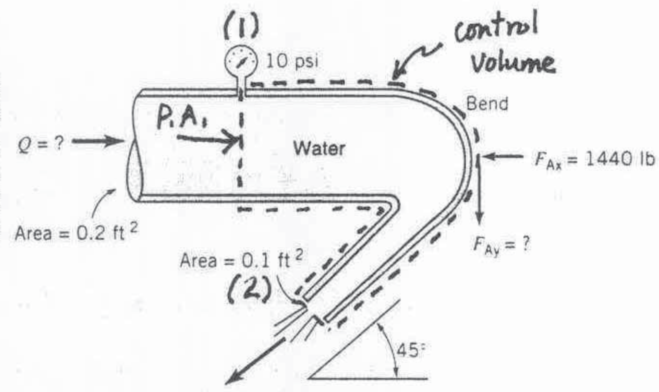
5.40

5.40 Water flows through a horizontal bend and discharges into the atmosphere as shown in Fig. P5.40. When the pressure gage reads 10 psi, the resultant x-direction anchoring force, F_{Ax}, in the horizontal plane required to hold the bend in place is shown on the figure. Determine the flowrate through the bend and the y direction anchoring force, F_{Ay}, required to hold the bend in place. The flow is not frictionless.



■ FIGURE P5.40

A control volume that contains the bend and the water within the bend between sections (1) and (2) as shown in the sketch above is used. Application of the x-direction component of the linear momentum equation yields

$$-u_1\rho Q - V_2\cos 45^\circ \rho Q = p_1A_1 - F_{Ax} + \underbrace{p_2}_{0\text{ gage}}A_2\cos 45^\circ \qquad (1)$$

With

$$u_1 = \frac{Q}{A_1} \quad \text{and} \quad V_2 = \frac{Q}{A_2}$$

Eq. 1 becomes

$$-\frac{Q^2\rho}{A_1} - \frac{Q^2\rho\cos 45^\circ}{A_2} = p_1A_1 - F_{Ax}$$

or for part (a)

$$Q = \sqrt{\frac{-p_1A_1 + F_{Ax}}{\rho\left(\frac{\cos 45^\circ}{A_2} + \frac{1}{A_1}\right)}}$$

$$Q = \sqrt{\frac{-\left(10\,\frac{\text{lb}}{\text{in.}^2}\right)\left(144\,\frac{\text{in.}^2}{\text{ft}^2}\right)\left(0.2\text{ ft}^2\right) + 1440\text{ lb}}{\left(1.94\,\frac{\text{slugs}}{\text{ft}^3}\right)\left(1\,\frac{\text{lb}\cdot\text{s}^2}{\text{slug}\cdot\text{ft}}\right)\left(\frac{\cos 45^\circ}{0.1\text{ ft}^2} + \frac{1}{0.2\text{ ft}^2}\right)}}$$

$$Q = \underline{\underline{7.01}}\ \frac{\text{ft}^3}{\text{s}}$$

(con't)

5.40 (con't)

For part (b) we use the y-direction component of the linear momentum equation to get

$$F_{AY} = V_2 \sin 45^\circ \rho Q = \frac{Q}{A_2} \sin 45^\circ \rho Q$$

or

$$F_{AY} = \frac{Q^2}{A_2} \sin 45^\circ \rho$$

and

$$F_{AY} = \frac{\left(7.01 \frac{ft^3}{s}\right)^2}{(0.01\ ft^2)} \sin 45^\circ \left(1.94 \frac{slugs}{ft^3}\right)\left(1 \frac{lb \cdot s^2}{slug \cdot ft}\right) = \underline{\underline{674\ lb}}$$