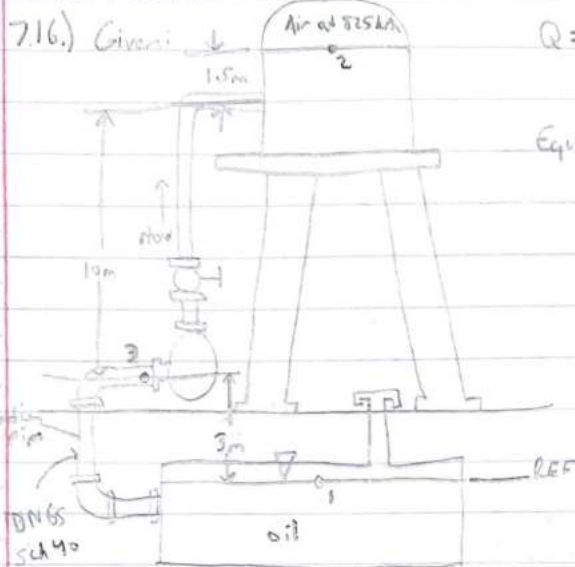


Concrete Suction

7.16.) Given:



$$Q = 840 \text{ L/min} \quad \text{oil: } \rho = 0.85$$

$$\hookrightarrow 0.014 \text{ m}^3/\text{s}$$

$$\text{Equation: Pump: } P_A = \rho Q h_A$$

Bernoulli:

$$h_A + \frac{p_1}{\rho} + \frac{V_1^2}{2g} + Z_1 = \frac{p_2}{\rho} + \frac{V_2^2}{2g} + Z_2 + h_A + h_L$$

Determine:

a) If  $h_L = 4.2 \text{ N}\cdot\text{m}/\text{N}$ , calculate power delivered by pump.

$$\text{Solution: } h_A + \frac{p_1}{\rho} + \frac{V_1^2}{2g} + Z_1 = \frac{p_2}{\rho} + \frac{V_2^2}{2g} + Z_2 + h_A + h_L$$

$$h_A = \frac{p_2}{\rho} + Z_2 + h_L$$

$$h_A = \frac{825000 \text{ N/m}^2}{8338.5 \text{ N/m}^3} + 14.5 \text{ m} + 4.2 \text{ N}\cdot\text{m}/\text{N}$$

$$h_A = 117.64 \text{ N}\cdot\text{m}/\text{N}$$

$$\text{Power: } P_A = \rho Q h_A$$

$$P_A = (8338.5 \text{ N/m}^3)(0.014 \text{ m}^3/\text{s})(117.64 \text{ N}\cdot\text{m}/\text{N})$$

$$P_A = 13733.18 \text{ W} \Rightarrow \boxed{13.73 \text{ kW}}$$

b) If  $h_{L\text{ suction}} = 1.4 \text{ N}\cdot\text{m}/\text{N}$ , calculate pressure at pump inlet.

$$\text{Solution: } h_A + \frac{p_1}{\rho} + \frac{V_1^2}{2g} + Z_1 = \frac{p_2}{\rho} + \frac{V_2^2}{2g} + Z_2 + h_A + h_L$$

$$0 = \frac{p_2}{\rho} + \frac{V_2^2}{2g} + Z_2 + h_L$$

$$Q = AV$$

$$A = \pi r^2 = \pi (.03135 \text{ m})^2 = .0031 \text{ m}^2$$

$$0.014 \text{ m}^3/\text{s} = (.0031 \text{ m}^2)(V)$$

$$4.52 \text{ m/s} = V$$

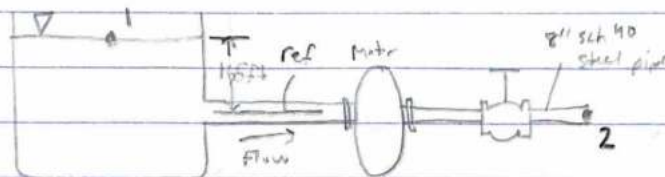
$$0 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L$$

$$0 = \frac{P_2}{8338.5 \text{ N/m}^3} + \frac{(4.52 \text{ m/s})^2}{2(9.81 \text{ m/s}^2)} + 3 \text{ m} + 1.4 \text{ N}\cdot\text{m/N}$$

$$\frac{P_2}{8338.5 \text{ N/m}^3} = -5.44 \text{ N/m}^2$$

$$P_2 = -45372.3 \text{ Pa} \Rightarrow -45.37 \text{ kPa}$$

7.30.) Given:



$$\text{water @ } 40^\circ\text{F} \quad \gamma = 62.4 \text{ lb/ft}^3$$

$$Q = 100 \text{ gal/min}$$

Determine: If  $h_{\text{motor}} = 37 \text{ hp}$  from fluid, calculate energy loss in system.

$$\text{S. When: } \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_e + h_L$$

$$-h_L = h_e - z_1$$

$$-h_L = 146.37 - 165$$

$$\boxed{h_L = 18.63 \text{ ft}}$$

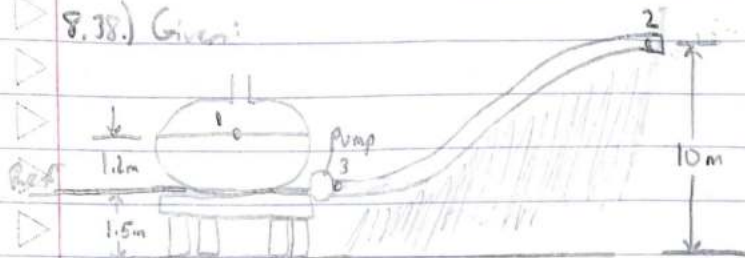
$$P_e = \gamma Q h_e$$

$$h_e = \frac{P_e}{\gamma Q}$$

$$h_e = \frac{(37 \text{ hp} \times 550 \text{ ft}\cdot\text{lb/r})}{(62.4 \text{ lb/ft}^3)(2.228 \text{ ft}^3/\text{s})}$$

$$h_e = 146.37 \text{ ft}$$

8.38.) Given:



$P_2 = 140 \text{ kPa}$  Hose = smooth plastic, ID = 25 mm,  $L = 85 \text{ m}$

Fertilizer solution -  $\text{Sg} = 1.10$

$$\eta = 2.0 \times 10^{-3} \text{ Pa}\cdot\text{s}$$

$$Q = 95 \text{ L/min} = .00158 \text{ m}^3/\text{s}$$

Determine: a) power delivered by pump to solution.

$$\text{Solution: } h_A + \frac{p_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + h_f + h_L$$

$$h_A = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + z_2 - z_1 + h_L$$

$$h_L = f \times \frac{L}{D} \times \frac{V^2}{2g} ; D = 25 \text{ mm} = .025 \text{ m}$$

$$h_L = .0214 \times \frac{85}{.025} \times \frac{3.22^2}{2(9.81)} ; L = 85 \text{ m}$$

$$h_L = 38.45 \text{ ft}$$

$$V = \frac{Q}{A} \text{ where } A = \pi r^2 = \pi (12.5)^2 = 490.9 \text{ mm}^2 = 4.909 \times 10^{-4} \text{ m}^2$$

$$V = .00158 \text{ m}^3/\text{s}$$

$$\delta = \text{Sg} \times \delta_w$$

$$4.909 \times 10^{-4} \text{ m}^2$$

$$\delta = (1.10)(9.81)$$

$$V = 3.219 \text{ m/s}$$

$$\delta = 10.791 \text{ kN/m}^3$$

$$\text{Re} = \frac{\rho V D}{\eta}$$

$$\rho = (\text{Sg})(\rho_w)$$

$$\rho = (1.10)(1000 \text{ kg/m}^3)$$

$$\text{Re} = \frac{(1100 \text{ kg/m}^3)(3.22 \text{ m/s})(.025 \text{ m})}{2.0 \times 10^{-3} \text{ Pa}\cdot\text{s}} ; \rho = 1100 \text{ kg/m}^3$$

$$\text{Re} = 44275$$

$$E = 3.0 \times 10^{-7}$$

$$\frac{D}{E} = \frac{.025}{3.0 \times 10^{-7}}$$

$$E = 3.0 \times 10^{-7} \text{ m}$$

$$f = \frac{.25}{\left[ \log \left( \frac{1}{3.7(44275)} + \frac{5.74}{44275^{0.9}} \right) \right]^2}$$

$$f = .0214$$

$$h_A = \frac{P_2^2}{\gamma} + \frac{V_2^2}{2g} + z_2 - z_1 + h_L$$

$$h_A = \frac{140 \text{ kPa}}{10.791 \text{ kN/m}^3} + \frac{(3.22 \text{ m/s})^2}{2(9.81 \text{ m/s}^2)} + 7.3 \text{ m} + 38.45 \text{ ft}$$

$$h_A = 58.9 \text{ m}$$

$$P_A = \rho Q h_A$$

$$P_A = (10.791 \text{ kN/m}^3)(0.00158 \text{ m}^3/\text{s})(58.9 \text{ m})$$

$$P_A = 1.009 \text{ kW}$$

b) Pressure at outlet of pump.

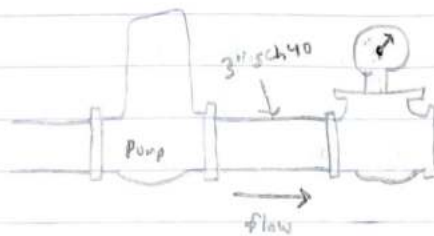
$$h_A + \frac{P_1^2}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2^2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L$$

$$-\frac{P_2}{\gamma} = \frac{V_2^2}{2g} - z_1$$

$$-\frac{P_2}{10.791 \text{ kN/m}^3} = \frac{(3.22 \text{ m/s})^2}{2(9.81 \text{ m/s}^2)} - 1.2 \text{ m}$$

$$P_2 = 7.25 \text{ kPa}$$

10.39.) Given:



No flow to line leading to gauge

Determine: Energy loss as  $0.40 \text{ ft}^3/\text{s}$  of water at  $50^\circ\text{F}$  flows through the tee.

Solution: 
$$h_L = f \times \frac{L}{D} \times \frac{V^2}{2g}$$

$$A = \pi r^2 = \pi (1.531')^2 = 7.39 \text{ in}^2 \approx 0.514 \text{ ft}^2$$

$$V = \frac{Q}{A} = \frac{0.40 \text{ ft}^3/\text{s}}{0.514 \text{ ft}^2} = .79 \text{ ft/s}$$

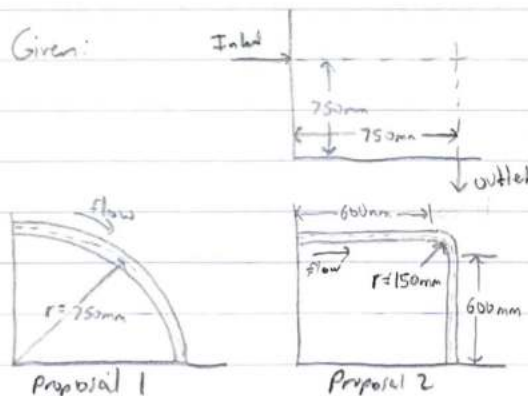
$$h_L = 0.017 \times 20 \times \frac{.79^2}{2(32.2)}$$

$$h_L = .0033 \text{ ft}$$

$$L/D = 20 \text{ - Table 10.4}$$

$$f = 0.017 \text{ - Table 10.5}$$

10.43.) Given:



$$Q = 750 \text{ L/min} \approx 0.0125 \text{ m}^3/\text{s}$$

Propyl alcohol at  $25^\circ\text{C}$

Material: 50 mm OD x 2.0 mm wall  
copper tube

Determine: Energy loss due to the bend and friction for straight tube.

Proposed 1:  $ID_{\text{tube}} = 46 \text{ mm} \approx 0.046 \text{ m}$

$$A = \pi r^2 = \pi (.023)^2 = .001662 \text{ m}^2 \approx 1.66 \times 10^{-3} \text{ m}^2$$

$$V = \frac{Q}{A} = \frac{0.0125 \text{ m}^3/\text{s}}{1.66 \times 10^{-3} \text{ m}^2} = 7.52 \text{ m/s}$$

Pipe bend:  $r = \frac{r}{D} = \frac{750 \text{ mm}}{46 \text{ mm}} = 16.30$

$$\frac{L}{D} = 43 \quad \text{— from graph in textbook (fig 10.28, pg 246)}$$

D

$$\epsilon = 1.5 \times 10^{-6} \text{ m} \quad \text{— from table 8.2}$$

$$\eta = 1.92 \times 10^{-3} \text{ Pa}\cdot\text{s}$$

$$\rho = 802 \text{ kg/m}^3$$

$$Re = \frac{\rho v D}{\eta} = \frac{(802 \text{ kg/m}^3)(7.52 \text{ m/s})(0.046 \text{ m})}{1.92 \times 10^{-3} \text{ Pa}\cdot\text{s}} = 144493.67$$

$$\frac{D}{\epsilon} = \frac{0.046 \text{ m}}{1.5 \times 10^{-6} \text{ m}} = 30666.67$$

$$\epsilon = 1.5 \times 10^{-6} \text{ m}$$

$$f_r = .0095 \quad \text{— from Moody's diagram} \quad f = .0160$$

$$K = f_r \left( \frac{L}{D} \right) = .0095 (43) = .4085$$

$$h_L = K \frac{v^2}{2g} = \frac{.4085 (7.52 \text{ m/s})^2}{2(9.81 \text{ m/s}^2)} = \boxed{1.177 \text{ m}}$$

$$\text{Proposal 2: Pipe bend: } r = \frac{r}{D} = \frac{150}{46} = 3.26$$

$$\frac{L}{D} = 13$$

$$h_{L\text{ bend}} = f_r \frac{L}{D} \times \frac{v^2}{2g} = .0095 \times 13 \times \frac{(7.52 \text{ m/s})^2}{2(9.81 \text{ m/s}^2)} = .356 \text{ m}$$

$$h_{L\text{ tube}} = f \times \frac{L}{D} \times \frac{v^2}{2g} = .0160 \times 1.2 \times \frac{(7.52 \text{ m/s})^2}{2(9.81 \text{ m/s}^2)} = 1.203 \text{ m}$$

$$h_L = h_{L\text{ bend}} + h_{L\text{ tube}} = .356 \text{ m} + 1.203 \text{ m} = \boxed{1.56 \text{ m}}$$