3.51

3.51 Water flows through the pipe contraction shown in Fig. P3.51. For the given 0.2-m difference in manometer level, determine the flowrate as a function of the diameter of the small pipe, D.

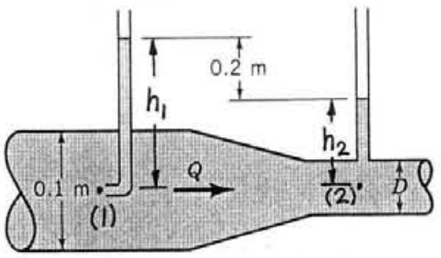

FIGURE P3.51

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

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

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

$$Q=A_2V_2=\frac{\pi}{4}D^2V_2=\frac{\pi}{4}D^2\sqrt{2(9.81)(0.2)}=1.56\,D^2\ \frac{m^3}{s} \text{ when } D\sim m$$