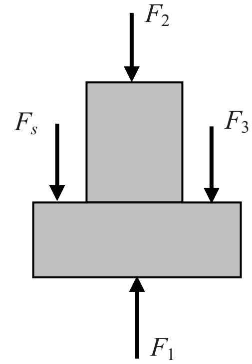
Review Problems

2-72 The deflection of the spring of the two-piston cylinder with a spring shown in the figure is to be determined.

Analysis Summing the forces acting on the piston in the vertical direction gives

$$F_s + F_2 + F_3 = F_1$$
$$kx + P_2 A_2 + P_3 (A_1 - A_2) = P_1 A_1$$



which when solved for the deflection of the spring and substituting $A = \pi D^2 / 4$ gives

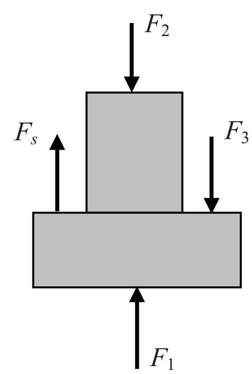
$$\begin{aligned} x &= \frac{\pi}{4k}\left[P_1 D_1^2 - P_2 D_2^2 - P_3 (D_1^2 - D_2^2)\right] \\ &= \frac{\pi}{4 \times 800}\left[5000 \times 0.08^2 - 10{,}000 \times 0.03^2 - 1000(0.08^2 - 0.03^2)\right] \\ &= 0.0172 \text{ m} \\ &= \mathbf{1.72\ cm} \end{aligned}$$

We expressed the spring constant k in kN/m, the pressures in kPa (i.e., kN/m^2) and the diameters in m units.

2-73 The pressure in chamber 1 of the two-piston cylinder with a spring shown in the figure is to be determined.

Analysis Summing the forces acting on the piston in the vertical direction gives

$$F_s + F_1 = F_2 + F_3$$
$$kx + P_1 A_1 = P_2 A_2 + P_3 (A_1 - A_2)$$



which when solved for the P_3 and substituting $A = \pi D^2 / 4$ gives

$$\begin{aligned} P_1 &= P_2 \frac{A_2}{A_1} + P_3\left(1 - \frac{A_2}{A_1}\right) - \frac{kx}{A_1} \\ &= P_2\left(\frac{D_2}{D_1}\right)^2 + P_3\left[1 - \left(\frac{D_2}{D_1}\right)^2\right] - \frac{4kx}{\pi D_1^2} \\ &= (8000 \text{ kPa})\left(\frac{3}{7}\right)^2 + (300 \text{ kPa})\left[1 - \left(\frac{3}{7}\right)^2\right] - \frac{4(1200 \text{ kN/m})(0.05 \text{ m})}{\pi (0.07 \text{ m})^2} \\ &= 13{,}880 \text{ kPa} = \mathbf{13.9\ MPa} \end{aligned}$$