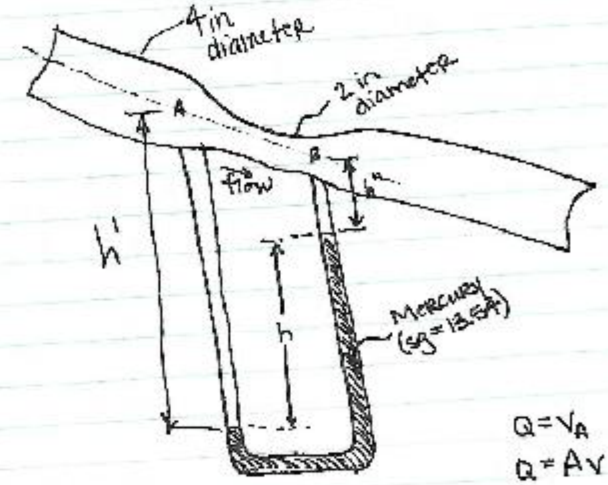
Rebecca Sopher

6.79 Oil with a specific gravity of 0.90 is flowing downward through the venturi meter shown in Fig. 6.33. If the manometer deflection h is 28 in, calculate the volume flow rate of oil.



$Q = V_A$

$Q = Av$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B$$

$$\rightarrow \frac{P_A}{\gamma} + \frac{Q^2}{2gA_A^2} + z_A = \frac{P_B}{\gamma} + \frac{Q^2}{2gA_B^2} + z_B$$

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

$(z_A - z_B) + h'' + h = h'$

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

$$P_A + \gamma_{oil} h' - \gamma_{merc} \underbrace{h}_{28in} - \gamma_{oil} h'' = P_B$$

$$P_A - P_B = \gamma_{Hg} h + \gamma_{oil}(h'' - h')$$

6.79 continued

$A_A = \pi r_A^2 = 0.0873\ ft^2$

$A_B = \pi r_B^2 = 0.0218\ ft^2$

$$\cancel{\frac{P_B - P_A}{(13.54)} = (z_A - z_B)}$$

$$Q = \sqrt{\frac{2(32.2\,\frac{ft}{s^2})\left(1 - \frac{13.54}{0.90}\right)(28in)\left(\frac{1ft}{12in}\right)}{\frac{1}{(0.0873\,ft^2)^2} - \frac{1}{(0.0218\,ft^2)^2}}}$$

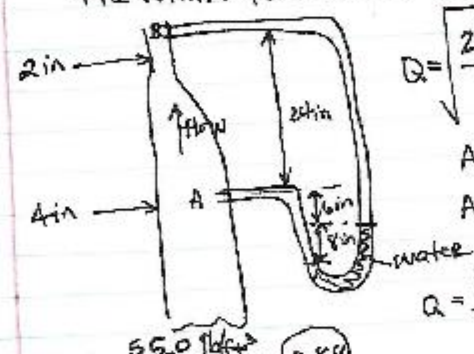
131.2113829 − 2104.199983

$$= \sqrt{\frac{-2110.411852\,\frac{ft^2}{s^2}}{-1972.9886}}$$

$$= \sqrt{1.06965}$$

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

6.82 Oil with a specific weight of 55.0 lb/ft³ flows from A to B through the system shown. Calculate the volume flow rate of the oil.



$$Q = \sqrt{\frac{2(32.2\,ft/s^2)\left(1 - \frac{sg_{water}}{sg_{oil}}\right)h}{\frac{1}{A_A^2} - \frac{1}{A_B^2}}}$$ 8in

$A_A = 0.0873\ ft^2 \rightarrow (\pi r_A^2)$

$A_B = 0.0218\ ft^2 \rightarrow (\pi r_B^2)$

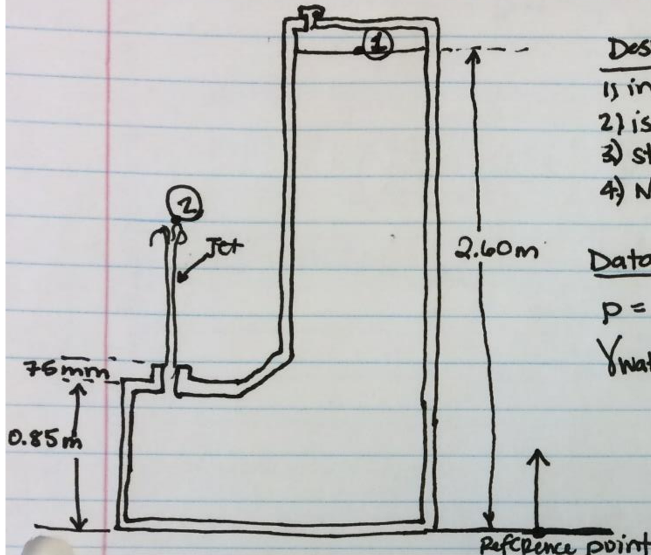
$$Q = \sqrt{\frac{2(32.2)\left(1 - \frac{1}{.88}\right)8\left(\frac{1ft}{12in}\right)}{\frac{1}{(0.0873)^2} - \frac{1}{(0.0218)^2}}}$$

$$sg_{oil} = \frac{55.0\ lb/ft^3}{62.4\ lb/ft^3} = 0.88$$

$$= \sqrt{\frac{-5.8545}{-1972.9886}}$$

$$\boxed{Q = 0.054\ ft^3/s}$$

6.91 To what height will the jet of fluid rise for the conditions shown in Fig. 6.39?



Design Considerations
1) incompressible fluid
2) isothermal process
3) steady state
4) No energy losses

Data & Variables

p = 0.0 psig above surface of water

$\gamma_{water} = 9.81\ kN/m^3$ (found in book)

Bernoulli's equation

$$\frac{p_1}{\gamma} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{v_2^2}{2g} + z_2$$

Need to find z_2 so...

$$z_2 = \cancel{\frac{p_1 - p_2}{\gamma}} + \cancel{\frac{v_1^2 - v_2^2}{2g}} + z_1$$

both pressures are 0 psig

these should both be ZERO → highest point – briefly not moving before beginning to fall @ 2
negligible inside tank @ surface of water

$\therefore z_2 = z_1$

$z_1 = 2.60\ m$

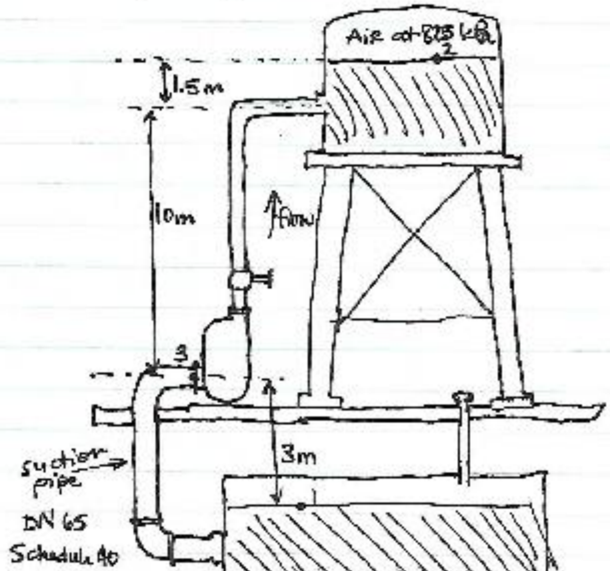
so

$$\boxed{z_2 = 2.60\ m}$$

7.16 Figure 7.21 shows a pump delivering 840 L/min of crude oil ($sg = 0.85$) from an underground storage drum to the first stage of a processing system.

a) if the total energy loss in the system is 4.2 N·m/N of oil flowing, calculate the power delivered by the pump.

b) if the energy loss in the suction pipe is 1.4 N·m/N of oil flowing, calculate the pressure at the pump inlet.



$$h_A + \frac{P_1}{\gamma} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{v_2^2}{2g} + z_2 + h_{L1-2}$$

$$P = \gamma Q h_A$$

$$h_A = \frac{P_2 - \cancel{P_1}^{\,0}}{\gamma} + \frac{\cancel{v_2^2}^{\,0} - \cancel{v_1^2}^{\,0}}{2g} + z_2 - \cancel{z_1}^{\,0} + h_{L1-2}$$

$$h_A = \frac{P_2}{\gamma} + z_2 + h_{L1-2} = \frac{825\,kPa}{(0.85)(9810\,\frac{N}{m^3})} + 14.5 + 4.2 = 117.64\,m$$

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

$$\boxed{P = 13.733\ \frac{N\cdot m}{s}\ \cancel{/kW}}\ \text{ⓐ}$$

b)
$$\frac{\overset{0\,kPa}{\cancel{P_1}}}{\gamma} + \frac{\overset{\circ\text{ no movement @ point 1}}{\cancel{V_1^2}}}{2g} + \overset{\circ\text{ starting point/reference}}{\cancel{z_1}} = \frac{P_3}{\gamma} + \frac{V_3^2}{2g} + z_3 + h_{L1\text{-}3}$$

$\therefore$

$$\frac{P_3}{\gamma} = \frac{-V_3^2}{2g} - z_3 - h_{L1\text{-}3}$$

$$V_3 = \frac{Q \rightarrow 0.014\frac{m^3}{s}}{A_3 \rightarrow 3.09\times10^{-3}\,m^2} = 4.531\,m/s$$

$$P_3 = -\gamma\left(\frac{V_3^2}{2g} + z_3 + h_{L1\text{-}3}\right)$$

$$P_3 = -\left(0.85\cdot 9810\frac{N}{m^3}\right)\left(\frac{\left(4.531\frac{m}{s}\right)^2}{2\cdot 9.81\frac{m}{s^2}} + 3m + 1.4m\right)$$

$$P_3 = \left(-8338.5\frac{N}{m^3}\right)(4.63\,m)$$

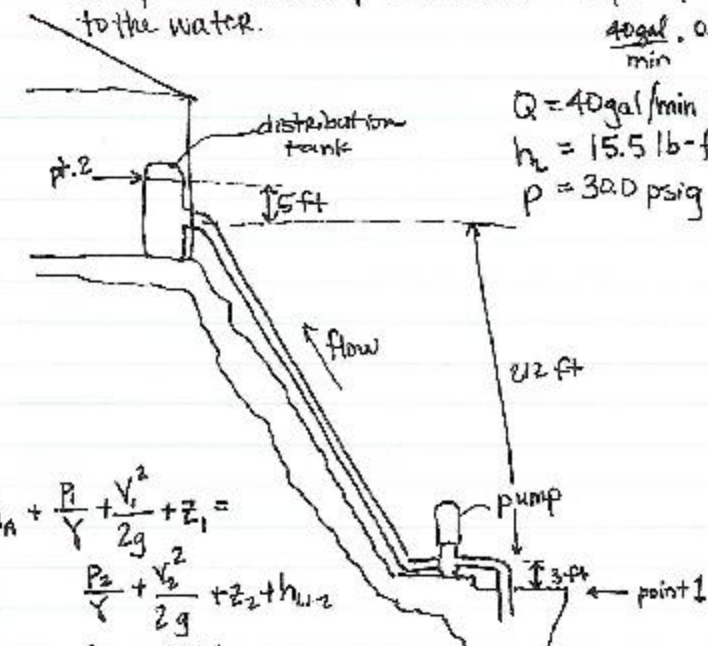
$$= -38615.075\frac{N}{m^2}\cdot\frac{1\,kN}{1000\,N}$$

$$-38.62\,\frac{kN}{m^2} = \boxed{-38.62\,kPa}\ \text{ⓑ}$$

I was checking this against what you did in class (you did this problem) & my answer has the same numbers but comes out to a different final answer.

7.42 Professor Crocker is building a cabin on a hillside & has proposed the water system shown. The distribution tank in the cabin maintains a pressure of 30.0 psig above the water. There is an energy loss of 15.5 lb-ft/lb in the piping. When the pump is delivering 40 gal/min of water, compute the horsepower delivered by the pump to the water.

$\frac{40\,gal}{min} \cdot 0.002228 = 0.089\,\frac{ft^3}{s}$



$Q = 40\,gal/min = 0.089\,\frac{ft^3}{s}$

$h_L = 15.5\ lb\text{-}ft/lb$

$p = 30.0\ psig$

$$h_A + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_{L1\text{-}2}$$

$$P_m = \frac{P_A}{\eta_A} = \frac{\gamma Q h_A}{}$$

$$h_A = \frac{P_2 - \overset{0\,kPa}{\cancel{P_1}}}{\gamma} + \frac{\overset{0}{\cancel{V_2^2}} - \overset{0}{\cancel{V_1^2}}}{2g} + z_2 - \overset{0\,elev.}{\cancel{z_1}} + h_{L1\text{-}2}$$

$$h_A = \frac{P_2}{\gamma} + z_2 + h_{L1\text{-}2} = \frac{\frac{30\,lb}{in^2} \cdot \frac{144\,in^2}{1\,ft^2}}{62.4\,\frac{lb}{ft^3}} + 220\,ft + 15.5\,lb\text{-}ft/lb = 304.73\,ft$$

$$P_A = \gamma Q h_A = \left(62.4\,\frac{lb}{ft^3}\right)\left(0.089\,\frac{ft^3}{s}\right)(304.73\,ft) = 1692.35\,\frac{ft\,lb}{s} = \boxed{3.077\,HP}$$