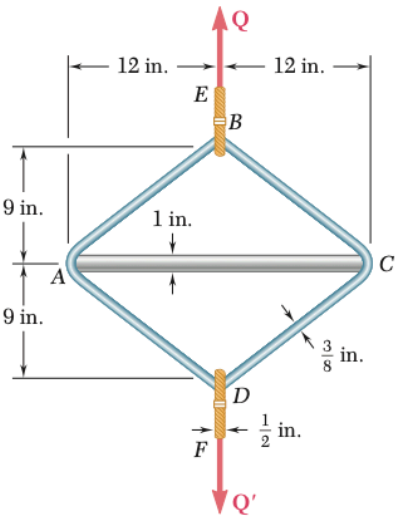
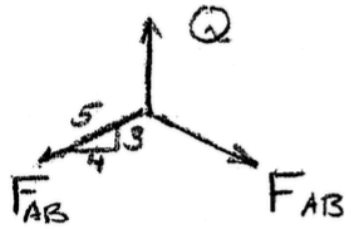


PROBLEM 1.37

A steel loop *ABCD* of length 5 ft and of $\frac{3}{8}$-in. diameter is placed as shown around a 1-in.-diameter aluminum rod *AC*. Cables *BE* and *DF*, each of $\frac{1}{2}$-in. diameter, are used to apply the load **Q**. Knowing that the ultimate strength of the steel used for the loop and the cables is 70 ksi, and that the ultimate strength of the aluminum used for the rod is 38 ksi, determine the largest load **Q** that can be applied if an overall factor of safety of 3 is desired.

SOLUTION



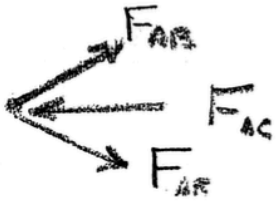
Using joint *B* as a free body and considering symmetry,

$$2 \cdot \frac{3}{5} F_{AB} - Q = 0 \quad Q = \frac{6}{5} F_{AB}$$

Using joint *A* as a free body and considering symmetry,

$$2 \cdot \frac{4}{5} F_{AB} - F_{AC} = 0$$

$$\frac{8}{5} \cdot \frac{5}{6} Q - F_{AC} = 0 \quad \therefore \quad Q = \frac{3}{4} F_{AC}$$



Based on strength of cable *BE*,

$$Q_U = \sigma_U A = \sigma_U \frac{\pi}{4} d^2 = (70) \frac{\pi}{4} \left(\frac{1}{2} \right)^2 = 13.7445 \text{ kips}$$

Based on strength of steel loop,

$$Q_U = \frac{6}{5} F_{AB,U} = \frac{6}{5} \sigma_U A = \frac{6}{5} \sigma_U \frac{\pi}{4} d^2$$

$$= \frac{6}{5} (70) \frac{\pi}{4} \left(\frac{3}{8} \right)^2 = 9.2775 \text{ kips}$$

Based on strength of rod *AC*,

$$Q_U = \frac{3}{4} F_{AC,U} = \frac{3}{4} \sigma_U A = \frac{3}{4} \sigma_U \frac{\pi}{4} d^2 = \frac{3}{4} (38) \frac{\pi}{4} (1.0)^2 = 22.384 \text{ kips}$$

Actual ultimate load Q_U is the smallest, $\therefore \quad Q_U = 9.2775$ kips

Allowable load: $$Q = \frac{Q_U}{F.S.} = \frac{9.2775}{3} = 3.0925 \text{ kips}$$ $Q = 3.09$ kips ◀