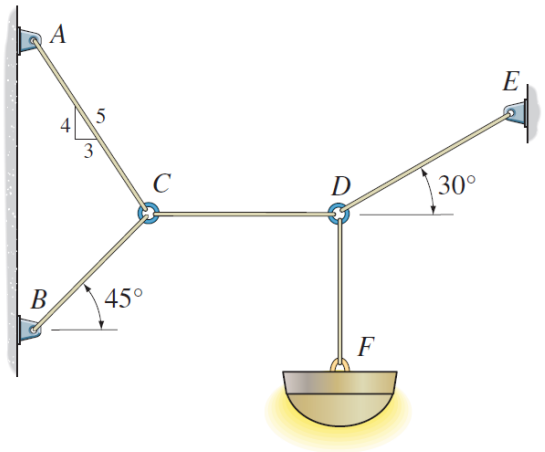
Problem 3-30

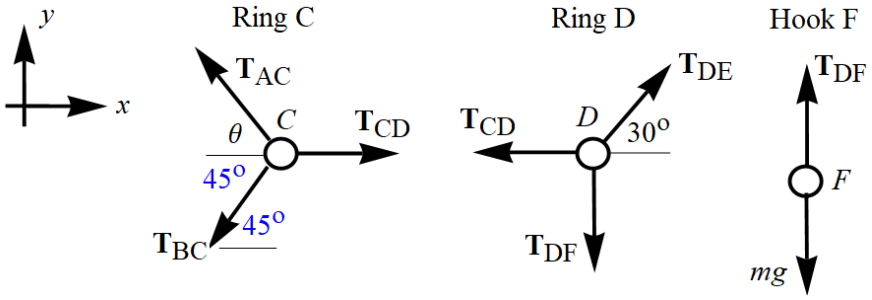
Determine the maximum mass of the lamp that the cord system can support so that no single cord develops a tension exceeding 400 N.



Probs. 3–29/30

Solution

Draw one free-body diagram for ring C, one free-body diagram for ring D, and one free-body diagram for hook F.



In order for the system to be in equilibrium, the sum of the forces in each direction must be zero.

$$\sum F_x = 0: \quad T_{CD} - T_{AC}\cos\theta - T_{BC}\cos 45^\circ = 0 \qquad T_{DE}\cos 30^\circ - T_{CD} = 0 \qquad 0 = 0$$

$$\sum F_y = 0: \quad T_{AC}\sin\theta - T_{BC}\sin 45^\circ = 0 \qquad T_{DE}\sin 30^\circ - T_{DF} = 0 \qquad T_{DF} - mg = 0$$

Here θ represents the angle that $\mathbf{T}_{\text{AC}}$ makes with the x-axis, so $\cos\theta = 3/5$ and $\sin\theta = 4/5$. It was found in the previous problem that T_{DE} has the highest tension, so set its magnitude to 400 N.

$$\left.\begin{aligned} T_{\text{CD}} - \frac{3}{5}T_{\text{AC}} - T_{\text{BC}}\cos 45^\circ &= 0 \\ \frac{4}{5}T_{\text{AC}} - T_{\text{BC}}\sin 45^\circ &= 0 \\ 400\cos 30^\circ - T_{\text{CD}} &= 0 \\ 400\sin 30^\circ - T_{\text{DF}} &= 0 \\ T_{\text{DF}} - mg &= 0 \end{aligned}\right\}$$

Since $g = 9.81\ \text{m/s}^2$, solving this system yields

$$\begin{aligned} T_{\text{AC}} &= \frac{1000\sqrt{3}}{7}\ \text{N} \approx 247\ \text{N} \\ T_{\text{BC}} &= \frac{800\sqrt{6}}{7}\ \text{N} \approx 280.\ \text{N} \\ T_{\text{CD}} &= 200\sqrt{3}\ \text{N} \approx 346\ \text{N} \\ T_{\text{DF}} &= 200\ \text{N} \\ m &= \frac{200\ \text{N}}{g} \approx 20.4\ \text{kg}. \end{aligned}$$