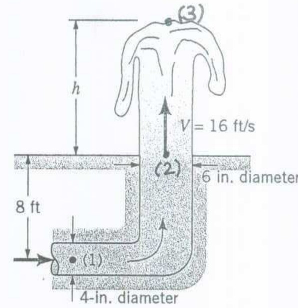
3.60

3.60 Water exits a pipe as a free jet and flows to a height h above the exit plane as shown in Fig. P3.60. The flow is steady, incompressible, and frictionless. (a) Determine the height h. (b) Determine the velocity and pressure at section (1).



■ FIGURE P3.60

(a) From the Bernoulli eqn.,

$$\frac{p_2}{\gamma}+\frac{V_2^2}{2g}+z_2=\frac{p_3}{\gamma}+\frac{V_3^2}{2g}+z_3,\ \text{where } p_2=p_3=0,\ \text{and } V_3=0.$$

Thus,

$$\frac{V_2^2}{2g}=z_3-z_2=h$$

or

$$h=\frac{V_2^2}{2g}=\frac{(16\ ft/s)^2}{2(32.2\ ft/s)}=\underline{\underline{3.98\ ft}}$$

(b) Also, $A_1V_1=A_2V_2$

or

$$V_1=\frac{A_2}{A_1}V_2=\frac{\frac{\pi}{4}(6in.)^2}{\frac{\pi}{4}(4in.)^2}\left(16\frac{ft}{s}\right)=\underline{\underline{36.0\frac{ft}{s}}}$$

From the Bernoulli equation,

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

or since $\gamma=\rho g$,

$$p_1=p_2+\frac{1}{2}\rho(V_2^2-V_1^2)+\gamma(z_2-z_1)\ \text{where } p_2=0$$

Thus,

$$p_1=\frac{1}{2}\left(1.94\frac{slugs}{ft^3}\right)\left[\left(16\frac{ft}{s}\right)^2-\left(36.0\frac{ft}{s}\right)^2\right]+62.4\frac{lb}{ft^3}(8ft)$$

$$=-1009\left(\frac{slugs\cdot ft}{s^2}\right)/ft^2+499\frac{lb}{ft^2}$$

$$=\underline{\underline{-510\frac{lb}{ft^2}}}$$