

3.53

3.53 Water flows through the pipe contraction shown in Fig. P3.53. For the given 0.2-m difference in the manometer level, determine the flowrate as a function of the diameter of the small pipe, D .

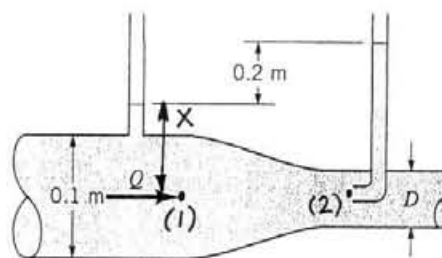


FIGURE P3.53

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2$$

where $Z_1 = Z_2$ and $V_2 = 0$.

Thus,

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} = \frac{P_2}{\gamma}$$

But

$\frac{P_1}{\gamma} = X$ and $\frac{P_2}{\gamma} = 0.2\text{ m} + X$ so that

$$X + \frac{V_1^2}{2g} = 0.2\text{ m} + X \quad \text{or}$$

$$V_1 = \sqrt{2g(0.2\text{ m})} = \left(2\left(9.81 \frac{\text{m}}{\text{s}^2}\right)(0.2\text{ m})\right)^{1/2} = 1.98 \frac{\text{m}}{\text{s}}$$

Thus,

$$Q = A_1 V_1 = \frac{\pi}{4} (0.1\text{ m})^2 (1.98 \frac{\text{m}}{\text{s}}) = \underline{\underline{0.0156 \frac{\text{m}^3}{\text{s}} \text{ for any } D}}$$