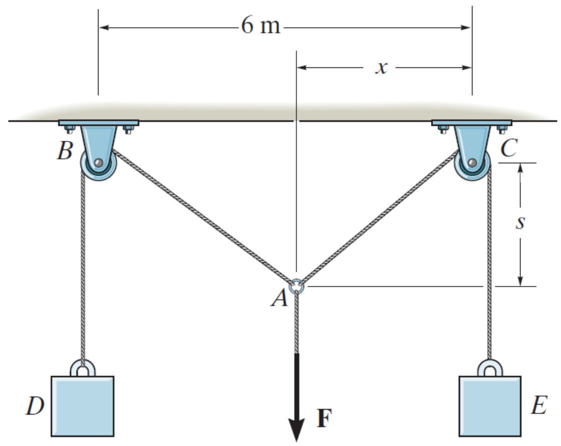
Problem 3-31

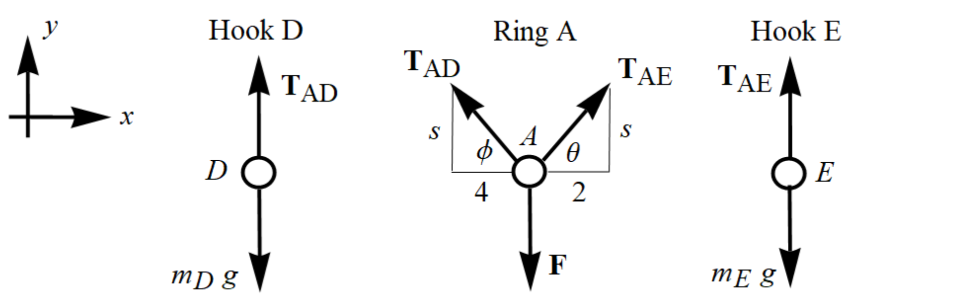
Blocks D and E have a mass of 4 kg and 6 kg, respectively. If $x = 2$ m determine the force **F** and the sag s for equilibrium.



Probs. 3–31/32

Solution

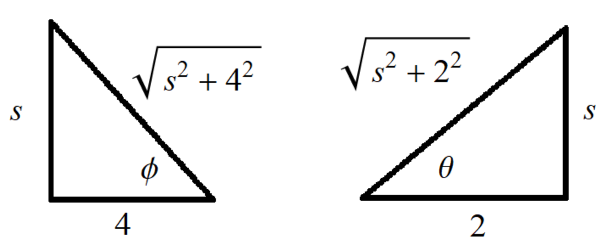
Draw one free-body diagram for ring A, one free-body diagram for hook D, and one free-body diagram for hook E.



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

$$\begin{array}{lcccc} \sum F_x = 0: & 0 = 0 & T_{\text{AE}} \cos\theta - T_{\text{AD}} \cos\phi = 0 & 0 = 0 \\ \sum F_y = 0: & T_{\text{AD}} - m_D g = 0 & T_{\text{AE}} \sin\theta + T_{\text{AD}} \sin\phi - F = 0 & T_{\text{AE}} - m_E g = 0 \end{array}$$

Use the Pythagorean theorem to find each triangle's hypotenuse.



As a result,

$$\cos\phi = \frac{4}{\sqrt{s^2+4^2}} \quad \text{and} \quad \sin\phi = \frac{s}{\sqrt{s^2+4^2}} \quad \text{and} \quad \cos\theta = \frac{2}{\sqrt{s^2+2^2}} \quad \text{and} \quad \sin\theta = \frac{s}{\sqrt{s^2+2^2}}.$$

Since $T_{\text{AD}} = m_D g = 4g$ and $T_{\text{AE}} = m_E g = 6g$, the last two equations become

$$6g\frac{2}{\sqrt{s^2+2^2}} - 4g\frac{4}{\sqrt{s^2+4^2}} = 0 \tag{1}$$

$$6g\frac{s}{\sqrt{s^2+2^2}} + 4g\frac{s}{\sqrt{s^2+4^2}} - F = 0. \tag{2}$$

Solve equation (1) for s

$$s = 4\sqrt{\frac{5}{7}}\text{ m} \approx 3.38\text{ m}$$

and then plug it into equation (2) to solve for F. ($g = 9.81$ m/s^2)

$$F = 6g\frac{s}{\sqrt{s^2+2^2}} + 4g\frac{s}{\sqrt{s^2+4^2}} \approx 76.0\text{ N}$$