5.38

5.38 Determine the anchoring force required to hold in place the conical nozzle attached to the end of the laboratory sink faucet shown in Fig. P5.38 when the water flowrate is 10 gal/min. The nozzle weight is 0.2 lb. The nozzle inlet and exit inside diameters are 0.6 and 0.2 in., respectively. The nozzle axis is vertical and the axial distance between sections (1) and (2) is 1.2 in. The pressure at section (1) is 68 psi.

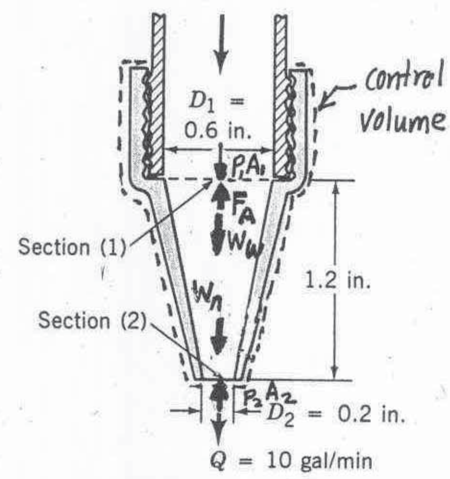

FIGURE P5.38

The analysis leading to the solution of this problem is similar to the one outlined in Example 5.10. Included in the control volume are the nozzle and the water in the nozzle at an instant. Application of the vertical or z-direction component of the linear momentum equation (Eq. 5.22) to the flow through this control volume leads to

$$F_A = \rho w_1^2 A_1 - \rho w_2^2 A_2 + W_n + P_1 A_1 + W_w - P_2 A_2 \qquad (1)$$

which is Eq. 4 of Example 5.10.

The conservation of mass equation yields

$$\dot{m} = \rho w_1 A_1 = \rho w_2 A_2$$

thus Eq. 1 becomes

$$F_A = \dot{m}(w_1 - w_2) + W_n + P_1 A_1 + W_w - P_2 A_2 \qquad (2)$$

The different terms in Eq. 2 are calculated below.

$$\dot{m} = \rho Q = \left(1.94\ \frac{slugs}{ft^3}\right)\left(10\ \frac{gal}{min}\right)\frac{1}{\left(7.48\ \frac{gal}{ft^3}\right)}\frac{1}{\left(60\ \frac{s}{min}\right)} = 0.0432\ \frac{slug}{s}$$

$$w_1 = \frac{Q}{A_1} = \frac{Q}{\frac{\pi D_1^2}{4}} = \frac{\left(10\ \frac{gal}{min}\right)\left(12\ \frac{in.}{ft}\right)^2}{\pi\frac{(0.6\ in.)^2}{4}\left(7.48\ \frac{gal}{ft^3}\right)\left(60\ \frac{s}{min}\right)} = 11.4\ \frac{ft}{s}$$

$$w_2 = \frac{Q}{A_2} = \frac{Q}{\frac{\pi D_2^2}{4}} = \frac{\left(10\ \frac{gal}{min}\right)\left(12\ \frac{in.}{ft}\right)^2}{\pi\frac{(0.2\ in.)^2}{4}\left(7.48\ \frac{gal}{ft^3}\right)\left(60\ \frac{s}{min}\right)} = 102\ \frac{ft}{s}$$

$$P_1 A_1 = P_1\frac{\pi D_1^2}{4} = \left(68\ \frac{lb}{in.^2}\right)\pi\frac{(0.6\ in.)^2}{4} = 19.2\ lb$$

(con't)

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5.38 (con't)

$$W_w = \rho g \forall_w = \rho g \frac{\pi}{12}\left(D_1^2 + D_2^2 + D_1 D_2\right) h$$

$$W_w = \left(1.94 \frac{slugs}{ft^3}\right)\left(32.2 \frac{ft}{s^2}\right)\left(1 \frac{lb}{slug \frac{ft}{s^2}}\right) \frac{\pi}{12} \left[(0.6 \text{ in.})^2 + (0.2 \text{ in.})^2 + (0.6 \text{ in.})(0.2 \text{ in.})\right] \frac{(1.2 \text{ in.})}{\left(1728 \frac{in.^3}{ft^3}\right)}$$

$$W_w = 0.00591 \text{ lb}$$

$$P_2 A_2 = P_2 \pi \frac{D_2^2}{4} = \left(0 \frac{lb}{in.^2}\right) \pi \frac{(0.2 \text{ in.})^2}{4} = 0 \text{ lb}$$

Thus with Eq. 2

$$F_A = \left(0.0432 \frac{slug}{s}\right)\left(11.4 \frac{ft}{s} - 102 \frac{ft}{s}\right)\left(1 \frac{lb}{slug \frac{ft}{s^2}}\right) + 0.2 lb + 19.2 lb + 0.00591 lb - 0 lb$$

$$F_A = \underline{\underline{15.5 \text{ lb}}}$$

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