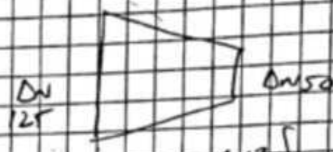
HOMEWORK
MODULE 3

ROY SHEPARD

10.20

DN 125 Sch 80 pipe
to
DN 50 Sch 80 pipe



Angle 105°

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

500 L/min = 0.0083 m³/s

See Table F.2

DN125 DN50

$D_1 = 122.3$ mm $D_2 = 49.3$

$A_1 = 0.01173\ m^2$ $A_2 = 0.001905$

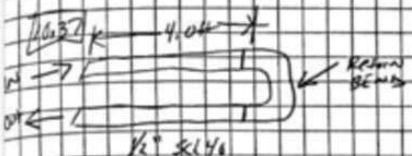
$v_2 = \frac{Q}{A_2} = \frac{0.0083}{0.001905} = 4.37$ m/s

See Table 10.8

$\frac{D_1}{D_2} = \frac{122.3}{49.3} = 2.48$ $K = 0.38$

$h_L = K \cdot \left(\frac{v_2^2}{2g}\right) = 0.38\left(\frac{4.37^2}{2 \cdot 9.81}\right) = \boxed{0.370\ m}$

10.37



ethylene glycol
12.5 gal/min = 0.0278 ft³/s
Temp 77°

$\frac{p_1}{\gamma} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{v_2^2}{2g} + z_2 + h_{L\,pipe} + h_{L\,bend}$

Bend $h_L = K\left(\frac{v^2}{2g}\right) = f_T \cdot \frac{L_e}{D} \cdot \frac{v^2}{2g}$

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

$\rightarrow p_1 - p_2 = \gamma\left[\left(\frac{v_2^2 - v_1^2}{2g}\right) + (z_2 - z_1) + h_{L\,pipe} + h_{L\,bend}\right]$

$\rightarrow p_1 - p_2 = \gamma \cdot (h_{L\,pipe} + h_{L\,bend})$

$\Delta p = \frac{\gamma \cdot v^2}{2g}\left(f \cdot \frac{L}{D} + f_T \cdot \frac{L_e}{D}\right)$

From Table F.1

$D = 0.622$ in $A = 0.00211\ ft^2$
$= .05184$

$v = \frac{Q}{A} = \frac{0.0278}{0.00211} = 13.17\ \frac{ft}{s}$

Table 6.2

$\nu = 0.000159$

$\gamma = 68.47\ \frac{lb}{ft^3}$

$N_R = \frac{vD}{\nu} = \frac{(13.17)(.0518)}{(0.000159)}$

$N_R = 4{,}290$

Table 8.2

$\frac{D}{\varepsilon} = \frac{.0518}{0.000159} = 325.78$

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

*Error need to find use Moody Diagram for N_R

$f = \cancel{\frac{0.25}{\left[\log\left(\frac{1}{3.7(4290)} + \frac{5.74}{324^{0.9}}\right)\right]^2} = .1105}$

Check with Moody

$f = 0.0417$

See Table 10.4 & 10.5

$\frac{L_e}{D} = 50$ $f_T = 0.026$

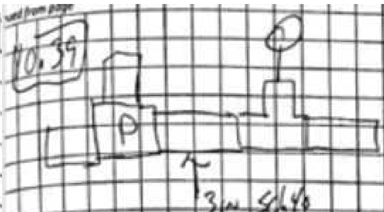
$\Delta p = \gamma \cdot \frac{v^2}{2g} \cdot \left(f \cdot \frac{L}{D} + f_T \cdot \frac{L_e}{D}\right)$

$68.47 \cdot \frac{13.7^2}{2 \cdot 32.2} \cdot \left(0.0417 \cdot \frac{8}{.0518} + 0.026 \cdot 50\right)$

$= 1427.37 = 9.91$ psf

$\boxed{\text{Book Answer } 9.81 \text{ psi}}$ ✓

10.39



$Q = 0.4\ \frac{ft^3}{s}$

$T = 50°F$

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

Table F.1

$D = 3.068$ in $A = .05132\ ft^2$

$v = \frac{Q}{A} = \frac{0.4}{.05132} = 7.79\ \frac{ft}{s}$

Table A.2 For Glycol @ 50°F

$\nu = .00014\ \frac{ft^2}{s}$

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

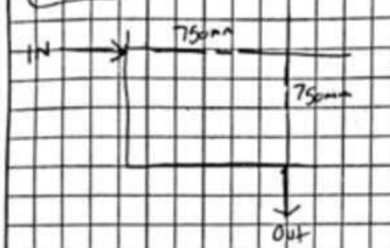
See Table 10.4 & 10.5

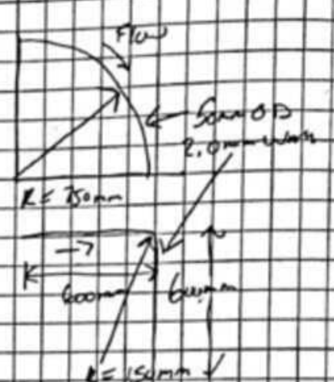
$\frac{L_e}{D} = 20$ $f_T = 0.017$

$h_L = f_T \cdot \frac{L_e}{D} \cdot \frac{v^2}{2g} = 0.017 \cdot 20 \cdot \left(\frac{7.79^2}{2 \cdot 32.2}\right)$ ✓

$= 0.321$ ft $\boxed{\text{Book Answer } 0.321 \text{ ft}}$

10.43





OD = 50 mm

$t = 2\,mm$

$Q = 750 \frac{L}{min} = .0125\ m^3/s$

$r_1 = 750\,mm \qquad h_L = K\cdot\left(\frac{v^2}{2g}\right) = f_T \cdot \frac{L_e}{D}\cdot\frac{v^2}{2g}$

$r_2 = 150\,mm$

$T = 25°C \qquad ID = OD - 2\cdot t = 50 - 2\cdot 2 = 46\,mm = .046\,m$

$v = \frac{Q}{A} = \frac{4\cdot Q}{D^2\cdot\pi} = \frac{4\cdot 0.0125}{(.046)^2\cdot\pi} = 7.522\ m/s$

Table B.1 Alcohol @ 25°C

$\nu = .000002\ m^2/s \qquad \gamma = 7.87\ \frac{kN}{m^3}$

$N_R = \frac{vD}{\nu} = \frac{7.522\cdot 0.046}{.000002} = 144775$

Table 8.2

$\frac{D}{\varepsilon} = \frac{.046}{0.0000015} = 30666$

Use moody Diagram

$f_T = 0.0097 \qquad f = 0.0167$

Continued to p

Table 10.28

$\frac{r_1}{D} = \frac{750}{46} = 16.3 \qquad \frac{L_e}{D} = 42$

$h_{L,b} = f_T\cdot\frac{L_e}{D}\cdot\frac{v^2}{2g} = 0.0097\cdot 42\cdot\frac{7.522^2}{2\cdot 9.81} = \boxed{1.175\,m}$ $\boxed{h_{L,b}}$

$\frac{r_2}{D} = \frac{150}{46} = 3.3 \qquad \frac{L_e}{D} = 12$

$h_{L,b} = h_{L\,pipe} + h_{L\,bend}$

$= f\cdot\frac{L}{D}\cdot\frac{v^2}{2g} + f_T\frac{L_e}{D}\cdot\frac{v^2}{2g}$

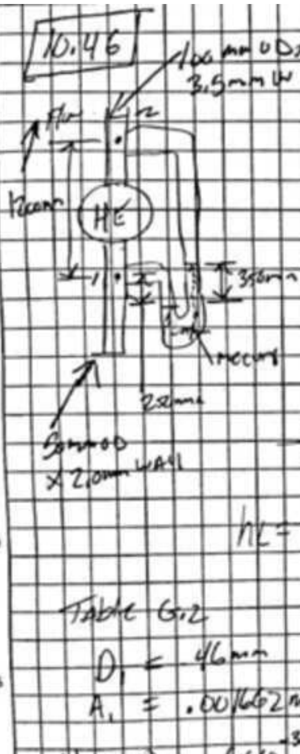
$= 0.0167\cdot\frac{1200}{46}\cdot\frac{7.522^2}{2\cdot 9.81} + 0.0097\cdot 12\cdot\frac{7.522^2}{2\cdot 9.81}$

$\boxed{h_{L,b} = 1.552\,m}$

Book answers ✓

$\boxed{h_L = 1.77\,m \qquad h_L = 1.552\,m}$

10.46



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

$T = 50°C$

$OD_1 = 50\,mm$

$t_1 = 2\,mm$

$OD_2 = 100\,mm$

$t_2 = 3.5\,mm$

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

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

Table G.2

$D_1 = 46\,mm \qquad D_2 = 93\,mm$

$A_1 = .001662\,m^2 \qquad A_2 = .006793\,m^2$

$v_1 = \frac{Q}{A_1} = \frac{6\times 10^{-3}}{.001662} = 3.61\,m/s \qquad v_2 = \frac{Q}{A_2} = \frac{6\times10^{-3}}{.006793} = 0.883$

Table A.1 & G.1

$\nu_{water} = 5.48\times 10^{-7}\,m^2/s \qquad \nu_{Hg} = 1.13\times 10^{-7}\,m^2/s$

$\gamma_{water} = 9.63\ \frac{kN}{m^3} \qquad \gamma_{Hg} = 132.8\ kN/m^3$

Find Head difference using manometer

$P_1 + \gamma_{water}\cdot h_1 - \gamma_{Hg}\cdot h_2 - \gamma_{water}\cdot h_3 = P_2$

$\gamma_{water}\cdot(h_3 - h_1) + \gamma_{Hg}\cdot h_2 = P_1 - P_2$

$h_3 - h_1 + \frac{\gamma_{Hg}}{\gamma_{water}}\cdot h_2 = \frac{P_1 - P_2}{\gamma_{water}}$

$(1.2 - 0.1 - 0.25)\ \frac{132.8}{9.63}\cdot 0.35 = \frac{P_1 - P_2}{\gamma_{water}}$

$= 5.682\,m$

$h_L = \frac{P_1 - P_2}{\gamma_{water}} + \frac{v_1^2 - v_2^2}{2g} + (z_1 - z_2)$

$= 5.682 + \frac{3.61^2 - 0.883^2}{2\cdot 9.81} - 1.2 = \boxed{5.106\,m}$

$h_L = K\cdot\left(\frac{v_1^2}{2g}\right) = K = \frac{2\cdot h_L\cdot g}{v_1^2}$

$= \frac{2\cdot 5.106\cdot 9.81}{3.61^2} = \boxed{7.69}$

Find Head difference using manometer

$$P_1 + \gamma_{water} \cdot h_1 - \gamma_{hg} \cdot h_2 - \gamma_{water} \cdot h_3 = P_2$$

$$\gamma_{water} \cdot (h_3 - h_1) + \gamma_{hg} \cdot h_2 = P_1 - P_2$$

$$h_3 - h_1 + \frac{\gamma_{hg}}{\gamma_{water}} \cdot h_2 = \frac{P_1 - P_2}{\gamma_{water}}$$

$$(1.2 - 0.1 - 0.25)\ \frac{132.8}{9.81} \cdot 0.35 = \frac{P_1 - P_2}{\gamma_{water}}$$

$$= 5.682\,m$$

$$h_L = \frac{P_1 - P_2}{\gamma_{water}} + \frac{U_1^2 - U_2^2}{2g} + (z_1 - z_2)$$

$$= 5.682 + \frac{3.61^2 - 0.883^2}{2 \cdot 9.81} - 1.2 = \boxed{5.106\,m}$$

$$h_L = K \cdot \left(\frac{U_1^2}{2g}\right) = K = \frac{2 \cdot h_L \cdot g}{U_1^2}$$

$$= \frac{2 \cdot 5.106 \cdot 9.81}{3.61^2} = \boxed{7.69}$$

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TITLE PROJECT

Continued from page

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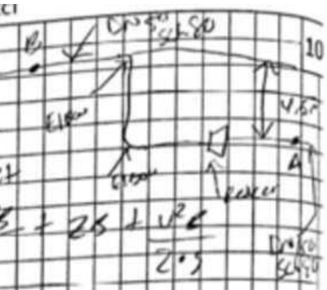
Problem 5



Use points shown in drawings
see excel sheet

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

Find pressure @ A

$$P_A = \gamma\left[h_L + \frac{P_B}{\gamma} + (z_B - z_A) + \left(\frac{V_B^2}{2g} - \frac{V_A^2}{2 \cdot g}\right)\right]$$

$$h_L = 2 \cdot h_1 + h_{2A} + h_{2B} + h_3$$

$$\text{Elbows} = h_1 = f_T \cdot \frac{L_e}{D} \cdot \frac{V_B^2}{2 \cdot g}$$

Find Friction Factor

$$f_T = \frac{0.25}{\left[\log\left(\frac{1}{3.7 \cdot (D/\epsilon)}\right) + \frac{5.74}{N_R^{0.9}}\right]^2} \qquad D = 2.0 \qquad \frac{L_e}{D_B} = 20$$

$A_B = 0.001945$ From Table 10.2
$f_T = 0.019$ From Table 10.2

$$V_B = \frac{Q}{A_B} = \frac{0.015}{0.001945} = 7.71\,m/s$$

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Elbows losses

$$h_1 = f_T \cdot \frac{L_e}{D_B} \cdot \frac{V_B^2}{2g} = 0.019 \cdot 20 \cdot \frac{7.71^2}{2 \cdot 9.81} =$$

$$\boxed{1.15\,m}$$

Pipe losses

$$h_2 = \frac{f \cdot L \cdot V^2}{D \cdot 2 \cdot g} = \frac{0.035 \cdot 150 \cdot 0.85^2}{0.152 \cdot 2 \cdot 9.81} = \boxed{1.72\,m}$$

Find f using Friction Factor Formula 150 Sch 80

$$f = \frac{0.25}{\left[\log\frac{1}{3.7\left(\frac{D}{\epsilon}\right)} + \frac{5.74}{N_R^{0.9}}\right]^2} = \frac{0.25}{\left[\log\frac{1}{3.7\left(\frac{0.152}{0.000046}\right)} + \frac{5.74}{\left(\frac{0.85 \cdot 0.1524}{0.000212}\right)}\right]}$$

$$\boxed{f = 0.035}$$

DN 150 $A_A = 1.670 \times 10^{-2}\,m^2$

$$V_A = \frac{Q}{A_A} = \frac{0.015}{1.670 \times 10^{-2}} = 0.89\,m/s$$

Friction Factor using DN50 Sch 80

$$f = \frac{0.25}{\left[\log\frac{1}{3.7\left(\frac{0.0508}{0.000046}\right)} + \left(\frac{5.74}{\frac{7.71 \cdot 0.0508}{0.000212}}\right)^{0.9}\right]^2}$$

$$= 0.028$$

Continued to page

$$h_{2B} = \frac{f \cdot L}{D_B} \frac{V_B^2}{2 \cdot g} = \frac{0.028 \cdot 80 \cdot 7.71^2}{0.0508 \cdot 2 \cdot 9.81}$$

$$= \boxed{135.4\,m}$$

Reducer

$$h_3 = K \cdot \frac{V_B^2}{2 \cdot g} = 0.37\,\frac{7.71^2}{2 \cdot 9.81} = 1.12\,m$$

$$h_L = 2 \cdot h_1 + h_{2A} + h_{2B} + h_3$$

$$= (2 \cdot 1.15) + 1.72 + 135.4 + 1.12 = 140.5\,m$$

$$P_A = \gamma\left[h_L + \frac{P_B}{\gamma} + (z_B - z_A) + \left(\frac{V_B^2}{2 \cdot g} - \frac{V_A^2}{2 \cdot g}\right)\right]$$

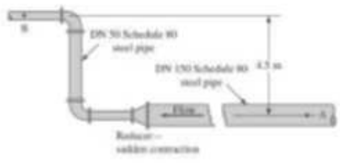
$$P_A = 8.80\left[140.4 + \frac{12.5 \times 10^6}{8.80} + 4.5 + \left(\frac{0.85^2}{2 \cdot 9.81} - \frac{7.71^2}{2 \cdot 9.81}\right)\right]$$

$$\boxed{P_A = 12.50}$$

Roy Shepard
MET330 HW 3.2

Q	0.015	m^3/s
ZB-ZA	4.5	m
PB	12.5	MPa
L1	100	m
L2	30	m
γ	9.8	kN/m^3
ν	0.0000012	m^2/s

fT	0.019		Table 10.5
DB	2	in	Table 10.5
Le/D	20		Table 10.4
AB	0.001945	m^2	APPENDIX F
DA	6	in	APPENDIX F
AA	0.0187	m^2	APPENDIX F
DA	0.152	150 SCH 80	APPENDIX F
ε	0.000046		TABLE 8.2
DB	0.0508	50 SCH 80	APPENDIX F
K	0.37		



vB=Q/AB	
7.712082	m/s

h1=fT*Le/DB*V^2B/2g
1.151914605

h2=f*L*v^2/D*2*g	
1.779843	m

vA=Q/AA		
	0.8021036	m/s

NR=(VA*DA)/v
6429.956788

DA/E
3304.347826

NR=(VB*DB)/v
16479.89522

DB/E
1104.347826

h2=f*L*v^2/D*2*g
125.4047486

h3=K*V2B/2*g	
1.123621	m

Friction Factor
f=0.25/[log(1/3.7*(D/E)+5.74/(Nr^0.9)]^2
6.1750E-05
0.002143484
-2.410811223
7.037407379
0.03512446

Friction Factor
f=0.25/[log(1/3.7*(D/E)+5.74/(Nr^0.9)]^2
0.000044733
0.000029626
-2.368850613
0.01407389
0.035363729

hL=2*h1+h1a+h2b+h2
140.5600824

pA/g=pB+γ*[(zB+(v^2B/2*g)+hL-ZA-(V^2A/2*g)]	
12500000	1426454.545
	1426599.606
0.80677	0.04112197
59.47621	3.033407381
	2.99019762
	1426596.631
	12501250.21
	1000000
	13.56125601

BOOK ANSWER
h=13.36m

See excel wk & Drawing Attach
USE Pounds Slug INDY

Problem 13

14 in

A

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

$$Q_A = Q_B \qquad V_A \cdot \frac{d^2\pi}{4} = V_B \frac{D^2\cdot\pi}{4}$$

$$V_A = \frac{d^2\cdot V_B}{D^2}$$

$$h_L = h_1 + h_2$$

$$h_L = k\cdot\frac{V_B^2}{2\cdot g} + f\cdot\frac{L}{D}\cdot\frac{V_A^2}{2\cdot g}$$

$$V_B = \sqrt{\frac{2\cdot g\left(\frac{P_A}{\gamma} + (z_A - z_B)\right)}{1 - \frac{d^4}{D^4} + k + f\frac{L\cdot d^4}{D^5}}}$$

$$\frac{D}{\varepsilon} = \frac{0.041}{0.00015} = 277.7 \qquad N_R = \frac{V_B\cdot d^2}{D\cdot\nu} = \frac{1.002}{0.0416\cdot 7.37\times10^{-6}} = 1412.02$$

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7\left(\frac{D}{\varepsilon}\right)} + \frac{5.74}{N_R^{0.9}}\right)\right]^2} = \frac{0.25}{\left[\log\left(\frac{1}{3.7\cdot 277.7} + \frac{5.74}{1412^{0.9}}\right)\right]^2}$$

$$f = 0.060$$

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See excel wk & Drawing Attach
USE Pounds Slug INDY

Problem 13

14 in

A

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

$$Q_A = Q_B \qquad V_A \cdot \frac{d^2\pi}{4} = V_B \frac{D^2\cdot\pi}{4}$$

$$V_A = \frac{d^2\cdot V_B}{D^2}$$

$$h_L = h_1 + h_2$$

$$h_L = k\cdot\frac{V_B^2}{2\cdot g} + f\cdot\frac{L}{D}\cdot\frac{V_A^2}{2\cdot g}$$

$$V_B = \sqrt{\frac{2\cdot g\left(\frac{P_A}{\gamma} + (z_A - z_B)\right)}{1 - \frac{d^4}{D^4} + k + f\frac{L\cdot d^4}{D^5}}}$$

$$\frac{D}{\varepsilon} = \frac{0.041}{0.00015} = 277.7 \qquad N_R = \frac{V_B\cdot d^2}{D\cdot\nu} = \frac{1.002}{0.0416\cdot 7.37\times10^{-6}} = 1412.02$$

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7\left(\frac{D}{\varepsilon}\right)} + \frac{5.74}{N_R^{0.9}}\right)\right]^2} = \frac{0.25}{\left[\log\left(\frac{1}{3.7\cdot 277.7} + \frac{5.74}{1412^{0.9}}\right)\right]^2}$$

$$f = 0.060$$

T	100	F		
D1	0.5	in	0.041666667	ft
D2	0.25	in	0.020833333	ft
L	20	ft		
K	0.15			
ZB	18	ft		
E	0.00015			
v	0.000007377			

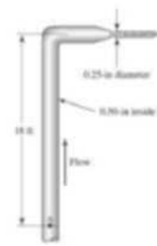
D/E
277.7777778

NR=VB*d^2/D*v
0.000434028
3.07375E-07
1412.046451

Friction Factor
f=0.25/[log(1/3.7*(D/E)+5.74/(Nr^0.9)]^2
0.000972973
0.008395524
-2.028330079
4.114122911
0.060766293

vb=sqrt(2*g((pa/y)+za-zb)/1-(d^4/D^4)+K+f((L*d^4)/D^5)			
64.4		64.4	
44.85981308		179.4392523	
26.85981308		179.4392523	
1729.771963		11555.88785	
0.0625		0.0625	
1.0875		1.0875	
3.7676E-06		3.7676E-06	
1.25587E-07		1.25587E-07	
1.822988803		1.822988803	
1.982500323		1.982500323	
872.5203938		5828.946264	
29.53845619	CASE A	76.34753607	CASE B

BOOK ANSWER	BOOK ANSWER
v=32.44 ft/s	v=81.44 ft/s



Cleaner with nozzle for Problem 11.13

Problem 15 — See excel file & drawing

A · 10m · USED DATUM Surface

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

$$h_L = z_A - z_B$$

$$h_L = h_1 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7 + h_8$$

$$h_L = \frac{f_T \cdot L_2 \cdot v_2^2}{D_2 \cdot 2 \cdot g} + f \cdot \frac{L_e}{D} \cdot \frac{v_2^2}{2g} + k \cdot \frac{v_2^2}{2g} + f \frac{L_e}{D} \cdot \frac{v_2^2}{2g} + k \cdot \frac{D_2^4 \cdot v_2^2}{D_1^4 \cdot 2g} + \frac{f_T \cdot L_1 \cdot D_2^4 \cdot v_2^2}{D_1^4 \cdot 2 \cdot g} + k \cdot \frac{D_2^4 \cdot v_2^2}{D_1^4 \cdot 2 \cdot g} + f \cdot \frac{L_e \cdot v_2^2}{D \cdot 2 \cdot g}$$

ES1

$$v_2 = \sqrt{\frac{2\cdot g(z_A - z_B)}{\left(\frac{f_T \cdot L_1 \cdot D_2^4}{D_1^4} + f\frac{L_e}{D} + k + k \cdot \frac{D_2^4}{D_1^4} + k\frac{D_2^4}{D_1^4} + f \cdot \frac{L_e}{D} + 2 \cdot f \frac{L_e}{D} + f\frac{L_e}{D_2}\right)}}$$

$K = 1$ exit $\quad K = 0.78$ inward pipe $\quad K = 0.45$ contraction

$\frac{L_e}{D} = 45$ butterfly $\quad \frac{L_e}{D} = 30$ elbow $\quad \frac{L_e}{D} = 0.45$ contraction

For 6 in

$$\frac{D}{\varepsilon} = \frac{0.152}{1.2\times10^{-4}} = 1270 \qquad N_R = \frac{v_2 \cdot D_2}{\nu} = \frac{1 \cdot 0.1524}{6.56\times10^{-7}} = 232317$$

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7(1270)} + \frac{5.74}{232317^{0.9}}\right)\right]^2} = 0.020$$

For 4 in

$$N_R = \frac{v_1 D}{\nu} = \frac{1 \cdot 0.10}{6.56\times10^{-7}} = 154878.0488$$

$$\frac{D}{\varepsilon} = \frac{0.10}{2\times10^{-4}} = 882.5$$

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7(882)} + \frac{5.74}{154878.04^{0.9}}\right)\right]^2} = 0.022$$

v_2 = ES1 on page 1 of this problem — SEE EXCEL Sheet 3

$$= \sqrt{\frac{196.2}{73.54}} = 1.63\ \text{m/s}$$

$$v_1 = v_2 \cdot \frac{D_2^2}{D_1^2} = 1.64 \cdot \frac{0.152^2}{0.101^2} = 3.675\ \text{m/s}$$

$$Q = v_1 \cdot \frac{D_1^2 \cdot \pi}{4} = 3.675 \cdot \frac{0.101^2 \cdot \pi}{4}$$

$$\boxed{= 0.029\ \text{m}^3/\text{s}}$$

T	40 C		
D1	4 in	0.1016	m
D2	6 in	0.1524	m
L1	55 m		
L2	30 m		
ZA-ZB	10 m		
ν	[illegible] m^2/s		
ε	[illegible]		

K1	0.78
K2	0.45
Le/D1	45
Le/D2	30
ft	[illegible]

D/ε	1270

NR=(v2*D2)/ν
232317.0732

Friction Factor
f=0.25/(log(1/3.7*(D/ε)+5.74/(NR^0.9)))^2
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

D/ε	[illegible]

NR=(v2*D2)/ν
154878.0488

Friction Factor
f=0.25/(log(1/3.7*(D/ε)+5.74/(NR^0.9)))^2
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

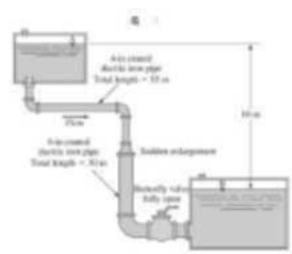
v2=...
196.2
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
73.54

[illegible]	m/s

v1=v2*(D2^2/D1^2)
[illegible]

Q=v1*(D1^2)*PI/4
[illegible]

BOOK ANSWER
Q=0.0279 m^3/s



Water flow from reservoir for Problem 11.15.

Problem 22

A · Fully open gate valve · elbow · B

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

$$h_L = z_A - z_B = 12\ \text{ft}$$

$$v = \frac{4Q}{\pi D^2}$$

$$\frac{P_A}{\gamma} + \frac{v_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{v_B^2}{2g} + h_{L\,A\text{-}B}$$

$$z_A = f\frac{8LQ^2}{g\pi^2} + h_s + \left(k_{globe} + k_{elbow} + f\frac{L}{D}\right)\frac{8Q^2}{g\pi^2 D^4}$$

$$A = Q/v = 0.56 / 9.84 =$$

$$= \sqrt{\frac{4\cdot A}{\pi}} = \sqrt{\frac{4\cdot 0.08}{\pi}} = 0.3375\ \text{ft}$$

$= 4.04$ inches

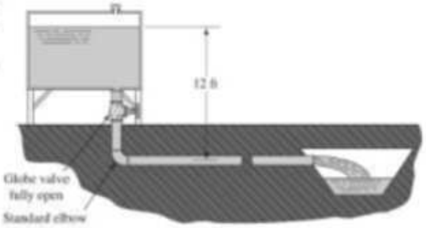
≈ 4 inch pipe

See excel sheet 4

Q	400	gal/min	0.50	ft^3/s
T	80	F		
L	75	ft		
V	9.84	ft/s	Assumption	
Za-Zb	12	ft		

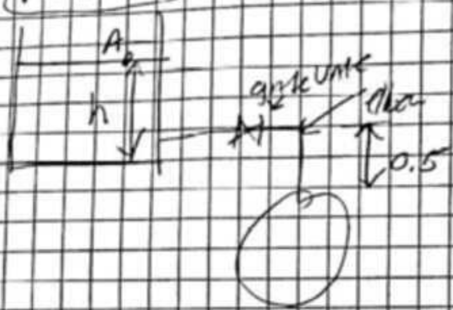
A=Q/V	
0.0894530894	ft^2
Diamter	
0.337441774	ft
4.049301294	inches
4	inche pipe

BOOK ANSWER
N/A



Sewer drain for Problem 11.22.

Problem 23 — See excel sheet 5



$h = z_A - z_B - 0.5$

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

$$h_L + \frac{v_B^2}{2g} = z_A - z_B$$

$A = 6.381 \times 10^{-3}$

$\frac{L_e}{D} = 30$ elbow

3.5 inch

$f_T = 0.017$

$h_L = h_1 + h_2 + h_3$

$$h_1 = f_T \cdot \frac{L_e}{D} \cdot \frac{v_B^2}{2g}$$

$$v_B = \frac{Q}{A} = \frac{1500 \times 10^{-3}}{6.381 \times 10^{-3} \cdot 60} = 3.91\ m/s$$

$$h_1 = 0.017 \cdot 30 \cdot \frac{3.91^2}{2 \cdot 9.81} = \boxed{0.39\ m}$$

$\frac{L_e}{D} = 160$ gate valve

$$h_2 = 0.017 \cdot 160 \cdot \frac{3.91^2}{2 \cdot 9.81} = \boxed{2.12\ m}$$

Problem

$$h_3 = K \cdot \frac{v_B^2}{2g} = 0.5 \cdot \frac{3.91^2}{2 \cdot 9.81} = \boxed{0.39\ m}$$

$h_L = h_1 + h_2 + h_3 = 0.39 + 2.12 + 0.39 = \boxed{2.91\ m}$

$$z_A - z_B = h_L + \frac{v_B^2}{2g} = 2.91 + \frac{3.91^2}{2 \cdot 9.81} =$$

3.70 m

$h = z_A - z_B - 0.5$

$h = 3.70 - 0.5 = \boxed{3.20\ m}$

Continued to page

Q	1500	L/min	Le/D2	160
t	25	C	K	0.5
sg	0.68			
d	3.5	in		
fT	0.017			
Le/D1	30			
A	6.381			

vB=Q/A
3.91788121

h1=fT*Le/D*vB^2/2*g
0.39900074

h1=fT*Le/D*vB^2/2*g
2.128003947

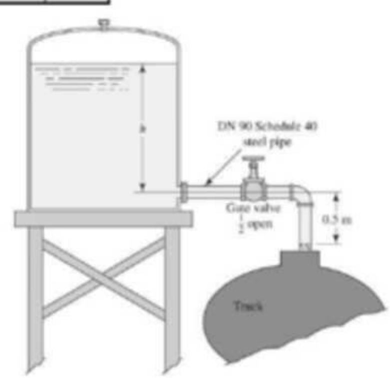
h3=K*vB^2/2*g
0.391177196

hL=h1+h2+h3
2.918181883

zA-zB=hL+vB^2/2*g
3.700536275

h=zA-zB-0.5	
3.200536275	m

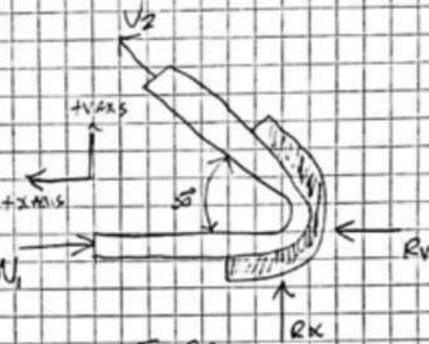
BOOK ANSWER
h=3.35m



Gasoline storage tank for Problem 11.23.

ROY SHEPPARD MET 330 HW 3.3

Problem 6



Water T = 160°F

Vane Angle 130°

$V = 22\ ft/s$

$A = 2.95\ in^2 = 0.0204\ ft^2$

$\theta = 50°$

$F = \rho Q \Delta V$

$Q = AV = (0.0204)(22) = 0.450\ ft^3/s$

See Appendix A

$T = 160°F \quad \rho = 1.88\ \frac{slug}{ft^3} = 1.88\ \frac{lbf \cdot s^2}{ft^4}$

Use continuity eq.

X) $V_{1X} = -V_1 = -22$

$V_{2X} = V_2 \cos 50° = 22 \cos 50°$

Y) $V_{1Y} = 0$

$V_{2Y} = V_2 \sin 50 = 22 \sin 50$

Rx) $F = \rho Q \Delta V \qquad R_X = \rho Q(V_{2X} - V_{1X})$

$(1.88)(0.450)(22\cos 50 - (-22))$

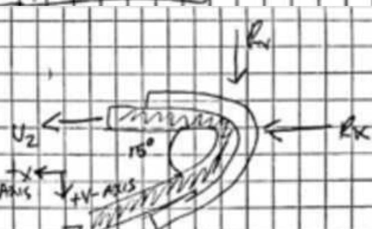
$\boxed{R_X = 30.58\ lbf}$

Ry) $F = \rho Q \Delta V \qquad R_Y = \rho Q(V_{2Y} - V_{1Y})$

$(1.88)(0.450)(22 \sin 50 - 0)$

$\boxed{R_Y = 14.26\ lbf}$

Problem 20



$V_0 = 12\ m/s$

$V_1 = 30\ m/s$

$D_1 = 200\ mm = 0.2\ m$

$F = \rho Q \Delta V$

$A_1 = \frac{\pi d^2}{4}$

$Q = A_1 V_1$

$Q = \frac{\pi d^2}{4} V_1 = \frac{\pi (0.2)^2}{4}(30)$

$Q = 0.942\ m^3/s$

X) $V_1 = V_2$

$V_{1X} = V_1 \cos 15° = 30 \cos 15 = 28.978\ m/s$

$V_{2X} = V_2 = 30\ m/s$

Y) $V_{1Y} = -V_1 \sin 15° = 30 \sin 15 = 7.765\ m/s$

$V_{2Y} = 0\ m/s$

Appendix A for water

$\rho = 1000\ kg/m^3$

X) $F = \rho Q \Delta V$

$R_X = \rho Q(V_{2X} - V_{1X})$

$= (1000)(0.942)(30 - (-28.978))$

$= 55557.3\ N = \boxed{55.56\ KN}$

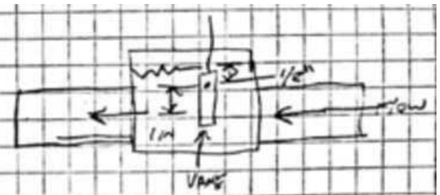
Y) $F = \rho Q \Delta V$

$R_Y = \rho Q(V_{2Y} - V_{1Y})$

$(1000)(0.942)(0 - (-7.765))$

$R_Y = 7314.63\ N = \boxed{7.31\ KN}$

Problem 11



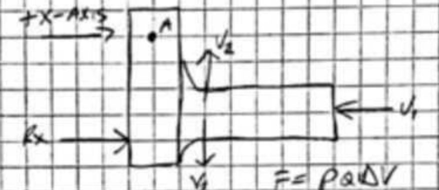
$Q = 100\ gal/min = .223\ ft^3/s$

$D_1 = 1\ in = 0.0833\ ft$

See Appendix F

1 inch Sch 40

$A = 0.006\ ft^2$



$Q = AV$

$F = \rho Q \Delta V$

$0.223 = 0.006\ V_1 = 37.167\ ft/s$

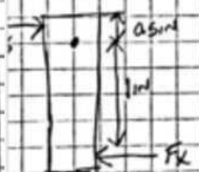
See Appendix A for water

$\rho = 1.94\ slug/ft^3 = 1.94\ \frac{lbf \cdot s^2}{ft^4}$

X) $F = \rho Q \Delta V \qquad R_X = \rho Q(V_{2X} - V_{1X})$

$= (1.94)(0.223)(0 - (-37.167))$

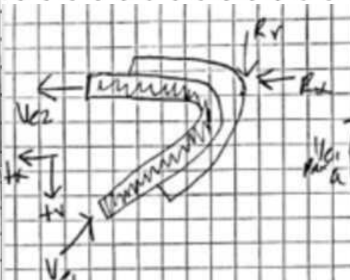
$R_X = 16.08\ lbf$

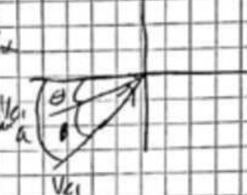


$+\sum M_A = 0$

$F_S(0.5) = R_X(1) = F_S(0.5) = (16.08)(1)$

$\boxed{F_S = 32.16\ lbf}$





$V_{e1} = V_1 - V_0 \qquad V_{e1X} = -V_1 \cos 15 - (-V_0)$

$= -30 \cos 15 - (-12) = -16.978\ m/s$

$V_{e1Y} = -V_1 \sin 15$

$= -30 \sin 15 = -7.765\ m/s$

$V_{e1} = \sqrt{V_{e1X}^2 + V_{e1Y}^2} = \sqrt{(-16.978)^2 + (-7.765)^2} = 18.669\ m/s$

$\alpha = \tan^{-1}\left(\frac{V_{e1Y}}{V_{e1X}}\right) = \tan^{-1}\left(\frac{-7.765}{-16.978}\right) = 24.577°$

$Q_e = A_1 V_{e1} = \frac{\pi D_1^2}{4} V_{e1} = \frac{\pi (0.2)^2}{4}(18.669) = 0.587\ m^3/s$

$\beta = \alpha - \theta = 24.577 - 15 = 9.577°$

$V_{e2} = V_{e1}(par) = V_{e2} = V_{e1} \cos \beta = (18.669)\cos(9.577) = 18.409\ m/s$

X) $F = \rho Q \Delta V$

$R_X = \rho Q_e(V_{e2X} - V_{e1X})$

$= (1000)(0.587)(18.409 - (-16.978)) = 20773.3\ N$

$\boxed{20.77\ KN}$

Y) $F = \rho Q \Delta V$

$R_Y = \rho Q_e(V_{e2Y} - V_{e1Y})$

$(1000)(0.587)(0 - (-7.765)) = 4558.06\ N$

$\boxed{4.56\ KN}$

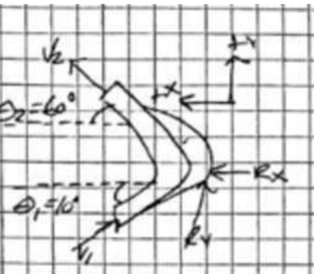
ROY SHEPARD CH 13 Problems 17, 19, 22, 23, 34

Problem 29

$V_1 = 25\,m/s$

$D_1 = 7.50\,mm = 0.0075\,m$

$T = 16°C$



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

$Q = AV = \frac{\pi D^2}{4} V_1 = \frac{\pi (0.0075)^2}{4}(25) = 0.001104\,m^3/s$

$V_1 = V_2$

x) $V_{1x} = -V_1 \cos(10) = -25\cos(10) = -24.62\,m/s$

$V_{2x} = V_2 \cos(60) = 25\cos(60) = 12.5\,m/s$

y) $V_{1y} = V_1 \sin(10) = 25\sin(10) = 4.34\,m/s$

$V_{2y} = V_2 \sin(60) = 25\sin(60) = 21.65\,m/s$

Appendix A $T = 15°C = 1000\,kg/m^3$

x) $F = \rho Q \Delta V$

$R_x = \rho Q (V_{2x} - V_{1x}) = (1000)(.001104)(12.5 - (-24.62))$

$R_x = 40.98\,N = \boxed{41.0\,N}$

y) $F = \rho Q \Delta V$

$R_y = \rho Q (V_{2y} - V_{1y}) = (1000)(.001104)(21.65 - 4.34)$

$R_y = 19.1\,N = \boxed{19.1\,N}$

Problem 17

$N_2 = \frac{N_1}{2}$ $\quad \frac{h_1}{h_2} = \left(\frac{N_1}{N_2}\right)^2$

$h_2 = ?$ $\quad = \left(\frac{N_1}{\frac{N_1}{2}}\right)^2 = \boxed{4}$

$\frac{h_1}{h_2} = 4$ $\quad \boxed{h_2 = \frac{h_1}{4}}$ $\quad$ Book answer = 4 ✓

Problem 19

$D_2 = D_1 - 0.25 \cdot D_1$

$Q_2 = ?$

$\frac{Q_1}{Q_2} = \frac{D_1}{D_2}$ $\quad D_2 = D_1 - 0.25 \cdot D_1 = 0.75 \cdot D_1$

$\frac{Q_1}{Q_2} = \frac{D_1}{D_2} = \frac{D_1}{0.75 \cdot D_1} = \frac{1}{0.75}$ $\quad Q_2 = 0.75 \cdot Q_1$

Pump reduced by $\boxed{25\%}$ if the impeller is reduced by 25%

25% Book check ✓

Problem 22

$1\frac{1}{2} \times 3-6$

$1\frac{1}{2}$ = Nominal diameter of Discharge connection

3 = Nominal diameter of Suction connection

6 = max impeller that can be inserted in casing

Problem 23

$Q = 100\,\frac{gal}{min}$

$H_t = 300\,ft$

Using Figure 13.22 & all above data we get a size of,

$\boxed{1\tfrac{1}{2} \times 3-10}$ $\quad$ Book Answer $1\frac{1}{2} \times 3-10$ ✓

Problem 25

Pump 2x3-10

$D_1 = 8\,in$

$H_t = 200\,ft$

See Figure 13.28

$Q \approx 234\,gal/min$

$\eta \approx 53.5$

$NPSH_R \approx 11$

Problem 34 Only Chose 2

a. $Q = 500\,gal/min$

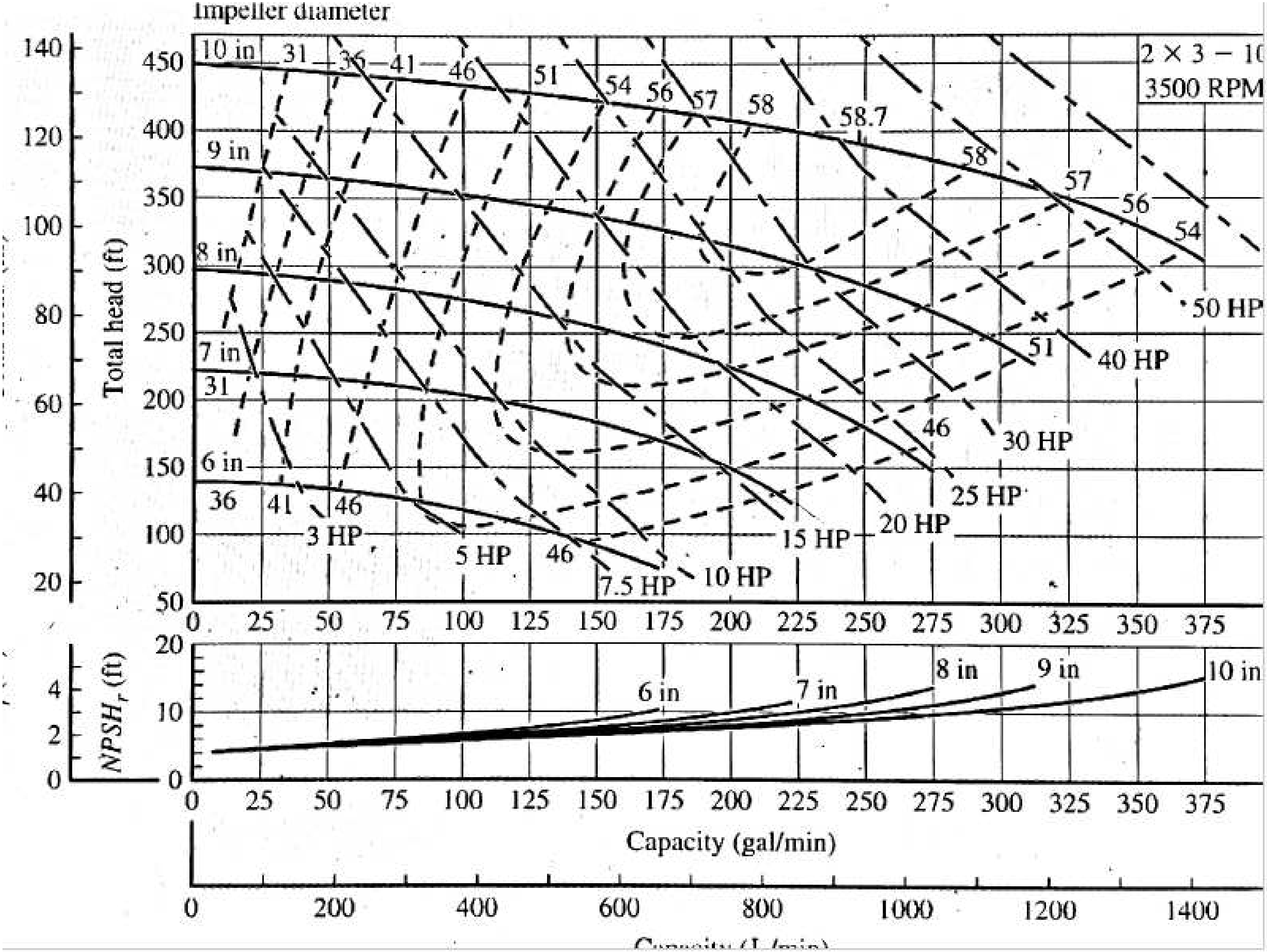
$H_t = 80\,ft$

Options of Reciprocating or Rotary or Centrifugal

b. $Q = 50\,gal/min$

$H_t = 800\,ft$

Options of Reciprocating or Rotary



Impeller diameter
2 × 3 − 10
3500 RPM
Total head (ft)
NPSH$_r$ (ft)
Capacity (gal/min)
10 in
9 in
8 in
7 in
6 in
31
36
41
46
51
54
56
57
58
58.7
3 HP
5 HP
7.5 HP
10 HP
15 HP
20 HP
25 HP
30 HP
40 HP
50 HP