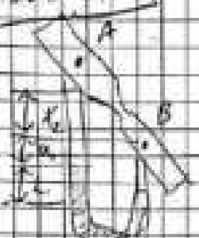
HOMEWORK MODULE 2

ROY SHEPARD

Roy Stephens MET 330 Chap 6
HW 2-1 79, 82, 91

Problem 79



$D_{@large} = 4\,in = 0.333\,ft$

$D_{@small} = 2\,in = 0.167\,ft$

$S_{gm} = 13.54$

$S_{go} = 0.90$

$h = 28\,in = 2.333\,ft$

$\gamma_w = 62.4\,\frac{lb}{ft^3}$

Area @ A

$A_A = \frac{D^2 \cdot \pi}{4} = \frac{(0.333\,ft)^2 \cdot \pi}{4} = 0.087$

Area @ B

$A_B = \frac{D^2 \cdot \pi}{4} = \frac{(0.167)^2 \cdot \pi}{4} = 0.0219$

Find velocity @ A & B

$Q = A_A \cdot V_A = A_B \cdot V_B \therefore V_A = \frac{Q}{A_A},\ V_B = \frac{Q}{A_B}$

Find γ_o

$\gamma_o = S_{go} \cdot \gamma_w = 0.9(62.4) = 56.16\,\frac{lb}{ft^3}$

Find $\gamma_m = S_{gm} \cdot \gamma_w = 13.54(62.4) = 844.81\,\frac{lb}{ft^3}$

Difference of elevation between A & B

$z_A - z_B = x_2$

Find flow rate

$$\frac{p_A}{\gamma_o} - z_A + \frac{v_A^2}{2 \cdot g} = \frac{p_B}{\gamma_o} + z_B + \frac{v_B^2}{2 \cdot g}$$

$$v_B^2 - v_A^2 = 2g\left(\frac{\Delta p}{\gamma_o} + x_2\right)$$

$$\left(\frac{Q}{A_B}\right)^2 - \left(\frac{Q}{A_A}\right)^2 = 2g\left(\frac{(\gamma_m - \gamma_o) \cdot h}{\gamma_o} - \frac{\gamma_o \cdot x}{\gamma_o} + x\right)$$

$$Q^2 \cdot \frac{A_A^2 - A_B^2}{A_A^2 \cdot A_B^2} = 2gh\left(\frac{\gamma_m - \gamma_o}{\gamma_o}\right)$$

$$Q = \sqrt{\frac{A_A^2 \cdot A_B^2}{A_A^2 - A_B^2}} \cdot \sqrt{2gh\left(\frac{\gamma_m - \gamma_o}{\gamma_o}\right)}$$

$$Q = \sqrt{\frac{(0.087)^2 \cdot (0.0219)^2}{(0.087)^2 - (0.0219)^2}} \cdot \sqrt{2 \cdot 32.2 \cdot 2.333\left(\frac{844.81 - 56.16}{56.16}\right)}$$

$$\boxed{Q = 1.087\,\frac{ft^3}{s}}$$

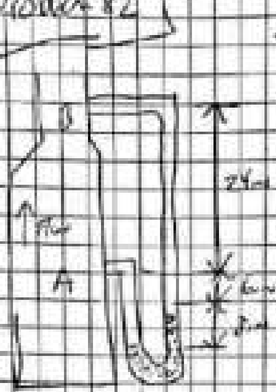
Problem 82

large pipe = 4 in sch 40

Small pipe = 2 in sch 40

$\gamma_o = 55\,\frac{lb}{ft^3}$

$\gamma_w = 62.4\,\frac{lb}{ft^3}$



Find Area see table 5

$A_A = 8.727 \times 10^{-2}$

$A_B = 2.162 \times 10^{-2}$

Find velocity @ A & B

$Q = A_A \cdot V_A = A_B \cdot V_B$

$V_A = \frac{Q}{A_A} \qquad V_B = \frac{Q}{A_B}$

Find pressure between A & B

$p_A = p_B + \gamma_o \cdot \frac{8\,ft}{12} - \gamma_w \cdot \frac{8}{12} + \gamma_o \cdot \frac{6 + 24}{12}\,ft$

$p_A - p_B = \Delta p = 55 \cdot 1.833 + 62.4 \cdot 0.667$

$\Delta p = 114.536\,\frac{lb}{ft^2}$

Elevation difference

$z_B - z_A = \Delta z = 24 = \frac{24}{12} = 2\,ft$

Find flow rate

$$\frac{p_A}{\gamma_o} + z_A + \frac{v_A^2}{2 \cdot g} = \frac{p_B}{\gamma_o} + z_B + \frac{v_B^2}{2 \cdot g}$$

$$v_B^2 - v_A^2 = 2g\left(\frac{\Delta p}{\gamma_o} - \Delta z\right)$$

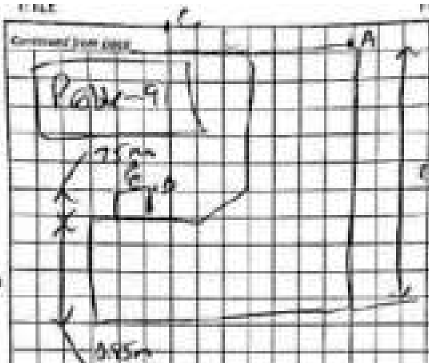
$$\left(\frac{Q}{A_B}\right)^2 - \left(\frac{Q}{A_A}\right)^2 = 2g\left(\frac{\Delta p}{\gamma_o} - \Delta z\right)$$

$$Q = \sqrt{\frac{A_A^2 \cdot A_B^2}{A_A^2 - A_B^2}} \cdot \sqrt{2g\left(\frac{\Delta p}{\gamma_o} - \Delta z\right)}$$

$$Q = \sqrt{\frac{(0.0884)^2 \cdot (0.0233)^2}{(0.0884)^2 - (0.0233)^2}} \cdot \sqrt{2 \cdot 32.2\left(\frac{114.536}{55} - 2\right)}$$

$$\boxed{Q = 0.0581\,\frac{ft^3}{s}}$$

Problem-9



Find elevation between A & B

$z_A - z_B = 2.6 - 0.85 - 0.75 = 1.675m$

Torricelli theorem to find velocity

$v_B = \sqrt{2g(z_A - z_B)} = \sqrt{2 \cdot 9.81 \cdot 1.675} = 5.733 \frac{m}{s}$

Find height of z_C

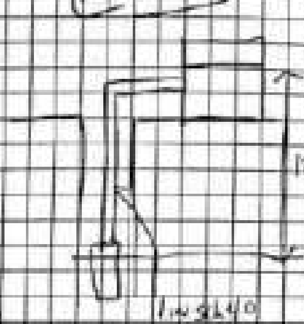
$z_C - z_B + h$

$z_B + \frac{v_B^2}{2g} = z_C \quad z_C - z_B = h = \frac{v_B^2}{2g}$

$\left(\frac{5.733^2}{2 \cdot 9.81}\right) = \boxed{1.675m}$

Chapter 7 11, 16, 22, 29, 35, 42

Problem 11



Pump delivers 745 gal/h
Pipe = 1 in sch 40
Loss = 10.5 lb·ft/lb

Energy

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

$\cancel{\frac{p_1}{\gamma}} + z_1 + h_A - h_L = \frac{p_2}{\gamma} + z_2$

$z_1 + h_A - h_L = \frac{p_2}{\gamma} + z_2$

$= h_A = \frac{p_2}{\gamma} + z_2 - z_1 + h_L = \frac{40 \cdot 144}{62.4} + 120 + 10.5$

$h_A = 222.8 ft$

$Q = \frac{745}{60 \cdot 448} = 0.0277 \frac{ft^3}{s}$

Find power of pump

$P_A = h_A \cdot \gamma \cdot Q$

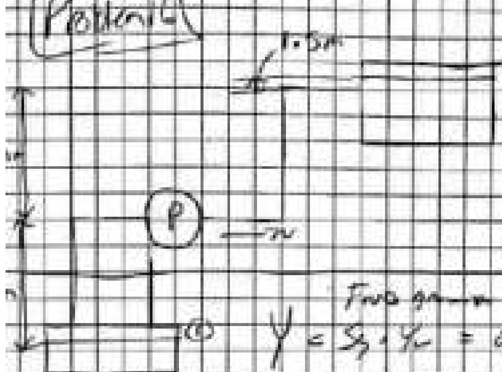
$P_A = 222.8 \cdot 62.4 \cdot 0.0277 \frac{ft^3}{s} = 0.7hp$

$\boxed{P_A = 0.7hp}$

Efficiency

$e_M = \frac{P_A}{P_I} = \frac{0.7}{1} = \boxed{e_M = 0.7}$

Problem 16



Flow = 840 L/min
sg = 0.85
P2 = 825 kPa
Pipe DN 50 sch 40
γ_w = 9.81

Find gamma

$\gamma = s_g \cdot \gamma_w = 0.85(9.81) = 8338.5 \frac{N}{m^3}$

Pump power

$P_A = h_A \cdot \gamma \cdot Q = (4.2)(8338.5)\left(0.014 \frac{m^3}{s}\right) = \boxed{490.3 W}$

Find energy

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

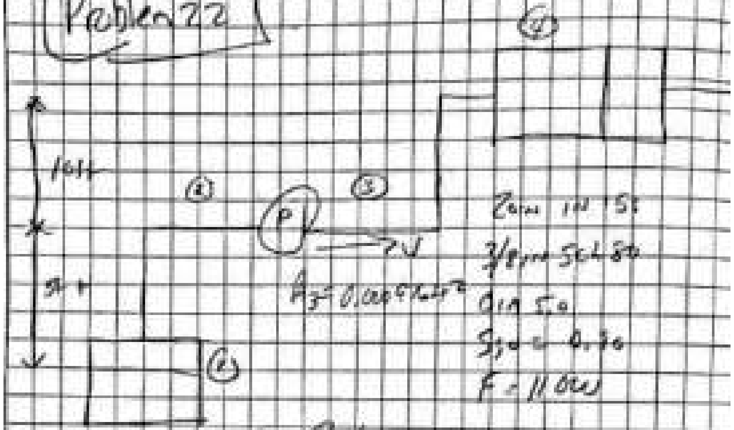
$\frac{p_1}{\gamma} = z_2 - z_1 + \frac{p_2}{\gamma} + h_L$

$p_1 = \gamma\left(z_2 - z_1 + \frac{p_2}{\gamma} + h_L\right)$

$p_1 = (8338.5)\left((3+10+1.5) + \left(\frac{825000}{8338.5}\right) + 1.4\right)$

$= 957587 Pa = \boxed{957.587 kPa}$

Problem 22



2 in in 1.5
3/8 in sch 80
D in 5.0
$S_{go} = 0.90$
$F = 1100$

Find Area @ 4

$A_4 = \frac{D_4^2 \cdot \pi}{4} = \frac{\left(\frac{5}{12}\right)^2 \cdot \pi}{4} = 0.1364 ft^2$

$Q = \frac{A_4 \cdot L}{t} = \frac{0.1364 \cdot 20 \cdot \frac{1}{12}}{15} = \boxed{0.01515 \frac{ft^3}{s}}$

Find Pressure

$P_4 = \frac{F}{A_4} = \frac{1100}{0.1364} = \boxed{80645.16 \frac{lb}{ft^2}}$

$U_3 = \frac{Q}{A_3} = \frac{0.01515}{0.000976} = 15.52 \frac{ft}{s}$

$U_4 = \frac{L}{t} = \frac{20}{15 \cdot 12} = 0.1111 \frac{ft}{s}$

$\gamma_o = S_{go} \cdot \gamma_w = 0.9 \cdot 62.4 = 56.16 \frac{lb}{ft^3}$

Energy for P_3 and P_4

$\frac{P_3}{\gamma_o} + z_3 + \frac{U_3^2}{2g} + h_A - h_R - h_{L,3-4} = \frac{P_4}{\gamma_o} + z_4 + \frac{U_4^2}{2g}$

$P_3 = \gamma_o\left(\frac{P_4}{\gamma_o} + z_4 - z_3 + \frac{U_4^2 - U_3^2}{2g} + h_{L,3-4}\right)$

$P_3 = 56.16\left(\frac{80645.16}{56.16} + 10 + \frac{0.1111^2 - 15.52^2}{2 \cdot 32.2} + 30\right)$

$\boxed{= 82362.32 \frac{lb}{ft^2}}$

Energy P_1 and P_2

$\frac{P_1}{\gamma_o} + z_1 + \frac{U_1^2}{2g} + h_A - h_R - h_{L,1-2} = \frac{P_2}{\gamma_o} + z_2 + \frac{U_2^2}{2g}$

$P_2 = \gamma_o\left(z_1 - z_2 - \frac{U_2^2}{2g} - h_{L,1-2}\right) = 56.16\left(-5 - \frac{15.52^2}{2 \cdot 32.2} - 11.5\right)$

$\boxed{= -1134.72 \frac{lb}{ft^2}}$

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Energy @ P1 & P4

$\frac{P_1}{\gamma_o} + z_1 + \frac{U_1^2}{2g} + h_A - h_R - h_{L,1-4} = \frac{P_4}{\gamma_o} + z_4 + \frac{U_4^2}{2g}$

$h_A = \frac{P_4}{\gamma_o} + z_4 - z_1 + \frac{U_4^2}{2g} + h_{L,1-4}$

$h_A = \frac{80645.16}{56.16} + 10 + 5 + \frac{0.1111^2}{2 \cdot 32.2} + 46.5$

$= 1497.49 ft$

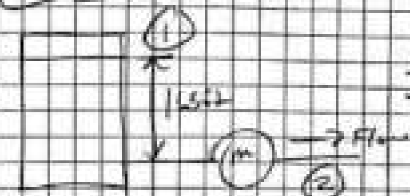
$P_P = h_A \cdot \gamma_o \cdot Q$

$1497.49 \cdot 56.16 \cdot 0.01515 \frac{1}{550}$

$\boxed{= 2.317 hp}$

Problem 34

$D_1 = 0.6651 ft$ 60°F
6 in sch 40
1000 gal/min $= 2.227 \frac{ft^3}{s}$
37 hp
$\gamma_w = 62.4$



Find Area @ 1

$A_1 = \frac{D_1^2 \cdot \pi}{4} = \frac{(0.6651)^2 \cdot \pi}{4} = 0.3474 ft^2$

Find Velocity

$U_1 = \frac{Q}{A_1} = \frac{2.227}{0.3474} = 6.41 \frac{ft}{s}$

Find energy removed

$P_M = h_R \cdot \gamma \cdot Q \quad h_R = \frac{P_M}{\gamma \cdot Q} = \frac{37 \cdot 550}{62.4 \cdot 2.227} = 146.44 ft$

Energy @ ...

$\frac{P_1}{\gamma} + z_1 + \frac{U_1^2}{2g} + h_A - h_R - h_L = \frac{P_2}{\gamma} + z_2 + \frac{U_2^2}{2g}$

$h_L = z_1 - z_2 - \frac{U_2^2}{2g} - h_R = 165 - \frac{6.41^2}{2 \cdot 32.2} - 146.43$

$\boxed{= 17.552 ft}$

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Problem 35

3 in 2.1 ft
2.5 in 3.1 ft
$S_g = 0.93$

$Q = 0.28\,ft^3/s = 175\,gal/min$
$P_{wire\ input} = 28.4\,hp$
$e_{pump} = 80\%$

h Energy loss 1-2 = 8.0 lb-ft/lb
h Energy loss 3-4 = 5.0 lb-ft/lb
h Energy loss 5-6 = 35.0 lb-ft/lb

$$e_P = \frac{P_A}{P_I} \Rightarrow P_A = P_I \cdot e_P = 28.4 \cdot 0.8 = 22.72\,hp$$

$$\gamma = S_g \cdot \gamma_w = 0.93 \cdot 62.4 = 58.032\ \frac{lb}{ft^3}$$

$$A_6 = \frac{D_6^2 \pi}{4} = \frac{(0.2056)^2 \cdot \pi}{4} = 0.03320\,ft^2$$

$$v_6 = \frac{Q}{A_6} = \frac{0.39}{0.03320} = 11.72\ \frac{ft}{s}$$

Energy

$$\frac{P_1}{\gamma} + z_1 + \frac{v_1^2}{2g} + h_A - h_R - h_L = \frac{P_6}{\gamma} + z_6 + \frac{v_6^2}{2g}$$

$h_L = h_{L,1-2} + h_{L,3-4} + h_{L,5-6}$

$h_L = 2.8 + 26.5 + 3.5 = 34.5\,ft$

$$P_A = h_A \cdot \gamma \cdot Q \Rightarrow h_A = \frac{P_A}{\gamma Q} \quad \frac{22.72 \cdot 550}{58.032 \cdot 0.39} = 552.13\,ft$$

$$h_R = -h_L + z_1 - z_6 + h_A - \frac{v_6^2}{2g}$$

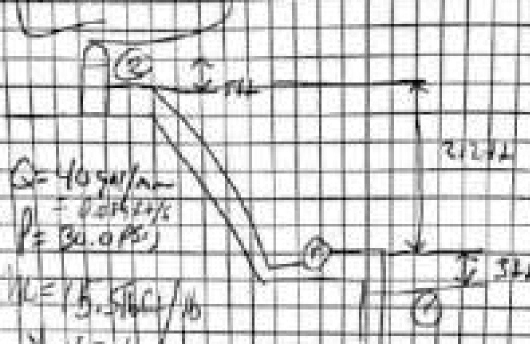
$$h_R = -34.5 + (-1) + 552.13 - \frac{11.72^2}{2 \cdot 32.2} = 514.24$$

$P_R = h_R \cdot \gamma \cdot Q$

$= 514.2 \cdot 58.032 \cdot 0.39 \cdot \frac{1}{550}$

$\boxed{= 21.16\,hp}$

Problem 42



$Q = 40\,gal/min = 0.0891\,ft^3/s$
$P = 30.0\,psi$
$h_L = 15.5\,lb\text{-}ft/lb$
$\gamma = 62.4$

Energy Eq

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

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

$$= \frac{30 \cdot 144}{62.4} + (5 + 212 + 7) + 15.5$$

$= 304.73\,ft$

$P_A = h_A \cdot \gamma \cdot Q$

$= (304.73)(62.4)(0.0891)\left(\frac{1}{550}\right) = \boxed{3.07\,hp}$

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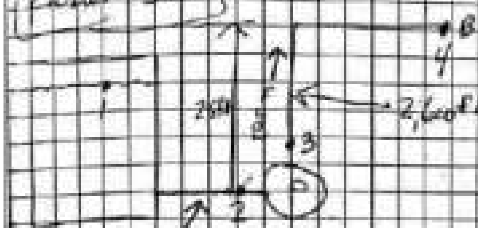
Problem 33



$Q = 1500 \frac{gal}{min} = 3.342 \frac{ft^3}{s}$ $T = 60°F$

$P_A = 5\ psig = \frac{lb}{in^2} = \frac{144\ in}{ft^2}$

$L = 45ft$
$L = 2600ft$
$H = 25ft$

$P_B = 85 psig = \frac{85\ lb}{in^2} = \frac{}{144 \frac{in}{ft^2}}$

Apply Bernoulli eq for pt 1 & pt 2

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

$$= h = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + h_L$$

Find Area of 10in pipe w/ft

$$A = \frac{\pi D^2}{4} = A = \frac{\pi\left(\frac{10}{12}\right)^2}{4} = 0.547 ft^2$$

Find velocity flow @ pt 2

$$V_2 = \frac{Q}{A} = \frac{\left(\frac{1500}{449}\right)}{0.547} = 6.1 ft/s$$

Find Reynolds number Use Table A.2 $V = 1.21 \times 10^{-5}$

$$N_R = \frac{V_2 D}{V} = \frac{6.1\left(\frac{10}{12}\right)}{1.21 \times 10^{-5}} = 420107.438$$

Find relative roughness
Use Table 8.2 & graph 8.7 $\varepsilon = 1.5 \times 10^{-4}$

$$\frac{D}{\varepsilon} = \frac{\left(\frac{10}{12}\right)}{1.5 \times 10^{-4}} = 5555.33$$

Moody Diagram
Use 420107.438 & 5555.33
$f = 0.0155$
Find Head loss

$$h_L = \frac{f L V_2^2}{2g D} = \frac{0.0155 \times 45 \times 6.1^2}{2 \times 32 \times \frac{10}{12}} = 0.486 ft$$

Find height

$$h = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + h_L = \frac{720}{62.4} + \frac{6.1^2}{2(32.2)} = \boxed{12.6 ft}$$

matches book

Apply Bernoulli for point A & B

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

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

$$A_B = \frac{\pi D_B^2}{4} = \frac{\pi\left(\frac{8}{12}\right)^2}{4} = 0.349 ft$$

$$V_B = \frac{Q}{A_B} = \frac{\left(\frac{1500}{449}\right)}{0.349} = 9.57 ft/s$$

$$N_R = \frac{V_B D_B}{V} = \frac{9.57 \times \left(\frac{8}{12}\right)}{1.21 \times 10^{-5}} = 527272.72$$

Find Relative Roughness Table 8.2 $\varepsilon = 1.5 \times 10^{-4} ft$

$$\frac{D}{\varepsilon} = \frac{\left(\frac{8}{12}\right)}{1.5 \times 10^{-4}} = 4444.67$$

Moody Diagram 527272.72, 4444.67 = $f = 0.016$

$$h_L = \frac{f L V_B^2}{2g D} = \frac{0.016 \times 2600 \times 9.57^2}{2 \times 32 \times \left(\frac{8}{12}\right)} = 89.34$$

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

$$\frac{12240 - 720}{62.4} + 25 + \frac{9.57^2 - 6.1^2}{2 \times 32.2} + 89.3$$

$= 299.76 ft$

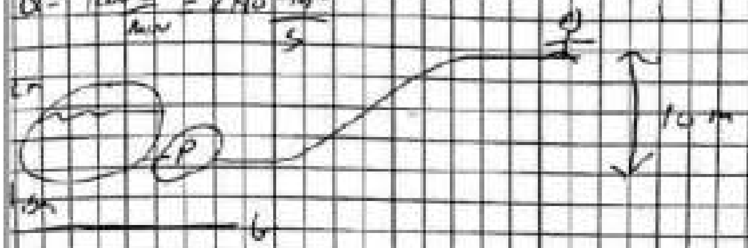
$P = h_A \gamma_w Q$ $Q = \frac{3.34}{550} = 6.07 \times 10^{-3}$

$P = 299.76 \times 62.4 \times 6.07 \times 10^{-3}$

$= \boxed{113.56}$ matches book

Problem 8.5 | $T = 100°C$. $L = 32\ km$ $S_g = 0.93$

$Q = 1200\ \frac{L}{min} = 2 \times 10^{-2}\ \frac{m^3}{s}$



From Table F.2 For 150 DN

$D = 146.3\ mm = 0.1463\ m$

$A = 1.682 \times 10^{-2}\ m^2$

From Table D.1 dynamic viscosity

$\eta = 7.9 \times 10^{-3}\ Pa \cdot s$

$\gamma_{oil} = 0.93 \cdot 9.81 \left(\frac{kN}{m^3}\right) = 9.1233\ \frac{kN}{m^3}$

$\rho_{oil} = 0.93 \cdot 1000\ \frac{kg}{m^3} = 930\ \frac{kg}{m^3}$

Find velocity of oil

$v = \frac{Q}{A} = \frac{2 \times 10^{-2}\ \frac{m^3}{s}}{1.682 \times 10^{-2}\ m^2} = 1.189\ \frac{m}{s}$

N reynolds #

$N_R = \frac{D \cdot v \cdot \rho}{\eta} = \frac{0.1463\ m \cdot 1.189\ \frac{m}{s} \cdot 930\ \frac{kg}{m^3}}{7.9 \times 10^{-3}\ Pa \cdot s}$

$= 2.02 \times 10^4$

Relative Roughness From Table 8.2

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

$\frac{D}{\varepsilon} = \frac{0.1463\ m}{4.6 \times 10^{-5}\ m} = 3180$

Moody Table

$2.02 \times 10^4,\ 3180 \Rightarrow f = 0.0247$

$h_L = \frac{f L v^2}{2gD} = \frac{0.0247 \cdot 32\ km \cdot (1.189)^2}{2(9.81)(0.1463)}$

$= 38.93\ m$

Pressure Drop

$P_1 - P_2 = h_L \cdot \gamma = 38.93 \cdot 9.1233 = \boxed{355.2\ kPa}$

Find Power

$P = \gamma \cdot h_L \cdot Q = 9.1233 \cdot 38.93 \cdot 2 \times 10^{-2}$

$\boxed{= 7\ kW}$

From Book answer for 8.57

$\Delta P = 853\ kPa$

Find Distance

$L = \frac{(P_1 - P_2) \cdot D \cdot 2g}{\gamma \cdot f \cdot v^2} = \frac{853\ kPa \cdot 0.1463\ m \cdot 2 \cdot 9.81}{9.1233 \cdot 0.0247 \cdot (1.189)^2}$

$= 70118\ m = \boxed{70.118\ km}$

Continued

General energy Eq:

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

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

Using Table F.2

$D = 0.6651\ ft$

$A = 0.3472\ ft^2$

Find Dynamic Viscosity $T = 60°F$ Appendix A

$\eta = 2.35 \times 10^{-5}\ \frac{lb \cdot s}{ft^2}$

$\rho = 1.94\ \frac{slugs}{ft^3}$

$\gamma = 62.4\ \frac{lb}{ft^3}$

Continued from page

$v = \frac{Q}{A} = \frac{4\ \frac{ft^3}{s}}{0.3472\ ft^2} = 11.52\ \frac{ft}{s}$

$N_R = \frac{D v \rho}{\eta} = \frac{0.6651\ ft \cdot 11.52 \cdot 1.94}{2.35 \times 10^{-5}}$

$= 6.326 \times 10^5$ Turbulent Flow

Relative Roughness

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

$\frac{D}{\varepsilon} = \frac{0.6651\ ft}{1.5 \times 10^{-4}\ ft} = 4434$

Using Moody Diagram

$6.326 \times 10^5,\ 4434 \Rightarrow f = 0.0150$

$h_L = \frac{f L v^2}{2gD} = \frac{0.0150 \cdot 2500 \cdot (11.52)^2}{2(32.2)(0.6651)}$

$= 117\ ft$

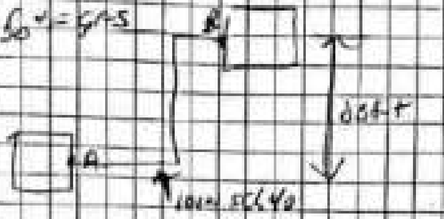
$P_1 = \gamma[(z_2 - z_1) + h_L]$

$P_1 = 62.4 \cdot [(210 - 0) + 117] \cdot \frac{1}{144}$

$= \boxed{141.7\ psig}$

Problem 46

S_g = GAS



$L = 5200\ ft$

$Q = 4.25\ ft^3/s$

$z_B - z_A = 85\ ft$

$P_B = 40\ psig = 5760\ lb/ft^2$

$$\frac{P_A}{\gamma} + z_A + \frac{v_A^2}{2g} - h_L = \frac{P_B}{\gamma} + z_B + \frac{v_B^2}{2g}$$

$$P_A + z_A - h_L = \frac{P_B}{\gamma} + z_B$$

$$P_A = P_B + \gamma\left[(z_B - z_A) + h_L\right]$$

Density of gasoline

$$\rho = 0.68 \cdot 1.94\left[\frac{slug}{ft^3}\right] = 1.3192\ \frac{slug}{ft^3}$$

DYNAMIC VISCOSITY TABLE D.1

$$\eta = 7.1 \times 10^{-6}\ \frac{lb \cdot s}{ft^2}$$

TABLE F.2 10in SCH40

$D = 0.835\ ft$

$A = 0.5475\ ft^2$

Find Velocity

$$v = \frac{Q}{A} = \frac{4.25}{0.5475} = 7.76\ ft/s$$

Continued to page

$$N_R = \frac{vD\rho}{\eta} = \frac{7.76 \cdot 0.835 \cdot 1.3192}{7.1 \times 10^{-6}}$$

$$= 1.2 \times 10^6$$

ϵ from TABLE 8.2 $\epsilon = 1.5 \times 10^{-4}$

$$\frac{D}{\epsilon} = \frac{0.835}{1.5 \times 10^{-4}} = 5567$$

Moody chart using

1.2×10^6, 5567 $= f = 0.0145$

$$h_L = \frac{fLv^2}{2gD} = \frac{0.0145 \cdot 5200 \cdot (7.76)^2}{2(32.2)(0.835)}$$

$$= 51.96\ ft$$

Specific weight of gas

$$\gamma_G = 0.68 \cdot 62.4\ \frac{lb}{ft^3} = 42.4\ \frac{lb}{ft^3}$$

$$P_A = P_B + \gamma\left[(z_B - z_A) + h_L\right]$$

$$P_A = 5760 + 42.4(85 + 51.96)$$

$$\boxed{= 80.33\ PSI}$$

Problem 49

OD: 80mm

WT: 2.8mm

$T = 25°C$

$L = 25.8m$

$\Delta = 0.68m$

$Q\ 180\ \frac{L}{min} = 3 \times 10^{-3}\ \frac{m^3}{s}$

$D = 0.0744$ from G.2

ρ = 1258 from B.1

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

$$P_1 - P_2 = \gamma(z_2 - z_1 + h_L)$$

$A = 4.347 \times 10^{-3}m$ from G.2

$$v = \frac{Q}{A} = \frac{3 \times 10^{-3} m^3/s}{4.347 \times 10^{-3} m} = 0.69\ m/s$$

$$N_R = \frac{D \cdot v \cdot \rho}{\eta} = \frac{0.0744m \cdot 0.69 \cdot 1258}{0.960\ Pa\ s}$$

$$= 67.3$$

$$f = \frac{64}{N_R} = \frac{64}{67.3} = 0.951$$

$$h_L = \frac{fLv^2}{2gD} = \frac{(0.951)(25.8)(0.690)^2}{2(9.81)(0.0744)} = 8m$$

$$P_1 - P_2 = \gamma(z_2 - z_1 + h_L)$$

γ from B.1 $= 12.34\ \frac{kN}{m^3}$

$$12.34\ \frac{kN}{m^3}\left(0.68m - 0.+8m\right)$$

$$\boxed{= 107.11\ \frac{kN}{m^2}}$$

60

Problem 6.2

OD: 120m

Wall: 3.5mm

$Q = 1000 \frac{L}{min} = 1.667\times10^{-2}\ \frac{m^3}{s}$

$L = 45m$

$h_L = L\left[\frac{Q}{0.85\cdot A\cdot C_h\cdot R^{0.63}}\right]^{1.852}$

$C_h = 130$ From Table 6.3

from Table 6.2

$R = \frac{D}{4} = \frac{.113m}{4} = 0.02825m$

$D = 113mm = 0.113m$

$A = 1.003\times10^{-2}m^2$

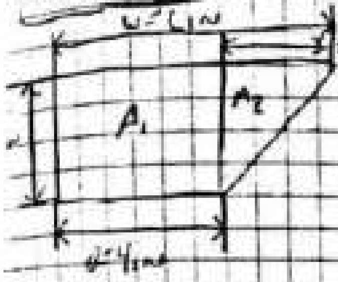
$h_L = 45\left[\frac{1.667\times10^{-2}\frac{m^3}{s}}{0.85\cdot1.003\times10^{-2}m^2\cdot130\cdot(0.02825)^{0.63}}\right]^{1.852}$

$\boxed{= 1.2m}$

62

Roughness 6, 15, 21, 30

Problem 6



Find Area

$A = A_1 + A_2$

$A = BD + \frac{1}{2}XD$

$A = 4(2) + \frac{1}{2}(2)(2)$

$A = 10in^2$

Find wetted length

$L = \sqrt{x^2+D^2} = \sqrt{2^2+2^2} = 2.828in$

Wetted Perimeter

$WP = D+B+L = 2+4+2.828 = 8.828in$

Hydraulic Radius

$R = \frac{A}{WP} = \frac{10}{8.828} = \boxed{1.13in}$

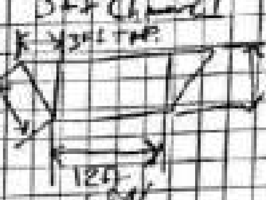
Problem 15

$n = 0.04$

$S = 0.0045$

$D_1 = 3ft$

$D_2 = 6ft$



Use Pythag to find L

$L = \sqrt{3^2+3^2} = 4.243$

Find Radius

$R = \frac{A}{WP} = \frac{WD}{W+2L} = \frac{12\cdot3+2(\frac{1}{2}\cdot3\cdot3)}{12+2\cdot4.243}$

$= 2.197ft$

Use Manning Eq Find Discharge

$V = \frac{1.49}{n}R^{2/3}S^{1/2} / A$

$Q_1 = \frac{1.49}{n}AR^{2/3}S^{1/2} = \frac{1.49}{0.04}\cdot45\cdot2.197^{2/3}\cdot.0045^{1/2}$

$Q_1 = 316.695\ \frac{ft^3}{s}$

$\boxed{\text{Book Answer } 317}$ ✓

64

Problem 15

6ft

$L_1 = \sqrt{4^2+4^2} = 5.657ft$

$L_2 = \sqrt{2^2+2^2} = 2.828ft$

$R = \frac{A}{WP} = \frac{A}{W+2L+2L_2+2\cdot10}$

$= \frac{12\cdot4+2(\frac{1}{2}\cdot4\cdot4)+2(\frac{1}{2}\cdot2\cdot2)+(6-4)\cdot40}{12+2\cdot5.657+2\cdot2.828+2\cdot10}$

$= 3.022ft$

$V = \frac{1.49}{n}R^{2/3}S^{1/2} / A$

$Q_2 = \frac{1.49}{n}AR^{2/3}S^{1/2}$

$= \frac{1.49}{0.04}\cdot148\cdot3.022^{2/3}\cdot0.0045^{1/2}$

$\boxed{= 141.13\ \frac{ft^3}{s}}$

$\boxed{\text{Book Answer } 141.1\ ft^3/s}$ ✓

Problem 21

$n = 0.013$ (REF TABLE 14.1)

$Q = 500 \frac{GAL}{MIN} = 1.11 \frac{ft^3}{s}$

$S = 0.1\%$

$R = \frac{A}{WP} = \frac{\frac{D^2\pi}{8}}{\frac{D\pi}{2}} = \frac{D}{4}$

$V = \frac{1.49}{n} R^{2/3} S^{1/2} / A$

$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$

$AR^{2/3} = \frac{Qn}{1.49 S^{1/2}} =$

$\frac{D^2\pi}{8} \cdot \frac{D}{4}^{2/3} = \frac{1.11 \cdot 0.013}{1.49 \cdot 0.001^{1/2}} = 0.3074$

$\boxed{D = 1.29 ft}$ Book Ans = 1.23 ✓

Problem 26 Use Table 14.3

$Q = 1.25 \frac{ft^3}{s}$ $V = 2.75 \frac{ft}{s}$

$Q = VA = A = \frac{Q}{V} = \frac{1.25}{2.75} = 0.455 ft^2$

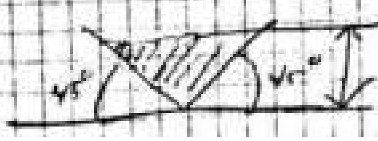
Rectangle

$A = 2y^2$ $y = \sqrt{\frac{A}{2}} = \sqrt{\frac{0.455}{2}} = 0.477 ft$

$b = 2y = 2 \cdot 0.477 = 0.954 ft$

Triangle

$A = y^2 = y = \sqrt{A} = \sqrt{0.455} = \boxed{0.675 ft}$



Trapezoid

$A = 1.73y^2 = y\sqrt{\frac{A}{1.73}} = \sqrt{\frac{0.455}{1.73}} = \boxed{0.513ft}$

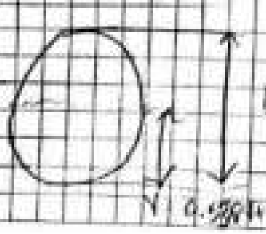
$b = 1.155y = 1.155 \cdot 0.513 = \boxed{0.593 ft}$

Semicircle

$A = 0.5\pi y^2$

$y = \sqrt{\frac{2a}{\pi}} = \sqrt{\frac{2 \cdot 0.455}{\pi}} = 0.538 ft$

$D = 2y = 2 \cdot 0.538 = 1.076 ft$



20 SHEPARD MET 330 CH'S: 4, 9, 15 70

9.4

$D_1 = 1in = .083ft$

$d_1 = 1in = .0833ft$

$d_2 = 2in = .084ft$

$Q = 25 gal/min = 0.056 ft^3/s$

$SG = 0.83$

Find Area

$A = \frac{D^2\pi}{4} = \frac{.83(\pi)}{4} = 0.541 ft^2$

Find other

$A_2 = \frac{D^2\pi}{4} = \frac{.083(\pi)}{4} = 0.0041 ft^2$

Find Specific gravity

$\rho_1 = SG_1(\rho_w) = 0.83(1.94) = 1.61 \ slug/ft^3$

Find velocity

$V_1 = \frac{Q}{A_1} = \frac{0.056}{0.541} = 0.1035 \ ft/s$

Find Kinematic Viscosity

$\nu_1 = \frac{\mu_1}{\rho_1} = \frac{2.5 \times 10^{-6}}{0.402} = .35 \times 10^{-6} \ ft^2/s$

FIND REYNOLDS NUMBER

$$N_R = \frac{V_1 D_1}{\nu} = \frac{0.1035(.83)}{1.55\times10^{-5}} = 55400$$

FIND DISCHARGE COEFFICIENT

$$\beta = \frac{d}{D} = \frac{1}{10} = 0.1$$

USE TABLE 15.7 $C = 0.595$

FIND FLOW VELOCITY

$$v_1 = C\sqrt{\frac{2gh\left[(\gamma_m/\gamma_f)-1\right]}{(A_1/A_2)^2-1}} =$$

$$\left(\frac{v_1}{C}\right)^2 = \frac{2gh\left[(\gamma_m/\gamma_f)-1\right]}{(A_1/A_2)^2-1}$$

$$h = \left(\frac{v_1}{C}\right)^2 \frac{(A_1/A_2)^2-1}{2g\left((\gamma_m/\gamma_f)-1\right)}$$

$$h = \left(\frac{0.1035}{0.595}\right)^2 \frac{(0.541/0.00541)^2-1}{2\cdot 32.2\left[(62.4/51.75)-1\right]}$$

$$\boxed{h = 2.74}$$

b)

$$A_2 = \frac{(.58)^2\pi}{4} = 0.264\,ft^2$$

$$\beta = \frac{7}{10} = 0.7$$

USE TABLE 15.7 $C = 0.62$

72

$$h = \left(\frac{0.1035}{0.62}\right)^2 \frac{(0.541/0.264)^2-1}{2\cdot 32.2\left[(62.4/51.75)-1\right]}$$

$$\boxed{h = 0.04672\,ft}$$

$$A_1 = \frac{A}{\sqrt{\frac{2gh(\gamma_m/\gamma)(C_{max}A)^2}{v^2_{max}A}+1}}$$

FROM TABLE B.2 $\gamma_m = 844.9\ lb/ft^3$

$\gamma = 58\ lb/ft^3$

$$\sqrt{\frac{2(32.2)(0.667)\left(\frac{844.9}{58}\right)(.561)^2}{17.68^2}+1}$$

$= 0.0745\,ft^2$

$$A_1 = \frac{\pi}{4}d^2 = \sqrt{\frac{A_1\times4}{\pi}} = \frac{0.0745(4)}{\pi}$$

$= 0.308\,ft = \boxed{3.7\,in}$

15.9

SEE TABLE ...

$D_1 = 4.805\,in = 0.4004\,ft$ $h = 8.0 = 0.667\,ft$

$A = .1259\,ft^2$

SEE TABLE B.1

$\nu = 3.84\times10^{-4}\ ft^2/s$

$\gamma = 58\ lb/ft^3$

$$V_{min} = \frac{Q_{min}}{A} = \frac{\frac{0.1336\times700}{60}}{0.1259} = 12.37\,ft/s$$

$$N_{R\,min} = \frac{V_{min}D}{\nu} = \frac{12.37(0.400)}{3.84\times10^{-4}} = 12854.16$$

USING TABLE 15.5

$C_{min} = 0.556$

$$V_{max} = \frac{Q_{max}}{A} = \frac{\frac{0.1336\times1000}{60}}{0.1259} = 17.68\,ft/s$$

$$N_{R\,max} = \frac{V_{max}D}{\nu} = \frac{17.68\times0.4004}{3.84\times10^{-4}} = 18416$$

USE TABLE 15.5

$C_{max} = 0.561$

$$V_{max} = C_{max}\sqrt{\frac{2gh\left[(\gamma_m/\gamma)-1\right]}{(A/A_1)^2-1}}$$

$$A_1 = \frac{A}{\sqrt{\frac{2gh(\gamma_m/\gamma)(C_{max})^2}{v^2_{max}}+1}}$$

15-15

AIR TEMP $= 80°F$

$h = 0.24\,in = 0.02\,ft$

$$v_1 = \sqrt{2gh(\gamma_m-\gamma)/\gamma}$$

USE TABLE E.2

$\gamma = 0.0736\ lb/ft^3$

USE TABLE A.2

$\gamma_m = 62.4\ lb/ft^3$

$$v_1 = \sqrt{2(32.2)(0.02)(62.4-0.0736)/0.0736}$$

$$\boxed{v = 33\,ft/s}$$

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