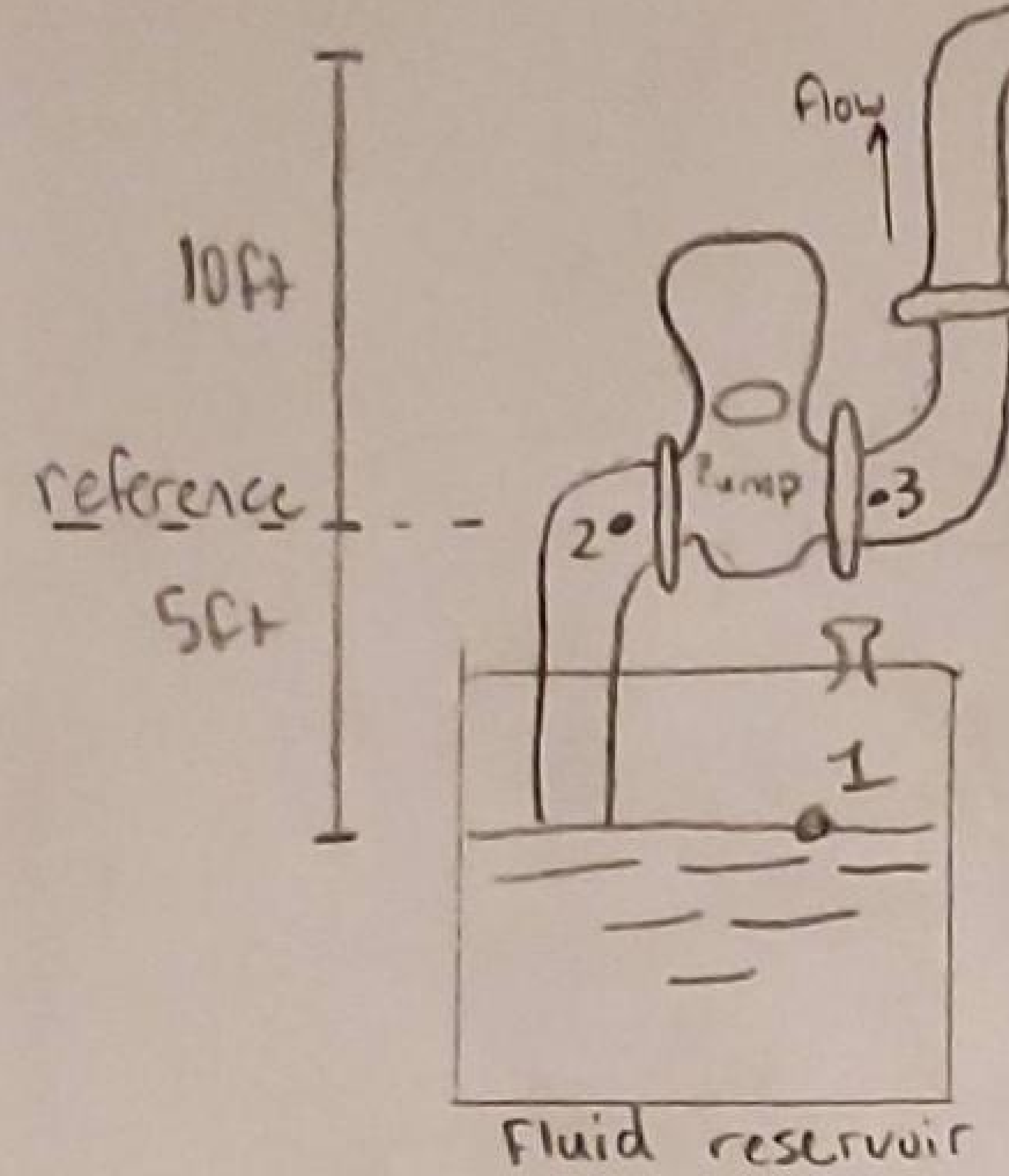
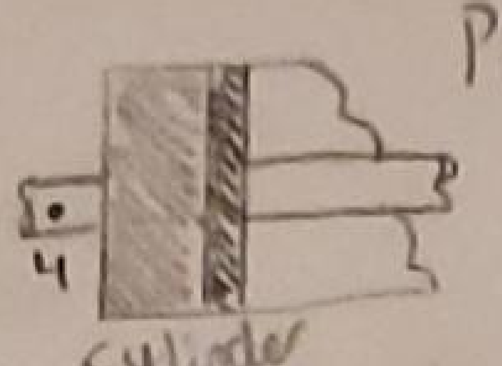
$\divideontimes$ 7.22

C. Betton
Team 7





Piston moves $\frac{20\,in}{15\,sec} = V_{piston} = V_4$

$\gamma_o = sg \cdot \gamma_w$

- $Sg_{oil} = 0.90 \cdot 62.4 \frac{lb}{ft^3} = \gamma_{oil} = 56.16 \frac{lb}{ft^3}$
- $d_{cyl} = 5.0\,in$, $F_{cyl} = 11{,}000\,lb$
- $h_{L\,suct} = 11.5 \frac{lb\text{-}ft}{lb}$ $\quad h_{L\,disch} = 35.0 \frac{lb\text{-}ft}{lb}$
- From Appendix F table F.2 schedule 80 $\frac{3}{8}''$ $= 0.000976\,ft^2$ flow area

a. Calculate volume flow rate through pump

$$Q = V_{Piston}A \Rightarrow Q = \frac{20\,in \cdot \frac{\pi}{4}\cdot(5.0\,in)^2 \cdot ft^3}{15\,sec \cdot 12^3\,in^3} = \boxed{0.015 \frac{ft^3}{sec}}$$

b. Calculate pressure at cylinder

$$P_4 = \frac{F}{A} = \frac{11{,}000\,lb}{\frac{\pi}{4}\cdot(5.0\,in)^2}$$

$$\boxed{P_4 = 560.225\,psi}$$

c. Calculate the pressure at pump outlet

$$\frac{P_3}{\gamma_o} + \frac{V_3^2}{2g} + z_3 - h_{L\,dis} = \frac{P_4}{\gamma_o} + \frac{V_4^2}{2g} + z_4 \Rightarrow \frac{P_3}{\gamma_o} = \frac{P_4}{\gamma_o} + \left(\frac{V_4^2 - V_3^2}{2g}\right) + (z_4 - z_3) + h_{L\,dis}$$

$$P_3 = \gamma_o \cdot \left(\frac{P_4}{\gamma_o} + \frac{V_4^2 - V_3^2}{2g} + (z_4 - z_3) + h_{L\,dis}\right), \quad V_3 = Q \cdot A = \frac{0.15\,ft^3}{sec \cdot 0.000976\,ft^2} = 15.523 \frac{ft}{sec}$$

$$P_3 = \frac{56.16\,lb}{ft^3} \cdot \left(\frac{560.225\,lb \cdot 12^2\,in^2 \cdot ft^3}{in^2 \cdot 1^2\,ft^2 \cdot 56.16\,lb} + \frac{\left(\frac{20\,in \cdot 1\,ft}{15\,sec \cdot 12\,in}\right)^2 - \left(15.523\frac{ft}{sec}\right)^2}{2 \cdot 32.2 \frac{ft}{sec^2}} + (10-0)\,ft + 35.0 \frac{lb\text{-}ft}{lb}\right)$$

$$\boxed{P_3 = 82989.4786 \frac{lb}{ft^2}} = \frac{82989.4786\,lb \cdot ft^2}{ft^2 \cdot in^2\, 12^2} = \boxed{576.32\,psi}$$

d. Calculate pressure at pump inlet

$$\frac{\cancel{P_1}}{\gamma_o} + \frac{\cancel{V_1^2}}{2g} + z_1 - h_{L\,suc} = \frac{P_2}{\gamma_o} + \frac{V_2^2}{2g} + z_2 \Rightarrow P_2 = \gamma_o \cdot \left((z_1 - z_2) - h_{L\,suc} - \frac{V_2^2}{2g}\right)$$

0 atm $\quad$ large tank

$$P_2 = 56.16\,lb \left(-5\,ft - \left(11.5 \frac{lb\text{-}ft}{lb}\right) - \left(\frac{15.523\,ft}{sec}\right)^2 \cdot \frac{1\,sec^2}{2 \cdot 32.2\,ft}\right)$$

$$P_2 = \frac{-1136.69\,lb \cdot ft^2}{ft^2 \cdot 12^2\,in^2} = \boxed{-7.89\,psi}$$

e. Power delivered to oil by pump

$$\frac{\cancel{P_1}}{\gamma_o} + \frac{\cancel{V_1^2}}{2g} + z_1 + h_A - h_{L\,suc} = \frac{P_3}{\gamma_o} + \frac{V_3^2}{2g} + z_3 + h_{L\,dis} \Rightarrow h_A = \frac{P_3}{\gamma_o} + (z_3 - z_1) + \frac{V_3^2}{2g} + h_{L\,suc} + h_{L\,dis}$$

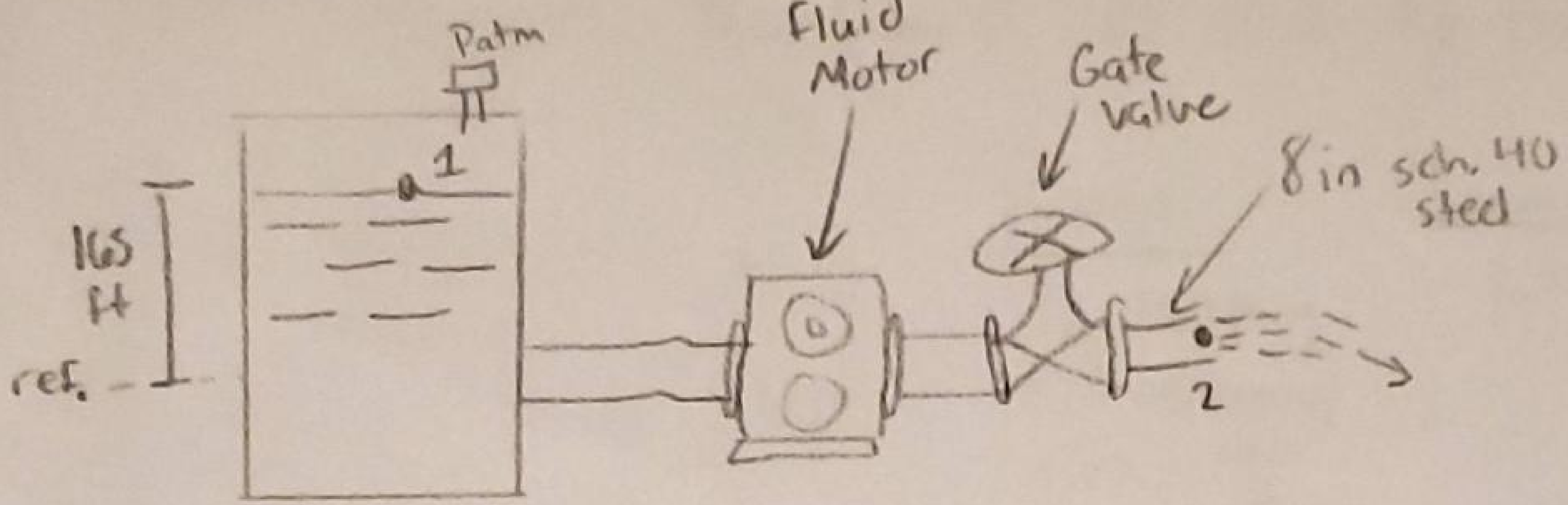
0 $\quad$ 0

$$h_A = \frac{82989.4786\,lb \cdot ft^3}{ft^2 \cdot 56.16\,lb} + 10 - (-5) - 11.5 + 35.0$$

$$h_A = 1516.23\,ft$$

$$P_{pump} = h_A \gamma_{oil} Q_{pump} = 1516.23\,ft \cdot 56.16 \cdot 0.015 = \boxed{1287.3\,ft\,lb/sec}$$

*7.30



- $Q_{motor} = \dfrac{1000\,gal}{min}\Big|\dfrac{1\,min}{60\,sec}\Big|\dfrac{1\,ft^3}{7.48052\,gal} = 2.228\dfrac{ft^3}{sec}$

- From table F.1

  Flow area @ 8in/sch40 $= 0.3472\,ft^2$

- $P_{motor} = 37\,hp\Big|\dfrac{550\,lb\,ft}{1\,hp \cdot sec}\Big| = 20350\,\dfrac{lb\cdot ft}{sec}$

$$\underbrace{\cancel{\frac{P_1}{\gamma}}}_{0\,atm} + z_1 + \underbrace{\cancel{\frac{V_1^2}{2g}}}_{\text{large surface area}} + \underbrace{\cancel{h_A}}_{\text{no added}} - h_R - L_L = \underbrace{\cancel{\frac{P_2}{\gamma}}}_{\text{free stream}} + z_2 + \frac{V_2^2}{2g}$$

$$\Rightarrow h_L = z_1 - z_2 - \frac{V_2^2}{2g} - h_R \quad ,$$

$$h_L = 165\,ft - 0 - \frac{(6.41\ldots)^2}{2 \cdot 32.2\frac{ft}{sec^2}} - 146\ldots$$

$$\boxed{h_L = 19.21\,ft}$$

$P_{motor} = h_R \cdot \gamma \cdot Q$

$h_R = \dfrac{P_{motor}}{\gamma_w \cdot Q}$

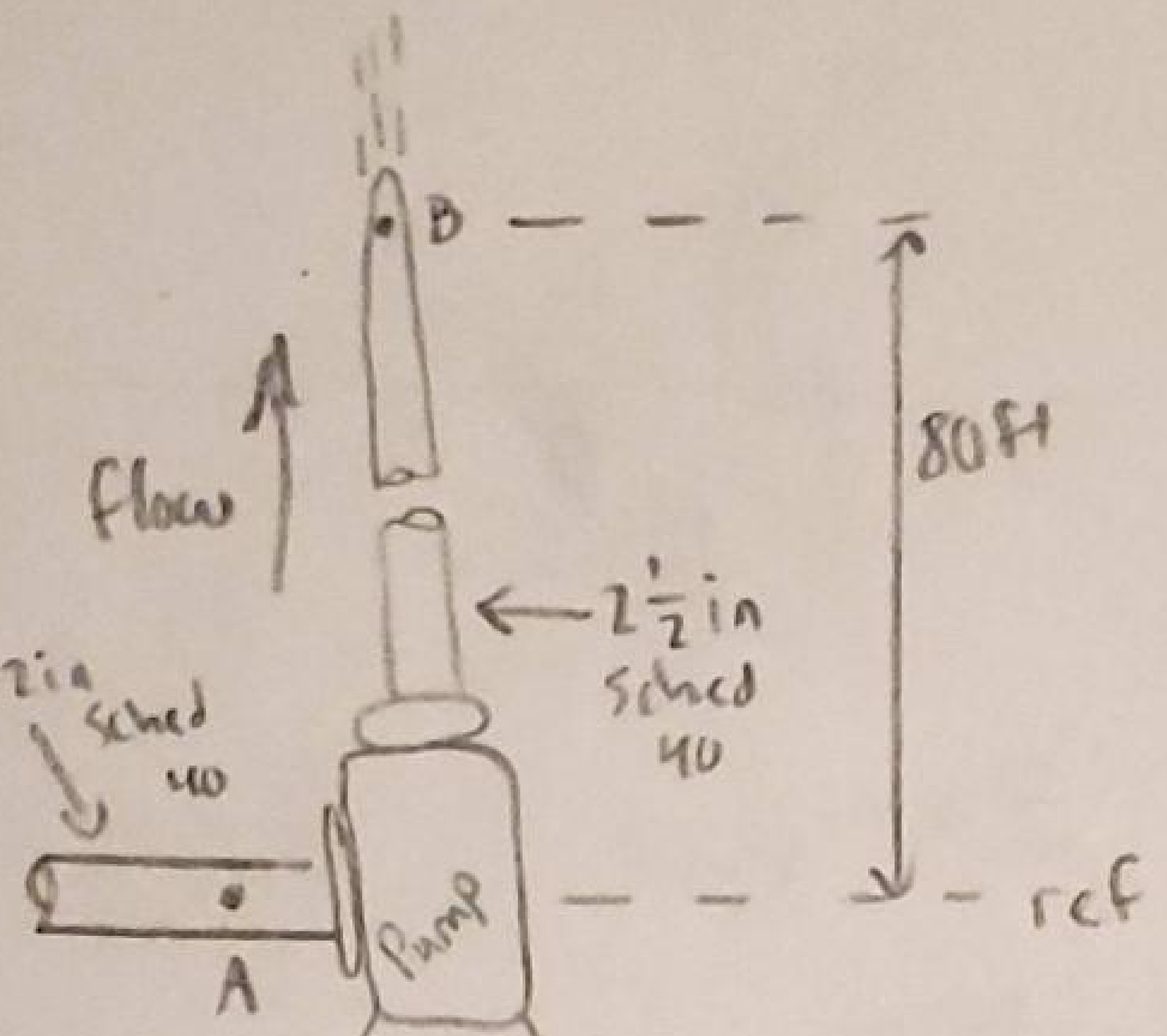
$= \dfrac{20350\,lb\cdot ft}{sec}\Big|\dfrac{ft^3}{62.4\,lb}\Big|\dfrac{sec}{2.228\,ft^3}$

$= 146.43\,ft$

$Q_{motor} = V_2 A_{flow} \Rightarrow V_2 = \dfrac{Q_{motor}}{A_{flow}} = \dfrac{2.228\,ft^3}{sec}\Big|\dfrac{1}{0.3472\,ft^2}$

$V_2 = 6.41709\,\dfrac{ft}{sec}$

*8.44 Compute the power delivered by the pump to fluid



Given

$P_B = 25.0\ psig$

$P_A = -3.50\ psig$

$Q = 0.50\ \frac{ft^3}{sec}$

$\mu = 4.0\times10^{-5}\ \frac{lb\cdot s}{ft^2}$

$sg_{dw} = 1.026$

$\gamma_f = sg\cdot\gamma_w = 1.026\cdot 62.4 = 64.0224\ \frac{lb}{ft^3}$

From text

$\rho_w = 1.94\ \frac{slug}{ft^3}$

From table F.1

- Flow area $= 0.06868\ ft^2$ ($3\frac{1}{2}$ in)
- Flow area $= 0.03326\ ft^2$ ($2\frac{1}{2}$ in)

From table 8.2

$\varepsilon = 1.5\times10^{-4}\ ft$

$$\frac{P_A}{\gamma_{dw}} + \frac{V_A^2}{2g} + z_A + h_A - h_L = \frac{P_B}{\gamma_{dw}} + \frac{V_B^2}{2g} + z_B \Rightarrow h_A = \frac{P_B}{\gamma_{dw}} + \frac{V_B^2}{2g} + z_B + h_L - \frac{P_A}{\gamma_{dw}} - \frac{V_A^2}{2g}$$

- $V_B = \frac{Q}{A_B} = \frac{0.50\ ft^3}{sec}\cdot\frac{1}{0.03326\ ft^2} = 15.033\ ft/sec$, $\cdot\ V_A = \frac{Q}{A_A} = \frac{0.50\ ft^3}{sec}\cdot\frac{1}{0.06868\ ft^2} = 7.28\ \frac{ft}{sec}$

- $h_L = f\cdot\frac{LV_B^2}{2gD_B}$
  - Rel rough $= \frac{D_B}{\varepsilon} = \frac{\sqrt{\frac{4}{\pi}\cdot A}}{1.5\times10^{-4}\ ft} = 1371.908$
  - $N_R = \frac{\rho V_B\cdot D_B}{\mu} = \frac{1.99\cdot\sqrt{\frac{4}{\pi}\cdot A}\cdot 15.033}{4.0\times10^{-5}}$

    $N_R = 153950$

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7(D/\varepsilon)} + \frac{5.74}{N_R^{0.9}}\right)\right]^2} = \frac{0.25}{\left[\log\left(\frac{1}{3.7(1371.908)} + \frac{5.74}{N_R^{0.9}}\right)\right]^2}$$

$f = 0.20$ (with calculator)

$h_L = 0.20\cdot\frac{80\ ft\,(15.033\ ft)^2}{.20578\ sec^2}\cdot\frac{sec^2}{2(32.2\ ft)}$

$h_L = 27.284\ ft$

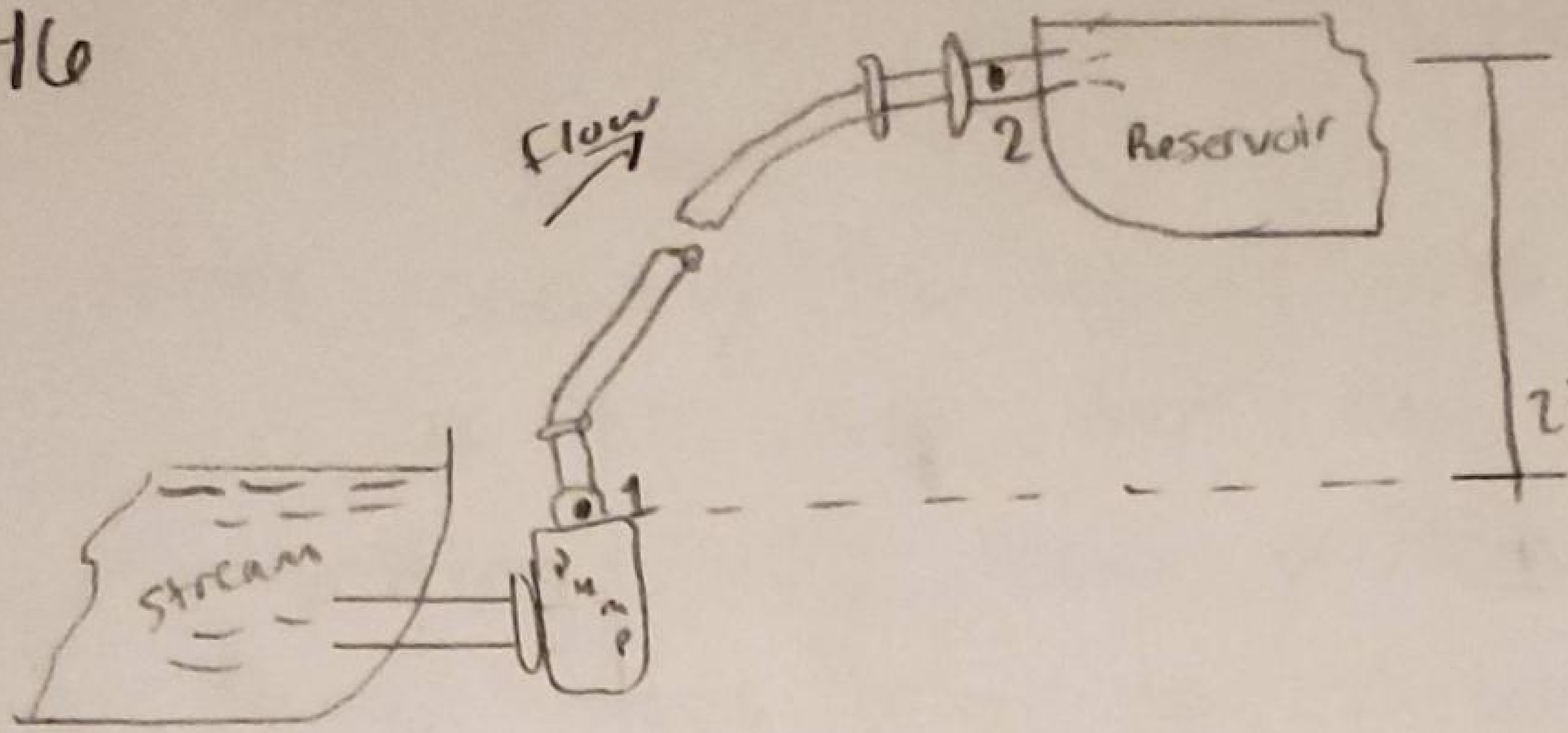
$$h_A = \frac{250\ lb}{in^2}\cdot\frac{12^2\ in^2}{ft^2} + \frac{\left(\frac{15.033\ ft}{sec}\right)^2}{2(32.2\ ft/s^2)} + 80\ ft + 27.284\ ft - \left(\frac{-3.50\ \cdot 144\ in}{1\ ft}\cdot\frac{ft^3}{64.0224}\right) - \frac{(7.28)^2\left(\frac{ft}{sec}\right)^2}{32.2\cdot 2\ ft/sec^2}$$

$h_A = 174.072\ ft$

$$P_{pump} = h_A\cdot\gamma_{dw}\cdot Q = 174.072\ ft\cdot 64.0224\ \frac{lb}{ft^3}\cdot 0.50\ \frac{ft^3}{sec}$$

$$= \boxed{5572.24\ \frac{ft\cdot lb}{sec}}$$

8.46



$L_{pipe} = 2500$ ft, $Q_{pump} = 4.00 \frac{ft^3}{sec}$, 8 in sched. 40 pipe, 60°f water

Table A.2

$\nu @ 60° = 1.21 \times 10^{-5} \frac{ft^2}{sec}$

Append F.1

Flow area @ 8" $= 0.3472 ft^2$

$\Rightarrow d = \sqrt{\frac{4}{\pi} \cdot A}$

$d = 0.66488 ft$

Table 8.2

steel, $\varepsilon = 1.5 \times 10^{-4}$ ft

· Roughness $= \frac{d}{\varepsilon}$

$= \frac{0.66488 ft}{1.5 \times 10^{-4}}$

$= 4432.55$

&

$N_R = \frac{VD}{\nu} = \frac{11.5208 \cdot 0.6648}{1.21 \times 10^{-5}}$

$N_R = 633055.0394$

∴ from Fig. 8.7

$f = 0.0150$

$$h_L = f \cdot \frac{LV^2}{2gD} = 0.0150 \times \frac{2500 ft}{2} \cdot \frac{1}{.6648 ft} \cdot \frac{(11.5208 ft)^2}{sec^2} \cdot \frac{sec^2}{32.2 ft}$$

$h_L = 116.258$ ft

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

no change, atm = 0, no change

$\Rightarrow P_1 = \gamma_w (h_L + (z_2 - z_1))$

$P_1 = \frac{62.4 lb}{ft^3} (210 ft + 116.258 ft)$

$P_1 = \frac{20358.44603 lb}{ft^2} \cdot \frac{1 ft^2}{12^2 in^2}$

$\boxed{P_1 = 141.4 psi}$

Chris Betton, Team 7

After reviewing the lecture notes and previous tests it is apparent that the first steps in setting up these problems. is most paramount. Those steps being to sketch a diagram, find a reference point, and determine what information is known.

The lecture notes also made it clear how to find data in figures & appendices. Being able to navigate these references is important in solving problems.

Lastly, after calculating friction factor by hand, I can see the efficiency of having a spreadsheet calculator. With time permitting, I intend on setting up a spreadsheet for these calculations.

Tai Booker

Ch 7 11 & 16   Ch 8 33 & 38

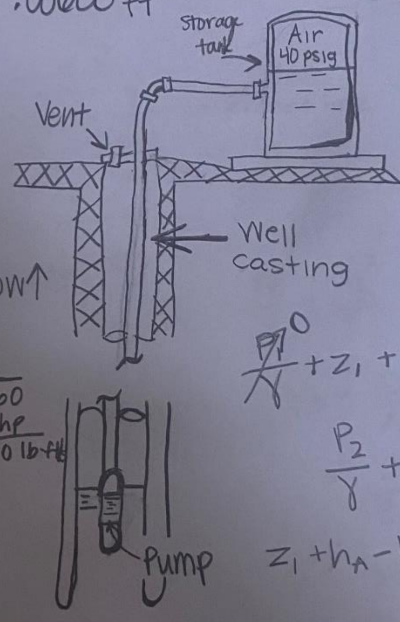
HW 1.4

MET 330

Chapter 7

11. A submersible deep-well pump delivers 745 gal/h of water through a 1-in schedule 40 pipe when operating in the system sketched. An energy loss of 10.5 lb-ft/lb occurs in the piping system. (a) Calculate the power delivered by the pump to the water. (b) If the pump draws 1 hp, calculate its efficiency.

1-in schedule 40 pipe is .00600 ft^2



$V = \frac{Q}{A} = \frac{\frac{745}{449 \times 60}}{0.006}$

$V = 4.61$ ft/s

energy equation

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

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

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

$h_A = \frac{5760.36}{62.4} + 120 + \frac{(4.61)^2}{2(32.18)} + 10.5$

$h_A = 92.3 + 120 + 0.33 + 10.5$

$h_A = 223.13$ ft

(a) $P_A = 223.13 \times 62.4 \times \frac{745}{449 \times 60}$

$P_A = 385.04$ lb-ft/s $\times \frac{1 hp}{550 \text{ lb-ft/s}}$

$\boxed{P_A = 0.70 \text{ hp}}$

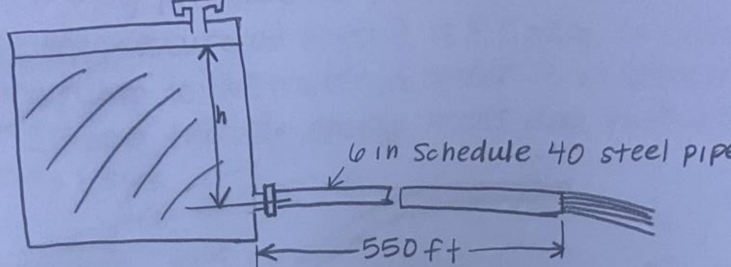
(b) $e_M = \frac{P_A}{P}$

$e_M = \frac{0.70}{1} = 0.70$ ×100

$\boxed{e_M = 70\%}$

Tai Booker
HW 1.4
Chapter 8

33. Water @ 80°F flows from a storage tank through 550 ft of 6 in Schedule 40 steel pipe, as shown. Taking the energy loss due to friction into account, calculate the required head h above the pipe inlet to produce a volume flow rate of 2.50 ft³/s.



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

$P_1 = P_2$

$$h + 0 - h_L = 0 + \frac{v_2^2}{2g}$$

$$h = h_L + \frac{v_2^2}{2g}$$

$$h_L = f \times \frac{L}{D} \times \frac{v^2}{2g}$$

$$h_L = .000094118 \times \frac{550}{0.5054} \times \frac{(12.46)^2}{2 \times 32.2}$$

$h_L = .24691664$ ft

$$h = h_L + \frac{v_2^2}{2g}$$

$$h = .24691664 + \frac{(12.46)^2}{2 \times 32.2}$$

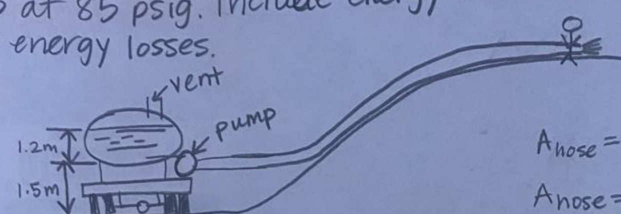
$\boxed{h = 2.66 \text{ ft}}$

Tai Booker
HW 1.4
Chapter 8

38. The figure shows a system for delivering lawn fertilizer in liquid form. The nozzle on the end of the hose requires 140 kPa of pressure to operate effectively. The hose is smooth plastic with an ID of 25 mm... The hose is smooth plastic with an ID of 25 mm...

(a) Calculate the required height h of the water level in the tank in order to maintain 5.0 psig pressure at point A.

(b) Assuming that the pressure at point A is 5.0 psig, calculate the power delivered by the pump to the water in order to maintain the pressure at point B at 85 psig. Include energy losses due to friction, but neglect any other energy losses.



$$A_{hose} = \frac{\pi D^2}{4} = \frac{\pi(0.025\,m)^2}{4}$$

$$A_{hose} = 4.909\times10^{-4}\,m^2$$

$$Q = 95\,L/min = 1.583\times10^{-3}\,m^3/s$$

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

$$V_2 = V_3 = \frac{Q}{A} = \frac{1.583\times10^{-3}\,m^3/s}{4.909\times10^{-4}\,m^2}$$

$P_1 = P_{atm}$ $V_1 = 0$

$$V_2, V_3 = 3.22\,m/s$$

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

$$Re = \frac{\rho V D}{\eta} = \frac{(1100\,kg/m^3)(3.22\,m/s)(0.025\,m)}{2\times10^{-3}\,Pa/s}$$

$$h_A = \left(\frac{P_2}{\gamma} - \frac{P_{atm}}{\gamma}\right) + (z_2 - z_1) + \frac{V_2^2}{2g} + h_L$$

$Re = 44275$ $f = 0.024$ moody's diagram

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

$$h_A = \left(\frac{140\,kPa}{10.791\,kN/m^3} - \frac{101\,kPa}{10.791\,kN/m^3}\right) + (10m - (1.5m + 1.2m)) + \frac{(3.22\,m/s)^2}{2(9.81\,m/s^2)} + 43.122\,m$$

$$h_L = 0.024\left(\frac{85\,m}{0.025\,m} \times \frac{(3.22\,m/s)^2}{2(9.81\,m/s)}\right)$$

$$h_L = 43.122\,m$$

$h_A = 54.02\,m$

$$\gamma_{fertilizer} = sg \times \gamma_{water} = 1.10 \times 9.81\,kN/m^3$$

$$\gamma_{fertilizer} = 10.791\,kN/m^3$$

$$P = \gamma Q h_A = (10.791\,kN/m^3)(1.583\times10^{-3}\,m^3/s)(54.02\,m)$$

$$\boxed{P = 0.923\,kW}$$

$$64.58 = \frac{P_3}{10.791} + 0.529$$

$$\boxed{P_3 = 691.17\,kPa}$$

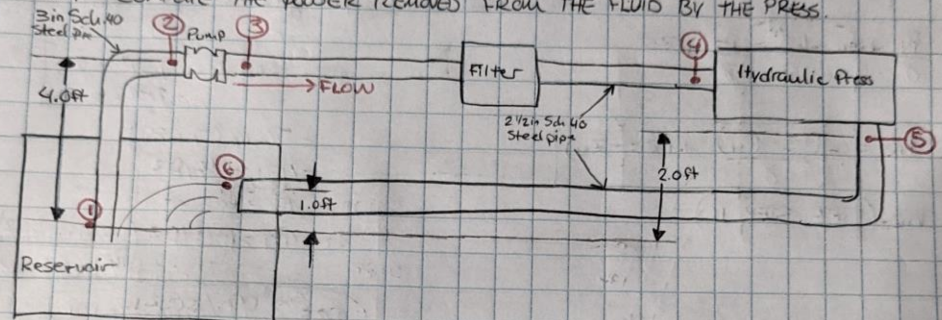
$$\frac{P_1}{\gamma} + z_1 + \cancel{\frac{V_1^2}{2g}}^{\,0} + h_A = \frac{P_3}{\gamma} + z_3 + \frac{V_3^2}{2g} \qquad V_1 = 0$$

$$\frac{101\,kPa}{10.791\,kN/m^3} + 1.2\,m + 54.02\,m = \frac{P_3}{10.791\,kN/m^3} + 0 + \frac{(3.22\,m/s)^2}{2(9.81\,m/s)}$$

HW L4	Ch 7 #35, 42 Ch 8 49, 62	TEAM 7	MELANIE CRUZ CONTEE

CH 7

35. COMPUTE THE POWER REMOVED FROM THE FLUID BY THE PRESS.



GIVEN:

1. THE FLUID IS OIL (SG = 0.90)
2. VOLUME FLOW RATE IS 175 gal/min (Q)
3. POWER INPUT TO THE PUMP IS 28.4 hp (P_I)
4. PUMP EFFICIENCY IS 80 % (e_M)
5. ENERGY LOSS FROM PT. 1–2 IS 2.80 lb-ft/lb
6. ENERGY LOSS FROM PT 3–4 IS 28.50 lb-ft/lb
7. ENERGY LOSS FROM PT 5–6 IS 3.50 lb-ft/lb

APPENDIX F, 3 in $A_2 = 0.05132 ft^2$

2 1/2 in $A = 0.03326 ft^2$

CONVERSION:

$$Q = 175 \text{ gal/min} \left(\frac{1 ft^3/s}{449 \text{ gal/min}}\right) = 0.3899 \ ft^3/s$$

$$P_I = 28.4 \text{ hp} \left(\frac{550 \text{ lb-ft/s}}{1 \text{ hp}}\right) = 15{,}620 \text{ lb ft/s} \approx 1.56 \times 10^4 \text{ lb ft/s}$$

SOLUTIONS (WORK SHOWN ON NEXT SHEET):

$h_R = 532.74$ ft

$P_2 = 431.81$ lb/ft² or 2.99 psi

$\gamma = 56.16$ lb/ft³

$v_2 = 7.57$ ft/s

$P_3 = 31{,}547.32$ lb/ft² or 219 psi

$h_A = 570.68$ lb-ft/lb

$P_A = 12{,}496$ lb ft/s

$v_3 = 11.73$ ft/s

$P_4 = 29\,946.76$ lb/ft² or 207.96 psi

$P_5 = 140.4$ lb/ft² or 0.975 psi

$\boxed{P_R = 11{,}665.29 \text{ lb ft/s or } 21.21 \text{ hp}}$

POWER REMOVED BY THE PRESS

SOLUTION:

① $\frac{p_4}{\gamma} + z_4 + \frac{v_4^2}{2g} + h_A - h_R - h_L = \frac{p_5}{\gamma} + z_5 + \frac{v_5^2}{2g}$

$\frac{p_4}{\gamma} + z_4 + \cancel{\frac{v_4^2}{2g}} - h_R = \frac{p_5}{\gamma} + z_5 + \cancel{\frac{v_5^2}{2g}}$

$\frac{p_4}{\gamma} + z_4 - h_R = \frac{p_5}{\gamma} + z_5$

$h_R = -\left[\frac{(p_5 - p_4)}{\gamma} + (z_5 - z_4)\right]$

$h_R =$ (SEE STEP 11)

Solve for pt 2

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

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

$p_2 = \gamma\left[(z_1 - z_2) - \frac{v_2^2}{2g} - h_L\right]$

$p_2 = 56.16\left[-4 - \frac{7.57^2}{2 \times 32.2} - 2.8\right]$

$= 56.16(7.689)$

$= 431.81\ lb/ft^2$

↓ convert

$431.81\ lb/ft^2 \cdot \left(\frac{0.006944\ lb/in^2}{1\ lb/ft^2}\right)$

$p_2 = 2.99\ lb/in^2$ or psi

specific weight

③ $\gamma = sg \times \gamma_w$

$= 0.90 \times 62.4\ lb/ft^3$

$\gamma = 56.16\ lb/ft^3$

flowrate pt 2

④ $v_2 = \frac{Q}{A_2}$

$= \frac{0.3899\ ft^3/s}{0.05132\ ft^2}$

$v_2 = 7.57\ ft/s$

weight flow rate

⑥ $P_A = h_A \gamma Q$

find h_A: $h_A = \frac{P_A}{\gamma Q} = \frac{12496\ lb \cdot ft/s}{(56.16)(0.3899)}$

$h_A = 570.68\ lb \cdot ft/lb$

pt 3

⑤ $p_3 = \gamma\left[\frac{p_2}{\gamma} + \frac{(v_2^2 - v_3^2)}{2g} + h_A\right]$

(SEE STEPS 6-8 FIRST)

Power delivered by Pump

⑦ $P_A = e_M P_I$

$= 0.8 \times 15620\ lb \cdot ft/s$

$P_A = 12496\ lb \cdot ft/s$

flow rate pt 3

⑧ $v_3 = \frac{Q}{A}$

$= \frac{0.389}{0.03326}$

$v_3 = 11.73\ ft/s$

$= 56.16\left[\frac{-431.81\ lb/ft^2}{56.16} + \frac{[\overset{57.3}{7.57^2} - \overset{137.6}{11.73^2}]^{-80.3}}{\underbrace{2(32.2)}_{64.4}} + 570.68\ lb \cdot ft/lb\right]$

$= 56.16\left[-7.69\ ft/s - 1.25\ ft/s + 570.68\ lb \cdot ft/lb\right]$

$56.16\ lb/ft^3 (561.74)$

$p_3 = 31547.32\ lb/ft^2$

↓ convert

$p_3 = 31547.32\ lb/ft^2 \left(\frac{1}{144}\right)$

$p_3 = 219$ psi

→

SOLUTION CONTINUED:

(9) Solve P4

$P_4 = \gamma\left(\frac{P_3}{\gamma} - h_L\right)$

$56.16\left(\frac{31547.32 \text{ lb/ft}^2}{56.16 \text{ lb/ft}^3} - 28.5\right)$ 561.74

$P_4 = 56.16\,(533.24)$

$= 29{,}946.76 \text{ lb/ft}^2$

↓ convert

$29{,}946.76\left(\frac{1 \text{ lb/in}^2}{144 \text{ lb/ft}^2}\right)$

$P_4 = 207.96$ psi

Solve P5

(10) $P_5 = \gamma\left[(z_6 - z_5) + h_L\right]$

$= 56.16\left[-1 + 3.5\right]$

$P_5 = 140.4 \text{ lb/ft}^2$

↓ convert

$140.4 \text{ lb/ft}^2\left(\frac{1 \text{ lb/in}^2}{144 \text{ lb/ft}^2}\right)$

$P_5 = 0.975$ psi

(11) BACK TO STEP 1

$h_R = -\left[\left(\frac{P_5 - P_4}{\gamma}\right) + (z_5 - z_4)\right]$

$h_R = -\left[\frac{140.4 - 29946.76}{56.16} + (-2)\right]$

$h_R = 530.74 + 2$

$h_R = 532.74$ ft

Solve PR

(12)

$P_R = h_R \gamma Q$

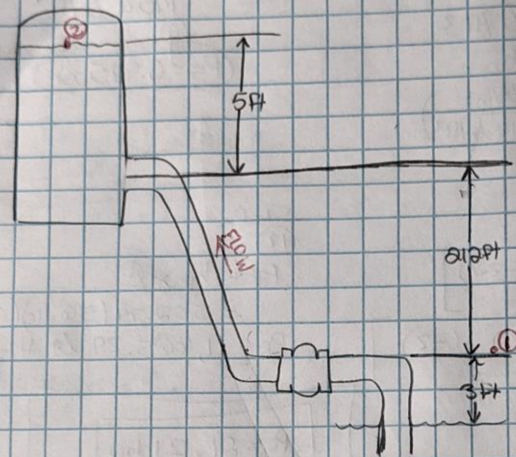
$= 532.74\,(56.16)(0.3899)$

$P_R = 11{,}665.29 \text{ lb}\cdot\text{ft/s}\left(\frac{1 \text{hp}}{550 \text{ lb}\cdot\text{ft/s}}\right)$

$\boxed{P_R = 21.21 \text{ hp}}$

FINAL ANSWER

42. PROFESSOR CROCKER IS BUILDING A CABIN ON A HILLSIDE AND HAS PROPOSED THE WATER SYSTEM SHOWN IN (7.38). THE DISTRIBUTION TANK IN THE CABIN MAINTAINS A PRESSURE OF 30 psig ABOVE 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



GIVEN:

$Q = 40\ \text{gal/min}\left(\frac{1\ ft^3/s}{449\ \text{gal/min}}\right) = 0.089\ ft^3/s$

$P_2 = 30\ \text{psig}\left(\frac{144}{1}\right) = 4320\ lb/ft^2$

$h_L = 15.5\ lb\cdot ft/lb$

$p_1 = 0, \quad z_1 - z_2 = 220ft$

EQN:

$P_A = h_A \gamma Q$

SOLUTION:

① $\frac{p_1}{\gamma}^0 + z_1 + \cancel{\frac{v_1^2}{2g}}^0 + h_A + \cancel{h_R}^0 - h_L = \frac{P_2}{\gamma} + z_2 + \cancel{\frac{v_2^2}{2g}}^0$

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

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

$= \frac{4320\ lb/ft^2}{62.4} + 220 + 15.5$

$h_A = 304.73ft$

② $P_A = h_A \gamma Q$

$= 304.73ft(62.4)(0.089ft^3/s)$

$P_A = 1692.35\ lb\cdot ft/s$

↓ CONVERT

$1692.35\ lb\cdot ft/s\left(\frac{1hp}{550\ lb\cdot ft/s}\right)$

$\boxed{P_A = 3.08hp}$

POWER DELIVERED BY THE PUMP

CH8 62. COMPUTE THE FRICTION FACTOR OF HEAVY FUEL OIL AT 77°F, FLOWS IN A 6-in SCHEDULE 40 STEEL PIPE AT 12 ft/s

GIVEN: f: 0038

$v = 12 ft/s$

APPENDIX F = $D = 0.5054 ft$

APPENDIX B = $\nu = 1.27 \times 10^{-3} ft^2/s$

TABLE 8.2 = $\varepsilon = 1.5 \times 10^{-4} ft$

EQN:

① $N_R = \frac{v D \rho}{\eta} = \frac{v D}{\nu}$

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

③ $h_L = f \times \frac{L}{D} \times \frac{v^2}{2g}$

SOLUTION:

① $N_R = \frac{v D}{\nu}$

$= \frac{12(0.5054)}{1.27 \times 10^{-3}}$

$N_R = 4775.43$

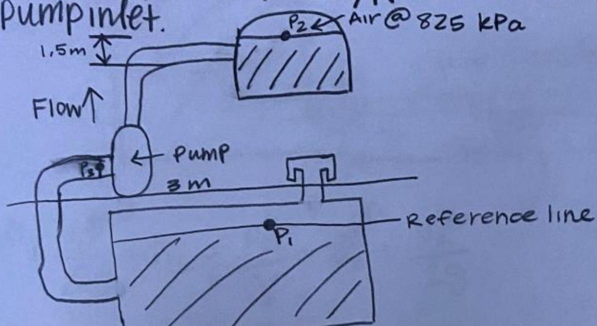
REYNOLD'S NUMBER GREATER THAN 4000
THUS, IS TURBULENT

② RELATIVE ROUGHNESS

$\frac{D}{\varepsilon} = \frac{0.5054}{1.5 \times 10^{-4} ft} = 3369$

Tai Booker
HW 1.4
Chapter 7

16. The figure 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.



$A_3 = 3.09 \times 10^{-3}\ m^2$
from appendix

At P_1 and P_2 pressure gauge = 0
height = 0

$$h_a = \frac{P_2}{\gamma} + z_2 + h_{L sys}$$

$$h_a = \frac{825\ kPa}{8338.5\ N/m^3} + 14.5\ m + 4.2\ m$$

$h_a = 117.64\ m$

$P = \gamma Q h_a$

$P = 8338.5\ N/m^3 \times 0.014\ m^3/s \times 117.64\ m$

$\boxed{P = 13.733\ kW}$

$$\frac{P_3}{\gamma} = \frac{V_3^2}{2g} - z_3 - h_{L suction}$$

$$V_3 = \frac{Q}{A_3}$$

$$V_3 = \frac{0.014\ m^3/s}{3.09 \times 10^{-3}\ m^2}$$

$V_3 = 4.531\ m/s$

$$P_3 = 8338.5\ N/m^3 \left(\frac{4.531}{2(9.81)} - 3 - 1.4\right)$$

$P_3 = -45.41\ kPa$