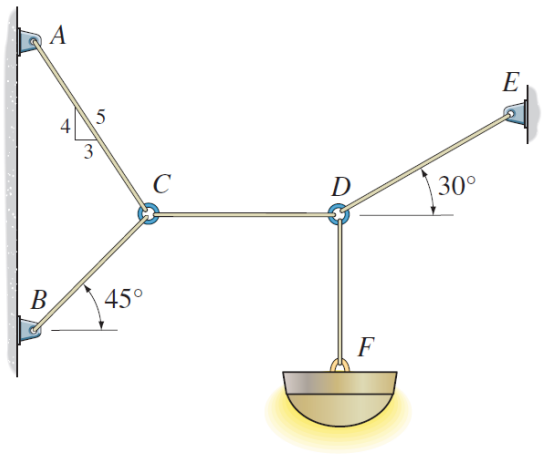
Problem 3-29

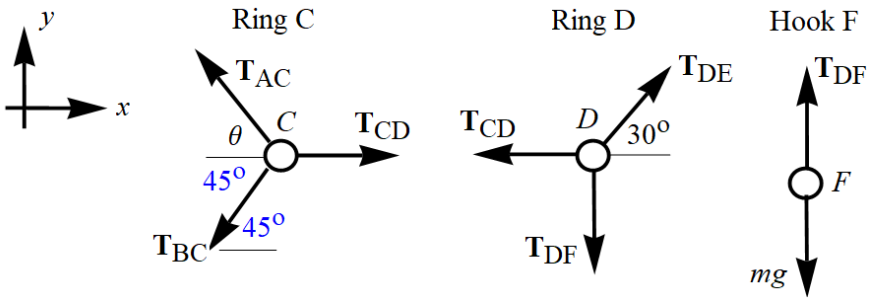
Determine the tension developed in each cord required for equilibrium of the 20-kg lamp.



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 $\mathbf{T}_{AC}$ makes with the x-axis, so $\cos\theta = 3/5$ and $\sin\theta = 4/5$.

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

Since $m = 20$ kg and $g = 9.81$ m/s^2, solving this system yields

$$T_{\text{AC}} = \frac{5\sqrt{3}}{7}mg \approx 243 \text{ N}$$

$$T_{\text{BC}} = \frac{4\sqrt{6}}{7}mg \approx 275 \text{ N}$$

$$T_{\text{CD}} = \sqrt{3}mg \approx 340. \text{ N}$$

$$T_{\text{DE}} = 2mg \approx 392 \text{ N}$$

$$T_{\text{DF}} = mg \approx 196 \text{ N}.$$