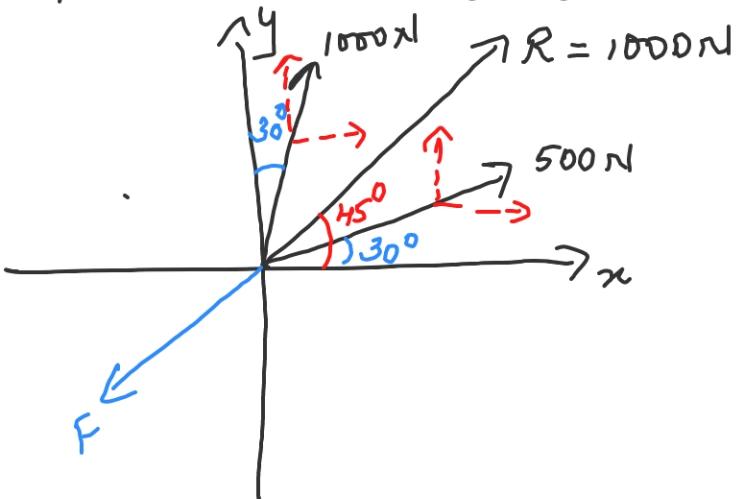


2) Two forces acting on a body are shown in fig. as 500N & 1000N. Determine the third force F such that the resultant of all the three forces is 1000N directed at 45° to x-axis.



Soln: Let the third force be F make an angle θ with x-axis

$$R \cos \alpha = \sum F_x$$

$$1000 \cos 45^\circ = 500 \cos 30^\circ + 1000 \sin 30^\circ + F \cos \theta$$

$$\boxed{F \cos \theta = -255.9 \text{ N}}$$

$$R \sin \alpha = \sum F_y$$

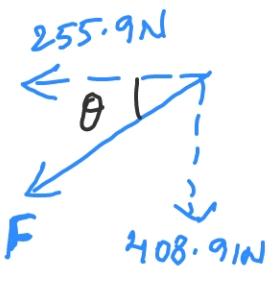
$$1000 \sin 45^\circ = 500 \sin 30^\circ + 1000 \cos 30^\circ + F \sin \theta$$

$$\boxed{F \sin \theta = -408.9 \text{ N}}$$

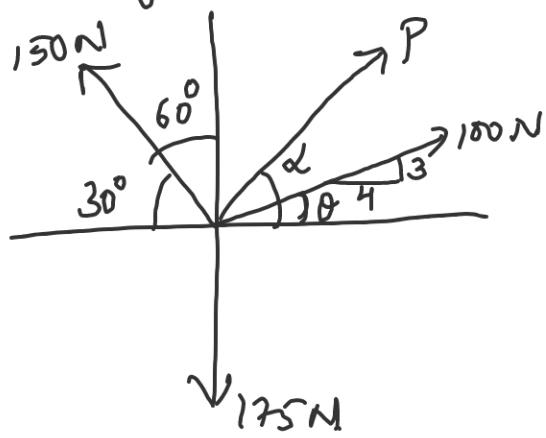
$$F = \sqrt{255.9^2 + 408.9^2}$$

$$\boxed{F = 467.2 \text{ N}}$$

$$\theta = \tan^{-1} \frac{408.9}{255.9} \Rightarrow \boxed{\theta = 61.08^\circ}$$



3] A force 'P' is in equilibrium under the action of four forces as shown in fig. Determine the magnitude and direction of the force P.

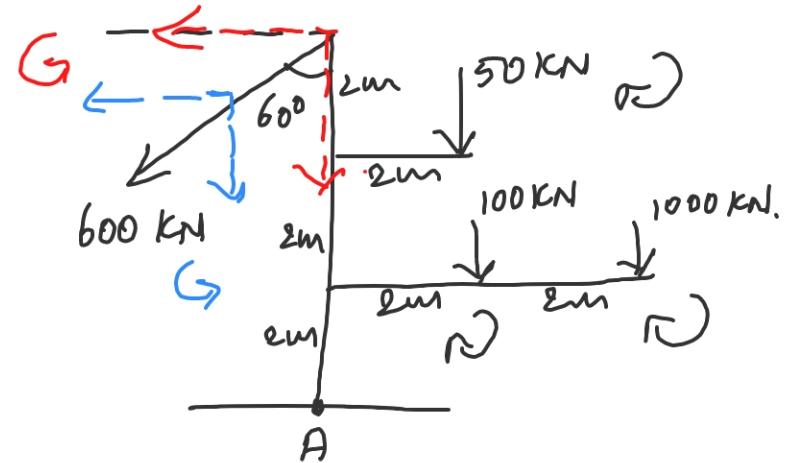


Sohc: $\tan \theta = \frac{3}{4} \Rightarrow \theta = 36.87^\circ$

$$\begin{aligned}\sum F_x &= 0 \\ \sum F_y &= 0\end{aligned}$$

$$\begin{aligned}\sum F_x &= 0 \quad \text{and} \quad \sum F_y = 0 \\ 100 \cos 36.87 + P \cos \alpha - 150 \cos 30 &= 0 \\ \therefore P \cos \alpha &= 49.90 \text{ N} \quad \rightarrow ① \\ \sum F_y &= 0 \\ 100 \sin 36.87 + P \sin \alpha + 150 \sin 30 - 175 &= 0 \\ P \sin \alpha &= 40 \quad \rightarrow ② \\ ②/① &\Rightarrow \frac{P \sin \alpha}{P \cos \alpha} = \frac{40}{49.9} = \frac{40}{50} \\ \tan \alpha &= 0.8 \Rightarrow \boxed{\alpha = 38.7^\circ} \\ ① &\Rightarrow P \cos \alpha = 49.90 \Rightarrow P = 49.9 / \cos 38.7 \\ &\Rightarrow \boxed{P = 63.94 \text{ N}}\end{aligned}$$

Q] Find R w.r.t. A.



Sohu:

$$\sum F_H = -600 \sin 60 = -519.61 \text{ kN}$$

$$\sum F_V = -600 \cos 60 - 50 - 100 - 1000$$

$$\boxed{\sum F_V = -1450 \text{ kN}}$$

$$R = \sqrt{(-519.61)^2 + (-1450)^2}$$

$$\boxed{R = 1540.3 \text{ kN}}$$

$$\theta = \tan^{-1} \frac{\sum F_V}{\sum F_H}$$

$$\boxed{\theta = 70.3^\circ}$$

$$\sum M_A = (50 \times 2) + (100 \times 2) + (1000 \times 4) - (600 \sin 60 \times 6)$$

$$\boxed{\sum M_A = 1182.4 \text{ kN-m}}$$

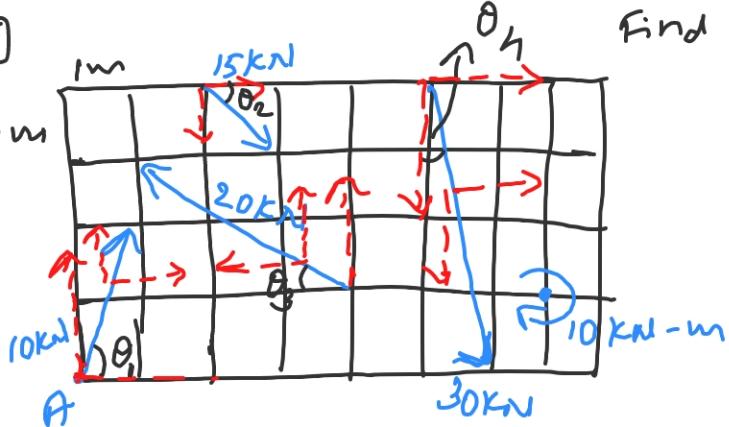
$$f_c = \frac{\sum M_A}{R} = \frac{1182.4}{1540.3}$$

$$f_c = 0.77 \text{ m from A}$$

$$x = \frac{\sum M_A}{\sum F_y} = 0.82 \text{ m}$$

$$y = \frac{\sum M_A}{\sum F_x} = 2.27 \text{ m.}$$

5)



Find Resultant w.r.t. A.

$$\sum F_H = 10 \cos 63.43 + 15 \cos 45 - 20 \cos 33.69 \\ + 30 \sin 14.03$$

$$\boxed{\sum F_H = 5.7 \text{ kN}}$$

$$\sum F_V = 10 \sin 63.43 - 15 \sin 45 + 20 \sin 33.69 \\ - 30 \cos 14.03$$

$$\boxed{\sum F_V = -19.68 \text{ kN}}$$

$$R = \sqrt{5.7^2 + (-19.68)^2} \Rightarrow \boxed{R = 20.49 \text{ kN}}$$

$$\theta = \tan^{-1} \frac{\sum F_y}{\sum F_x}$$

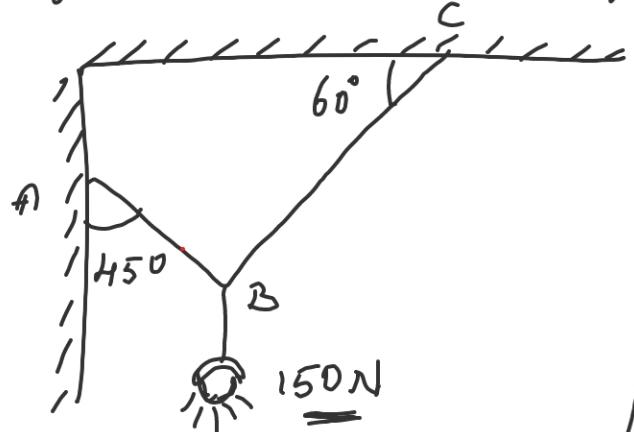
$$\boxed{\theta = 73.7^\circ}$$

$$\sum M_A = (15 \cos 45 \times 4) + \\ (15 \sin 45 \times 2) - (20 \cos 33.69 \times 1) - \\ (20 \sin 33.69 \times 4) + (30 \cos 14.03 \times 5) \\ + (30 \sin 14.03 \times 6) + 10$$

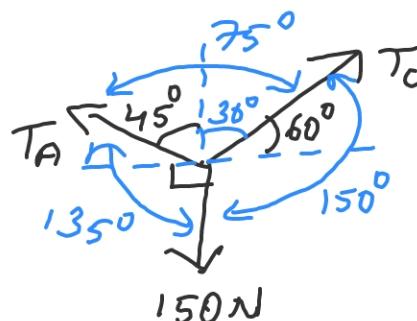
$$\boxed{\sum M_A = 187.3 \text{ kNm}} \quad R = \frac{\sum M_A}{R} \Rightarrow R = 9.14 \text{ m}$$

$$y = \frac{\sum M_A}{\sum F_x} = 32.8 \text{ m} \quad x = \frac{\sum M_A}{\sum F_y} = 9.5 \text{ m}$$

6] Find the forces developed in the wires, supporting an electric fixture as shown in fig.



Solu:

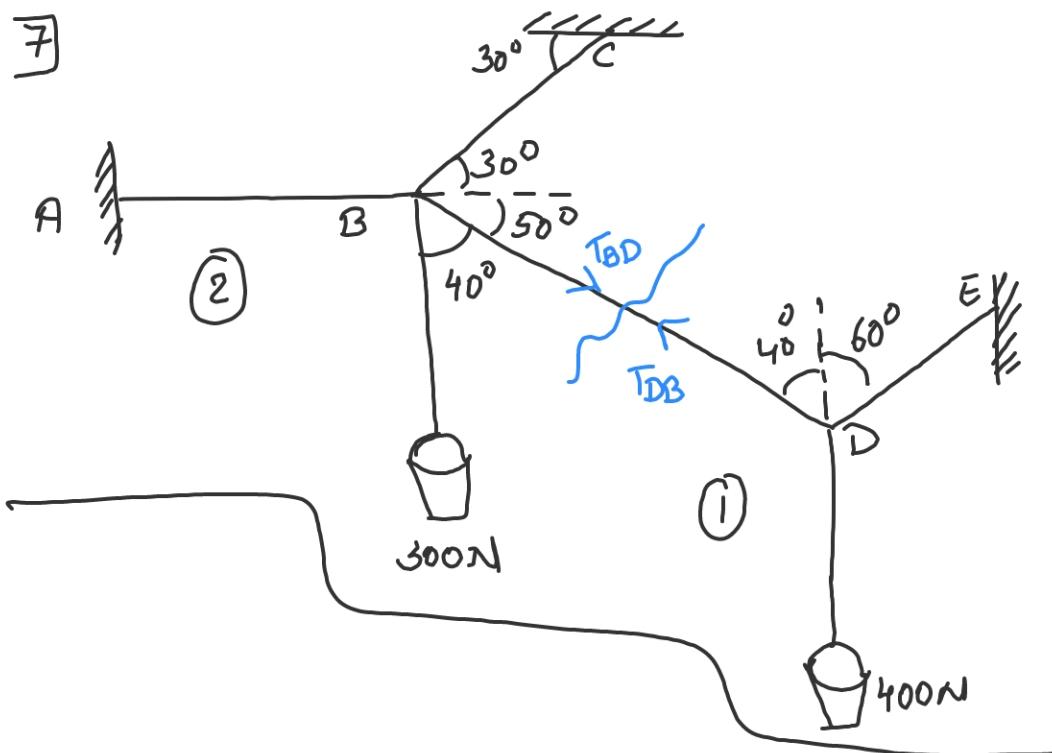


T = Tensile force

$$\frac{T_A}{\sin 150^\circ} = \frac{150}{\sin 75^\circ} = \frac{T_C}{\sin 135^\circ}$$

$$T_A = 77.6 \text{ N}$$

$$T_C = 109.8 \text{ N}$$



Sohi:

FBD of ①

$$\frac{TDE}{\sin 140^\circ} = \frac{400}{\sin 100^\circ} = \frac{TDB}{\sin 120^\circ}$$

$$TDE = 261.08 \text{ N}$$

$$TDB = 351.75 \text{ N}$$

$\sum F_H = 0$

$$T_{BC} \cos 30^\circ + 351.75 \cos 50^\circ - T_{BA} = 0$$

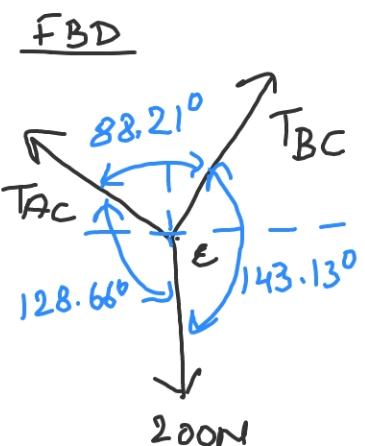
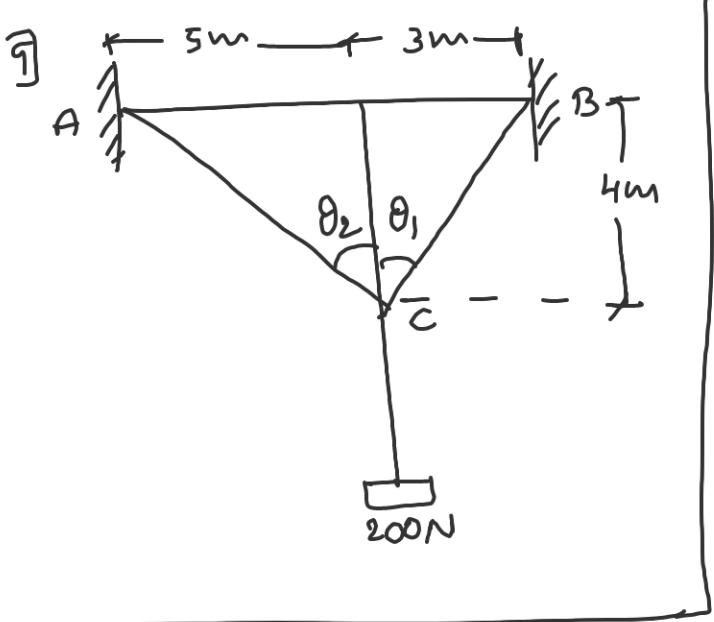
$$T_{BC} \cos 30^\circ - T_{BA} = -226.26 \quad \rightarrow \textcircled{1}$$

$\sum F_V = 0$

$$T_{BC} \sin 30^\circ - 351.75 \sin 50^\circ - 300 = 0$$

$$T_{BC} = 1138.91 \text{ N}$$

$\therefore \textcircled{1} \Rightarrow T_{BA} = 1212.42 \text{ N}$



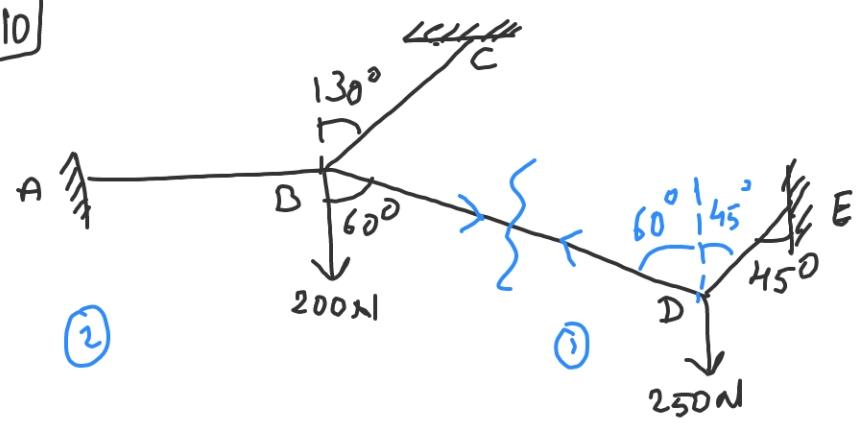
$$\frac{T_{AC}}{\sin 143.13} = \frac{200}{\sin 88.21} = \frac{T_{AB}}{\sin 128.66}$$

$T_{AC} = 120.06 \text{ N}$
$T_{BC} = 156.25 \text{ N}$

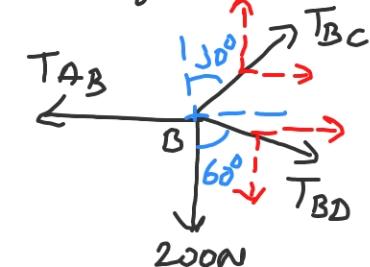
sln: $\theta_1 = \tan^{-1} \frac{3}{4} \Rightarrow \theta_1 = 36.87^\circ$

$\theta_2 = \tan^{-1} \frac{5}{4} \Rightarrow \theta_2 = 51.34^\circ$

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FBD of ②:



$$\sum F_H = 0$$

$$T_{BC} \sin 30 + 183.01 \sin 60 - T_{AB} = 0$$

$$T_{BC} \sin 30 - T_{AB} = -158.49 \rightarrow ①$$

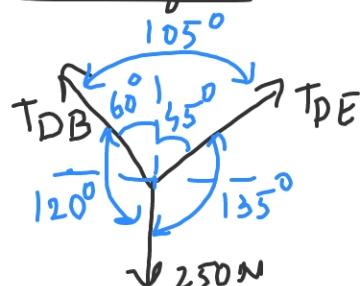
$$\sum F_V = 0$$

$$T_{BC} \cos 30 - 183.01 \cos 60 - 200 = 0$$

$$T_{BC} = 336.6 \text{ N}$$

$$\therefore ① \Rightarrow T_{AB} = 326.79 \text{ N}$$

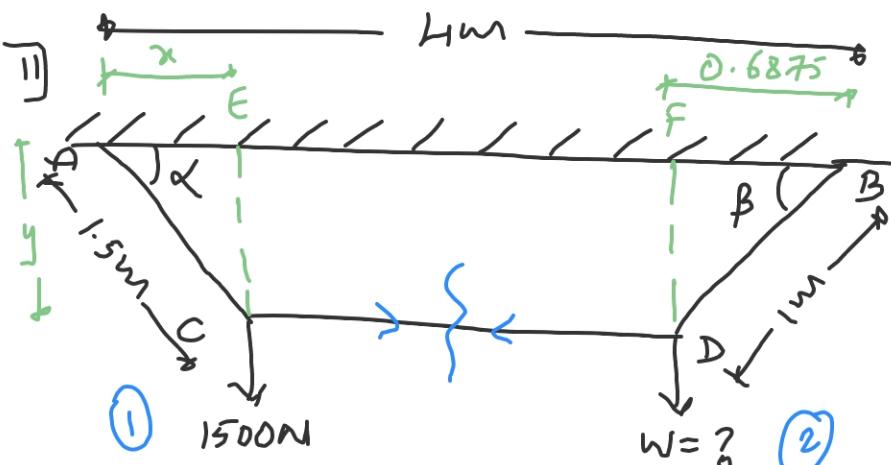
FBD of ①:



$$\frac{T_{DB}}{\sin 135} = \frac{250}{\sin 105} = \frac{T_{DE}}{\sin 120}$$

$$T_{DB} = 183.01 \text{ N}$$

$$T_{DE} = 224.14 \text{ N}$$



$$\text{In } \triangle DF\bar{B}, BF^2 + DF^2 = \bar{B}^2$$

$$(2-x)^2 + y^2 = 1 \rightarrow \textcircled{3}$$

$$\textcircled{1} - \textcircled{3}$$

$$x^2 - (2-x)^2 = 1.25$$

$$x^2 - 4 + 4x - x^2 = 1.25 \Rightarrow x = 1.3125\text{m}$$

$$\cos \alpha = \frac{1.3125}{1.5} \Rightarrow \alpha = 28.955^\circ$$

$$\cos \beta = \frac{0.6875}{1} \Rightarrow \beta = 46.567^\circ$$

Sohu: $\triangle AEC, x^2 + y^2 = 1.5^2$
 $x^2 + y^2 = 2.25 \rightarrow \textcircled{1}$

$$AB = 4\text{m}, AC + CD + DB = 4.5\text{m}$$

$$CD = 4.5 - 1.5 - 1$$

$$CD = 2\text{m}$$

$$\therefore EF = 2\text{m}$$

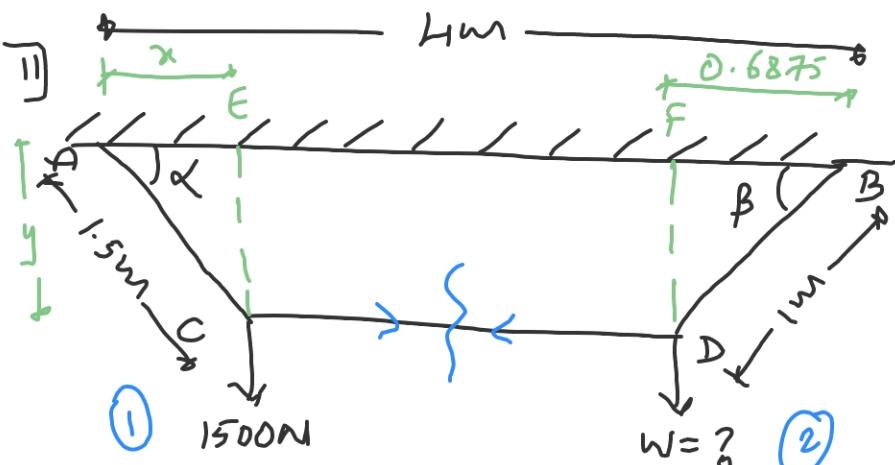
$$\begin{aligned} BF &= AB - (AE + EF) \\ BF &= 4 - (x + 2) \\ BF &= 2 - x \end{aligned} \rightarrow \textcircled{2}$$

FBD $\textcircled{1}$

$$\frac{T_1}{\sin 90} = \frac{T_2}{\sin(90 + 28.955^\circ)}$$

$$= \frac{1500}{\sin(180 - 28.955^\circ)}$$

$T_1 = 3098.4\text{N}$
$T_2 = 2711.1\text{N}$



By $\Delta DF B$, $BF^2 + DF^2 = 1^2$
 $(2-x)^2 + y^2 = 1 \rightarrow ③$

 $x^2 - (2-x)^2 = 1.25$
 $x^2 - 4 + 4x - x^2 = 1.25 \Rightarrow x = 1.3125\text{m}$
 $\cos \alpha = \frac{1.3125}{1.5} \Rightarrow \alpha = 28.955^\circ$
 $\cos \beta = \frac{0.6875}{1} \Rightarrow \beta = 46.567^\circ$

Solu: FBD of ②

Free Body Diagram of section ② (CD). At joint C, there is a vertical force of 1500N downwards and a horizontal force of 0.6875 downwards. At joint D, there is a vertical force T_1 upwards at an angle α to the horizontal, and a horizontal force T_2 to the left. At joint D, there is also a horizontal force T_3 to the right at an angle β to the horizontal. The weight W acts downwards at point D.

$$\frac{T_3}{\sin 90} = \frac{W}{\sin(180 - 46.567^\circ)}$$

$$= \frac{T_2}{\sin(90 + 46.567^\circ)}$$

$$T_3 = 3943.4\text{N}$$

$$W = 2863.6\text{N}$$

FBD ①

Free Body Diagram of section ① (CE). At joint C, there is a vertical force T_1 upwards and a horizontal force T_2 to the left. At joint E, there is a vertical force 1500N downwards and a horizontal force x to the right.

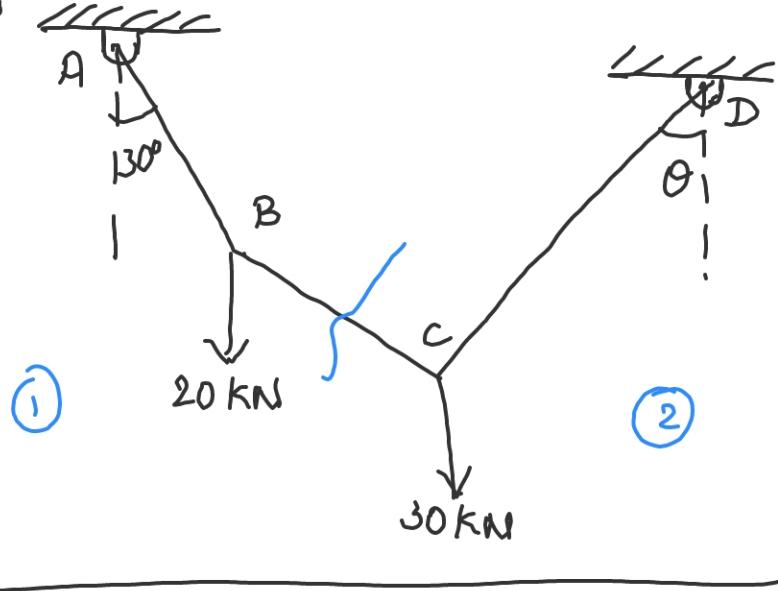
$$\frac{T_1}{\sin 90} = \frac{T_2}{\sin(90 + 28.955^\circ)}$$

$$= \frac{1500}{\sin(180 - 28.955^\circ)}$$

$$T_1 = 3098.4\text{N}$$

$$T_2 = 2711.1\text{N}$$

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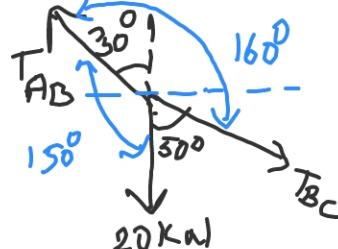


$$\sum F_V = 0$$

$$T_{BC} \cos 30 + T_{CD} \cos \theta - 30 = 0$$

$$T_{CD} \cos \theta = 11.20 \rightarrow ②$$

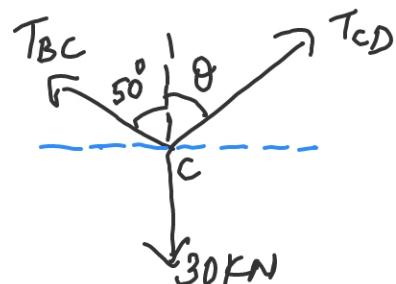
sln: FBD of ①:



$$\frac{T_{AB}}{\sin 30} = \frac{20}{\sin 160} = \frac{T_{BC}}{\sin 50}$$

$T_{AD} = 44.80 \text{ kN}$
$T_{BC} = 29.2 \text{ kN}$

FBD of ②:



$$\sum F_H = 0$$

$$T_{BC} \sin 50 = T_{CD} \sin \theta$$

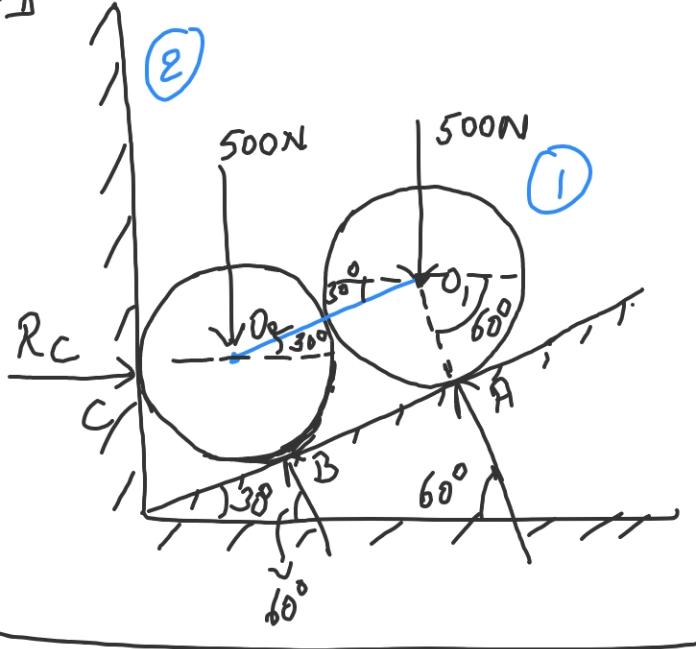
$$T_{CD} \sin \theta = 22.4$$

①

solving ① & ②

$$\frac{T_{CD} \sin \theta}{T_{CD} \cos \theta} = \frac{22.4}{11.20} \Rightarrow \frac{\tan \theta = 2}{\theta = 63.43^\circ}$$

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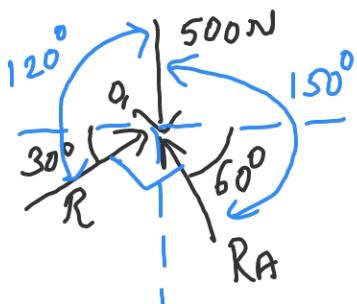


$$\sum F_v = 0$$

$$-250 \sin 30 + R_B \sin 60 - 500 = 0$$

$$R_B = 721.7 \text{ N} \quad (1) \Rightarrow R_C = 577.34 \text{ N}$$

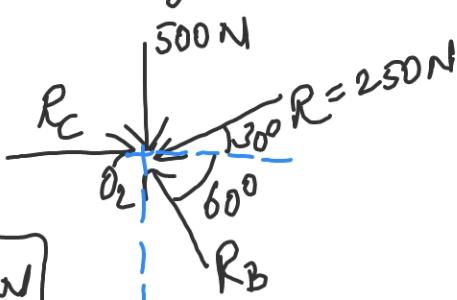
Soh:

FBD of upper rollerUsing
(law)

Applying Lami's theorem

$$\frac{R}{\sin 150} = \frac{500}{\sin 90} = \frac{R_A}{\sin 120}$$

$R = 250 \text{ N}$
$R_A = 433 \text{ N}$

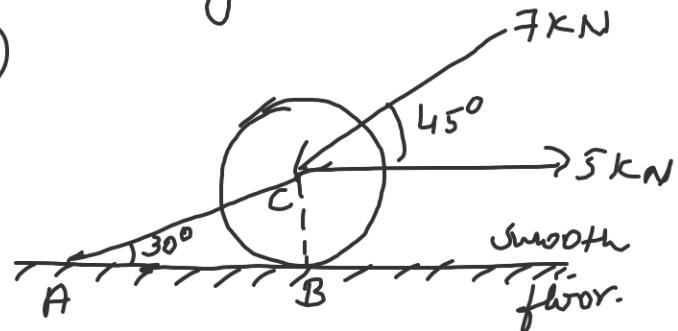
FBD of lower rollerUsing equilibrium eqn
 $\sum F_H = 0$

$$-250 \cos 30 - R_B \cos 60 + R_C = 0$$

$$R_C - R_B \cos 60 = 250 \cos 30 \rightarrow (1)$$

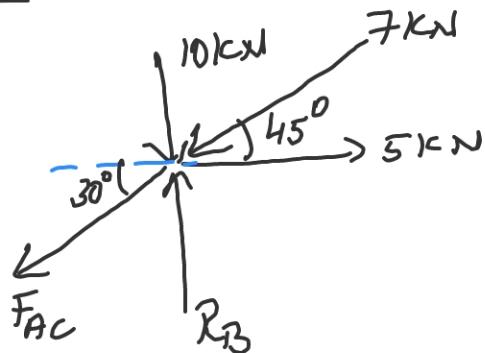
(13) → Assignment

(15)



Soln: FBD

(assumed)



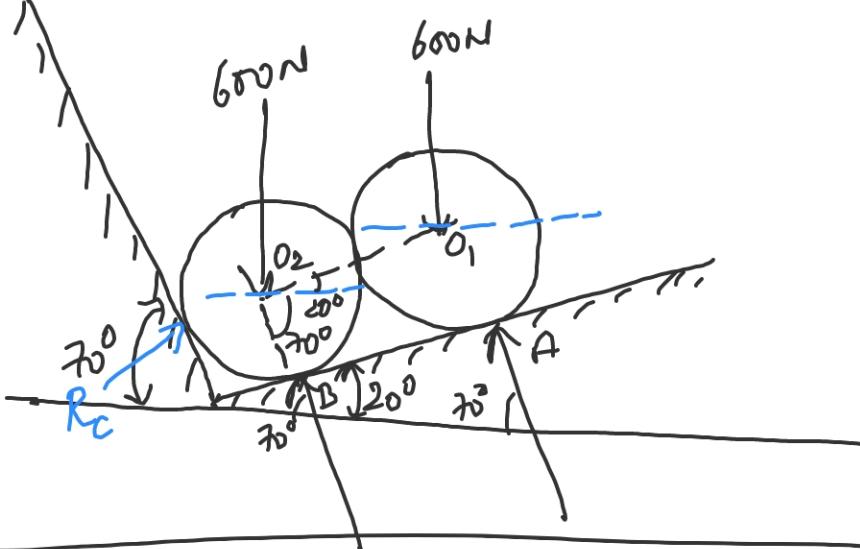
$$\sum F_H = 0 \Rightarrow -7 \cos 45 - F_{AC} \cos 30 + 5 = 0 \Rightarrow F_{AC} = 0.058 \text{ kN}$$

$$\sum F_V = 0 \Rightarrow -7 \sin 45 - 10 + R_B - F_{AC} \sin 30 = 0$$

$$R_B = 14.98 \text{ kN}$$

∴ Assumed direction is correct

16.

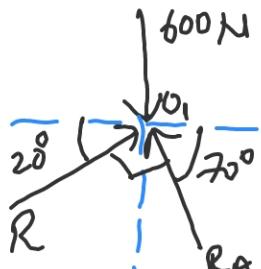


$$\sum F_V = 0 \Rightarrow R_B \sin 70 + R_C \sin 20 - 205.21 \sin 20 = 0$$

$$R_B \sin 70 + R_C \sin 20 = 205.21 \sin 20 \rightarrow ②$$

solving ① + ② $R_B = 563.82 \text{ N}$ $R_C = -410.42 \text{ N}$

FBD of upper cylinder

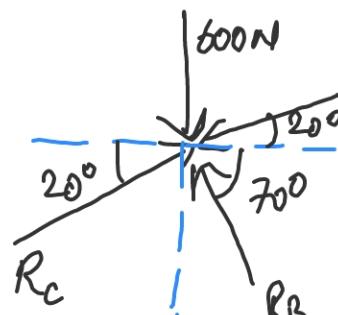


$$\frac{R}{\sin 160^\circ} = \frac{600}{\sin 70^\circ} = \frac{R_A}{\sin 110^\circ}$$

$$R = 205.21 \text{ N}$$

$$R_A = 563.82 \text{ N}$$

FBD of lower cylinder



$$R = 205.21 \text{ N}$$

$$\sum F_H = 0$$

$$-R_B \cos 70 + R_C \cos 20 - 205.21 \cos 20 = 0$$

$$-R_B \cos 70 + R_C \cos 20 = 205.21 \cos 20 \rightarrow ①$$

17] → Assignment

