5.104

5.104 For the 180° elbow and nozzle flow shown in Fig. P5.104, determine the loss in available energy from section (1) to section (2). How much additional available energy is lost from section (2) to where the water comes to rest?

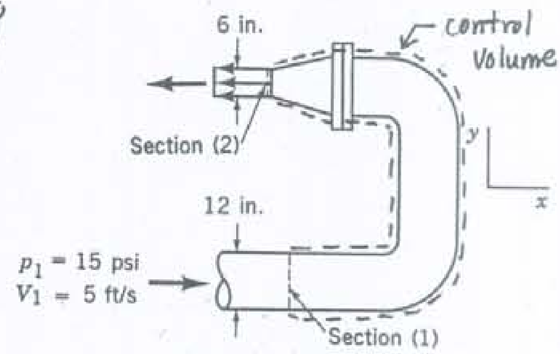

FIGURE P5.104

For solving the first part of this problem, the control volume shown in the sketch above is used. To determine the loss accompanying flow from section 1 to section 2 Eq. 5.79 can be used as follows.

$$_1loss_2 = \frac{p_1 - p_2}{\rho} + \frac{V_1^2 - V_2^2}{2} + g(z_1 - z_2)$$

Since x-y coordinates are specified we assume that the flow is horizontal and $z_1 - z_2 = 0$. Also, $p_2 = p_{atm} = 0$ psi.

From the conservation of mass principle we conclude that

$$V_2 = V_1 \frac{A_1}{A_2} = V_1\left(\frac{D_1^2}{D_2^2}\right)$$

Thus

$$_1loss_2 = \frac{p_1}{\rho} + \frac{V_1^2}{2}\left[1 - \left(\frac{D_1^2}{D_2^2}\right)^2\right] = \frac{p_1}{\rho} + \frac{V_1^2}{2}\left[1 - \left(\frac{D_1}{D_2}\right)^4\right]$$

or

$$_1loss_2 = \frac{\left(15 \frac{lb}{in.^2}\right)\left(144 \frac{in.^2}{ft^2}\right)}{\left(1.94 \frac{slugs}{ft^3}\right)} + \frac{\left(5 \frac{ft}{s}\right)^2}{2}\left[1 - \left(\frac{12 \text{ in.}}{6 \text{ in.}}\right)^4\right]\left(\frac{1 \text{ lb}}{slug \cdot \frac{ft}{s^2}}\right)$$

$$_1loss_2 = \underline{\underline{926}} \ \frac{ft \cdot lb}{slug}$$

For the second part of this problem we consider the flow of a fluid particle from section 2 to a state of rest, a. Eq. 5.79 leads to

$$_2loss_a = \frac{V_2^2}{2}$$

Note that we have assumed that $p_2 = p_a = p_{atm}$ and $z_2 = z_a$.

Thus

$$_2loss_A = \frac{V_2^2}{2} = \frac{V_1^2}{2}\left(\frac{D_1^2}{D_2^2}\right)^2 = \frac{V_1^2}{2}\left(\frac{D_1}{D_2}\right)^4 = \frac{\left(5 \frac{ft}{s}\right)^2\left(\frac{12 \text{ in.}}{6 \text{ in.}}\right)^4\left(\frac{1 \text{ lb}}{slug \cdot \frac{ft}{s^2}}\right)}{2}$$

$$_2loss_A = \underline{\underline{200}} \ \frac{ft \cdot lb}{slug}$$