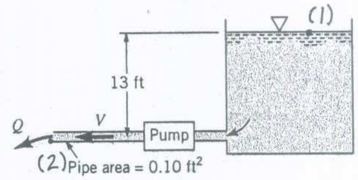
5.116

5.116 Water is pumped from the large tank shown in Fig. P5.116. The head loss is known to be equal to $4V^2/2g$ and the pump head is $h_p = 20 - 4Q^2$, where h_p is in ft when Q is in ft^3/s. Determine the flowrate.



■ FIGURE P5.116

$$\frac{p_1}{\gamma} + z_1 + \frac{V_1^2}{2g} + h - h_L = \frac{p_2}{\gamma} + z_2 + \frac{V_2^2}{2g},$$ where $p_1 = p_2 = 0$, $z_1 = 13\,ft$, $z_2 = 0$, $h_s = h_p$ and $V_1 = 0$.

Thus,

(1) $$z_1 + h_p - h_L = \frac{V_2^2}{2g}$$

Also,

$$h_L = 4\frac{V^2}{2g} = 4\frac{V_2^2}{2g} = 4\frac{(Q/A_2)^2}{2g}$$ since $V_2 = \frac{Q}{A_2}$

Hence, Eq. (1) becomes

$$z_1 + (20 - 4Q^2) - 4\frac{(Q/A_2)^2}{2g} = \frac{(Q/A_2)^2}{2g}$$

or

$$\left[\left(\frac{5}{2g A_2^2}\right) + 4\right] Q^2 = 20 + z_1$$, where $g \sim \frac{ft}{s^2}$, $A_2 \sim ft^2$, and $Q \sim \frac{ft^3}{s}$

Thus, with the given data

$$\left[\left(\frac{5}{2(32.2\frac{ft}{s^2})(0.1\,ft^2)^2}\right) + 4\right] Q^2 = 20 + 13\,ft$$

or

$$Q = 1.67\,\frac{ft^3}{s}$$