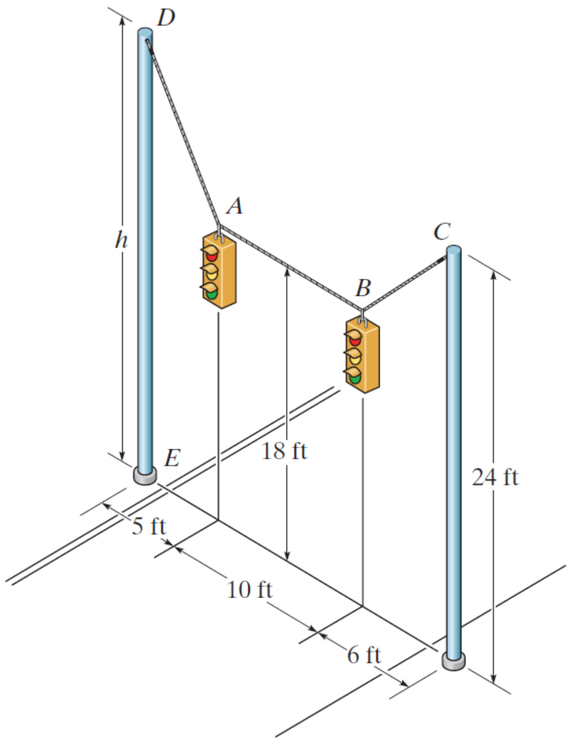
Problem 3-28

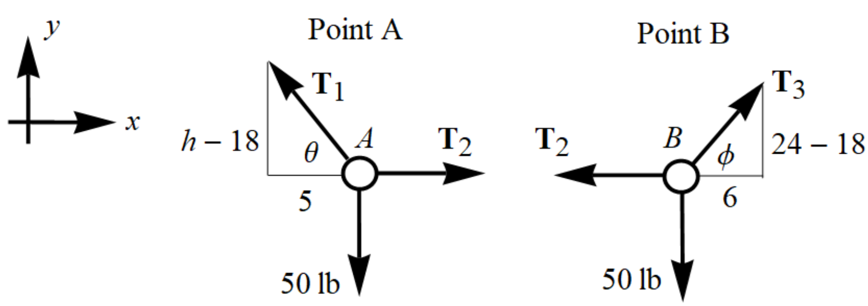
The street-lights at A and B are suspended from the two poles as shown. If each light has a weight of 50 lb, determine the tension in each of the three supporting cables and the required height h of the pole DE so that cable AB is horizontal.



Prob. 3–28

Solution

Draw one free-body diagram for point A and one free-body diagram for point B.

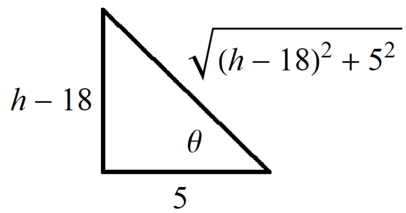


In order for the system to be in equilibrium, the sum of the forces in each direction must be zero.

$$\sum F_x = 0: \qquad -T_1\cos\theta + T_2 = 0 \qquad -T_2 + T_3\cos\phi = 0$$

$$\sum F_y = 0: \qquad T_1\sin\theta - 50 = 0 \qquad T_3\sin\phi - 50 = 0$$

Use the Pythagorean theorem to determine the left triangle's hypotenuse.



As a result,

$$\cos\theta = \frac{5}{\sqrt{(h-18)^2+5^2}} \quad \text{and} \quad \sin\theta = \frac{h-18}{\sqrt{(h-18)^2+5^2}}.$$

Since ϕ is known,

$$\tan\phi = \frac{24-18}{6} = 1 \quad \rightarrow \quad \phi = 45^\circ,$$

the four equations can be solved for T_1, T_2, T_3, and h.

$$\left.\begin{aligned} -T_1\frac{5}{\sqrt{(h-18)^2+5^2}} + T_2 &= 0 \\ T_1\frac{h-18}{\sqrt{(h-18)^2+5^2}} - 50 &= 0 \\ -T_2 + T_3\cos 45^\circ &= 0 \\ T_3\sin 45^\circ - 50 &= 0 \end{aligned}\right\}$$

Solving the system yields

$$T_1 = 50\sqrt{2}\text{ lb} \approx 70.7\text{ lb}$$

$$T_2 = 50\text{ lb}$$

$$T_3 = 50\sqrt{2}\text{ lb} \approx 70.7\text{ lb}$$

$$h = 23\text{ ft}.$$