3.97

3.97 Air flows from a hole of diameter 0.03 m in a flat plate as shown in Fig. P3.97. A circular disk of diameter D is placed a distance h from the lower plate. The pressure in the tank is maintained at 1 kPa. Determine the flowrate as a function of h if viscous effects and elevation changes are assumed negligible and the flow exits radially from the circumference of the circular disk with uniform velocity.

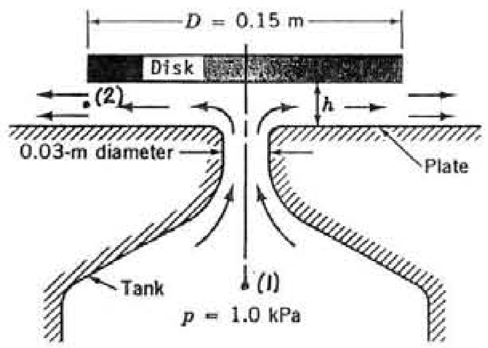

FIGURE P3.97

$$\frac{p_0}{\gamma} + \frac{V_0^2}{2g} + z_0 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2$$ where $p_0 = 1\,\frac{kN}{m^2}$, $p_2 = 0$, $z_0 \approx z_2$, and $V_0 = 0$

Thus,

$$V_2 = \sqrt{\frac{2p_0}{\rho}} = \sqrt{\frac{2\left(1\times10^3\,\frac{N}{m^2}\right)}{1.23\,\frac{kg}{m^3}}} = 40.3\,\frac{m}{s}$$

so that

$$Q = A_2 V_2 = \pi D_2 h V_2 = \pi (0.15m) h \left(40.3\,\frac{m}{s}\right)$$

or

$$Q = \underline{\underline{19.0\,h\,\frac{m^3}{s}}} \quad \text{where } h \sim m$$