3.107

3.107 Water flows from the pipe shown in Fig. P3.107as a free jet and strikes a circular flat plate. The flow geometry shown is axisymmetrical. Determine the flowrate and the manometer reading, H.

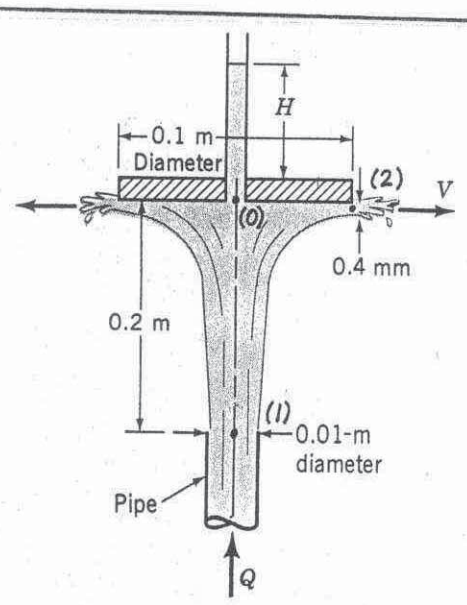

FIGURE P3.107

$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2$, where $p_1 = 0$, $p_2 = 0$, $z_1 = 0$, and $z_2 = 0.2m$

Thus,

$\frac{V_1^2}{2g} = \frac{V_2^2}{2g} + z_2$ where $A_1 V_1 = A_2 V_2 = Q$ (1)

or $V_1 = \frac{A_2}{A_1} V_2 = \frac{\pi D_2 h}{\frac{\pi}{4} D_1^2} V_2 = \frac{4 D_2 h}{D_1^2} V = \frac{4(0.1m)(4\times10^{-4}m)}{(0.01m)^2} V_2 = 1.6 V_2$

Hence, Eq. (1) gives

$(1.60V_2)^2 = V_2^2 + 2(9.81\frac{m}{s^2})(0.2m)$ or $V_2 = 1.59\frac{m}{s}$

so that

$Q = A_2 V_2 = \pi(0.1m)(4\times10^{-4}m)(1.59\frac{m}{s}) = \underline{\underline{2.00\times10^{-4}\frac{m^3}{s}}}$

Also,

$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_0}{\gamma} + \frac{V_0^2}{2g} + z_0$, where $V_0 = 0$, $z_0 = 0.2m$, $V_1 = 1.60 V_2$

or $V_1 = 1.60(1.59\frac{m}{s}) = 2.54\frac{m}{s}$, and $p_1 = 0$

Thus,

$H = \frac{p_0}{\gamma} = \frac{V_1^2}{2g} - z_0 = \frac{(2.54\frac{m}{s})^2}{2(9.81\frac{m}{s^2})} - 0.2m = \underline{\underline{0.129\ m}}$