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, \( F_x \), in the horizontal plane required to hold the bend in place is shown on the figure. Determine the flow rate through the bend and the y-direction anchoring force, \( F_y \), 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:

\[
-u_i p Q - V_x \cos 45^\circ \rho Q = P_{A_i} - F_x + \rho A_x \cos 45^\circ
\]

With \( u_i = \frac{Q}{A_i} \) and \( V_x = \frac{Q}{A_x} \),

Eq. 1 becomes

\[
\frac{Q^2 \rho}{A_i} - \frac{Q \rho \cos 45^\circ}{A_x} = P_{A_i} - F_x
\]

or for part (a):

\[
Q = \sqrt{-P_{A_i} + F_x \rho \left( \frac{\cos 45^\circ}{A_i} + \frac{1}{A_x} \right)}
\]

\[
Q = \sqrt{-\left(10 \text{ lb} \text{ in}^{-2}\right)\left(144 \text{ in}^2 \text{ ft}^2\right)\left(0.2 \text{ ft}^3\right) + 1440 \text{ lb}}
\]

\[
Q = \sqrt{\left(194 \text{ slugs ft s}^{-1}\right)\left(1 \text{ lb s}^{-2}\right)\left(0.2 \text{ ft}^3\right) - \frac{1}{0.1 \text{ ft}^3} + \frac{1}{0.2 \text{ ft}^3}}
\]

\[
Q = \frac{7.01 \text{ ft}^3}{s}
\]

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

\[
F_{AY} = \frac{V}{2} \sin 45^\circ \rho A = \frac{Q}{A_2} \sin 45^\circ \rho Q
\]

or

\[
F_{AY} = \frac{Q}{A_2} \sin 45^\circ \rho
\]

and

\[
F_{AR} = \left( \frac{7.01 \text{ ft}^3}{0.01 \text{ ft}^3} \right) \sin 45^\circ \left( 1.94 \frac{\text{slug} \cdot \text{ft}}{\text{ft}^2} \right) \left( \frac{1 \text{ lb} \cdot \text{ft}^2}{\text{slug} \cdot \text{ft}} \right) = 674 \text{ lb}
\]