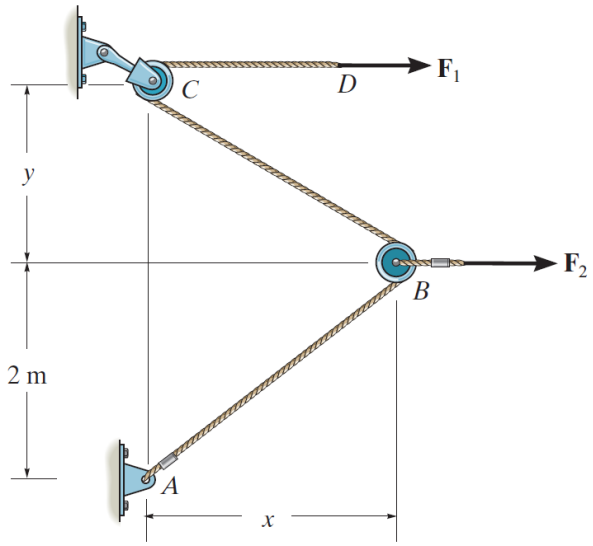
Problem 3-24

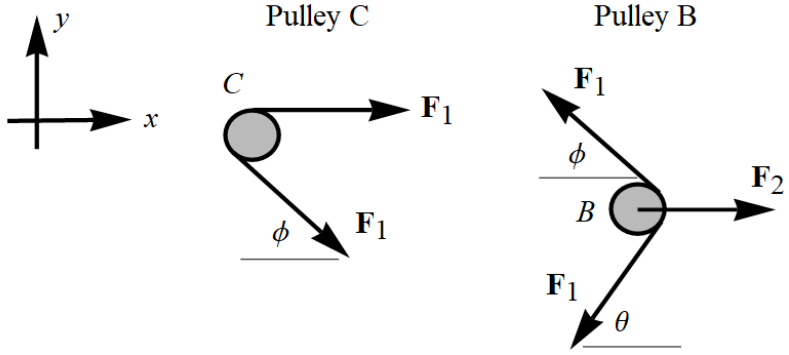
Determine the distances x and y for equilibrium if $F_1 = 800$ N and $F_2 = 1000$ N.



Probs. 3–24/25

Solution

Draw one free-body diagram for the pulley at C and one free-body diagram for the pulley at B, assuming that the pulleys are frictionless.



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

$$\sum F_x = 0: \qquad F_2 - F_1 \cos\phi - F_1 \cos\theta = 0 \tag{1}$$

$$\sum F_y = 0: \qquad F_1 \sin\phi - F_1 \sin\theta = 0 \tag{2}$$

This second equation implies that $\sin\phi = \sin\theta$, or $\phi = \theta$.

$$\tan\phi = \tan\theta \quad \rightarrow \quad \frac{y}{x} = \frac{2\text{ m}}{x} \quad \rightarrow \quad y = 2\text{ m}$$

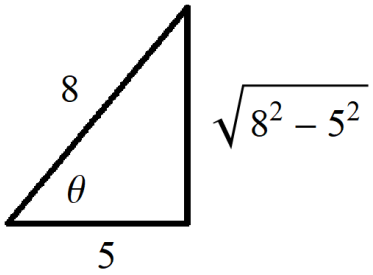
As a result, equation (1) becomes

$$F_2 - F_1 \cos\theta - F_1 \cos\theta = 0.$$

Solve for $\cos\theta$.

$$\cos\theta = \frac{F_2}{2F_1} = \frac{1000 \text{ N}}{2(800 \text{ N})} = \frac{5}{8}$$

Draw the implied right triangle.



Therefore,

$$\tan\theta = \frac{\sqrt{8^2 - 5^2}}{5} = \frac{2 \text{ m}}{x} \quad \rightarrow \quad x = \frac{5(2)}{\sqrt{8^2 - 5^2}} \text{ m} = \frac{10}{\sqrt{39}} \text{ m} \approx 1.60 \text{ m}.$$