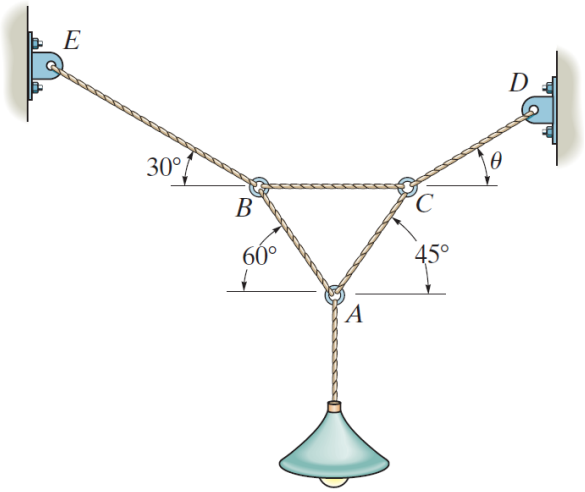
Problem 3-34

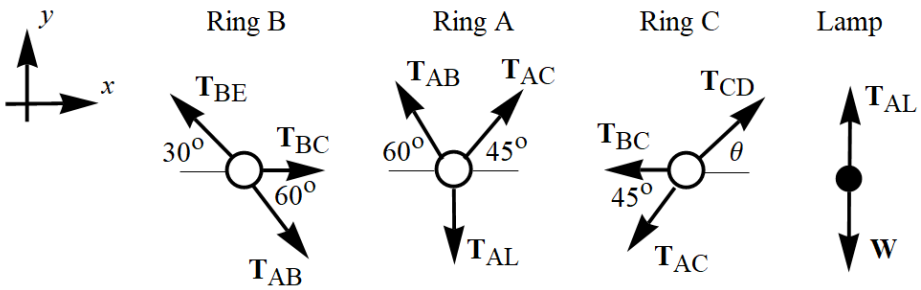
Each cord can sustain a maximum tension of 20 lb. Determine the largest weight of the lamp that can be supported. Also, determine θ of cord DC for equilibrium.



Probs. 3–33/34

Solution

Draw one free-body diagram for each of the rings and one for the lamp.



In order for the system to be in equilibrium, the sum of the forces in each direction must be zero. Below are the equations for ring B and ring A.

$$\sum F_x = 0: \quad T_{\text{AB}} \cos 60° + T_{\text{BC}} - T_{\text{BE}} \cos 30° = 0 \qquad T_{\text{AC}} \cos 45° - T_{\text{AB}} \cos 60° = 0$$

$$\sum F_y = 0: \quad T_{\text{BE}} \sin 30° - T_{\text{AB}} \sin 60° = 0 \qquad T_{\text{AC}} \sin 45° + T_{\text{AB}} \sin 60° - T_{\text{AL}} = 0$$

And below are the equations for ring C and the lamp.

$$\sum F_x = 0: \quad T_{\text{CD}} \cos\theta - T_{\text{BC}} - T_{\text{AC}} \cos 45° = 0 \qquad 0 = 0$$

$$\sum F_y = 0: \quad T_{\text{CD}} \sin\theta - T_{\text{AC}} \sin 45° = 0 \qquad T_{\text{AL}} - W = 0$$

In the previous problem it was found that T_{BE} has the largest tension, so set $T_{\text{BE}} = 20$ lb and solve these seven equations for the remaining five tensions, W, and θ.

$$T_{\text{AB}} = \frac{20}{\sqrt{3}} \text{ lb} \approx 11.5 \text{ lb}$$

$$T_{\text{AC}} = 10\sqrt{\frac{2}{3}} \text{ lb} \approx 8.16 \text{ lb}$$

$$T_{\text{BC}} = \frac{20}{\sqrt{3}} \text{ lb} \approx 11.5 \text{ lb}$$

$$T_{\text{CD}} = 10\sqrt{\frac{10}{3}} \text{ lb} \approx 18.3 \text{ lb}$$

$$T_{\text{AL}} = \frac{10}{3}(3+\sqrt{3}) \text{ lb} \approx 15.8 \text{ lb}$$

$$W = \frac{10}{3}(3+\sqrt{3}) \text{ lb} \approx 15.8 \text{ lb}$$

$$\theta = \cos^{-1}\left(\frac{3}{\sqrt{10}}\right) \approx 18.4^\circ$$