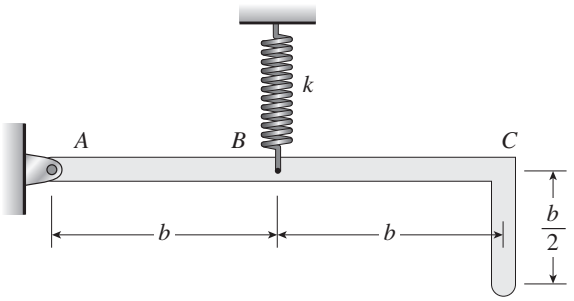
2

Axially Loaded Members

Changes in Lengths of Axially Loaded Members

Problem 2.2-1 The L-shaped arm *ABC* shown in the figure lies in a vertical plane and pivots about a horizontal pin at *A*. The arm has constant cross-sectional area and total weight *W*. A vertical spring of stiffness *k* supports the arm at point *B*. Obtain a formula for the elongation of the spring due to the weight of the arm.



Solution 2.2-1

Take first moments about A to find c.g.

$$x = \frac{\left(\frac{2b}{\frac{5}{2}b}\right)W(b) + \left[\frac{\frac{b}{2}}{\left(\frac{5}{2}b\right)}\right]W(2b)}{W}$$

$$x = \frac{6}{5}b$$

Find force in spring due to weight of arm

$$\sum M_A = 0 \qquad F_k = \frac{W\left(\frac{6}{5}b\right)}{b} \qquad F_k = \frac{6}{5}W$$

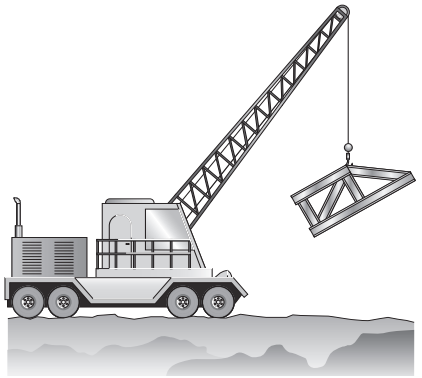
Find elongation of spring due to weight of arm

$$\delta = \frac{F_k}{k} \qquad \delta = \frac{6W}{5k} \quad \leftarrow$$

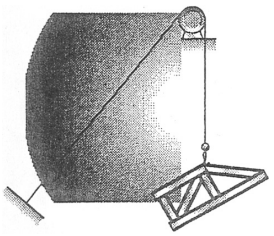
Problem 2.2-2 A steel cable with nominal diameter 25 mm (see Table 2-1) is used in a construction yard to lift a bridge section weighing 38 kN, as shown in the figure. The cable has an effective modulus of elasticity $E = 140$ GPa.

(a) If the cable is 14 m long, how much will it stretch when the load is picked up?

(b) If the cable is rated for a maximum load of 70 kN, what is the factor of safety with respect to failure of the cable?



Solution 2.2-2 Bridge section lifted by a cable



$A = 304 \text{ mm}^2$ (from Table 2-1)

$W = 38$ kN

$E = 140$ GPa

$L = 14$ m

(a) STRETCH OF CABLE

$$\delta = \frac{WL}{EA} = \frac{(38 \text{ kN})(14 \text{ m})}{(140 \text{ GPa})(304 \text{ mm}^2)}$$

$$= 12.5 \text{ mm} \quad \leftarrow$$

(b) FACTOR OF SAFETY

$P_{ULT} = 406$ kN (from Table 2-1)

$P_{\max} = 70$ kN

$$n = \frac{P_{ULT}}{P_{\max}} = \frac{406 \text{ kN}}{70 \text{ kN}} = 5.8 \quad \leftarrow$$

Problem 2.2-3 A steel wire and a copper wire have equal lengths and support equal loads P (see figure). The moduli of elasticity for the steel and copper are $E_s = 30{,}000$ ksi and $E_c = 18{,}000$ ksi, respectively.

(a) If the wires have the same diameters, what is the ratio of the elongation of the copper wire to the elongation of the steel wire?

(b) If the wires stretch the same amount, what is the ratio of the diameter of the copper wire to the diameter of the steel wire?