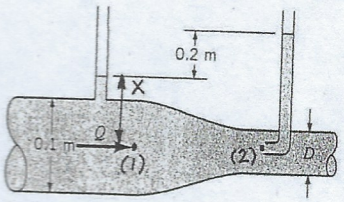
3.52

3.52 Water flows through the pipe contraction shown in Fig. P3.52. 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 P3.52

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2$$

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 $\frac{p_2}{\gamma} = 0.2\,m + X$ so that

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

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

Thus,

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