

**3.173** The horizontal wye fitting in Fig. P3.173 splits the 20°C water flow rate equally, if  $Q_1 = 5 \text{ ft}^3/\text{s}$  and  $p_1 = 25 \text{ lbf/in}^2$  (gage) and losses are neglected, estimate (a)  $p_2$ , (b)  $p_3$ , and (c) the vector force required to keep the wye in place.

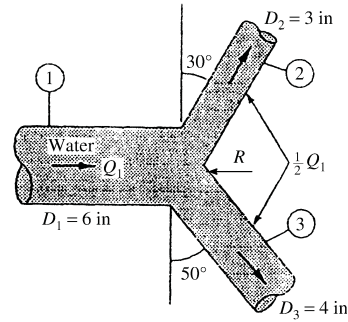


Fig. P3.173

$$V_1 = \frac{Q}{A_1} = \frac{5.0}{(\pi/4)(6/12)^2} = 25.46 \frac{\text{ft}}{\text{s}}; \quad V_2 = \frac{2.5}{(\pi/4)(3/12)^2} = 50.93 \frac{\text{ft}}{\text{s}}, \quad V_3 = 28.65 \frac{\text{ft}}{\text{s}}$$

Then apply Bernoulli from 1 to 2 and then again from 1 to 3, assuming  $\Delta z \approx 0$ :

$$p_2 = p_1 + \frac{\rho}{2}(V_1^2 - V_2^2) = 25(144) + \frac{1.94}{2}[(25.46)^2 - (50.93)^2] \approx 1713 \text{ psfg} \quad \text{Ans. (a)}$$

$$p_3 = p_1 + \frac{\rho}{2}(V_1^2 - V_3^2) = 25(144) + \frac{1.94}{2}[(25.46)^2 - (28.65)^2] \approx 3433 \text{ psfg} \quad \text{Ans. (b)}$$

(c) to compute the support force  $\mathbf{R}$  (see figure above), put a CV around the entire wye:

$$\begin{aligned} \sum F_x &= R_x + p_1 A_1 - p_2 A_2 \sin 30^\circ - p_3 A_3 \sin 50^\circ = \rho Q_2 V_2 \sin 30^\circ + \rho Q_3 V_3 \sin 50^\circ - \rho Q_1 V_1 \\ &= R_x + 707 - 42 - 229 = 124 + 106 - 247, \quad \text{or: } R_x = -453 \text{ lbf (to left)} \quad \text{Ans. (c)} \end{aligned}$$

$$\begin{aligned} \sum F_y &= R_y - p_2 A_2 \cos 30^\circ + p_3 A_3 \cos 50^\circ = \rho Q_2 V_2 \cos 30^\circ + \rho Q_3 (-V_3) \cos 50^\circ \\ &= R_y - 73 + 193 = 214 - 89, \quad \text{or: } R_y \approx +5 \text{ lbf (up)} \quad \text{Ans. (c)} \end{aligned}$$

**3.174** In Fig. P3.174 the piston drives water at 20°C. Neglecting losses, estimate the exit velocity  $V_2$  ft/s. If  $D_2$  is further constricted, what is the maximum possible value of  $V_2$ ?

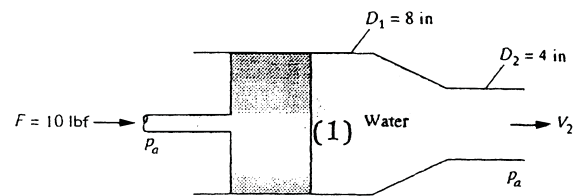


Fig. P3.174

**Solution:** Find  $p_1$  from a freebody of the piston:

$$\sum F_x = F + p_a A_1 - p_1 A_1, \quad \text{or: } p_1 - p_a = \frac{10.0 \text{ lbf}}{(\pi/4)(8/12)^2} \approx 28.65 \frac{\text{lbf}}{\text{ft}^2}$$