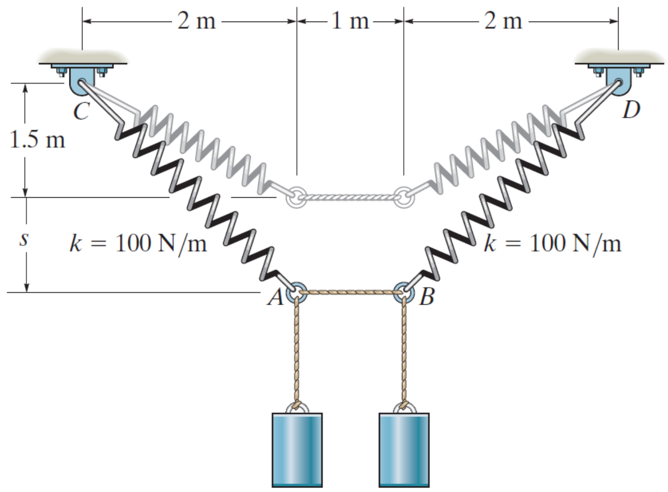
Problem 3-16

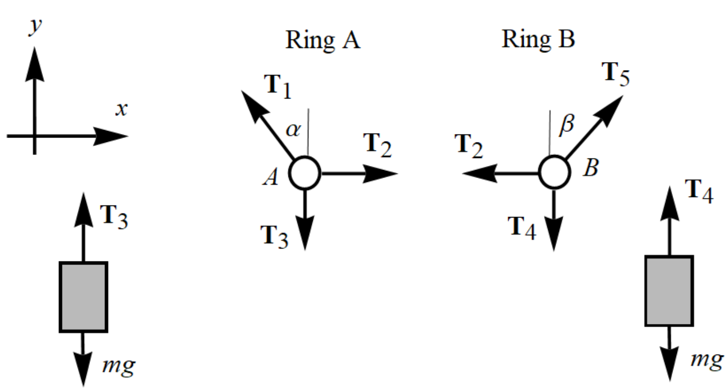
Determine the mass of each of the two cylinders if they cause a sag of $s = 0.5$ m when suspended from the rings at A and B. Note that $s = 0$ when the cylinders are removed.



Prob. 3–16

Solution

Draw one free-body diagram for the ring at A, one free-body diagram for the ring at B, and one free-body diagram for each cylinder.



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

$$\sum F_x = 0: \qquad -T_1 \sin\alpha + T_2 = 0 \qquad T_5 \sin\beta - T_2 = 0$$

$$\sum F_y = 0: \qquad T_1 \cos\alpha - T_3 = 0 \qquad T_5 \cos\beta - T_4 = 0$$

Since $T_3 = mg$ and $T_4 = mg$, the system of equations reduces to

$$\sum F_x = 0: \qquad -T_1 \sin\alpha + T_2 = 0 \qquad T_5 \sin\beta - T_2 = 0$$

$$\sum F_y = 0: \qquad T_1 \cos\alpha - mg = 0 \qquad T_5 \cos\beta - mg = 0.$$

It reduces further since T_1 and T_5 can be calculated; the only unknowns are m and T_2.

$$T_1 = k\Delta x_{AC} = \left(100\ \frac{\text{N}}{\text{m}}\right)\left(\sqrt{2^2+2^2}\ \text{m} - \sqrt{2^2+1.5^2}\ \text{m}\right) \approx 32.8\ \text{N}$$

$$T_5 = k\Delta x_{BD} = \left(100\ \frac{\text{N}}{\text{m}}\right)\left(\sqrt{2^2+2^2}\ \text{m} - \sqrt{2^2+1.5^2}\ \text{m}\right) \approx 32.8\ \text{N}$$

Use trigonometry to determine α and β.

$$\tan\alpha = \frac{2}{2} \quad \rightarrow \quad \alpha = \tan^{-1}(1) = 45^\circ$$

$$\tan\beta = \frac{2}{2} \quad \rightarrow \quad \beta = \tan^{-1}(1) = 45^\circ$$

Therefore, if $g = 9.81$ m/s^2, the mass is

$$m = \frac{T_1\cos\alpha}{g} = \frac{T_5\cos\beta}{g} \approx 2.37\ \text{kg}.$$