3.2 Equilibrium of Coplanar Concurrent Force system

The resultant of coplanar concurrent force system is:

$$R = \sqrt{{R_x}^2 + {R_y}^2}$$

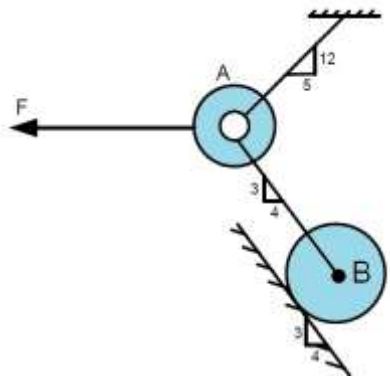
To achieve the equilibrium, the resultant must be equal to zero (i.e. R = 0), then:

$$R_x = 0 \quad \Longrightarrow \quad \sum F_x = 0 \dots\dots\dots\dots\dots (1)$$

$$R_y = 0 \quad \Longrightarrow \quad \sum F_y = 0 \dots\dots\dots\dots\dots (2)$$

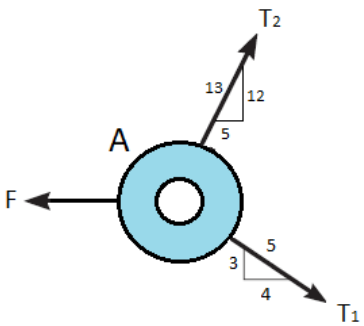
Only two unknowns can be determined

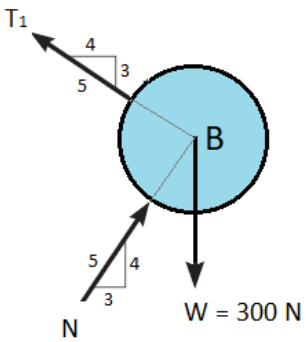
Example No. 1: Determine the force (F) in the figure below which must be applied to ring A in order to keep the 300 N cylinder B in equilibrium.



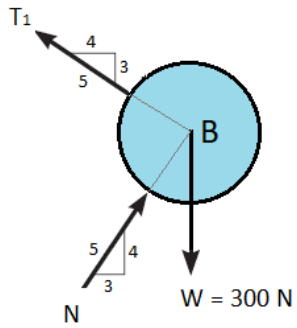
Solution:

Draw F.B.D. for Ring (A) and cylinder (B):





at cylinder (B):



$$\rightarrow^{+} \sum F_x = 0$$

$$N \times \frac{3}{5} - T_1 \times \frac{4}{5} = 0$$

$$N = 1.333\, T_1 \quad \ldots\ldots\ldots\ldots\ldots (1)$$

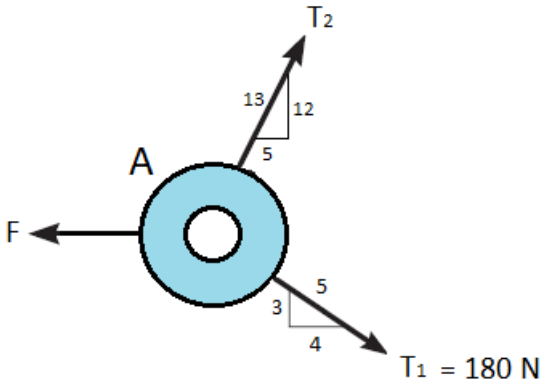
$$\uparrow^{+} \sum F_y = 0$$

$$N \times \frac{4}{5} + T_1 \times \frac{3}{5} - 300 = 0$$

$$1.333\, T_1 \times \frac{4}{5} + T_1 \times \frac{3}{5} = 300$$

$$\therefore T_1 = 180\ N$$

at Ring (A):



$$\uparrow^{+} \sum F_y = 0$$

$$-180 \times \frac{3}{5} + T_2 \times \frac{12}{13} = 0$$

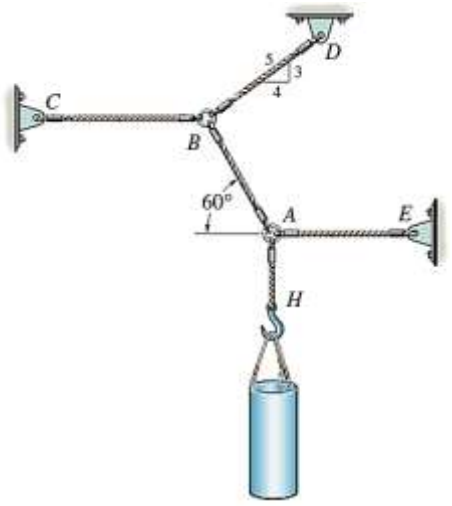
$$\therefore T_2 = 117\ N$$

$$\rightarrow^{+} \sum F_x = 0$$

$$180 \times \frac{4}{5} + 117 \times \frac{5}{13} - F = 0$$

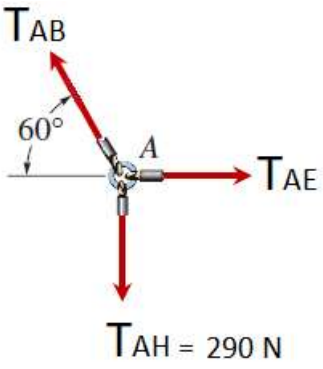
$$\therefore F = 189\ N \quad \leftarrow \quad \textit{answer}$$

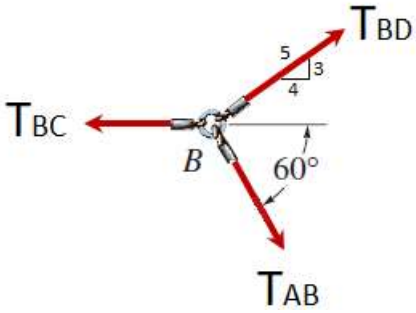
Example No. 2: The 290 N pipe is supported at A by a system of five-cords. Determine the force in each cord for equilibrium.



Solution:

Draw F.B.D. for system:





From F.B.D. of Ring A:

$$\uparrow^{+} \sum F_y = 0$$

$$T_{AB} \sin 60 - 290 = 0 \quad \rightarrow \quad T_{AB} = \frac{290}{\sin 60}$$

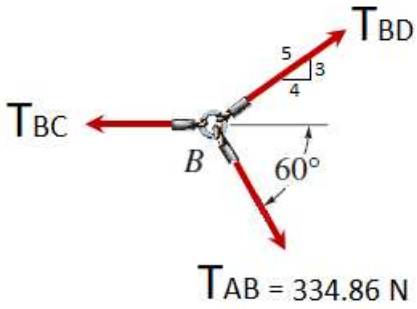
$$\therefore T_{AB} = 334.86\ N \quad \textit{answer}$$

$$\rightarrow^{+} \sum F_x = 0$$

$$T_{AE} - 334.86 \times \cos 60 = 0$$

$$T_{AE} = 167.43\ N \quad \textit{answer}$$

From F.B.D. of Ring B:



$$\uparrow^{+} \sum F_y = 0$$

$$T_{BD} \times \frac{3}{5} - 334.86 \times \sin 60 = 0$$

$$\therefore T_{BD} = 483.33\ N \qquad \textit{answer}$$

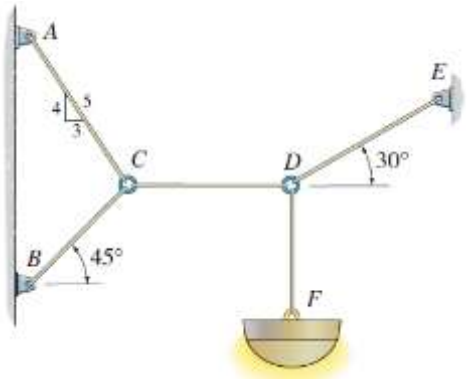
$$\rightarrow^{+} \sum F_x = 0$$

$$483.33 \times \frac{4}{5} + 334.86 \times \cos 60 - T_{BC} = 0$$

$$T_{BC} = 554.094\ N \qquad \textit{answer}$$

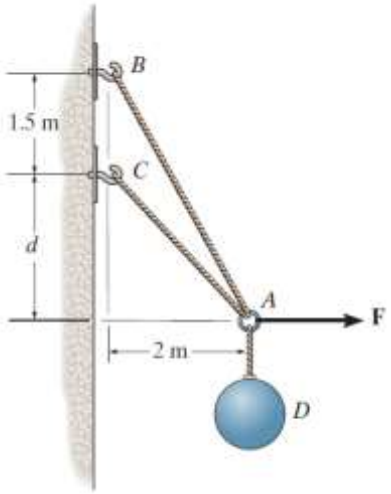
Problem:

1. Determine the tension developed in each cord required for equilibrium of the 20 kg lamp.



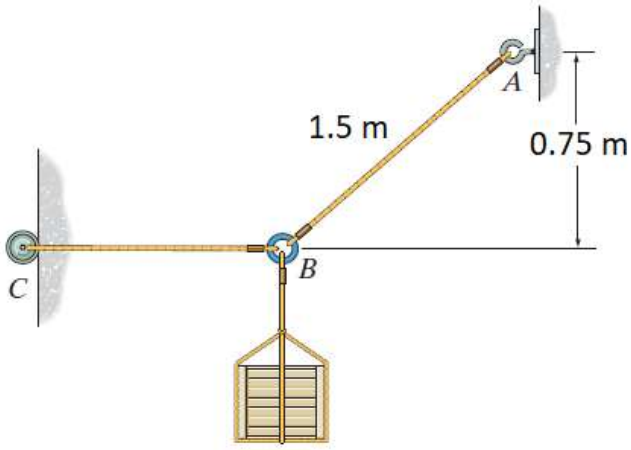
Answer: $T_{DE} = 392.4\ N,\ T_{CD} = 339.83\ N,\ T_{CB} = 274.62\ N,\ T_{CA} = 242.73\ N$

2. A system of cables connected together at A required for equilibrium of the 20 kg ball D as shown in the figure. Determine the largest dimension *d* so that the force in cable *AC* is zero and *F* = 100 N.



Answer: $d = 2.42\ m$

3. Determine the force in each rod for equilibrium of the 250 N crate.



Answer: $T_{AB} = 500\ N,\ \ T_{CB} = 433.33\ N$