Mason Finn

HW 1.3

During Class we discussed Hydrodynamics, including Mass flow rate, Volumetric Flow rate as well as Bernoulli Equation and how to Cancel Variable we don't need when looking at Certain problem. One thing that was mentioned is that if a pump is to be included in Bernoulli's Equation then it Needs to be in between the two points of flow. Like in problem 6.79 if there was a pump between point A and B then we would have to include it in the Equation. If it was placed before A or After B then we do Not Need to include it in the Calculation for Volume flow rate.

6-79

$D_A = 4''$

$D_B = 2''$

$h = 28''$

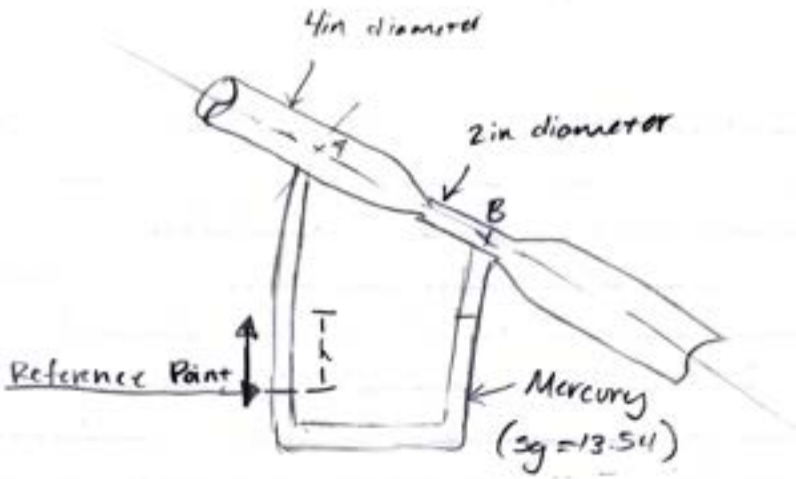
$Sg_{oil} = 0.90$

$Sg_{Hg} = 13.54$

$\gamma_{water} = 9.81\ kN/m^3$

$Q = V \cdot A$

$\Delta p = \gamma \cdot h$



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

$$\frac{Q^2}{2g}\left(\frac{1}{A_A^2} - \frac{1}{A_B^2}\right) = \frac{P_B - P_A}{\gamma} + (z_A - z_B)$$

$$Q = \sqrt{\frac{2g\left(\frac{P_B - P_A}{\gamma} + (z_A - z_B)\right)}{\frac{1}{A_A^2} - \frac{1}{A_B^2}}}$$

$$P_A + \gamma_{oil}\left((z_A - z_B) + h^* + h\right) - \gamma_{Hg} h - \gamma_{oil} h^* = P_B$$

$$\frac{P_B - P_A}{\gamma_{Hg}} = (z_A - z_B) + \left(1 - \frac{\gamma_{Hg}}{\gamma_{oil}}\right)h$$

$$Q = \sqrt{\frac{2g\left(1 - \frac{\gamma_{Hg}}{\gamma_{oil}}\right)h}{\frac{1}{A_A^2} - \frac{1}{A_B^2}}}$$

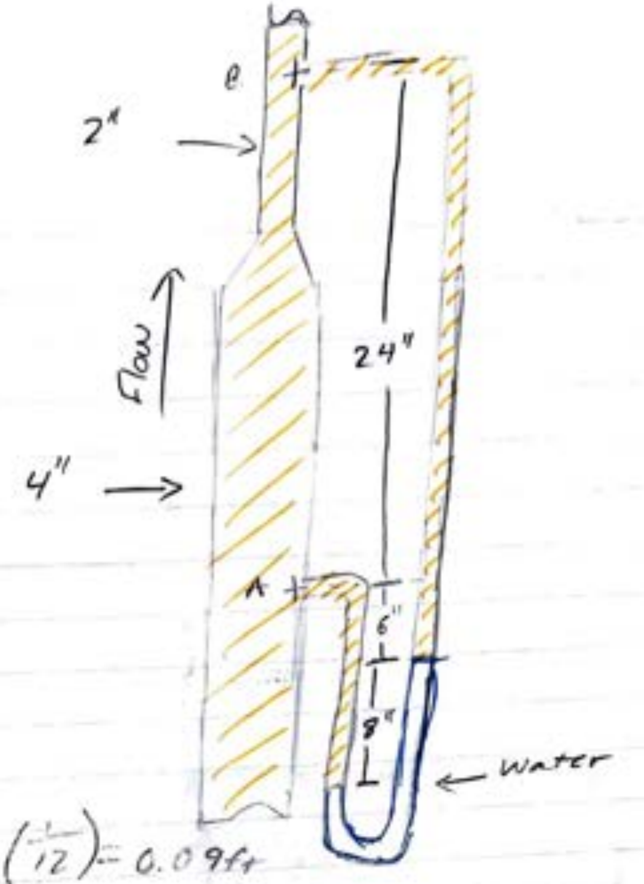
$$A_A = \frac{\pi}{4} D_A^{\,2} = \frac{\pi}{4}\left(\frac{4}{12}\right)^2 = 0.087 \text{ ft}^2$$

$$A_B = \frac{\pi}{4} D_B^{\,2} = \frac{\pi}{4}\left(\frac{2}{12}\right)^2 = 0.0218 \text{ ft}^2$$

$$g = 9.81 \text{ m/s}^2 = 32.18 \text{ ft/s}^2$$

$$Q = \sqrt{\frac{2 \cdot 32.18 \left(1 - \frac{13.54}{0.90}\right) \cdot 28'' \cdot \frac{1 \text{ ft}}{12''}}{\frac{1}{(0.087)^2} - \frac{1}{(0.0218)^2}}}$$

$$\boxed{Q = 1.03 \frac{\text{ft}^3}{s}}$$



6-82

$\gamma_{oil} = 55.0 \text{ lb/ft}^3$

A → B

Flow rate of oil?

$A_B = \frac{\pi}{4}\left(\frac{2}{12}\right)^2 = 0.0218 \text{ ft}^2$

$A_A = \frac{\pi}{4}\left(\frac{4}{12}\right)^2 = 0.087 \text{ ft}^2$

$h = 8\left[\frac{62.43}{55} - 1\right] = 1.08 \text{ in}\left(\frac{1}{12}\right) = 0.09 \text{ ft}$

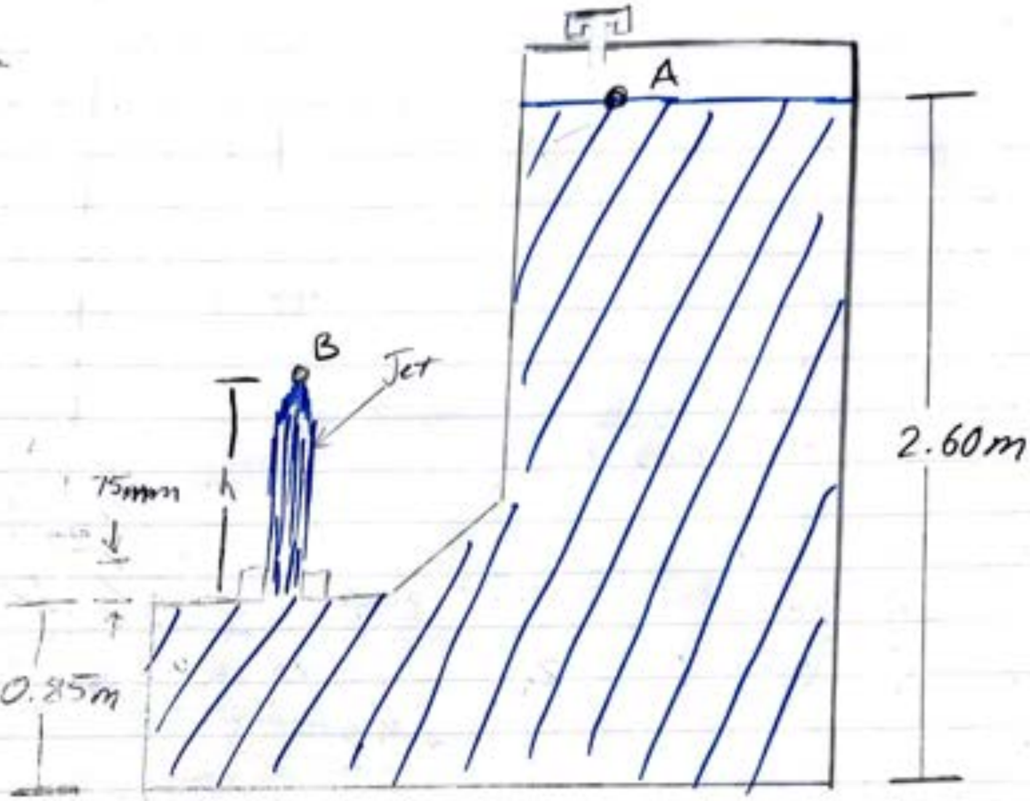
$\gamma_{water} = 62.43 \text{ lb/ft}^3$

$$Q = \frac{C_d\, A_A\, A_B \sqrt{2gh}}{\sqrt{A_A^2 + A_B^2}} = \frac{1\,(0.087\text{ft}^2)(0.0218\text{ft}^2)\sqrt{2(32.2)(0.09)}}{\sqrt{(0.087)^2\,(0.218)^2}}$$

$$= \frac{7.674 \cdot 10^{-3} \text{ ft}^3}{0.08265}$$

$$\boxed{Q = 0.093 \text{ ft}^3/\text{s}}$$

6-91



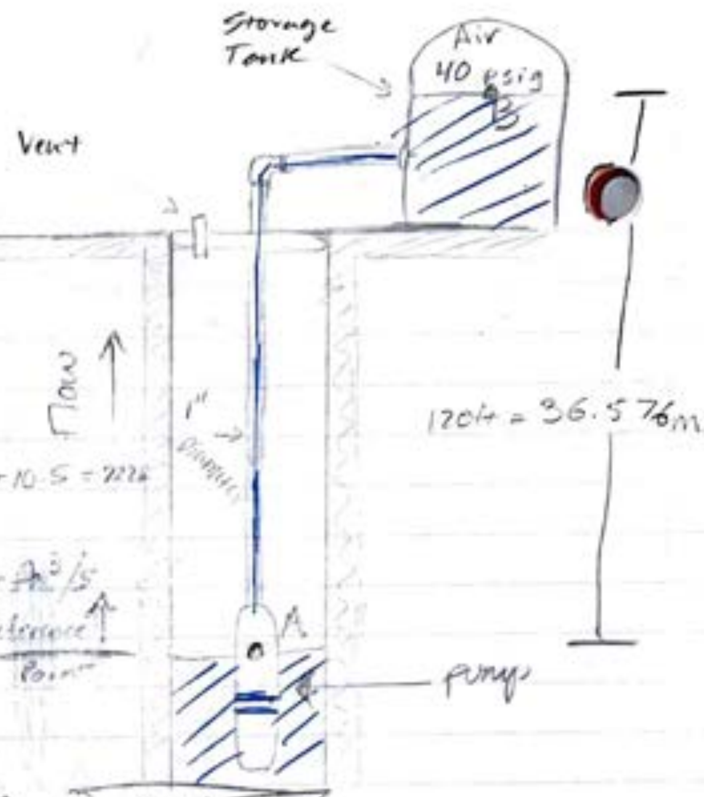
$$\frac{P_1}{\gamma}+\frac{V_1^2}{2g}+z_1=\frac{P_2}{\gamma}+\frac{V_2^2}{2g}+z_2$$

$$z_2=\frac{P_1-P_2}{\gamma}+\frac{\cancel{V_1^2}^{0}-\cancel{V_2^2}^{0}}{2g}+z_1$$

$$z_2=\frac{\cancel{P_1}^{0}-\cancel{P_2}^{0}}{\gamma}+z_1 \quad = \underline{z_2=z_1}$$

$\boxed{2.60\,m}$ is the height

7-11



745 gal/h $h_L = 10.5$ lb ft/lb

$$\frac{P_A}{\gamma_{water}} + \frac{V_1^2}{2g} + h_A - h_L = \frac{P_B}{\gamma_{water}} + z + \frac{V_2^2}{2g}$$

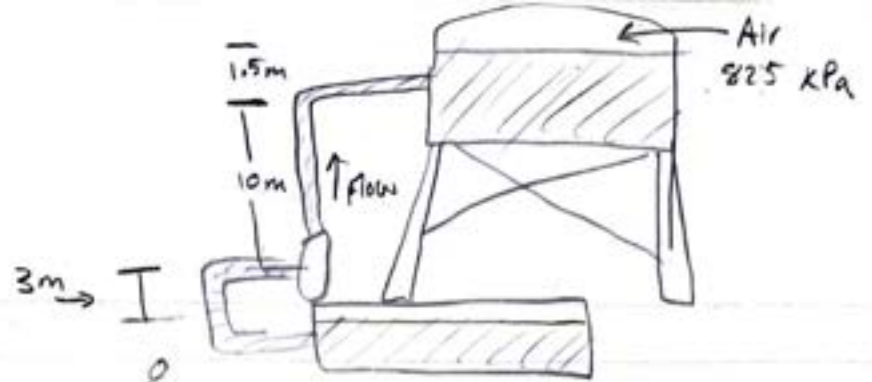
$$h_A = \frac{P_B}{\gamma_{water}} + (z_B - z_A) + h_L = \frac{40 \cdot 144}{62.4} + 120 + 10.5 = 222.6$$

$$Q = \frac{745\,\text{gal/h}}{60} = \frac{1}{449\,\text{gal/m}} = 0.0277\ \text{ft}^3/\text{s}$$

$$P_A = 62.4 \cdot 0.0277 \cdot 222.8 = \frac{385}{550\ \text{lb ft/lb}} = \boxed{0.7\ \text{hp}}$$

$\boxed{70\%}$

7-16



$$h_A = \frac{p_2 - \cancel{p_1}^{0}}{\gamma} + \frac{\cancel{v_2^2}^{0} - \cancel{v_1^2}^{0}}{2g} + z_2 - \cancel{z_1}^{0} + h_{L_{12}}$$

$$Q = \boxed{840\,L/min \rightarrow 0.014\,m^3/s}$$

$$h_A = \frac{p_2}{\gamma} + z_2 + h_{L_{12}}$$

$$h_A = \frac{825\,kPa}{0.85 \cdot 9810\,\frac{N}{m^3}} + 14.5\,m + 4.2\,m = 117.64\,m$$

$$P = \gamma Q h_A$$

$$P = \left(0.85 \cdot 9810\,\frac{N}{m^3}\right) \cdot 0.014\,m^3/s \cdot 117.64\,m$$

$$\boxed{P = 13.733\,kW}$$

$$\frac{\cancel{p_1}^{0}}{\gamma} + \frac{\cancel{v_1^2}^{0}}{2g} + \cancel{z_1}^{0} = \frac{p_3}{\gamma} + \frac{v_3^2}{2g} + z_3 + h_{L_{13}}$$

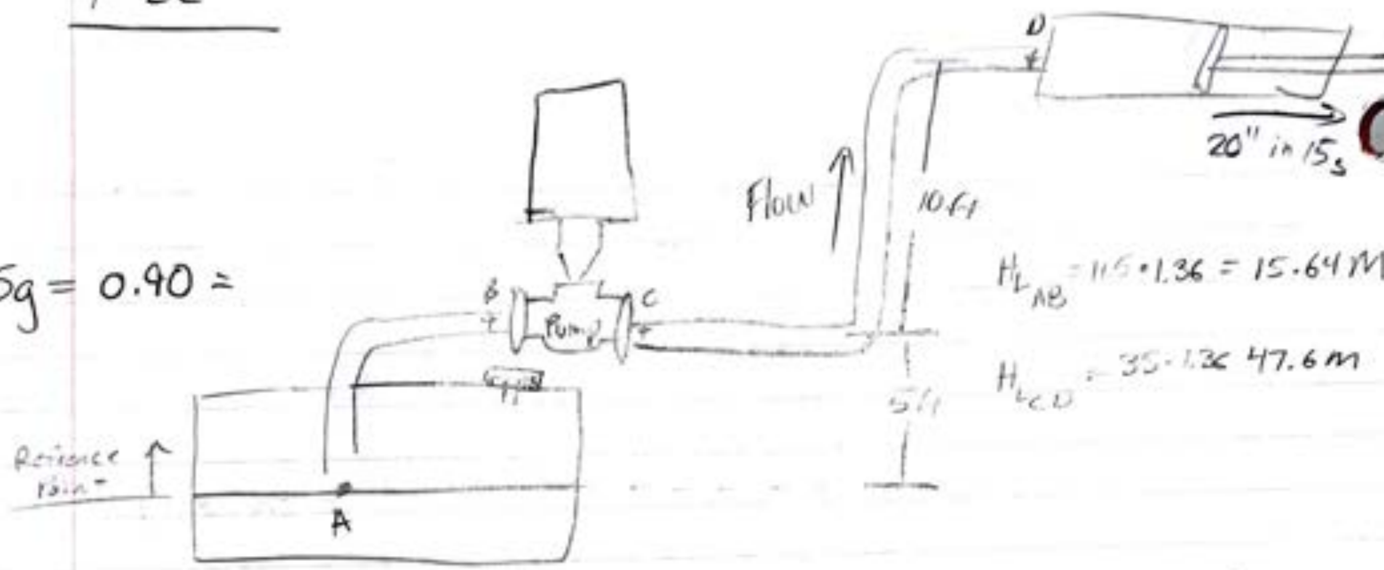
$$\frac{p_3}{\gamma} = -\frac{v_3^2}{2g} + z_3 - h_{L_{13}} \rightarrow v_3 = \frac{Q}{A_3}$$

$$v_3 = \frac{0.014\,m^3/s}{3.437 \times 10^{-4}\,m^2} = 4.073\,m/s$$

$$p_3 = \left(0.85 \cdot 9810\,\frac{N}{m^3}\right)\left(-\frac{\left(4.073\,\frac{m}{s}\right)^2}{2 \cdot 9.81\,\frac{m}{s^2}} - 3m - 1.4m\right) = \boxed{-43.74\,kPa}$$

7-22

$Sg = 0.90 =$



$A_{cylinder} = \frac{\pi}{4}(d_{cylinder})^2 = \frac{\pi}{4}(5)^2 \quad V_{out} = \frac{20}{15} = 1.33 \rightarrow 0.1108\ ft/s$

$A_{cylinder} = 19.635\ in^2$

$Q = V \cdot A = (1.33\ in/s)(19.635\ in^2) = 24.54\ in^3/s$ a)

$\hookrightarrow 1ft^2 = 144 in^2 \Rightarrow 1ft = 12in \Rightarrow 1ft^3 = 1728\,in^3$

$\boxed{a)\ Q = 0.0151\ ft^3/s}$

$P_{c,cylinder} = \frac{F}{A_{cylinder}} \quad P_c = \frac{11000\,lb}{19.635\,in^3} = 560.22\ lb/in^2$

$P_{C_{cylinder}} = 560.22 \times (12)^2 = 80671.68\ lb/ft^2 \quad 1ft^2 = 144\,in^2$

$\boxed{P_{C_{cylinder}} = 80671.68\ lb/ft^2\ \ b)}$ = Pressure point D

Given on pg. 501

$A_p = 0.000976\ ft^2$ (cross section of pipe)

$$\Rightarrow V_c = \frac{Q}{A_p} = \frac{0.0151}{0.000976} = 15.47\ ft/s$$

$$V_B = V_c = 15.47\ ft/s$$

γ_{oil} = specific weight of oil = $Sg(\gamma_w)$

$Sg = 0.90$

specific weight $\gamma_{water} = 62.43\ lb/ft^3$

$$\gamma_{oil} = 0.90 \times 62.43 = 56.187\ lb/ft^3$$

$\gamma_{oil} = 56.187\ lb/ft^3$ (specific weight of oil)

Bernoullis between (C + D)

$h_{L_{CD}} = 35\ lb\,ft/lb$

$$\frac{P_c}{\gamma_o} + \frac{V_c^2}{2g} + z_c = \frac{P_D}{\gamma_o} + \frac{V_D^2}{2g} + z_D + h_{L_{CD}}$$

$$\frac{P_c}{56.178} + \frac{15.47^2}{2 \cdot 32.2} + 5 = \frac{P_D}{56.178} + \frac{0.1108^2}{2 \cdot 32.2} + 15m + 35m$$

$$\boxed{c)\ P_c = 82990.93\ lb/ft^2}$$

d) $\cancel{\frac{P_A}{\gamma_o}}^{0} + \cancel{\frac{V_A^2}{2g}}^{0} + \cancel{z_A}^{0} = \frac{P_B}{\gamma_o} + \frac{V_B^2}{2g} + z_B + (h_f)_s$

$(h_f)_s$ = head loss due to friction $(h_f)_s = 11.5$ lb-ft/lb

$$0 = \frac{P_B}{56.187} + \frac{15.47^2}{2 \times 32.2} + 5 + 11.5$$

$$\boxed{\text{d)} \quad P_B = -1135.29 \text{ lb/ft}^2}$$

e) $\cancel{\frac{P_A}{\gamma_o}}^{0} + \cancel{\frac{V_A^2}{2g}}^{0} + \cancel{z_A}^{0} + H = \frac{P_0}{\gamma_o} + \frac{V_0^2}{2g} + z_0 + (h_f)_s + (h_f)_0$

$$H = \frac{80671.68}{56.187} + \frac{0.1108^2}{2 \times 32.2} + 15 + 11.5 + 35$$

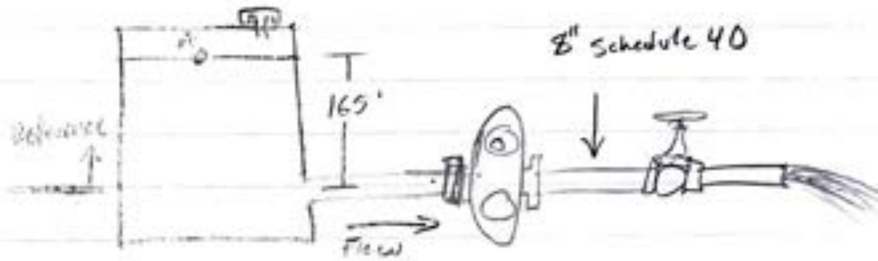
$$H = 1497.27 \text{ ft}$$

$$P = \frac{\gamma_o Q H}{550} = \frac{56.187 \cdot 0.0151 \times 1497.27}{550}$$

$$\boxed{\text{e)} \quad P = 2.31 \text{ HP}}$$

$\nearrow$ 0.06309 m^3/s

7-30 $Q = 1000$ gal/min water at 60°F



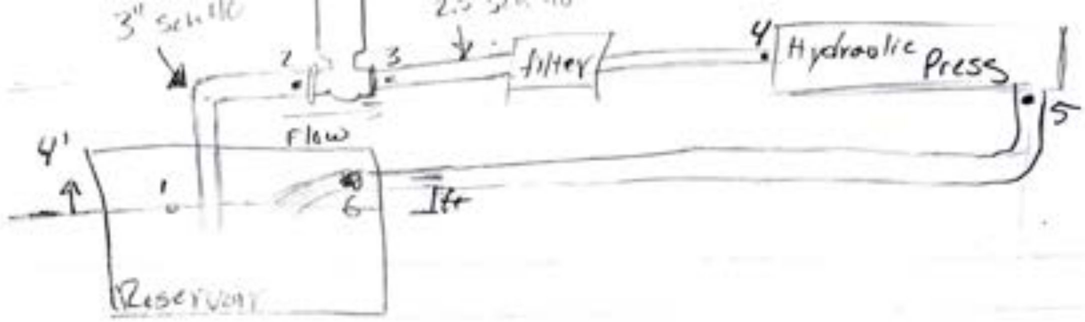
$$\frac{p_A}{w} + \frac{V_1^2}{2g} + z_1 + h_A + h_z - h_L = \frac{p_B}{w} + \frac{V_2^2}{2g} +$$

$$h_z = (z_1 - z_2) - \frac{V_2^2}{2g} - h_a$$

$$h_a = \frac{37.550}{62.4 \cdot 2.228 \ ft^3/s} \qquad h_a = 146.37 \ ft$$

$$V = \frac{Q}{A} = \frac{2.228}{\frac{\pi}{4}(8/12)^2} = 6.38 \ ft/s \qquad h_L = z_1 - z_2 - \frac{U_2^2}{2g}$$

$$(165 - 0) - \frac{6.38^2}{2 \cdot 32.2} - 146.43 = \boxed{17.93'}$$



7-35

$$\frac{P_0}{\gamma} + z_4 - \frac{V_4^2}{2g} - h_R = \frac{P_5}{\gamma} + z_5 + \frac{V_5^2}{2g}$$

$$h_R = -\left[\frac{P_5 - P_0}{\gamma} + (z_5$$

$$\gamma = .93 \cdot 62.4$$

$$58.0321 \text{ lb/ft}^3$$

$$V_2 = \frac{Q}{A_2} \quad \frac{.3844}{.05132} = 7.57 \text{ ft/s}$$

$$P_{P5} = 58.032\left(-4 \frac{-7.57^2}{2 \cdot 32.2} - 2.8\right) = 3.1 \text{ lb/in}^2$$

$$P_A = .8 \cdot 20.4$$

$$22.72 \text{ hp} \cdot \frac{550}{1} = 12496 \text{ lb ft/s}$$

$$h_A = \frac{12496}{58.032 \cdot 0.39} = 552.18 \text{ ft/lb}$$

$$V_3 = \frac{0.389}{0.03326} = 11.73 \text{ ft/s} \Rightarrow V_2 = \frac{0.389}{0.05132} = 7.6 \text{ ft/s}$$

$$P_c = 58.032\left(\frac{-446.2}{58.032} + \left(\frac{7.6^2 - 11.73^2}{64.4}\right) + 552.18 = \frac{31525.88}{144}\right.$$

$$= 219 \text{ Psi}$$

$$P_D = 58.032\left(\frac{31525.88}{58.032} - 28.5\right) = \frac{29871.97}{144} = 207.44 \text{ psi}$$

$$P_3 = \gamma(-1 + 3.5) = \frac{145.08}{144} = 1.01 \text{ psi}$$

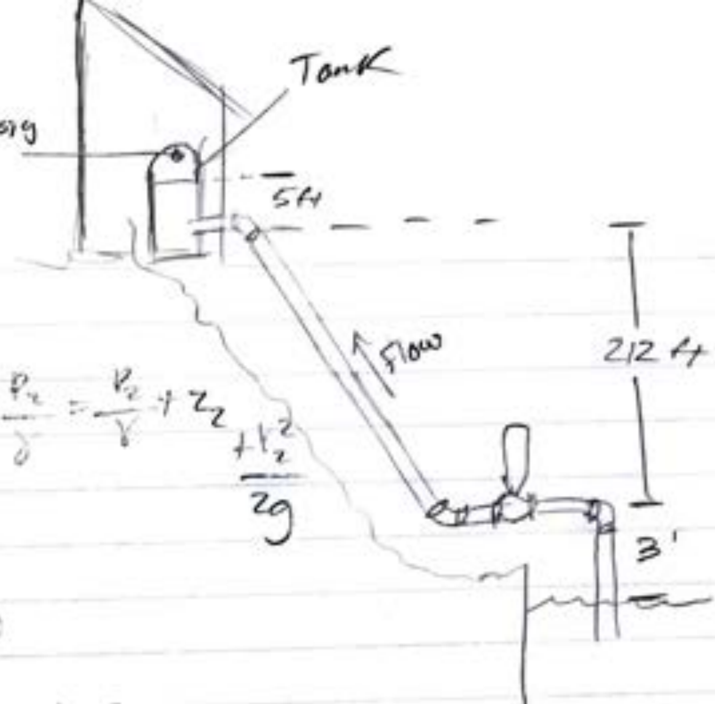
$$h_R = -\left[\frac{145.08 - 29868}{58.032} \cdot 82 + (-2)\right] = 514.19 \text{ ft}$$

$$P_e = 514.192 \cdot 58.032 \cdot 0.39 = \frac{11637.45}{550} = \boxed{21.16 \text{ hp}}$$

7-42

$h_L = 15.5\ ft$

$Q = 40$



$$\frac{P_1}{\gamma} + z_1 + \frac{v_1^2}{2g} + h_A - h_L = \frac{P_2}{\gamma} = \frac{P_2}{\gamma} + z_2 + \frac{v_2^2}{2g}$$

$$h_A - h_L = \frac{P_2}{\gamma} + (z_2 - z_1)$$

$$h_A - 15.5 = \frac{30 \frac{lb}{in^2} \times \frac{144\ in^2}{1\ ft^2}}{62.43\ lb/in^3} + (5 + 212 + 3)\ ft$$

$$h_A = 304.697\ ft$$

$$P_A = h_A W = h_A(\gamma Q)$$

$$= 304.697\ ft \frac{\left(62.43 \frac{lbm}{ft^3}\right) 40 \frac{gal}{min}}{\frac{7.48\ gal}{ft^3} \times \frac{60\ s}{min}}$$

$1695.386\ lbft/s$ $= \boxed{3.08\ hp}$