5.127

5.127 Water flows steadily down the inclined pipe as indicated in Fig. P5.127. Determine the following: **(a)** The difference in pressure $p_1 - p_2$. **(b)** The loss per unit mass between sections (1) and (2). **(c)** The net axial force exerted by the pipe wall on the flowing water between sections (1) and (2).

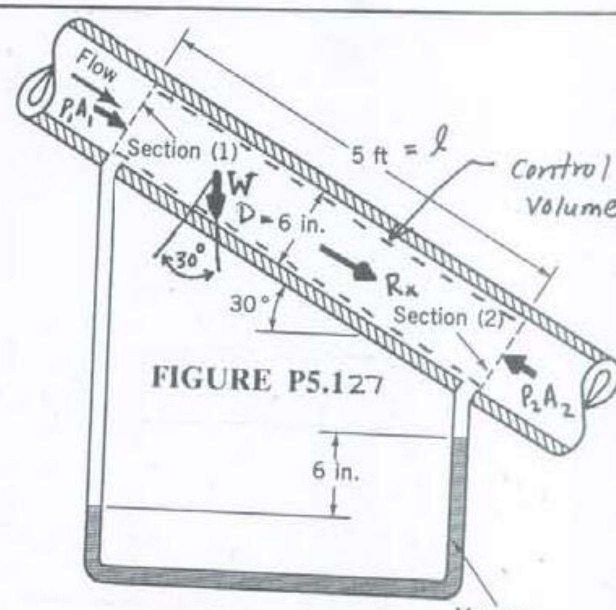

FIGURE P5.127

(a) The difference in pressure, $P_1 - P_2$, may be obtained from the manometer (see Section 2.6) with the fluid statics equation

$$P_1 - P_2 = -\gamma_{H_2O}\left[(5\text{ ft})\sin 30^\circ + \frac{(6\text{ in.})}{\left(12\frac{\text{in.}}{\text{ft}}\right)}\right] + \gamma_{Hg}\frac{(6\text{ in.})}{\left(12\frac{\text{in.}}{\text{ft}}\right)}$$

or

$$P_1 - P_2 = -\left(62.4\frac{\text{lb}}{\text{ft}^3}\right)\left[(5\text{ ft})\sin 30^\circ + (0.5\text{ ft})\right] + (13.6)\left(62.4\frac{\text{lb}}{\text{ft}^3}\right)(0.5\text{ ft}) = 237\frac{\text{lb}}{\text{ft}^3}$$

and

$$P_1 - P_2 = 237\frac{\text{lb}}{\text{ft}^3}\frac{1}{\left(144\frac{\text{in.}^2}{\text{ft}^2}\right)} = \underline{\underline{1.65\text{ psi}}}$$

(b) The loss per unit mass between sections (1) and (2) may be obtained with Eq. 5.79. Thus

$$\text{loss} = \frac{P_1 - P_2}{\rho} + \frac{V_1^2 - V_2^2}{2} + g(z_1 - z_2) = \left(237\frac{\text{lb}}{\text{ft}^2}\right)\frac{1}{\left(1.94\frac{\text{slugs}}{\text{ft}^3}\right)} + \left(32.2\frac{\text{ft}}{\text{s}^2}\right)(5\text{ ft})(\sin 30^\circ)\left(\frac{1\text{ lb}}{\text{slug}\cdot\frac{\text{ft}}{\text{s}^2}}\right)$$

or

$$\text{loss} = \underline{\underline{203\frac{\text{ft}\cdot\text{lb}}{\text{slug}}}}$$

(c) The net axial force exerted by the pipe wall on the flowing water may be obtained by using the axial component of the linear momentum equation (Eq. 5.22). Thus for the control volume shown above

$$R_x = -\frac{\pi D^2}{4}(P_1 - P_2) - \gamma\frac{\pi D^2}{4}(\ell)\sin 30^\circ = -\frac{\pi D^2}{4}\left[(P_1 - P_2) + \gamma\ell\sin 30^\circ\right]$$

or

$$R_x = -\frac{\pi}{4}\left(\frac{6\text{ in.}}{12\frac{\text{in.}}{\text{ft}}}\right)^2\left[237\frac{\text{lb}}{\text{ft}^2} + \left(62.4\frac{\text{lb}}{\text{ft}^3}\right)(5\text{ ft})\sin 30^\circ\right]$$

and

$$R_x = -77.2\text{ lb} = \underline{\underline{77.2\text{ lb opposite to flow direction.}}}$$