Fluids | Homework 1.4 | Archer Bresnahan

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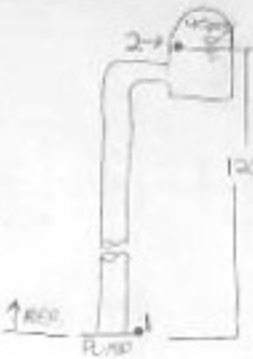
Problem 7.11



$Q_{PUMP} = 745 \frac{gal}{hr} = 0.0277 \frac{ft^3}{sec}$ $\quad 40 \frac{lb}{in^2} = 5760 \frac{lb}{ft^2}$

$h_L = 10.5 \frac{lb \cdot ft}{lb}$ $\quad A = 0.25\pi \cdot 1ft^2 = 0.785 ft^2$

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

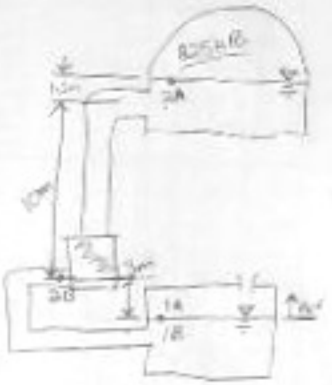
$$h_A = \frac{5760 \frac{lb}{ft^2}}{62.43 \frac{lb}{ft^3}} + 120ft + 10.5ft$$

$$\boxed{h_A = 222.76 ft}$$

$$P_A = h_A \gamma Q = 222.76 ft \left(62.43 \frac{lb}{ft^3}\right)\left(0.0277 \frac{ft^3}{sec}\right) = \boxed{385.23 \frac{ft \cdot lb}{s}}$$

$$\eta_M = \frac{P_A}{P_I} = \frac{385.23 \frac{ft \cdot lb}{sec}}{550 \frac{ft \cdot lb}{sec}} = 0.70 = \boxed{70\% \text{ efficient}}$$

Problem 7.16



$Q_{Pump} = 840\frac{L}{min} = 0.14\frac{m^3}{sec}$

$SG_{oil} = 0.85 \therefore \gamma_{oil} = 8.34\frac{kN}{m^3}$

$h_{L_{sys}} = 4.2\frac{Nm}{N}$ $\quad h_{L_{suc}} = 1.4\frac{Nm}{N}$

$\varnothing = 0.065m \therefore A = 0.25\pi \cdot 0.065^2 = 0.0033m^2$

Part A

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

$$h_A = \frac{P_2}{\gamma} + z_2 + h_L = \frac{825\frac{kN}{m^2}}{8.34\frac{kN}{m^3}} + 14.5m + 4.2m = 117.64m$$

$$P_A = h_A \gamma Q = 117.64m\left(8.34\frac{kN}{m^3}\right)\left(0.14\frac{m^3}{sec}\right) = 137.33\frac{kNm}{sec} = \boxed{137.33\,kW}$$

Part B

$$\cancel{\frac{P_1}{\gamma}} + \cancel{\frac{V_1^2}{2g}} + \cancel{z_1} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_{L_{suc}} \qquad V_2 = \frac{Q_{Pump}}{A} = \frac{0.14\frac{m^3}{sec}}{0.0033m^2} = 42.42\frac{m}{sec}$$

$$-\frac{P_2}{\gamma} = \frac{V_2^2}{2g} + z_2 + h_{L_{suc}} \qquad P_2 = -8.34\frac{kN}{m^3}\left(\left(\frac{42.42\frac{m^2}{s^2}}{2(9.81\frac{m}{s^2})}\right) + 3m + 1.4m\right)$$

$$\boxed{P_2 = -54.73\,kPa}$$

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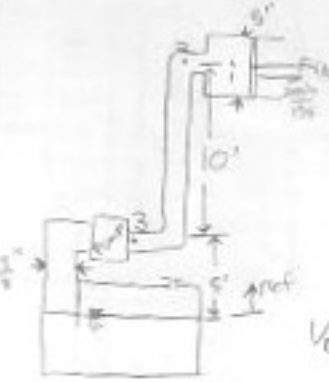
Pg 3

Problem 7.22

Need: Q_{PUMP} ✓ P_{CYL} ✓ P_{OUTLET} ✓ P_{INLET} P_A

$\gamma_{OIL} = 0.90 \cdot 62.43\frac{lb}{ft^3} = 56.187\frac{lb}{ft^3}$



$h_{L_{SUC}} = 11.5\frac{lb \cdot ft}{lb}$ $h_{L_{DIS}} = 35\frac{lb \cdot ft}{lb}$

$V_{DIS}A_{DIS} = V_{CYL}A_{CYL}$ $A_{CYL} = 0.25\pi 5^2 = 19.63in^2$

$A_{DIS} = 0.25\pi \cdot 0.375^2 = 0.11in^2$

$V_{CYL} = \frac{20in}{15sec}\left(\frac{1ft}{12in}\right) = 0.11\frac{ft}{sec}$

$V_{DIS} = \frac{1.33\frac{in}{sec} \cdot 19.63in^2}{0.11in^2} = 237.94\frac{in}{sec} = 19.83\frac{ft}{sec}$

$Q_{PUMP} = V_{DIS}A_{DIS} = 19.83\frac{ft}{sec} \cdot \frac{.11}{12^2}ft^2 = \boxed{0.015\frac{ft^3}{sec}}$

$P_{CYL} = \frac{F_{CYL}}{A_{CYL}} = 1100lb / 0.136ft^2 = \boxed{80692.82\,lb/ft^2}$

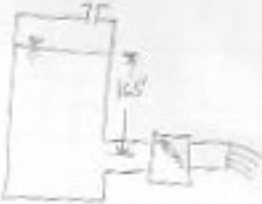
$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2$ $Z_1 - Z_2 = 0$ $\therefore \frac{P_1}{\gamma} + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g}$

$\frac{80692.82\frac{lb}{ft^2}}{56.187\frac{lb}{ft^3}} + \frac{(0.11ft/s)^2}{2(32.2ft/s^2)} = \frac{P_2}{\gamma} + \frac{(19.83ft/s)^2}{2(32.2ft/s^2)}$ $P_2 = 80349.75\,lb/ft^2$

$\frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 = \frac{P_3}{\gamma} + \frac{V_3^2}{2g} + Z_3 + h_{L}$ $V_2 - V_3 = 0$ $\therefore \frac{P_2}{\gamma} + Z_2 = \frac{P_3}{\gamma} + Z_3 + h_{Loss}$

$\frac{80349.75}{56.187} + 15' = \frac{P_3}{56.187} + 5' + 35'$ $\boxed{P_3 = 78945.07\,lb/ft^2}$

Problem 7.30



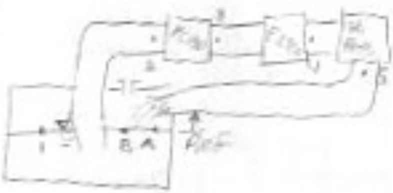
$P_M = 37\,hp = 20350 \frac{ft\cdot lb}{sec}$

$Q = 100 \frac{gal}{min} = 2.23 \frac{ft^3}{sec}$

$P_M = h_L \gamma Q \quad \gamma_{H_2O} = 62.366 \frac{lb}{ft^3}$

$$h_L = \frac{20350 \frac{ft\cdot lb}{sec}}{2.23 \frac{ft^3}{s} \cdot 62.366 \frac{lb}{ft^3}} = \boxed{146.32\,ft}$$

Problem 7.35



Knowns: Closed System

$P_M = h_L \gamma Q \quad S.g = 0.9 \therefore \gamma = 56.187 \frac{lb}{ft^3}$

$Q = 175 \frac{gal}{min} = 0.39 \frac{ft^3}{sec}$

$h_{L1\text{-}2} = 2.8\,ft \quad h_{L3\text{-}4} = 28.5\,ft \quad h_{L5\text{-}6} = 3.5\,ft$

$h_A + \cancel{\frac{P_A}{\gamma}} + \cancel{\frac{V_A^2}{2g}} + \cancel{z_A} = h_L + \cancel{\frac{P_B}{\gamma}} + \cancel{\frac{V_B^2}{2g}} + \cancel{z_B}$ $\quad P_I = 28.4\,hp = 15620 \frac{ft\cdot lb}{sec}$

$P_A = \eta_{Pump} P_I = 0.8 \cdot 15620 \frac{ft\cdot lb}{sec} = 12496 \frac{ft\cdot lb}{sec}$

$\therefore h_A = h_L$

$P_A = h_A \gamma Q \quad h_A = \frac{P_A}{\gamma Q} = \frac{12496 \frac{ft\cdot lb}{sec}}{56.187 \frac{lb}{ft^3} \cdot 0.39 \frac{ft^3}{sec}}$

$570.26 = 34.8 + h_{L\,Press}$

$h_A = 570.26\,ft \quad h_L = h_{Press} + \Sigma h_L$

$h_{L\,Press} = 535.46\,ft$

$P_L = h_{L\,Press} \gamma Q = 535.46\,ft \cdot 56.187 \frac{lb}{ft^3} \cdot 0.39 \frac{ft^3}{sec} = 11733.43 \frac{ft\cdot lb}{sec}$

$\boxed{P_L = 21.33\,hp}$

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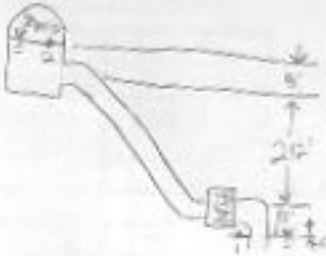
Problem 7.42



$Q = 40 \frac{gal}{min} = 0.089 \frac{ft^3}{sec}$ $\quad \gamma = 62.43 \frac{lb}{ft^3}$

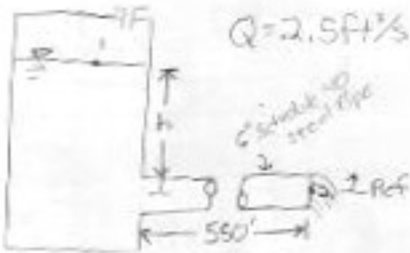
$h_L = 15.5 ft$ $\quad P_B = 30 \frac{lb}{in^2} = 4320 \frac{lb}{ft^2}$

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

$h_A = \frac{4320}{62.43} + 220 + 15.5 = 304.7 ft$

$P_A = h_A \gamma Q = 304.7 ft \cdot 62.43 \frac{lb}{ft^3} \cdot 0.089 \frac{ft^3}{sec} = 1692.98 \frac{ft \cdot lb}{sec} = \boxed{3.08 hp}$

Problem 8.33



$\rho = 62.217 \frac{lb}{ft^3}$ $\quad V = \frac{Q}{A} = \frac{2.5 \frac{ft^3}{s}}{0.196 ft^2} = 12.73 \frac{ft}{s}$

$Q = 2.5 ft^3/s$ $\quad \eta = 1.77 \cdot 10^{-5} \frac{lb \cdot s}{ft^2}$

$R_e = \frac{\rho V D}{\eta} = \frac{62.217 \frac{lb}{ft^3} \cdot 12.73 \frac{ft}{s} \cdot 0.5 ft}{1.77 \cdot 10^{-5} \frac{lb \cdot s}{ft^2}}$

$R_e > 4000$ assume turbulent

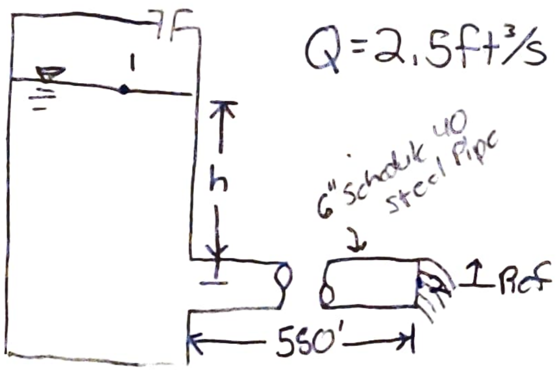
$f = \frac{0.25}{\left(\log\left(\frac{1}{3.7\left(\frac{0.5 ft}{5 \cdot 10^{-4} ft}\right)}\right) + \frac{5.74}{2237354^{0.9}}\right)^2} = 0.0086$

$h_L = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g} = 0.0086 \left(\frac{550'}{0.5'}\right) \cdot \frac{(12.73 \frac{ft}{s})^2}{64.4 \frac{ft}{s^2}} = 23.84 ft$

$\cancel{\frac{P_1}{\gamma}} + \cancel{\frac{V_1^2}{2g}} + z_1 = h_L + \cancel{\frac{P_2}{\gamma}} + \frac{V_2^2}{2g} + \cancel{z_2}$ $\quad \therefore h = 23.84' + \frac{(12.73)^2}{64.4} = \boxed{26.36 ft}$

Problem 8.33

$\rho = 62.217 \frac{lb}{ft^3}$ $\quad V = \frac{Q}{A} = \frac{2.5 \frac{ft^3}{s}}{0.196 ft^2} = 12.73 \frac{ft}{s}$



$Q = 2.5 ft^3/s$ $\quad \eta = 1.77 \cdot 10^{-5} \frac{lb\text{-}s}{ft^2}$

$$R_e = \frac{\rho V D}{\eta} = \frac{62.217 \frac{lb}{ft^3} \cdot 12.73 \frac{ft}{s} \cdot 0.5 ft}{1.77 \cdot 10^{-5} \frac{lb\text{-}s}{ft^2}}$$

$R_e > 4000$ assume turbulent

$$f = \frac{0.25}{\left(\log\left(\frac{1}{3.7\left(\frac{0.5 ft}{5 \cdot 10^{-4} ft}\right)} + \frac{5.74}{2237351 4^{0.9}}\right)\right)^2} = 0.0086$$

$$h_L = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g} = 0.0086 \left(\frac{550'}{0.5'}\right) \cdot \frac{\left(12.73 \frac{ft}{s}\right)^2}{64.4 \frac{ft}{s^2}} = 23.84 ft$$

$$\cancel{\frac{P_1}{\gamma}}^{0} + \cancel{\frac{V_1^2}{2g}}^{0} + z_1 = h_L + \cancel{\frac{P_2}{\gamma}}^{0} + \frac{V_2^2}{2g} + \cancel{z_2}^{0} \quad \therefore h = 23.84' + \frac{(12.73)^2}{64.4} = \boxed{26.36 ft}$$

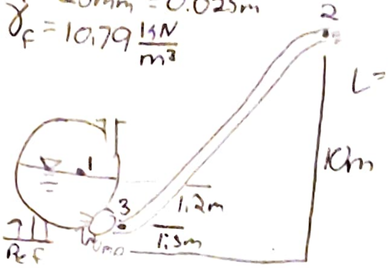
Problem 8.38

$Q = 95\frac{L}{min} = 0.00158\frac{m^3}{sec}$ $V = \frac{0.00158\frac{m^3}{s}}{0.025m} = 0.0632\frac{m}{s}$

$P_2 = 140kPa$ $\eta = 2\cdot10^{-3}Pa\cdot s$ $\rho = 1.1\frac{g}{cm^3} = 1100\frac{kg}{m^3}$

$\varnothing = 25mm = 0.025m$

$\gamma_f = 10.79\frac{kN}{m^3}$



$L = 85m$ $Re = \frac{\rho V D}{\eta} = \frac{1100\cdot0.0632\cdot0.025}{0.002} = 869$

Laminar Flow

$\therefore f = \frac{64}{Re} = \frac{64}{869} = 0.0736$

$$h_L = f\frac{L}{D}\frac{V^2}{2g} = 0.0736\left(\frac{85}{0.025}\right)\left(\frac{0.0632^2}{19.602}\right) = 0.051m$$

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

$$h_A + 2.7m = \frac{140\frac{kN}{m^2}}{10.79\frac{kN}{m^3}} + \frac{0.0632^2}{19.602} + 10m + 0.051m \qquad h_A = 20.33m$$

$$P_A = h_A\gamma Q = 20.33m\cdot10.79\frac{kN}{m^3}\cdot0.00158\frac{m^3}{sec} = 0.3465\frac{kN\cdot m}{sec}$$

$$\boxed{P_A = 0.46hp}$$

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

$$20.33m + 2.7m = \frac{P_3}{10.79\frac{kN}{m^3}} + \frac{0.0632^2}{19.602} + 1.5m \qquad \boxed{P_3 = 232.31kPa}$$

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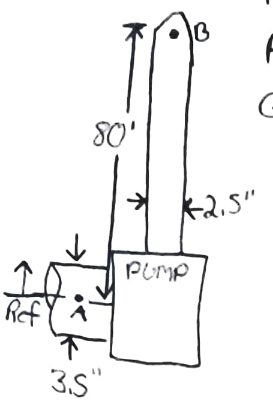
Problem 5.41



$P_B = 25\frac{lb}{in^2} = 3600\frac{lb}{ft^2}$

$P_A = -3.5\frac{lb}{in^2} = -504\frac{lb}{ft^2}$

$Q = 0.5\frac{ft^3}{sec}$

$\eta = 4.0\cdot 10^{-5}\frac{lb\cdot s}{ft^2}$

$S.G. = 1.026 \quad \gamma = 64.05\frac{lb}{ft^3}$

$\rho = 64.05\frac{lb}{ft^3}$

$A_B = 0.034 ft^2 \quad V_B = \frac{0.5\frac{ft^3}{sec}}{0.034 ft^2} = 14.67 ft/sec$

$$Re = \frac{\rho V D}{\eta} = \frac{64.05\frac{lb}{ft^3}\cdot 14.67 ft/sec \cdot 0.208 ft}{4.0\cdot 10^{-5}\frac{lb\cdot s}{ft^2}\cdot 32.2\frac{lb\cdot ft}{lb\cdot s^2}}$$

$Re = 151738.83$ Turbulent Flow

$A_A = 0.067 ft^2$

$$f = \frac{0.25}{\left(\log\left(\frac{1}{3.7\left(\frac{.208}{5\cdot 10^{-6}}\right)} + \frac{5.74}{151738.83^{.9}}\right)\right)^2} = 0.0166$$

$$h_L = f\frac{L}{D}\frac{V^2}{2g} = 0.0166\left(\frac{80}{0.208}\right)\left(\frac{14.67^2}{64.4}\right) = 21.32 ft$$

$$V_A = \frac{V_B A_B}{A_A} = \frac{0.034\cdot 14.67}{0.067} = 7.47 ft/sec$$

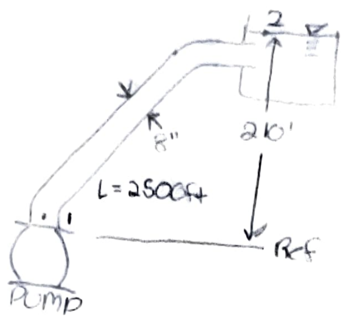
$$h_A + \frac{P_A}{\gamma} + \frac{V_A^2}{2g} + \cancel{z_A}^{0} = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_2 + h_L$$

$$h_A = \frac{P_B - P_A}{\gamma} + \frac{V_B^2 - V_A^2}{2g} + z_2 + h_L = \frac{3600 - -504}{64.05} + \frac{14.67^2 - 7.47^2}{64.04} + 80 + 21.32$$

$h_A = 167.88 ft \quad P_A = h_A\gamma Q = 167.88\cdot 64.05\cdot 0.5 = 5376.49\frac{ft\cdot lb}{sec}$

$\boxed{P_A = 9.78 hp}$

Problem 8.46



Water @ 60°F : $\gamma = 62.4 \frac{lb}{ft^3}$

$\rho = 1.94 \frac{slug}{ft^3}$ $\quad \mu = 2.35 \cdot 10^{-5} \frac{lb \cdot s}{ft^2}$

$A = 0.67 ft^2 \cdot \frac{\pi}{4} = 0.349 ft^2$

$Q = 4 \frac{ft^3}{s}$ $\quad V = \frac{Q}{A} = \frac{4}{0.349} = 11.5 \frac{ft}{sec}$

$R_e = \frac{\rho V D}{\mu} = \frac{1.94 \cdot 11.5 \cdot 0.67}{2.35 \cdot 10^{-5}} = 636072$

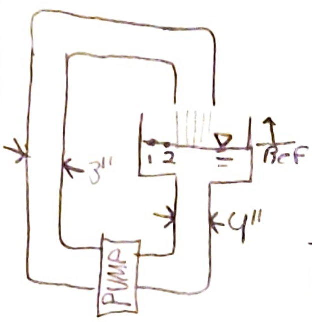
$$f = \frac{.25}{\left(\log\left(\frac{1}{3.7\left(\frac{.67}{5 \cdot 10^{-6}}\right)} + \frac{5.74}{636072^{.9}}\right)\right)^2} = 0.0127 \qquad h_L = 0.0127\left(\frac{2500}{.67}\right)\left(\frac{11.5^2}{64.4}\right)$$

$h_L = 97.2 ft$

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

$$\frac{P_1}{62.4} + \frac{11.5^2}{64.4} = 210' + 97.2' \qquad \boxed{P_1 = 19090.99 \frac{lb}{ft^2}}$$

Problem 8.49



$L_{3"p} = 75'$ Oil @ 104°F $\therefore$ $\gamma = 56.53 \frac{lb}{ft^3}$

$L_{4"p} = 25'$ $\rho = 1.76 \frac{slug}{ft^3}$ $\eta = 2.24 \cdot 10^{-3} \frac{lb \cdot s}{ft^2}$

$Q = 300 \frac{gal}{min} = 0.67 \frac{ft^3}{sec}$

3" Pipe

$V = \frac{Q}{A} = \frac{0.67}{\left(\frac{3}{12}\right)^2 \cdot 0.25\pi} = 13.65\ ft/sec$ $A = .049 ft^2$

$Re = \frac{\rho V D}{\eta} = \frac{1.76 \cdot 13.65 \cdot 0.25}{2.24 \cdot 10^{-3}} = 2669.3$

$f = \frac{0.25}{\left(\log\left(\frac{1}{3.7\left(\frac{.25}{5 \cdot 10^{-6}}\right)} + \frac{5.74}{2669.3^{.9}}\right)\right)^2} = 0.046$

$h_L = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right) = 0.046\left(\frac{75}{0.25}\right)\left(\frac{13.65^2}{64.4}\right) = 40.16 ft$

4" Pipe

$A = 0.087 ft^2$ $V = \frac{0.67}{0.087} = 7.68\ ft/sec$

$Re = \frac{\rho V D}{\eta} = \frac{1.76 \cdot 7.68 \cdot 0.33}{2.24 \cdot 10^{-3}} = 1990.7$ Laminar

$f = \frac{64}{Re} = \frac{64}{1990.7} = 0.032$ $h_L = 0.032\left(\frac{25}{0.33}\right)\left(\frac{7.68^2}{64.4}\right) = 2.23 ft$

$h_A + \overset{0}{\frac{P_1}{\gamma}} + \overset{0}{\frac{V_1^2}{2g}} + \overset{0}{z_1} = h_L + \overset{0}{\frac{P_2}{\gamma}} + \overset{0}{\frac{V_2^2}{2g}} + \overset{0}{z_2}$ $\therefore$ $h_A = h_L = 40.16 + 2.23 = 42.39 ft$

$P_A = h_A \gamma Q = 42.39 \cdot 56.53 \cdot 0.67 = 1605.53 \frac{ft \cdot lb}{sec} = \boxed{2.92 hp}$

Problem 8.62

Heavy oil @ 77°F ∴ $\gamma = 56.53 \frac{lb}{ft^3}$ $\rho = 1.76 \frac{slugs}{ft^3}$

$A = 0.196 ft^2$ $\eta = 2.24 \cdot 10^{-3} \frac{lb \cdot s}{ft^2}$ $D = 0.5 ft$

Steel Pipe ∴ $\varepsilon = 5 \cdot 10^{-5} ft$ $V = 12 ft/s$

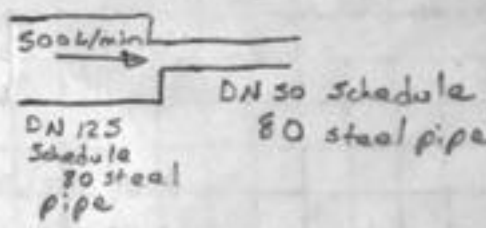
$$Re = \frac{\rho V D}{\eta} = \frac{1.76 \cdot 12 \cdot 0.5}{2.24 \cdot 10^{-3}} = 4714.29$$

$$f = \frac{0.25}{\left(\log\left(\frac{1}{3.7\left(\frac{0.5}{5 \cdot 10^{-5}}\right)} + \frac{5.74}{4714^{.9}}\right)\right)^2} = \boxed{0.035}$$

20, 37, 39

Ch10 (20.) Determine the energy loss for a sudden contraction from a DN 125 Schedule 80 steel pipe to a DN 50 Schedule 80 pipe for a flow rate of 500 L/min.

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



$$h_L = K \times \frac{v^2}{2g}$$

$Q = 500 \frac{L}{min} = 0.0083 \frac{m^3}{s}$

Roughness $= 4.6 \times 10^{-5}$ m

F.2 DN 125 schedule 80 — $D_{out} = 141.3$ mm, ~~thickness~~ $= 9.5$ mm

DN 50 Sched 80 — $D_{out} = 60.3$ mm, ~~thickness~~ $= 5.54$ mm

$Q = A \times V$

$v_1 = \frac{Q}{A_1}$ $\quad v_2 = \frac{Q}{A_2}$

$A = \frac{\pi}{4} d^2$

$D_1 = 141.3\,mm - 2(9.5\,mm)$
$= 0.1223$ m

$D_2 = 60.3\,mm - 2(5.54\,mm)$
$= 0.04922$ m

$$\frac{D_1}{D_2} = \frac{0.1223\cancel{m}}{0.04922\cancel{m}} = 2.485$$

$A_2 = \frac{\pi}{4} \times (0.04922\,m)^2 = 0.001904\,m^2$ $\qquad K = 0.39$

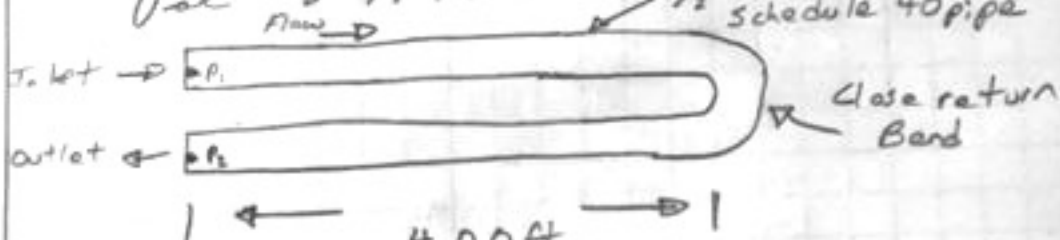
$v_2 = 0.0083 \frac{m^3}{s} / 0.001904\,m^2$

$V_2 = 4.3592$ m/s

$$h_L = 0.39 \left(\frac{(4.3592\,m/s)^2}{2\left(9.81 \frac{m}{s^2}\right)} \right)$$

$$\boxed{h_L = 0.3777\,m}$$

(37) A simple heat exchanger is made by installing a close return bend on two 1/2-in Schedule 40 steel pipes. Compute the pressure difference between the inlet and the outlet for a flow rate of 12.5 gal/min of ethylene glycol at 77°F.



$z_1 = z_2$
$v_1 = v_2$

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

$$\frac{P_1}{\gamma} = \frac{P_2}{\gamma} + h_L \qquad h_L = K\left(\frac{v^2}{2g}\right) = f \times \frac{L}{D} \times \frac{v^2}{2g}$$

1/2 in Schedule 40 $D_{in} = 0.0518$ ft
$A = 0.00211$ ft^2

Roughness of steel = 1.5×10^{-4} ft
$0.0518 \text{ ft} / 1.5 \times 10^{-4} \text{ ft} = 345.33$

$f = 0.026$

(online conversion calc)
$Q = 12.5 \text{ gal/min} = 0.03 \text{ ft}^3/\text{s}$

$Q = AV$

$$V = \frac{0.03 \text{ ft}^3/\text{s}}{0.00211 \text{ ft}^2} = 14.2180 \text{ ft/s}$$
$\to 4.3336$ m/s
(online conversion calculator)

$L/D = 50$

$$h_{L_1} = (0.026)(50)\left(\frac{(4.3336 \text{ m/s})^2}{2(9.81 \text{ m/s}^2)}\right)$$

$h_{L_1} = 1.2443$ m

Ethylene Glycol
$$N_R = \frac{vD}{\nu} = \frac{13.175(0.0518)}{1.59 \times 10^{-4}} = 4292.232$$

$D/\epsilon = 345.33$
$f = 0.0415$

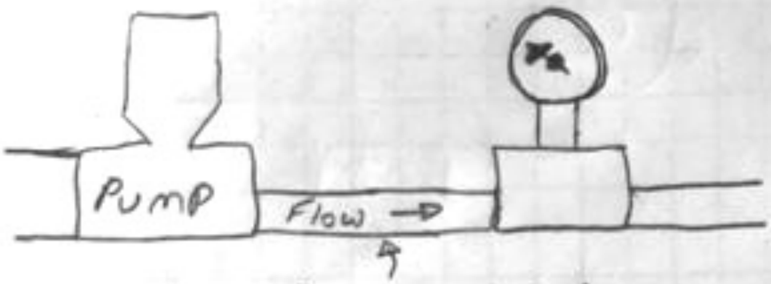
$$h_{L_2} = 0.0415 \times \frac{8 \text{ ft}}{0.0518} \times \frac{(13.175 \text{ ft/s})^2}{2(32.2 \text{ ft/s}^2)}$$

$h_{L_2} = 17.275$ ft
$\to = 5.2654$ m
(online calc)

$77°F = 25°C$
$\gamma = 10.79 \frac{kN}{m^3}$

$$P_1 - P_2 = (h_{L_1} + h_{L_2})\gamma = 10.79 \frac{kN}{m^3}(1.2443 \text{ m} + 5.2654 \text{ m})$$
$$= \boxed{70.2397 \frac{kN}{m^2}}$$

(39) A piping system for a pump contains a tee to permit the pressure at the outlet of the pump to be measured. However, there is no flow into the line leading to the gage. Compute the energy loss as 0.40 ft³/s of water at 50°F flows through the tee.



3-in Schedule 40 pipe → $A = 0.05132 \text{ mm}^2$

$Q = v(A) \qquad Q = 0.40 \text{ ft}^3/\text{s}$

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

$V = Q/A = \frac{0.40 \text{ ft}^3/\text{s}}{0.05132 \text{ ft}^2}$

$= 7.7942 \text{ ft/s}$

tee

Table 10.4 $L/D = 20$

Table 10.5 $f = 0.017$

$h_L = 0.017 (20) \left(\frac{(7.7942 \text{ ft/s})^2}{2 (9.81 \text{ m/s}^2)} \right)$

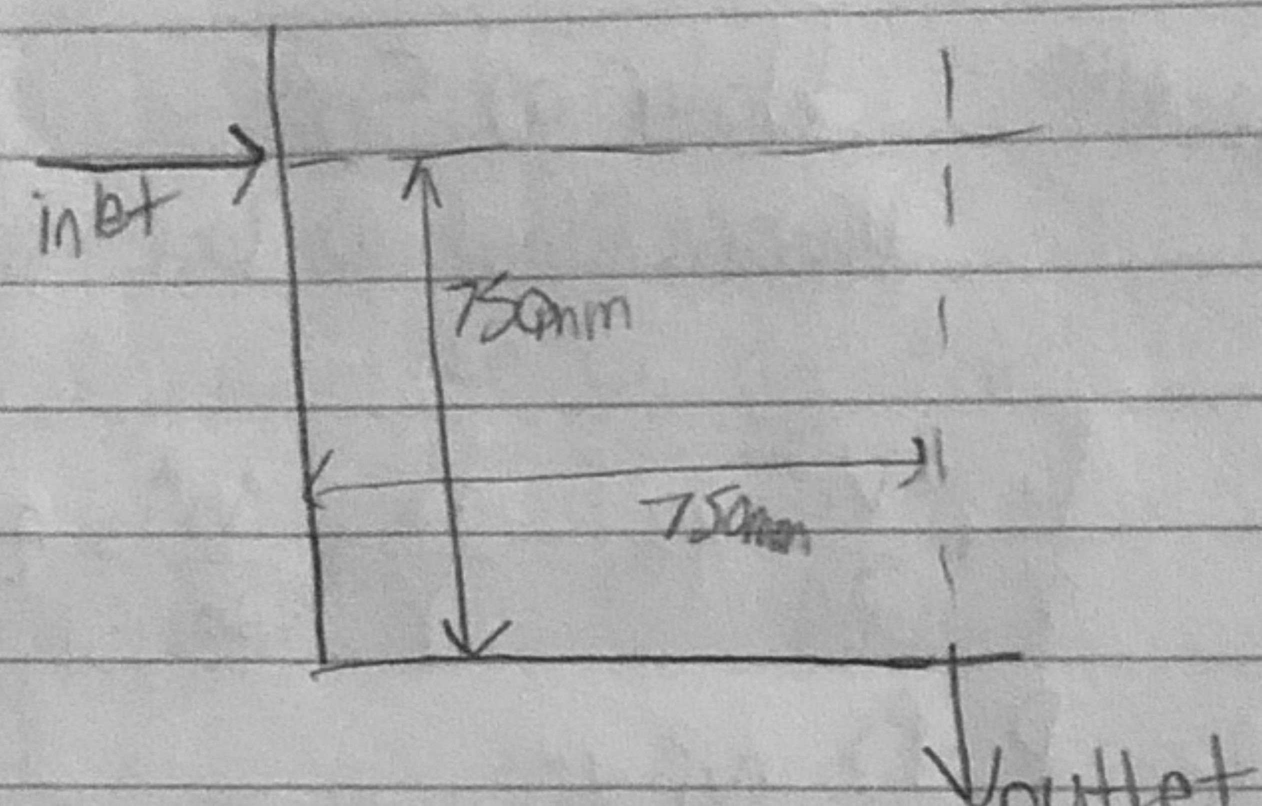
$h_L = 0.017 (20) \left(\frac{(2.3757 \text{ m/s})^2}{2 (9.81 \text{ m/s}^2)} \right)$

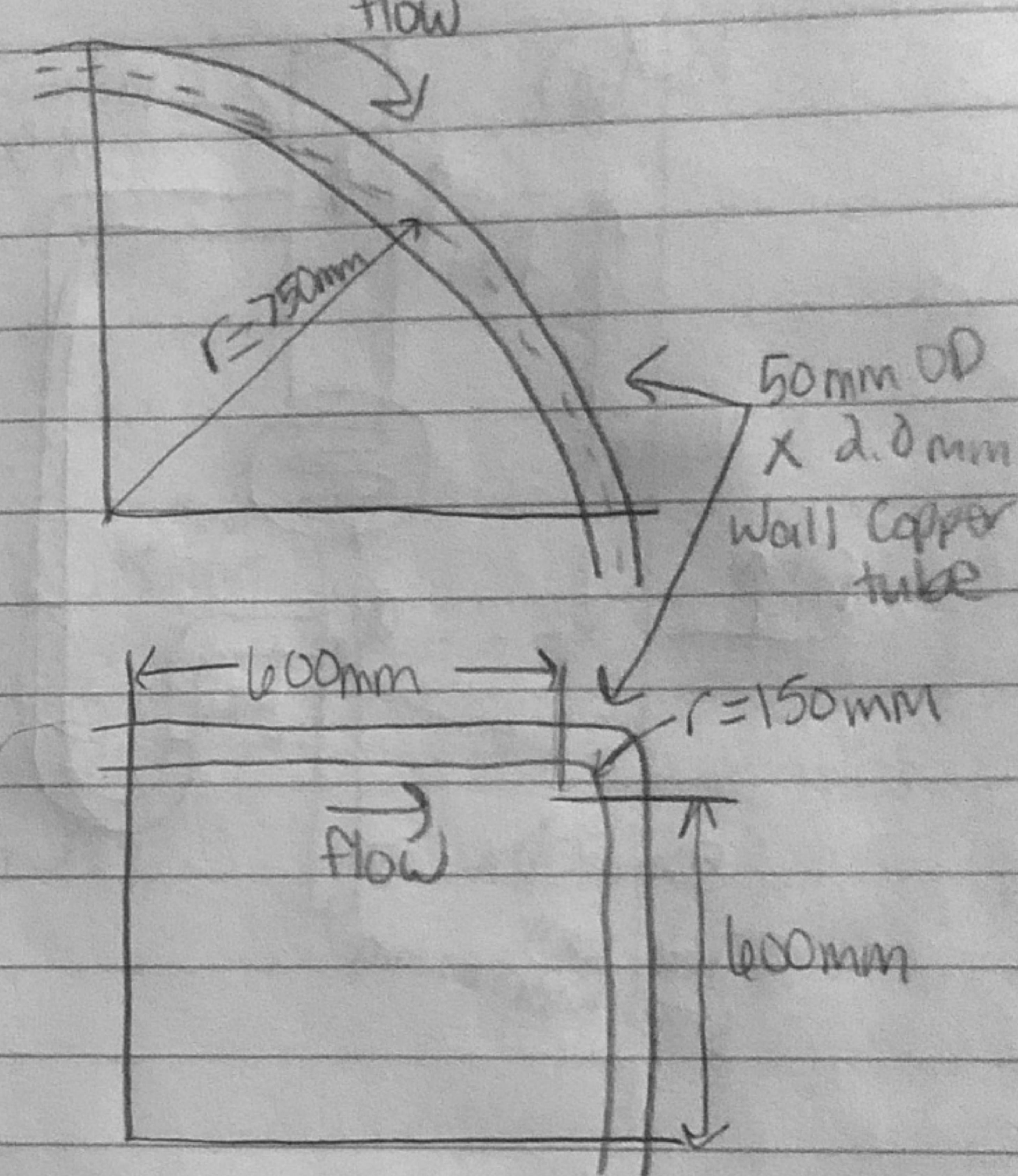
$\boxed{h_L = 0.0978 \text{ m}}$

Ch 10

20, 37, 39, 43, 46, 48

43)





OD = 50mm
thickness = 2mm
ID = 46mm

$750\,L/min = \dfrac{\left(\frac{1}{1000(60)}\right)}{1\,L/min}(750)$

$= 0.0125\,m^3/s$

$A = \dfrac{\pi(0.046)^2}{4} = 0.001662\,m^2$

$V = Q/A = 7.52\,m/s$

$\varepsilon = 1.5 \times 10^{-6}$

$\dfrac{r}{D} = \dfrac{750}{46} = 16.3$

$N_R = \dfrac{7.52(0.046)(802)}{1.92 \times 10^{-3}}$
$= 144493.67$

$\dfrac{D}{\varepsilon} = \dfrac{0.046}{1.5 \times 10^{-6}} = 30666.67$

$f_T = 0.0095$

$h_L = (0.0095)(43)\left(\dfrac{7.52^2}{2(9.81)}\right)$
$= \boxed{1.177m \text{ energy loss in pipe}}$

$h_{L_{bend}} = 0.0095(13)\left(\dfrac{7.52^2}{2(9.81)}\right)$
$= 0.356m$

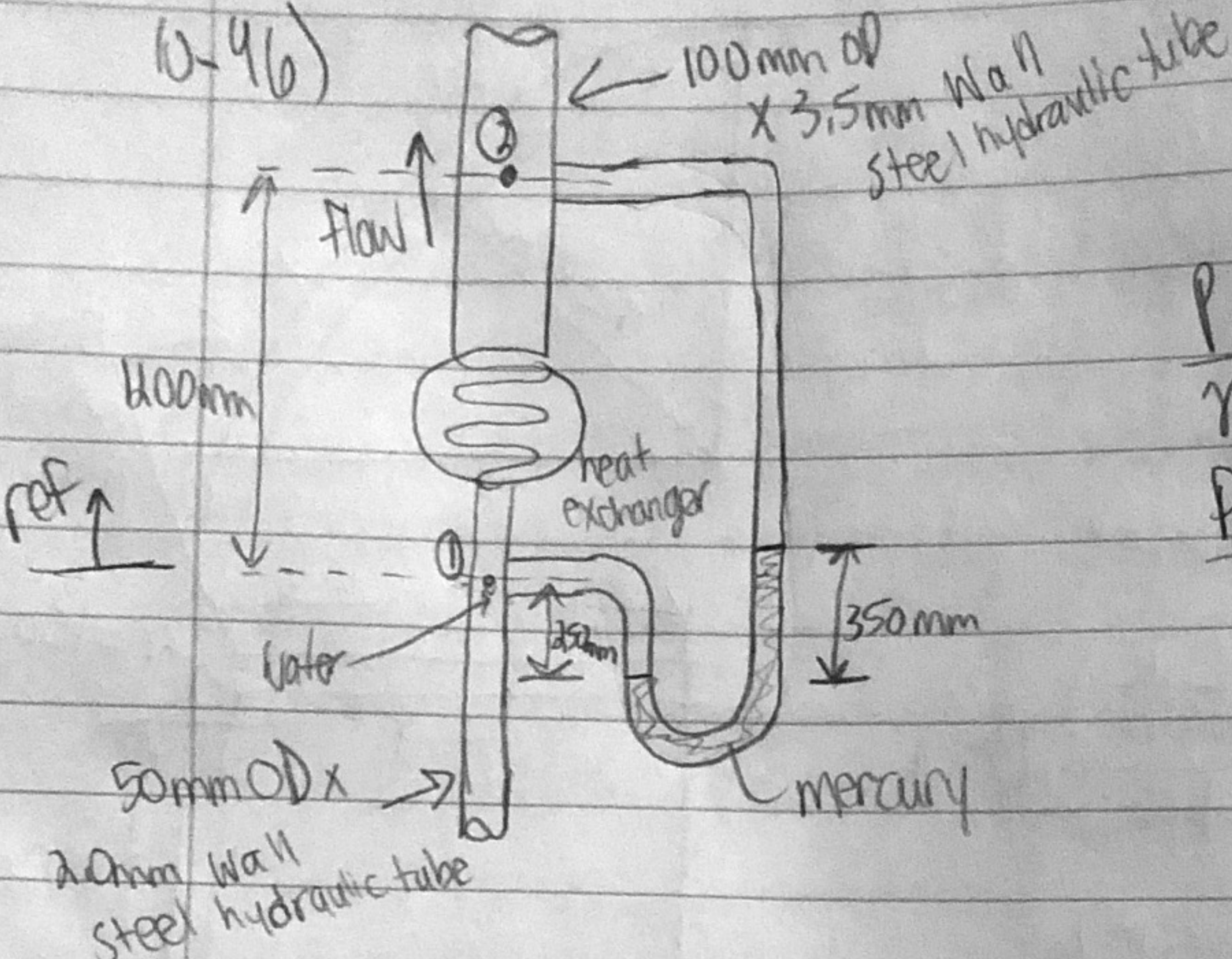
$\dfrac{r}{D} = \dfrac{150}{46} = 3.261$

$\dfrac{L_e}{D} = 13$

$h_{L_{tube}} = 0.0162\left(\dfrac{1.2}{0.046}\right)\left(\dfrac{7.52^2}{2(9.81)}\right)$
$= 1.218m$

$h_L = 0.356 + 1.218$
$= \boxed{1.574m \text{ total energy loss}}$

(10-46)



Water @ 50°C
upward flow @ $6.0 \times 10^{-3}\ m^3/s$

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

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

$$\gamma_w = 9.69\ kN/m^3$$
$$\gamma_m = 132.8\ kN/m^3$$

$$\frac{P_1 - P_2}{\gamma_w} = \frac{\gamma_m(0.35)}{\gamma_w} + \frac{\gamma_w(0.85)}{\gamma_w} = \frac{132.8(0.35)}{9.69} + 0.85$$

$$= \boxed{5.65 m}$$

$$Q = 6 \times 10^{-3}\ m^3/s$$

$$V_1 = \frac{6 \times 10^{-3}}{\pi/4\,(0.046)^2} = 3.61\ m/s$$

$$V_2 = \frac{6 \times 10^{-3}}{\pi/4\,(0.093)^2} = 0.8833\ m/s$$

$$\frac{3.61^2 - 0.8833^2}{2(9.81)} = \boxed{0.6245 m}$$

$$z_1 - z_2 = -1.2 m$$

$$h_L = 5.65 + 0.6245 - 1.2$$
$$= \boxed{5.07\ m}$$ energy loss

$$h_L = k\left(V_1^2/2g\right)$$

$$5.07 = k\,\frac{(3.61)^2}{2(9.81)}$$

$\boxed{k = 7.6}$ resistant coefficient

10-48) flow rate 27.5 gal/min
90° bend
1 1/4" OD
Wall thickness 0.083 in
radius 3.25 in

$\varepsilon = 1.5 \times 10^{-4}$ ft
$f_T = 0.021$

$Le/D = 30$

$v = Q/A$

$h_L = K\left(\frac{v^2}{2g}\right)$

$= 0.63\left(\frac{8.92^2}{2(9.81)}\right)$

19.62

$= \underline{\underline{2.55 \text{ ft}}}$

$h_L = K\left(\frac{v^2}{2g}\right)$

$\frac{r}{D} = \frac{3.25(1/12)}{0.0903} = 2.99$

$\frac{D}{\varepsilon} = \frac{0.0903}{1.5 \times 10^{-4}} = 602$

$K = (0.021)(30)$
$K = 0.63$ 0.336

$Q = 27.5$ gal/min $= (27.5)(0.1337)(1/60)$
$Q = 0.061$ ft³/s

$V = 0.061 / 6.842 \times 10^{-3}$

$V = 8.92$ ft/s