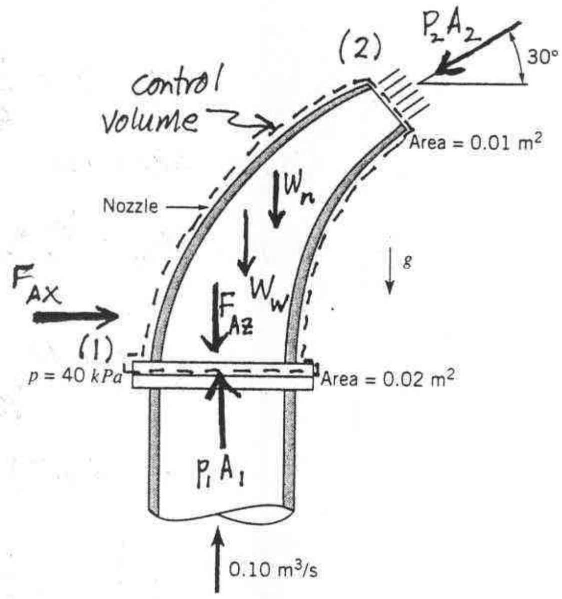
5.50

5.50 A nozzle is attached to a vertical pipe and discharges water into the atmosphere as shown in Fig. P5.50. When the discharge is 0.1 m^3/s, the gage pressure at the flange is 40 kPa. Determine the vertical component of the anchoring force required to hold the nozzle in place. The nozzle has a weight of 200 N, and the volume of water in the nozzle is 0.012 m^3. Is the anchoring force directed upward or downward?



■ FIGURE P5.50

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

$$\dot{m}(V_2 \sin 30^\circ - V_1) = p_1 A_1 - F_{AZ} - W_n - W_w - p_2 A_2 \sin 30^\circ \quad (1)$$

(p_2 = 0 gage)

Solving Eq. 1 for F_{AZ} yields

$$F_{AZ} = p_1 A_1 - W_n - W_w - \dot{m}(V_2 \sin 30^\circ - V_1) \quad (2)$$

For $\dot{m}$ we use $\dot{m} = \rho Q$

For W_w we use $W_w = \forall_w \gamma_w$

From conservation of mass we obtain

$$Q_2 = Q_1$$

or

$$V_2 = \frac{Q_1}{A_2}$$

(con't)

5.50 (con't)

Also, we not that $V_1 = \frac{Q_1}{A_1}$

Thus, Eq. 2 becomes

$$F_{Az} = P_1 A_1 - W_n - \forall_w \gamma_w - \rho Q\left(\frac{Q}{A_2}\sin 30^\circ - \frac{Q}{A_1}\right)$$

or

$$F_{Az} = (40\ kPa)\left(1\ \frac{N}{m^2 \cdot Pa}\right)\left(1000\ \frac{Pa}{kPa}\right)\left(0.02\ m^2\right) - 200\ N$$
$$-\left(0.012\ m^3\right)\left(9.8\ \frac{kN}{m^3}\right)\left(1000\ \frac{N}{kN}\right)$$
$$-\left(999\ \frac{kg}{m^3}\right)\left(0.01\ \frac{m^3}{s}\right)\left(1\ \frac{N \cdot s^2}{kg \cdot m}\right)\left[\left(\frac{0.01\ \frac{m^3}{s}}{0.01\ m^2}\right)\sin 30^\circ - \left(\frac{0.01\ \frac{m^3}{s}}{0.02\ m^2}\right)\right]$$

and

$$F_{Az} = 800N - 200N - 117.6N - 0N = \underline{\underline{482\ N}} \text{ downward}$$