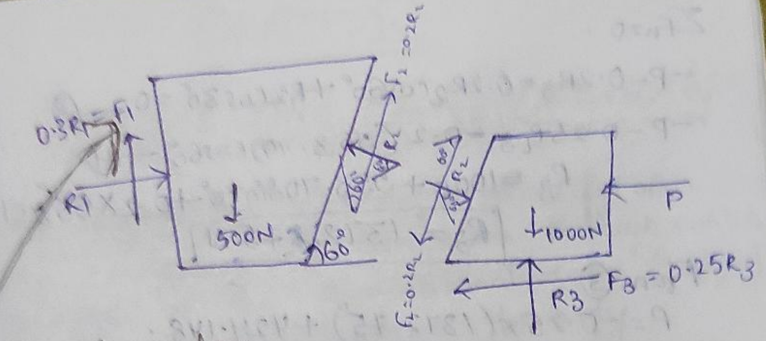
$\mu_2 = (\mu)_{Block} = 0.2$

FBD :-

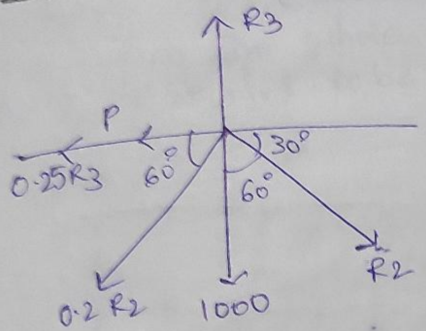


FBD of Load :-





FBD of Wedge:-



$\Sigma F_x = 0$

$R_1 + 0.2R_2\cos 60° - R_2\cos 30° = 0$

$R_1 + (0.2\cos 60° - \cos 30°)R_2 = 0$

$R_2 = \frac{R_1}{0.766} \Rightarrow R_1 = 0.766R_2$ — (1)

$\Sigma F_y = 0$

$0.2R_2\sin 60° + 0.3R_1 + R_2\sin 30° - 500 = 0$

$0.2R_2\sin 60° + 0.3[0.766R_2] + R_2\sin 30° = 500$

$R_2[0.2\sin 60° + 0.2298 + \sin 30°] = 500$

$R_2 = \frac{500}{0.9030}$

$R_2 = 553.70N$

(1) $\Rightarrow R_1 = 424.14N.$

POCO
SHOT ON POCO X2

$\Sigma F_x = 0$.

$-P - 0.2R_3 - 0.2R_2 \cos 60° + R_2 \cos 30° = 0$ — (3)

$-P - 0.25R_3 = 0.2(553.70)\cos 60°$ — (4)

$R_3 = 1000 + 553.70 \sin 30° + 0.2 \times 553.70 \sin 60°$

$\boxed{R_3 = 1372.875\ N}$

From (3),

$P = -0.25 \times (1372.75) + 424.148$.

$\boxed{P = 80.96\ N}$