3.109

3.109 Water flows steadily from a nozzle into a large tank as shown in Fig. P3.109. The water then flows from the tank as a jet of diameter d. Determine the value of d if the water level in the tank remains constant. Viscous effects are negligible.

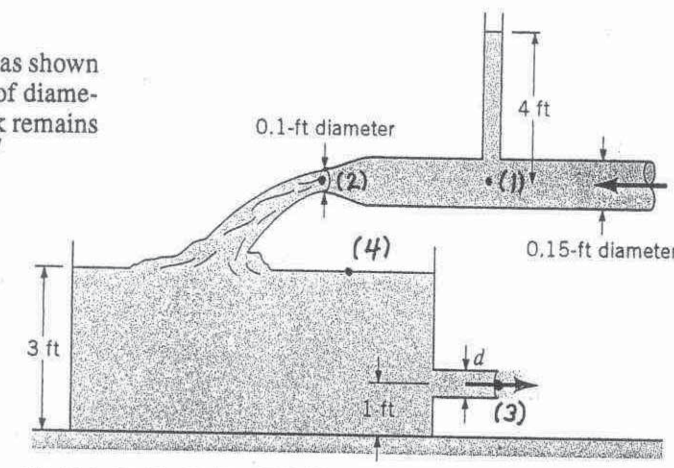

FIGURE P3.109

From the Bernoulli equation,

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

Also,

$$\frac{p_1}{\gamma} = 4 \text{ ft} \text{ and } A_1 V_1 = A_2 V_2$$

or

$$\frac{\pi}{4} D_1^2 V_1 = \frac{\pi}{4} D_2^2 V_2 \text{ so that}$$

(2) $$V_1 = \left(\frac{D_2}{D_1}\right)^2 V_2 = \left(\frac{0.10 \text{ ft}}{0.15 \text{ ft}}\right)^2 V_2 = 0.444 V_2$$

Thus, from Eqs. (1) and (2),

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} = \frac{V_2^2}{2g}$$

or

$$4 \text{ ft} = \frac{(V_2^2 - V_1^2)}{2g} = \frac{(1-(0.444)^2) V_2^2}{2(32.2 \text{ ft/s}^2)}$$

Hence,

$$V_2 = 17.9 \frac{\text{ft}}{\text{s}}$$

so that

$$Q_2 = A_2 V_2 = \frac{\pi}{4}(0.10 \text{ ft})^2 (17.9 \frac{\text{ft}}{\text{s}}) = 0.1407 \frac{\text{ft}^3}{\text{s}}$$

Also,

$$Q_3 = Q_2 \text{ where } Q_3 = A_3 V_3 \text{ and } V_3 = \sqrt{2g(z_4 - z_3)} = \sqrt{2(32.2 \frac{\text{ft}}{\text{s}^2})(3 \text{ ft} - 1 \text{ ft})}$$
$$= 11.35 \frac{\text{ft}}{\text{s}}$$

Hence,

$$\frac{\pi}{4} d^2 (11.35 \frac{\text{ft}}{\text{s}}) = 0.1407 \frac{\text{ft}^3}{\text{s}}$$

or

$$d = \underline{\underline{0.126 \text{ ft}}}$$