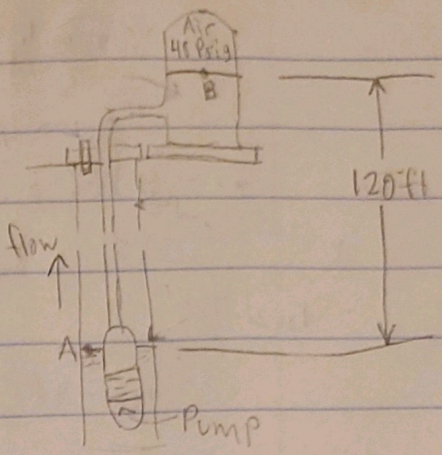
HW 1.4

7.11 $\frac{P_A}{\gamma} + z_A + \frac{V_A^2}{2g} + h_A - h_L = \frac{P_B}{\gamma} + z_B + \frac{V_B^2}{2g}$

$\hookrightarrow h_A = \frac{P_B}{\gamma} + z_B + h_L$

$h_A = \frac{(40)(144)}{62.4} + 120 + 10.5 = 222.81 \text{ ft-lb/lb}$



a) $P = h_A \gamma Q$

$Q = 745 \text{ gal/h} = 0.0277 \text{ ft}^3/\text{s}$

$P = (222.81)(62.4)(0.0277) = 385.12/550$

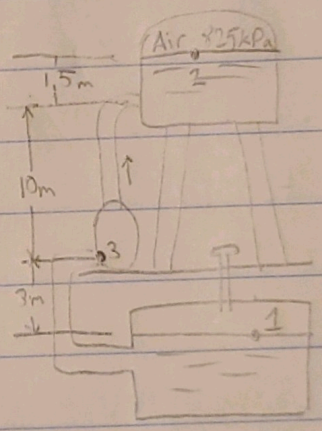
$\boxed{P = 0.70 \text{ hp}}$

b) $e_M = P_A / P_I = 0.7/1 = \boxed{0.70}$

7.16 $h_A + \frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_{L1-2}$

$h_A = \frac{P_2}{\gamma} + z_2 + h_{L1-2}$

$h_A = \frac{825}{0.85 \times 980} + 14.5 + 4.2 = 117.64 \text{ m}$



a) $P = (0.85 \times 9810) \times 0.014 \times 117.64 = \boxed{13.733 \text{ kW}}$

$\frac{P_3}{\gamma} + \frac{V_3^2}{2g} + z_1 = \frac{P_3}{\gamma} + \frac{V_3^2}{2g} + z_3 + h_{L1-3}$

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

$V_3 = Q/A_3 \rightarrow Q = 840 \text{ L/min} = 0.014 \text{ m}^3/\text{s}$

$V_3 = 0.014/0.00309 = 4.531 \text{ m/s}$

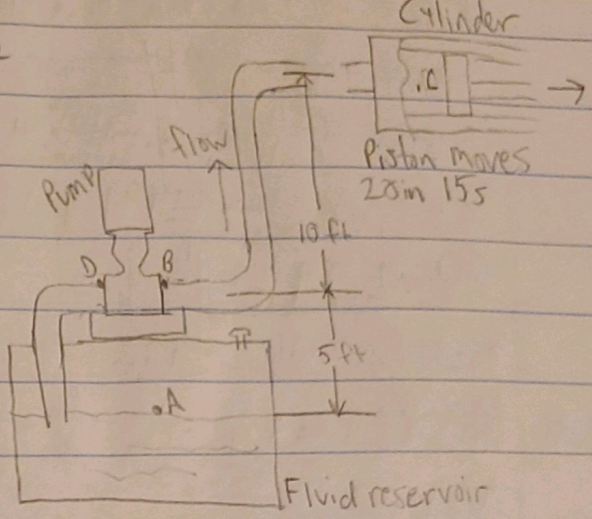
$P_3 = (0.85 \times 9810)\left(-\frac{4.531}{2 \times 9.81} - 3 - 1.4\right) = \boxed{-45.41 \text{ kPa}}$

7.22 a) $Q = vA$

$A = \pi(5\,in)^2/4 = 19.635\,in^2 \rightarrow 0.136\,ft^2$

$20\,in \rightarrow 1.667\,ft$

$Q = \left(\frac{1.667\,ft}{15\,s}\right)(0.136\,ft^2) = \boxed{0.015\,ft^3/s}$



b) $P = F/A = \frac{11000\,lb}{19.635\,in^2} = 560.22\,lb/in^2$

$\hookrightarrow \boxed{P = 80,671.68\,lb/ft^2}$

c) 3/8-in schedule 80: $0.000976\,ft^2$

Velocity at pump: $v = 0.015\,ft^3/s \,/\, 0.000976\,ft^2 = 15.37\,ft/s$

Velocity at cylinder: $v = 1.667\,ft \,/\, 15\,s = 0.111\,ft/s$

$\gamma_o = 0.9(62.4\,lb/ft^3) = 56.16\,lb/ft^3$

$\frac{P_B}{\gamma_o} + Z_B + \frac{V_B^2}{2g} - h_L = \frac{P_C}{\gamma_o} + Z_C + \frac{V_C^2}{2g}$

$\hookrightarrow P_B = P_C + \gamma_o\left(\left(V_C^2 - V_B^2/2g\right) + (Z_C - Z_B) + h_L\right)$

$P_B = 80,671.68 + 56.16\left(\left(\frac{(0.111)^2 - (15.37)^2}{2(32.2)}\right) + (10-0) + 35\right)$

$\boxed{P_B = 82,992.88\,lb/ft^3}$

d) $\frac{P_A}{\gamma_o} + Z_A + \frac{V_A^2}{2g} - h_L = \frac{P_D}{\gamma_o} + \frac{V_D^2}{2g} = Z_D \rightarrow Z_A - h_L = \frac{P_D}{\gamma_o} + \frac{V_D^2}{2g} + Z_D$

$\hookrightarrow \frac{P_D}{\gamma_o} = Z_A - h_L - \frac{V_D^2}{2g} - Z_D \rightarrow P_D = \gamma_o\left((Z_A - Z_D) - \frac{V_D^2}{2g} - h_L\right)$

$P_D = 56.16\left((-5-0) - \frac{(15.37)^2}{2(32.2)} - 11.5\right) = \boxed{-1132.65\,lb/ft^3}$

e) $\frac{P_A}{\gamma_0} + \frac{V_A^2}{2g} + z_A + h_A - h_{LS} - h_{Ld} = \frac{P_C}{\gamma_0} + \frac{V_C^2}{2g} + z_C$

$\hookrightarrow h_A = \frac{P_C}{\gamma_0} + \frac{V_C^2}{2g} + (z_C - z_A) + h_{LS} + h_{Ld}$

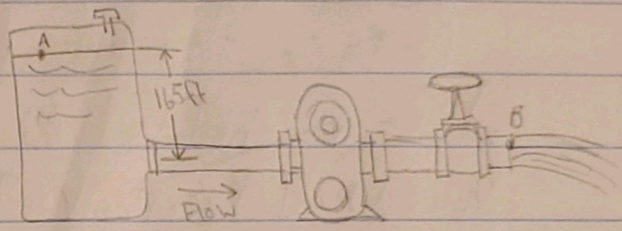
$\hookrightarrow h_A = \frac{80,671.68}{56.16} + \frac{(0.111)^2}{2(32.2)} + (10 - (-5)) + 11.5 + 35 = 1497.96\ ft$

$P = h_A \gamma Q \rightarrow (1497.96)(56.16)(0.015) = 1261.88\ lb \cdot ft/s$

$\boxed{P = 2.29\ hp}$

7.30 $\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A + h_R - h_L = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B$

diameter = 0.6651 ft



$z_A + h_R - h_L = \frac{V_B^2}{2g}$

$\hookrightarrow h_L = \frac{-V_B^2}{2g} + z_A - h_R$

$V = Q/A \quad 1000\ gal/min = 2.228\ ft^3/s$

$V = \frac{(4)(2.228)}{\pi (0.6651)^2} = 6.413\ ft/s$

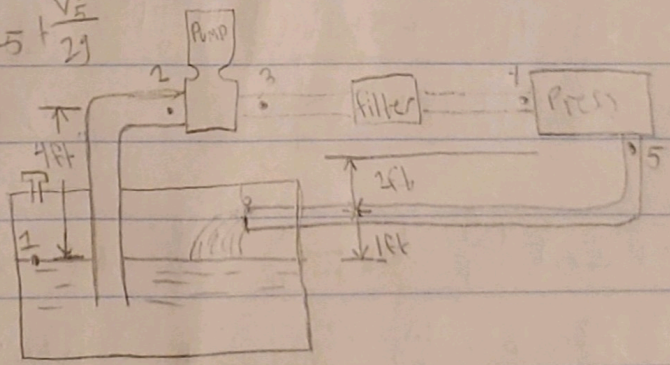
$P_R = h_R \gamma Q \rightarrow h_R = \frac{P_R}{\gamma Q} = \frac{37}{62.4 \times 2.228} \times 550 hp = 146.37\ ft$

$h_L = \frac{-(6.413)^2}{2(32.2)} + 165 - 146.37 = \boxed{17.99\ ft}$

7.35 $\frac{P_4}{\gamma} + z_4 + \frac{V_4^2}{2g} - h_R = \frac{P_5}{\gamma} + z_5 + \frac{V_5^2}{2g}$

$h_R = \frac{P_4 - P_5}{\gamma} + (z_4 - z_5) + \frac{V_4^2 - V_5^2}{2g}$

$h_R = z_4 - z_5 + \frac{V_5^2}{2g} - h_L$



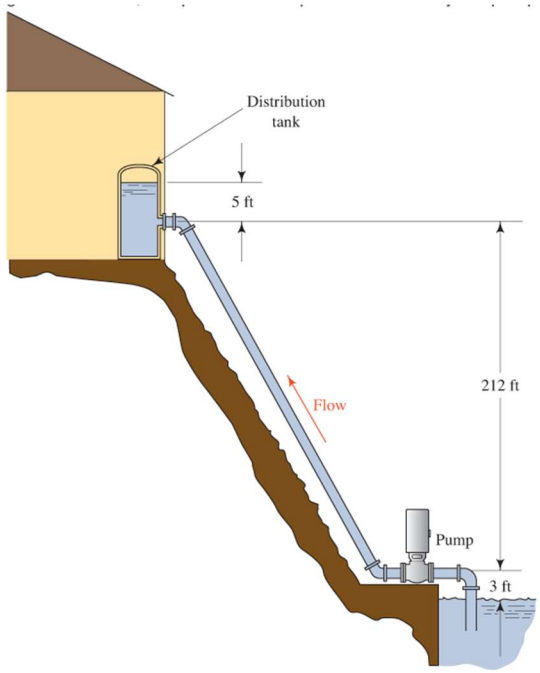
$Q = 175\ gal/min = 0.390\ ft^3/s$

$v_5 = 0.390 / 0.03326 = 11.73\ ft/s$

$h_R = 4 - 3 + \frac{11.73}{2 \times 32.2} = 1.18\ ft$

$P_R = h_R \gamma Q = (1.18)(56.16)(0.390) = 25.84 \rightarrow 0.047\ 0$

7-42



7-42 $Q = 0.089\ ft^3$ $h_L = 15.5\ Lb\cdot ft/lb$ $P = 30\ PSI$

$$h_A + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + h_{L1-2}$$

$$h_A = \frac{P_2 - P_1}{\gamma} + \frac{V_2^2 - V_1^2}{2g} + Z_2 - Z_1 + h_{L1-2}$$

$$h_A = \frac{P_2}{\gamma} + Z_2 + h_{L1-2}$$

$$\therefore h_A = \frac{30 \times 1440}{62.4} + 220 + 15.5$$

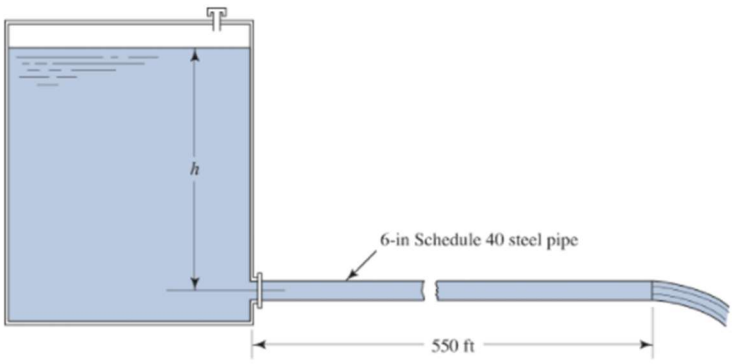
$$\therefore h_A = 304.73\ ft$$

$$\therefore P_A = \gamma Q h_A$$

$$\therefore P_A = (0.089)(62.4)(304.73)$$

$$\therefore P_A = 3.077\ h_P$$

8-33



8-33

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

$V_1 = 0 \quad P_1 = P_2 \quad Z_1 = h, \quad Z_2 = 0$

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

$$h - h_L = 0 + \frac{V_2^2}{2g}$$

$$h = h_L + \frac{V_2^2}{2g}$$

$$V = \frac{2.5}{0.2006}$$

$V = 12.46 \text{ FT/S}$

$\nu = 9.15 \times 10^{-6}$

$$N_R = \frac{VD}{\nu}$$

$N_R = 6.8 \times 10^5$

$$\text{Roughness} = \frac{D}{\varepsilon}$$

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

$$\frac{D}{\varepsilon} = 3367.3$$

$f = 0.01$

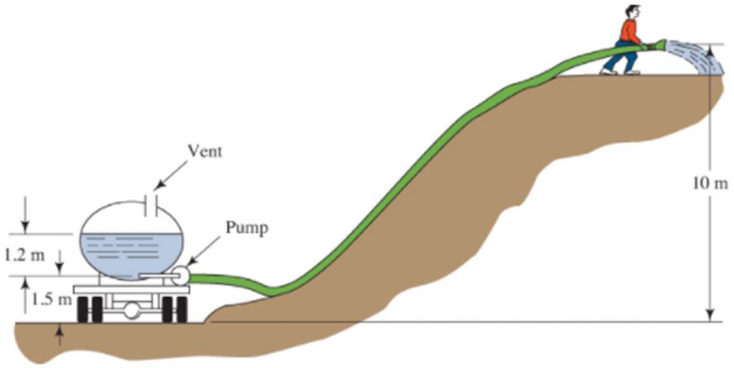
$$h_L = f\left(\frac{V_2^2}{2g} \cdot \frac{L}{D}\right)$$

$h_L = 43.28$

$$h = \frac{12.46^2}{2.32^2} + 43.28$$

$h = \boxed{45.6}$

8-38



8-38

$$\frac{P_1}{\gamma} + Z_1 + \frac{V_1^2}{2g} + h_A = \frac{P_2}{\gamma} + Z_2 + \frac{V_2^2}{2g} + h_L$$

$$h_A = \frac{P_2}{\gamma} - \frac{P_a}{\gamma} + Z_2 - Z_1 + \frac{V^2}{2g} + h_L$$

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

$d = 0.025\,m$

$A = 4.909 \times 10^{-4}\,m^2$

$$V = \frac{Q}{A}$$

$Q = 1.583 \cdot 10^{-3}\,m^3/s$

$V = 3.22\,m/s$

$\rho = Sg \cdot \rho_w$

$Sg = 1.1$

$\rho_w = 1000\,kg/m^3$

$\rho = 1100\,kg/m^3$

$$Re = \frac{\rho V d}{\eta}$$

$\eta = 2 \cdot 10^{-3}$

$Re = 44275$

$f = 0.024$

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

$L = 85\,m$

$h_L = 43.122\,m$

$\gamma = Sg \cdot \gamma_w$

$\gamma_w = 9.81\ KN/m^3$

$\gamma = 10.791\ KN/m^3$

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

$h_A = 54.197\ m$

$P = h_A \cdot Q \cdot \gamma$

$P = 0.592\ KW$

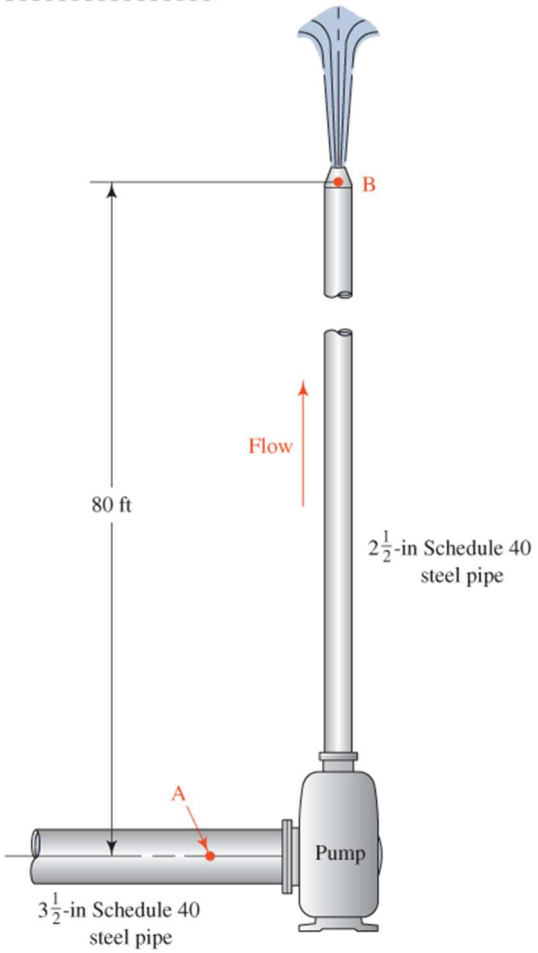
$\frac{P_1}{\gamma} + z_1 + h_A = \frac{P_3}{\gamma} + z_3 + \frac{V^2}{2g}$

$P_3 = 693\ KPA$

p

8-44

of the nozzle must be



8-44

$Q = 0.5 ft^3/s$ $A_A = 0.06868 ft^2$

$V_A = \frac{Q}{A_A}$

$V_A = 7.28 ft/s$

$V_B = \frac{Q}{A_B}$

$A_B = 0.03326 ft^2$

$V_B = 15.03 ft/s$

$P_f = SG \cdot P_w$

$1.94 \cdot 1.026$

$P_f = 1.9951 lb/ft^3$

$N_R = \frac{V_B D_B P_f}{\mu}$

$N_R = 1.54 \times 10^5$

$1.54 \times 10^5 > 2000$

Turbulent

$roughness = \frac{D_B}{\varepsilon}$

$\frac{0.2058 ft}{1.5 \times 10^{-4} ft}$

$roughness = 1372$

$$f = \frac{0.25}{\left(\log\left(\frac{1}{3.7(1372)} + \frac{5.47}{(1.54\times10^{5})^{0.9}}\right)\right)^{2}}$$

$f = 0.02$

$$h_L = \frac{f L V_B^2}{2gDB}$$

$$h_L = \frac{(0.02)(80)(15.03)^2}{2(32.2)(0.2058)}$$

$h_L = 27.27 ft$

$\gamma_f = Sg(\gamma_w)$

$\gamma_f = 1.026(62.4\ lb/ft^3)$

$\gamma_f = 64.02 lb/ft^3$

$$\frac{P_A}{\gamma_f} + \frac{V_A^2}{2g} + Z_A + h_A - h_L = \frac{P_B}{\gamma_f} + \frac{V_B^2}{2g} + Z_B$$

$$h_A = \frac{P_B - P_A}{\gamma_f} + Z_B - Z_A + \frac{V_B^2 - V_A^2}{2g} + h_L$$

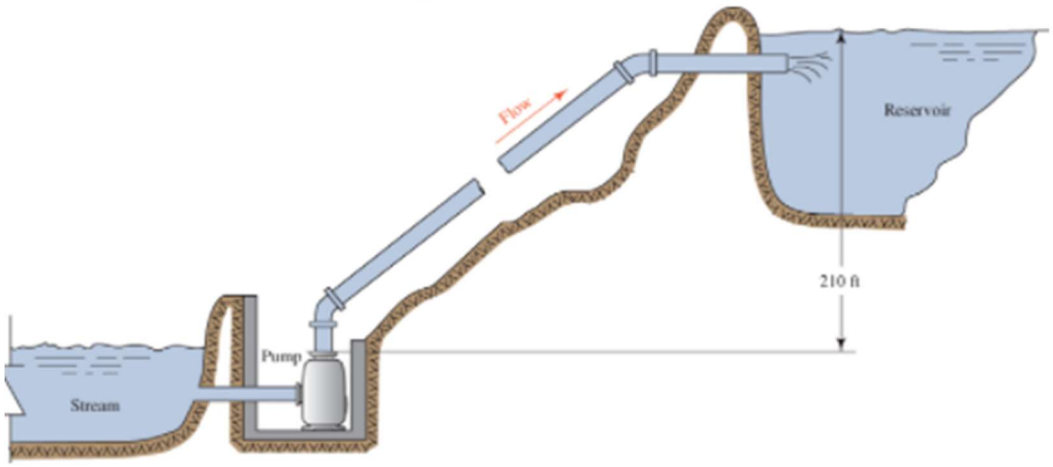
$h_A = 174.485 ft$

$$P = \frac{h_A \gamma_f Q}{550}$$

$P = \underline{10.2\ hp}$

8-46

s 0.68 m below the second point.



8-46

$Q = 4 ft^3/s$ $d = 0.75 ft$

$$V = \frac{Q}{\frac{\pi}{4} d^2}$$

$V = 11.46 \text{ ft/s}$

$\nu = 1.21 \cdot 10^{-5} ft^2/s$

$$N_R = \frac{Vd}{\nu}$$

$N_R = 631404.95$

$$\text{Roughness} = \frac{\epsilon}{d}$$

$\epsilon = 1.5 \times 10^{-4}$

Roughness $= 0.000225$

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

$h_L = 117 ft$

$$P_1 = \gamma((z_2 - z_1) + h_L)$$

$P_1 = 1411.7 \text{ Psia}$

49. $Q = 300 \frac{gal}{min}$ $sg = 0.89$ $\nu = 2.15 \cdot 10^{-3} \frac{ft^2}{s}$ Find pump power. $A_s = 0.0884\ ft^2$

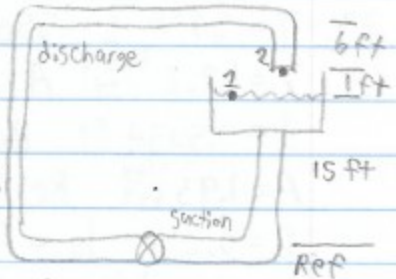
$h_a + z_1 = \frac{V_2^2}{2g} + z_2 + h_L$ $A_2 = 0.05132\ ft^2$ $V_2 = Q/A_2$

$Q = 300 \frac{gal}{min} = 0.669 \frac{ft^3}{s}$ $V_2 = 13.03 \frac{ft}{s}$

$d_d = 0.2557\ ft$ $d_s = 0.3355\ ft$ $h_L = h_s + h_d$

$Re_{,d} = (V_2 \cdot d_d)/\nu = 1550$ $f_d = 64/Re_{,d} = 0.0413$

$h_d = f_d \frac{L_d}{d_d} \cdot \frac{V_2^2}{2g}$ $L_d = 75\ ft$ $h_d = 31.97\ ft$



$Re_{,s} = (V_s \cdot d_s)/\nu$ $V_s = Q/A_s = 7.557 \frac{ft}{s}$ $Re_{,s} = 1179.2$

$f_s = 64/Re_{,s} = 0.0543$ $h_s = f_s \cdot \frac{L_s}{d_s} \cdot \frac{V_s^2}{2g}$ $L_s = 25\ ft$ $h_s = 3.59\ ft$

$h_a = \frac{V_2^2}{2g} + z_2 + h_s + h_d - z_1 = 39.2$ $P = h_a \cdot Q \cdot \gamma = 1454.2 \frac{ft \cdot lb}{s}$

$P = 1454.2/550 = 2.64\ hp$

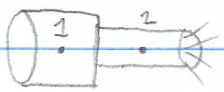
62. $V = 12\ ft/s$ $T = 77°F$ Find friction factor, f. $d = 0.5054\ ft$

$\nu = 1.27 \cdot 10^{-3} \frac{ft^2}{s}$ $Re = (V \cdot d)/\nu = 4775$ $f = 0.25/\left(\log\left(\frac{1}{3.7 \cdot d/\varepsilon} + \frac{5.74}{Re^{0.9}}\right)\right)^2$

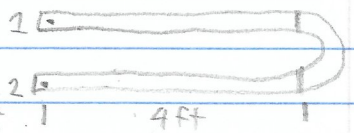
$\varepsilon = 1.5 \cdot 10^{-4}\ ft$ $f = 0.00566$

MET 330 Chapter 10 HW

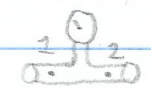
20. $Q = 500\ L/min$ $d_1 = 0.1223\ m$ $A_1 = 0.01173\ m^2$ $d_2 = 0.0493\ m$
$A_2 = 0.00191\ m^3$ Find energy loss, h_L.
$h_L = K \cdot V_2^2/2g$ $V_2 = Q/A_2$ $Q = 500\ L/min = 0.0093\ m^3/s$
$V_2 = 0.437\ m/s$ $d_1/d_2 = 2.48$ $K = 0.92$ $h_L = 0.00409\ \frac{N \cdot m}{N}$



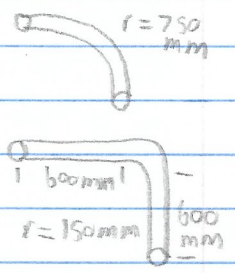
37. $Q = 12.5\ gal/min = 0.0279\ ft^3/s$ $d = 0.0518\ ft$ $A = 0.00211\ ft^2$
Find ΔP. $h_{Lb} = K \cdot \frac{V^2}{2g}$ $K = \frac{Le}{d} \cdot f_T$ $\frac{Le}{d} = 50$
$f_T = 0.026$ $K = 1.3$ $V = Q/A = 13.22\ ft/s$
$h_{Lb} = 3.53\ ft$ $Re = (V \cdot d)/\nu$ $\nu = 1.59 \cdot 10^{-4}\ ft^2/s$
$Re = 4307$ $f = 0.25/\left(\log\left(\frac{1}{3.7 \cdot D/\varepsilon} + \frac{5.74}{Re^{0.9}}\right)\right)^2$ $\varepsilon = 1.5 \cdot 10^{-4} \cdot f = 0.0429$
$h_L = f \cdot L/d \cdot \frac{V^2}{2g}$ $L = 8\ ft$ $h_L = 18\ ft$ $\frac{P_1}{\gamma} = h_L + h_{Lb} + \frac{P_2}{\gamma}$
$\Delta P = \gamma(h_L + h_{Lb})$ $\gamma = 68.47\ lb/ft^3$ $\Delta P = 1474.56\ lb/ft^2 = 10.24\ psi$



39. $Q = 0.4\ ft^3/s$ $T = 50^\circ F$ $\gamma = 62.4\ lb/ft^3$ $\nu = 1.4 \cdot 10^{-5}\ ft^2/s$ Find h_L.
$d = 0.2557\ ft$ $A = 0.05132\ ft^2$ $V = 7.79\ ft/s$
$K = 20 \cdot f_T$ $f_T = 0.017$ $K = 0.34$ $h_L = K \cdot \frac{V^2}{2g} = 0.32\ ft$



43. $Q = 750\ L/min$ $\gamma = 7.87\ kN/m^3$ $\nu = 2.39 \cdot 10^{-6}\ m^2/s$ $OD = 50\ mm$ $t_w = 2\ mm$
$d = 46\ mm$ $A = 1.662 \cdot 10^{-3}\ m^2$ Find h_L for each.
1) $Q = 0.0125\ m^3/s$ $V = 7.52\ m/s$ $r/d = 16.3$ $\frac{Le}{d} = 43$
$\varepsilon = 1.5 \cdot 10^{-6}\ m$ $d/\varepsilon = 30667$ $Re = 144736$
$f_T = 0.0095$ $K = f_T \cdot \frac{Le}{d} = 0.4085$ $h_L = 1.177\ m$
2) $r/d = 3.26$ $\frac{Le}{d} = 13$ $K = 0.1235$ $h_{Lb} = 0.356\ m$
$f = 0.0168$ $h_L = f \cdot \frac{L}{d} \cdot \frac{V^2}{2g}$ $L = 1.2\ m$ $h_L = 1.58\ m$



10.46 $\frac{P_1}{\gamma} + z_1 + \frac{V_1^2}{2g} - h_L = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g}$

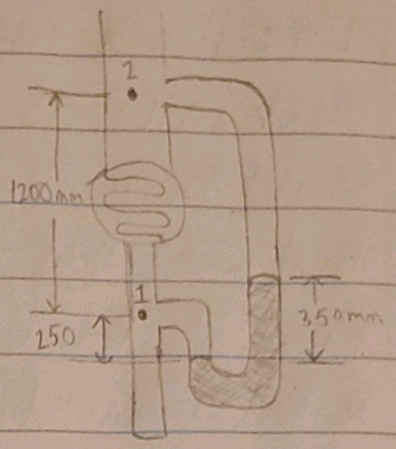
$\hookrightarrow h_L = \frac{P_1 - P_2}{\gamma} + z_1 - z_2 + \frac{V_1^2 - V_2^2}{2g}$

$A_1 = \frac{\pi(0.05)^2}{4} = 0.00196 m^2$

$A_2 = \frac{\pi(0.10)^2}{4} = 0.00785 m^2$

$V_1 = Q/A_1 = \frac{6 \times 10^{-3}}{0.00196} = 3.056 m/s$

$V_2 = \frac{6 \times 10^{-3}}{0.00785} = 0.764 m/s$



$P_1 + \gamma h_1 - \gamma h_2 - \gamma h_3 = P_2$

$\hookrightarrow P_1 - P_2 = \gamma h_1 + \gamma(h_3 - h_2) \rightarrow \frac{P_1 - P_2}{\gamma} = \frac{\gamma(0.35)}{\gamma} + \frac{\gamma(0.85)}{\gamma}$

$\frac{P_1 - P_2}{\gamma} = 4.80 + 0.85 = 5.65 m$

$h_L = 5.65 - 1.20 + \frac{(3.056)^2}{2(9.81)} - \frac{(0.764)^2}{2(9.81)} = 4.9 m$

$h_L = K(V^2/2g) \rightarrow K = \frac{h_L}{V^2/2g} = 4.9/0.476 = \boxed{10.3}$

10.48 $A = 6.409 \times 10^{-3} ft^2$ $D = 0.09033 ft$

$r/D = \frac{3.25 \times 1/12}{0.09033} = 2.998$

$\epsilon = 1.5 \times 10^{-4} ft \rightarrow D/\epsilon = 0.09033/1.5 \times 10^{-4} = 602.2$

$K = f_T(L_e/D) = (0.022)(12.5) = 0.2775$

$V = Q/A \rightarrow Q = 27.5 gal/min = 0.06127 ft^3/s$

$V = 0.06127/6.409 \times 10^{-3} = 9.559 ft/s$

$h_L = K(V^2/2g) = 0.2775 \times \frac{(9.559)^2}{2(32.2)} = \boxed{0.394 ft}$