3.20

3.20 Some animals have learned to take advantage of the Bernoulli effect without having read a fluid mechanics book. For example, a typical prairie dog burrow contains two entrances—a flat front door, and a mounded back door as shown in Fig. P3.20. When the wind blows with velocity V_0 across the front door, the average velocity across the back door is greater than V_0 because of the mound. Assume the air velocity across the back door is $1.07V_0$. For a wind velocity of 6 m/s, what pressure differences, $p_1 - p_2$, is generated to provide a fresh air flow within the burrow?

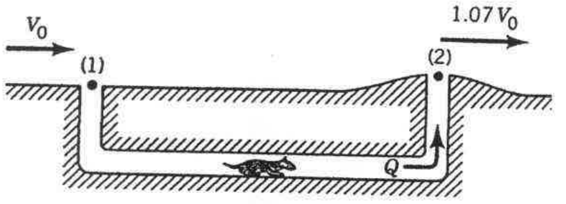


FIGURE P3.20

$$p_1 + \frac{1}{2}\rho V_1^2 + \gamma z_1 = p_2 + \frac{1}{2}\rho V_2^2 + \gamma z_2$$

Thus, with negligible gravitational effects (i.e. $z_1 \approx z_2$)

$$p_1 - p_2 = \frac{1}{2}\rho(V_2^2 - V_1^2)$$

$$= \frac{1}{2}\left(1.23 \frac{kg}{m^3}\right)\left(\left(1.07\left(6\frac{m}{s}\right)\right)^2 - \left(6\frac{m}{s}\right)^2\right)$$

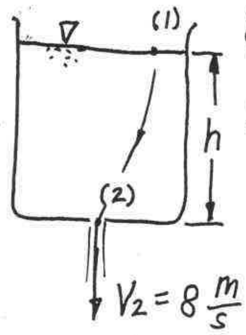
or

$$p_1 - p_2 = \underline{\underline{3.21 \frac{N}{m^2}}}$$

20 bi

3.29

3.29 Water flows through a hole in the bottom of a large, open tank with a speed of 8 m/s. Determine the depth of water in the tank. Viscous effects are negligible.



$$p_1 + \frac{1}{2}\rho V_1^2 + \gamma z_1 = p_2 + \frac{1}{2}\rho V_2^2 + \gamma z_2$$

Thus, with $p_1 = p_2 = z_2 = V_1 = 0$,

$\gamma z_1 = \frac{1}{2}\rho V_2^2$, where $\gamma = \rho g$ and $z_1 = h$

so that

$$\rho g h = \frac{1}{2}\rho V_2^2$$

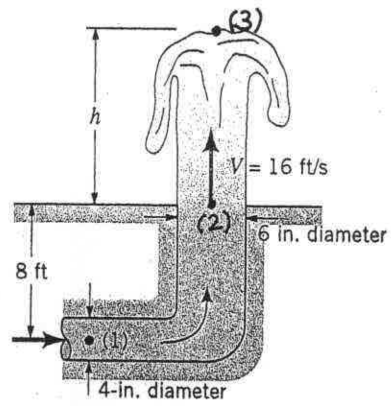
or

$$h = \frac{V_2^2}{2g} = \frac{(8\ \frac{m}{s})^2}{2(9.81\ \frac{m}{s^2})} = \underline{\underline{3.26\ m}}$$

26 bi

3.64

3.64 Water exits a pipe as a free jet and flows to a height h above the exit plane as shown in Fig. P3.64. The flow is steady, incompressible, and frictionless. (a) Determine the height h. (b) Determine the velocity and pressure at section (1).



■ FIGURE P3.64

(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

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

(b) Also, $A_1V_1 = A_2V_2$

or

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

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,

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

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

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