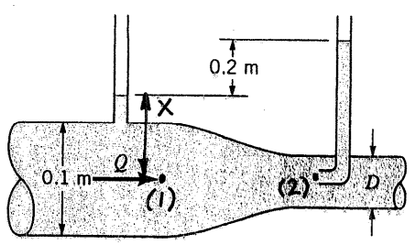
3.32

3.32 Water flows through the pipe contraction shown in Fig. P3.32. 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 P3.32

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

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

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

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

Thus,

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