3.151 Water flows through a circular nozzle, exits into the air as a jet, and strikes a plate. The force required to hold the plate steady is 70 N. Assuming frictionless one-dimensional flow, estimate (a) the velocities at sections (1) and (2); (b) the mercury manometer reading *h*.

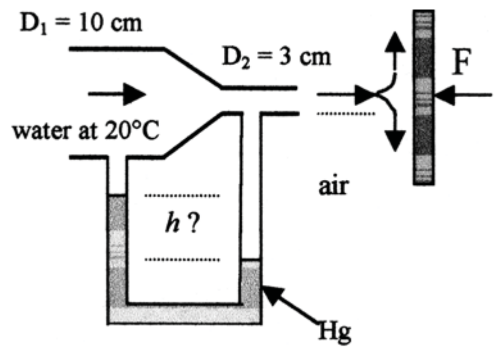

Fig. P3.151

Solution: (a) First examine the momentum of the jet striking the plate,

$$\sum F = F = -\dot{m}_{in}u_{in} = -\rho A_2 V_2^2$$

$$70\ N = -(998)\left(\frac{\pi}{4}\right)(0.03^2)(V_2^2) \quad \mathbf{V_2 = 9.96\ m/s} \quad \textit{Ans. (a)}$$

$$\textit{Then}\quad V_1 = \frac{V_2A_2}{A_1} = \frac{(9.96)\left(\frac{\pi}{4}\right)(0.03^2)}{\frac{\pi}{4}(0.1^2)} \quad \textit{or}\quad \mathbf{V_1 = 0.9\ m/s} \quad \textit{Ans. (a)}$$

(b) Applying Bernoulli,

$$p_2 - p_1 = \frac{1}{2}\rho\left(V_2^2 - V_1^2\right) = \frac{1}{2}(998)(9.96^2 - 0.9^2) = 49{,}100\ Pa$$

And from our manometry principles,

$$h = \frac{\Delta p}{\rho g} = \frac{49{,}100}{(133{,}100 - 9790)} \approx \mathbf{0.4\ m} \quad \textit{Ans. (b)}$$

3.152 A free liquid jet, as in Fig. P3.152, has constant ambient pressure and small losses; hence from Bernoulli's equation $z + V^2/(2g)$ is constant along the jet. For the fire nozzle in the figure, what are (a) the minimum and (b) the maximum values of θ for which the water jet will clear the corner of the building? For which case will the jet velocity be higher when it strikes the roof of the building?

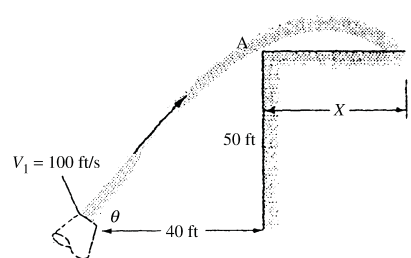

Fig. P3.152