8.61 What horsepower is added to water to pump it vertically through a 200-ft-long, 1.0-in.-diameter drawn tubing at a rate of 0.060 ft³/s if the pressures at the inlet and outlet are the same?

\[ \frac{Q}{A} + \frac{V_1^2}{2g} + Z_1 + h_p = \frac{Q}{A} + \frac{V_2^2}{2g} + Z_2 + f \frac{L}{D} \frac{V_2^2}{2g}, \text{ where } A_1 = A_2 \text{ and } V_1 = V_2. \text{ Thus,} \]

\[ h_p = Z_2 - Z_1 + f \frac{L}{D} \frac{V_2^2}{2g}, \text{ where } Z_2 - Z_1 = \ell = 200 \text{ ft} \quad \text{and} \quad \ell = 110 \text{ ft} \]

Also, \( \frac{Q}{A} = 0.06 \text{ ft}^3/\text{sec} \), \( \ell = 110 \text{ ft} \), and \( \frac{V_2}{A} = \frac{0.06 \text{ ft}^3/\text{sec}}{\pi/4 \left( \frac{1}{12} \text{ ft} \right)^2} = 11.0 \text{ ft/s} \)

and \( \text{Re} = \frac{V_2 D}{\nu} = \frac{110 \text{ ft/s} \left( \frac{1}{12} \text{ ft} \right) \frac{1}{2} \text{ sec}}{1.21 \text{ ft} \cdot \text{sec}^{-1} \cdot \text{ft}} = 7.58 \times 10^4 \) we obtain from Fig. 8.20

\[ f = 0.019 \]

From Eq. (1)

\[ h_p = 200 \text{ ft} + (0.019) \left( \frac{200 \text{ ft}}{\text{sec}} \right) \left( \frac{(110 \text{ ft/s})^2}{2 \left(32.2 \text{ ft/lb} \cdot \text{s}^2 \right)} \right) = 286 \text{ ft} \]

Thus,

\[ \mathcal{P} = 8 \cdot Q \cdot h_p = (62.4 \text{ lb/s}) \cdot (0.06 \text{ ft}^3/\text{sec}) \cdot (286 \text{ ft}) = 1071 \text{ ft} \cdot \text{lb} \left( \frac{1 \text{ hp}}{550 \text{ ft} \cdot \text{lb}/\text{s}} \right) = 1.95 \text{ hp} \]

8.62 Water flows from a lake as shown in Fig. P8.62 at a rate of 4.0 cfs. Is the device inside the building a pump or a turbine? Explain and determine the horsepower of the device. Neglect all minor losses and assume the friction factor is 0.025.

\[ \frac{Q}{A} + \frac{V_1^2}{2g} + Z_1 + h_p = \frac{Q}{A} + \frac{V_2^2}{2g} + Z_2 + h_t + f \frac{L}{D} \frac{V_2^2}{2g}, \text{ where } A_1 = A_2 \text{ and } V_1 = 0 \text{ and } V_2 = \frac{Q}{A} = \frac{4 \text{ ft}^3/\text{sec}}{\pi/4 \left( \frac{0.4 \text{ ft}}{12} \right)^2} = 31.8 \text{ ft/s} \]

Assume the device is a pump (\( h_t = 0 \)).

Thus, \( Z_1 + h_p = \frac{V_2^2}{2g} (1 + f \frac{L}{D}) + Z_2 \), or

\[ h_p = 495 \text{ ft} - 525 \text{ ft} + \left( \frac{31.8 \text{ ft/s}^2}{2 \left(32.2 \text{ ft/lb} \cdot \text{s}^2 \right)} \right) \left( 1 + 0.025 \left( \frac{300 \text{ ft}}{0.4 \text{ ft/s}^2} \right) \right) = 280 \text{ ft} \]

Note: Since \( h_p > 0 \), the device is a pump.

Also, \( \mathcal{P} = g \cdot h_p \cdot \frac{Q}{A} = (62.4 \text{ lb/s}) \cdot (4 \text{ ft/s}) \cdot (280 \text{ ft}) = 69,900 \text{ ft} \cdot \text{lb} \left( \frac{1 \text{ hp}}{550 \text{ ft} \cdot \text{lb}/\text{s}} \right) = 12.7 \text{ hp} \)

\[ \mathcal{P} = 12.7 \text{ hp} \]