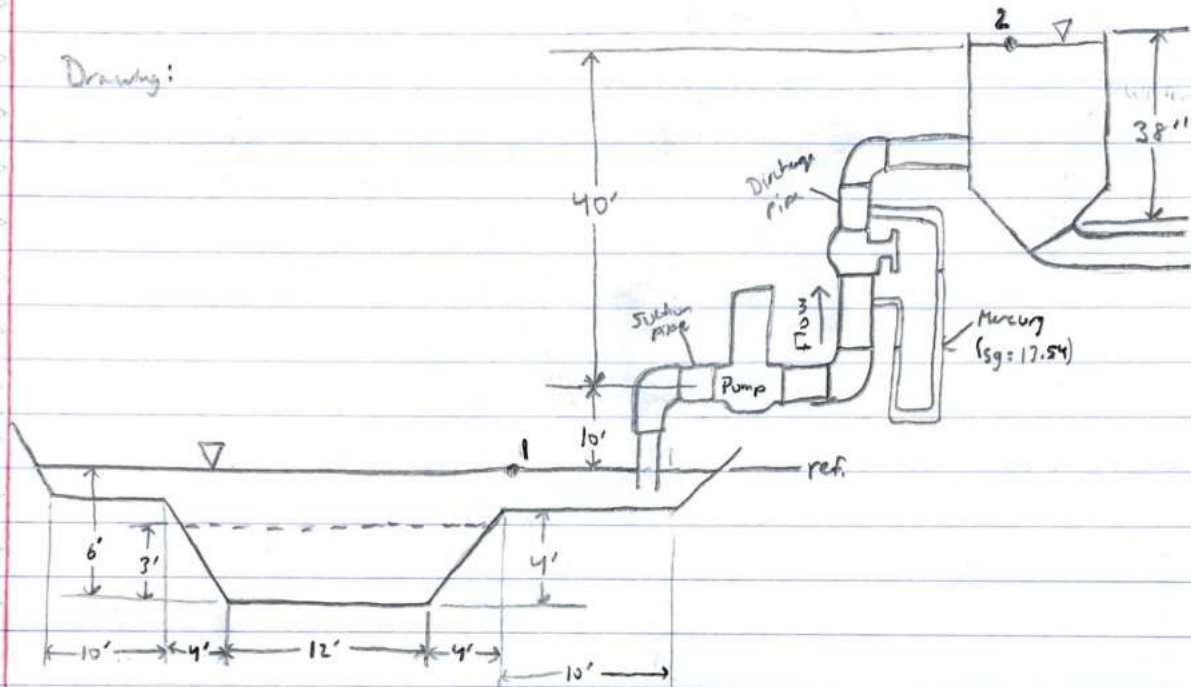


Cannon Sitten

Test #1

a) Purpose: Determine required pump power to deliver $3.387 \text{ ft}^3/\text{s}$ of water from the lower channel to upper open channel.

Drawing:



Source: Mott and Untener, Applied Fluid Mechanics, 7th Edition, Pearson, 2015,

Design considerations:

Steady flow

Incompressible fluid

Constant properties

Let sub s be suction line and sub d be discharge line

Data and variables:

$$T_{\text{water}} = 60^\circ\text{F}$$

$$Q = 3.387 \text{ ft}^3/\text{s}$$

$$\text{pump efficiency} = 60\% \approx .60$$

$$L_{\text{suction pipe}} = 11 \text{ ft}$$

$$L_{\text{discharge pipe}} = 2500 \text{ ft}$$

$$K_{\text{valve}} = 5.3$$

$$\rho_w = 1.94 \text{ slugs/ft}^3$$

$$\gamma_{\text{water}} = 62.4 \text{ lb/ft}^3$$

Materials:

Water

$$\text{Pipe diameter} = Q = AV$$

$$3.387 \text{ ft}^3/\text{s} = A(9.84 \text{ ft/s})$$

$$.344 \text{ ft}^2 = A$$

$$\frac{3 \text{ m}}{5} \times \frac{3.28 \text{ ft}}{1 \text{ m}} = 9.84 \text{ ft/s}$$

Table F.1: 8 in NPS Sch 40

Procedure:

$$h_A + \frac{P_1}{\rho} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho} + \frac{V_2^2}{2g} + z_2 + K_R + h_L$$

$$h_A = z_2 + h_L$$

$$V_s = V_d = \frac{Q}{A} = \frac{3.377 \text{ ft}^3/\text{s}}{0.3472 \text{ ft}^2} = 9.76 \text{ ft/s}$$

$$\frac{V_1^2}{2g} = \frac{(9.76 \text{ ft/s})^2}{2(32.2 \text{ ft/s}^2)} = .15 \text{ ft}$$

$$Re = \frac{\rho V D}{\mu} = \frac{(1.94)(.15)(.665)}{2.35 \times 10^{-5}} = 8234.68 \leftarrow \text{Turbulent flow}$$

$$\frac{D}{\epsilon} = \frac{.665}{9.6 \times 10^{-5}} = 14456.52$$

$$f_s = f_d = \frac{.25}{\left[\log \left(\frac{1}{3.7(D/\epsilon)} + \frac{5.74}{Re^{0.9}} \right) \right]^2} = \frac{.25}{\left[\log \left(\frac{1}{3.7(14456.52)} + \frac{5.74}{(8234.68)^{0.9}} \right) \right]^2} = .0328$$

$$h_L = 3h_{\text{elbow}} + h_{\text{valve}} + h_{LS} + h_{LD}$$

$$\text{Elbow: } h_L = K \left(\frac{V^2}{2g} \right) = 30(0.014) \left(\frac{.15}{2g} \right) = .063 \text{ ft}$$

$$\text{Valve: } h_L = K \left(\frac{V^2}{2g} \right) = 5.3 \left(\frac{.15}{2g} \right) = .795 \text{ ft}$$

$$\text{Suction: } h_L = f \times \frac{L}{D} \times \frac{V^2}{2g} = (0.014) \times \left(\frac{11}{.665} \right) \times \left(\frac{.15}{2g} \right) = .0347 \text{ ft}$$

$$\text{Discharge: } h_L = f \times \frac{L}{D} \times \frac{V^2}{2g} = (0.014) \times \left(\frac{2500}{.665} \right) \times \left(\frac{.15}{2g} \right) = 7.895 \text{ ft}$$

$$h_L = 3(.063) + .795 + .0347 + 7.895$$

$$h_L = 8.9137 \text{ ft}$$

$$h_A = z_2 + h_L = 50 \text{ ft} + 8.9137 \text{ ft} = 58.9137 \text{ ft}$$

$$P_A = \gamma Q h_A$$

$$P_A = (62.4 \text{ lb/ft}^3)(3.387 \text{ ft}^3/\text{s})(58.9137 \text{ ft})$$

$$P_A = 12451.34 \text{ lb-ft/s} \div 550 \text{ lb-ft/s}$$

$$P_A = \frac{22.64}{\eta} \text{ HP}$$

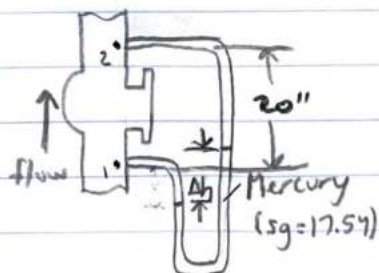
$$P_A = \frac{22.64}{.60}$$

$$P_A = 37.73 \text{ HP}$$

Analysis: The required pump power to deliver water from the open channel to the elevated one must be 37.73 HP, which accounts for the total energy losses of the system and the pump efficiency.

b.) Purpose: What is the reading on the manometer due to the pressure drop of the valve?

Drawing (taken from drawing for a.):



Design considerations:

Steady flow

Incompressible fluid

Constant properties

Data and variables:

$$\gamma_w = 62.4 \text{ lb/ft}^3$$

$$\rho_w = 1.94 \text{ slugs/ft}^3$$

$$K_{\text{valve}} = 5.3$$

$$h = 20 \text{ in} / 12 = 1.67 \text{ ft}$$

$$\gamma_{\text{mercury}} = 17.54$$

$$\frac{V}{2g} = .15 \text{ ft}$$

$$A = .3472 \text{ ft}^2$$

$$\rho_{\text{Hg}} = 34.03 \text{ slugs/ft}^3$$

$$\Delta h = \text{manometer reading}$$

Materials: Mercury and Water

Procedure:

$$\frac{\Delta p}{\gamma} = \frac{K V^2}{2g}$$

$$K_L + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + h_L + h_c$$

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + h_L$$

$$P_1 - P_2 = \gamma Z_2 + h_L$$

$$h_L = K \left(\frac{V}{2g} \right) = 5.3 \left(\frac{9.76^2}{2(32.2)} \right) = 7.84 \text{ ft}$$

$$V = \frac{Q}{A} = \frac{3.387 \text{ ft}^3/\text{s}}{.3472 \text{ ft}^2} = 9.76 \text{ ft/s}$$

$$\gamma = 62.4 \text{ lb/ft}^3$$

$$\Delta p = 7.84 \text{ ft}$$

$$62.4 \text{ lb/ft}^3 \times 7.84 \text{ ft} \times \frac{1 \text{ ft}^2}{144 \text{ in}^2}$$

$$\Delta p = 7.84 \text{ ft} \times 62.4 \frac{\text{lb}}{\text{ft}^3} \times \frac{1 \text{ ft}^2}{144 \text{ in}^2}$$

$$\Delta p = 3.39 \text{ psi}$$

Analysis: The manometer reading measures the pressure drop in the valve which is 3.39 psi.