

3.30

3.30 Water flows through the pipe contraction shown in Fig. P3.30. For the given 0.2-m difference in manometer level, determine the flow-rate as a function of the diameter of the small pipe,  $D$ .

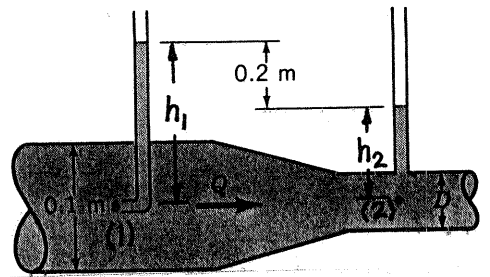


FIGURE P3.30

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 \quad \text{or with } z_1 = z_2 \text{ and } V_1 = 0$$

$$V_2 = \sqrt{2g \frac{(p_1 - p_2)}{\gamma}}$$

but  $p_1 = \gamma h_1$  and  $p_2 = \gamma h_2$  so that  $p_1 - p_2 = \gamma(h_1 - h_2) = 0.2\gamma$

Thus,

$$V_2 = \sqrt{2g \frac{0.2\gamma}{\gamma}} = \sqrt{2g(0.2)}$$

or

$$Q = A_2 V_2 = \frac{\pi}{4} D^2 V_2 = \frac{\pi}{4} D^2 \sqrt{2(9.81)(0.2)} = \underline{\underline{1.56 D^2 \frac{m^3}{s}}} \text{ when } D \sim m$$