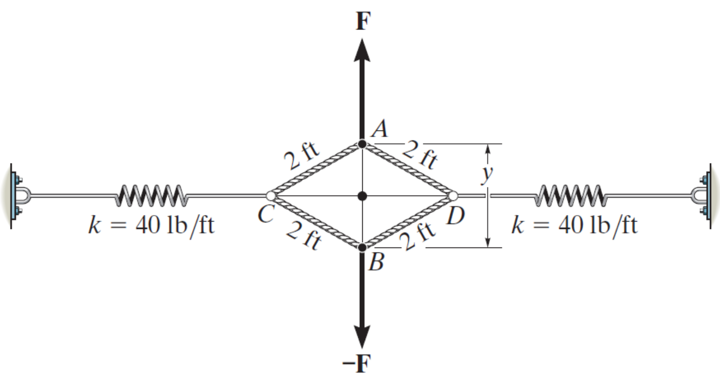
Problem R3-4

When y is zero, the springs sustain a force of 60 lb. Determine the magnitude of the applied vertical forces **F** and $-$**F** required to pull point A away from point B a distance of $y = 2$ ft. The ends of cords CAD and CBD are attached to rings at C and D.



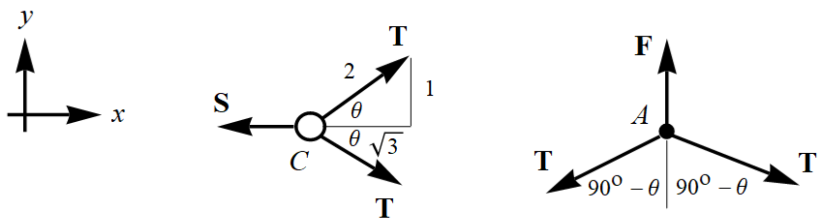
Prob. R3–4

Solution

Use the fact that the springs sustain a force of 60 lb to determine the stretch from equilibrium.

$$F = k\Delta x: \quad 60 \text{ lb} = \left(40 \, \frac{\text{lb}}{\text{ft}}\right) x_0 \quad \rightarrow \quad x_0 = 1.5 \text{ ft}$$

When the forces are applied at points A and B, rings C and D are brought closer together. Due to symmetry, the tension in cords CAD and CBD are equal, so it's necessary to draw a free-body diagram only at point A and ring C.



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

$$\sum F_x = 0 \qquad 2T\cos\theta - S = 0 \qquad T\sin(90^\circ - \theta) - T\sin(90^\circ - \theta) = 0$$

$$\sum F_y = 0 \qquad T\sin\theta - T\sin\theta = 0 \qquad F - 2T\cos(90^\circ - \theta) = 0$$

The two relevant equations are as follows.

$$\left.\begin{aligned} 2T\cos\theta - S &= 0 \\ F - 2T\sin\theta &= 0 \end{aligned}\right\}$$

Use the fact that $\cos\theta = \sqrt{3}/2$ and $\sin\theta = 1/2$.

$$\left.\begin{aligned} 2T\left(\frac{\sqrt{3}}{2}\right) - S &= 0 \\ F - 2T\left(\frac{1}{2}\right) &= 0 \end{aligned}\right\}$$

Eliminate T and solve for F.

$$F = \frac{S}{\sqrt{3}}$$

Therefore, writing a formula for the spring force,

$$F = \frac{k[x_0 + (2 - \sqrt{3})]}{\sqrt{3}} \text{ lb} \approx 40.8 \text{ lb}.$$