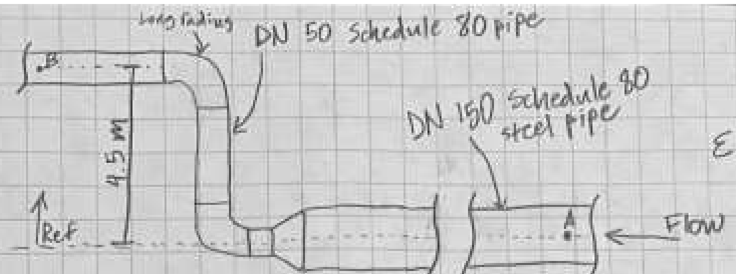
Fluid Mechanics Homework 3.1

Group 1

11.5

11.5.)



$\varepsilon = 1.5\times10^{-6}$

$\gamma_{oil} = 8.8\ kN/m^3$ $\quad l_{150} = 180\,m$ $\quad P_B = 12.5\ MPa$ $\quad P_A = ?$ $\quad f_{T_{150}} = 0.015$

$\nu = 2.12\cdot10^{-5}\ \frac{m^3}{s}$ $\quad l_{50} = 80\,m$ $\quad Q = 0.015\ \frac{m^3}{s}$ $\quad f_{T_{50}} = 0.019$ ← Table 10.5

$D_{150} = 146.3\ mm = 0.1463\,m$ $\quad D_{50} = 49.3\ mm = 0.0493\,m$

Long Radius elbow

$K = 20 f_T$

$Q = VA$ $\quad A_A = \frac{\pi}{4}D_{150}^2$ $\quad A_B = \frac{\pi}{4}D_{50}^2$

$V_A = \frac{Q}{A_A}$ $\quad A_A = \frac{\pi}{4}(0.1463m)^2$ $\quad A_B = \frac{\pi}{4}(0.0493m)^2$

$f_{50} = \frac{\varepsilon}{D_{50}}$

$V_B = \frac{Q}{A_B}$ $\quad \underline{A_A = 0.0168\,m^2}$ $\quad \underline{A_B = 0.00191\,m^2}$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + \cancel{z_A}^{\,0} = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B^{\,4.5m} + h_L$$

$f_{150} = \frac{\varepsilon}{D_{150}}$

$V_A = \frac{0.015\frac{m^3}{s}}{0.0168\,m^2}$ $\quad V_B = \frac{0.015\frac{m^3}{s}}{0.00191\,m^2}$ $\quad f_{50} = \frac{1.5\times10^{-6}}{0.0493\,m}$ $\quad f_{150} = \frac{1.5\times10^{-6}}{0.1463\,m}$

$\underline{V_A = 0.893\frac{m}{s}}$ $\quad \underline{V_B = 7.85\ m/s}$ $\quad f_{50} = 0.0000304\frac{1}{m}$ $\quad f_{150} = 0.0000103\frac{1}{m}$

$\frac{D_A}{D_B} = \frac{146.3\,mm}{49.3\,mm} = 2.97$ $\therefore K_{contract} = 0.39$ Fig 10.8

$$h_L = f_{50}\frac{L_{50}}{D_{50}}\frac{V_B^2}{2g} + K_{contract}\frac{V_B^2}{2g} + 2\left(20 f_{T_{50}}\frac{V_B^2}{2g}\right) + f_{150}\frac{L_{150}}{D_{150}}\cdot\frac{V_A^2}{2g}$$

$$h_L = (0.0000304\tfrac{1}{m})\left(\frac{80m}{0.0493m}\right)\left(\frac{(7.85m/s)^2}{2(9.81m/s^2)}\right) + (0.39)\left(\frac{(7.85m/s)^2}{2(9.81m/s^2)}\right)$$
$$+2\left(20\cdot0.019\left(\frac{(7.85\,m/s)^2}{2(9.81\,m/s^2)}\right)\right) + 0.0000103\tfrac{1}{m}\left(\frac{(0.893\,m/s)^2}{2(9.81\,m/s^2)}\right)$$

$h_L = 3.77\,m$

$$\frac{P_A}{8.8\frac{kN}{m^3}} + \frac{(0.893\frac{m}{s})^2}{2(9.81\frac{m}{s^2})} = \frac{12.5\,MPa}{8.8\frac{kN}{m^3}} + \frac{(7.85\frac{m}{s})^2}{2(9.81\frac{m}{s^2})} + 4.5m + 3.77m$$

$\rightarrow \boxed{P_A = 112.557\ MPa}$

11.13

input data		
specific weight	62	lb/ft^3
kinematic viscosity	0.00000737	ft^2/s
pressure A (80 psi)	11520	lb/ft^2
pressure A (20 psi)	2880	lb/ft^2
Pressure B	0	lb/ft^2
Z_B	18	ft
Tube Length	20	ft
diameter_1	0.04166667	ft
diameter_2	0.02083333	ft
Wall Roughness	0.00015	ft

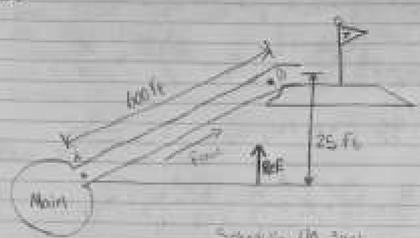
Computable Data		
Relative roughness (D/e)=	277.777778	
fT=	0.02755873	
K opening=	0.15	
K elbows=	0.82676178	
LHS (20 psi)=	28.4516129	ft
LHS (80 psi)=	203.806452	ft

For 20 psi					
Iteration	V (ft/s)	Re	f	RHS (m)	% diff
1	45	127204.9	0.028706	62.15937	-118.47%
2	45.9	129749	0.028686	64.67061	-127.30%
3	40	113071	0.028829	49.11359	-72.62%
4	30	84803.26	0.029184	27.6264	2.90%
5	32.44	91700.59	0.029079	32.30305	-13.54%
6	31	87630.03	0.029139	29.49886	-3.68%
7	30.5	86216.64	0.029161	28.55496	-0.36%
8	30.44	86047.04	0.029164	28.44272	0.03%

for 80 psi					
Iteration	V (ft/s)	Re	f	RHS (m)	% diff
1	12	33921.3	0.031047	4.420233	97.83%
2	50	141338.8	0.028606	76.73996	62.35%
3	40	113071	0.028829	49.11359	75.90%
4	70	197874.3	0.028339	150.4103	26.20%
4	80	226142	0.028253	196.4542	3.61%
5	81	228968.8	0.028245	201.3963	1.18%
6	75	212008.1	0.028293	172.6649	15.28%
7	73.9	208898.7	0.028303	167.6372	17.75%
8	81.44	230212.6	0.028242	203.5902	0.11%

11.20

P 11.20



Schedule 40 Steel

$P_{main} = 80$ psig $\qquad P_{min} = 60$ psig

$Q = 0.50\ ft^3/s$ @ $60°F$

→ Find diam of pipeline

Wall Roughness = 0.000150 ft

$\gamma = 62.4\ lb/ft^3 \qquad \nu = 1.21 \times 10^{-5}\ ft^2/s$

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_{L_{1-2}}$$

$$h_L = f\frac{L}{D}\frac{V^2}{2g} \qquad R_e = \frac{\rho V D}{\mu} = \frac{VD}{\nu}$$

D/ε (relative roughness) $\qquad V = \dfrac{4Q}{\pi D^2}$

$$\frac{P_1}{\gamma} + \cancel{\frac{V_1^2}{2g}} + \cancel{z_1} = \frac{P_2}{\gamma} + \cancel{\frac{V_2^2}{2g}} + z_2 + h_{L_{1-2}}$$

$$\frac{P_1}{\gamma} = \frac{P_2}{\gamma} + z_2 + h_{L_{1-2}}$$

$$\frac{P_1 - P_2}{\gamma} - z_2 = h_{L_{1-2}} \Leftarrow f\frac{L}{D}\frac{V^2}{2g}$$

$$\frac{P_1 - P_2}{\gamma} - z_2 = f\frac{L}{D}\frac{1}{2g}\frac{16Q^2}{\pi^2 D^4} \Leftarrow f\frac{L\,16\,Q^2}{2g\,\pi^2 D^5}$$

→ Solving for D:

$$D = \sqrt[5]{\frac{f\dfrac{8LQ^2}{g\pi^2}}{\dfrac{P_1 - P_2}{\gamma} - z_2}}$$

Using excel:

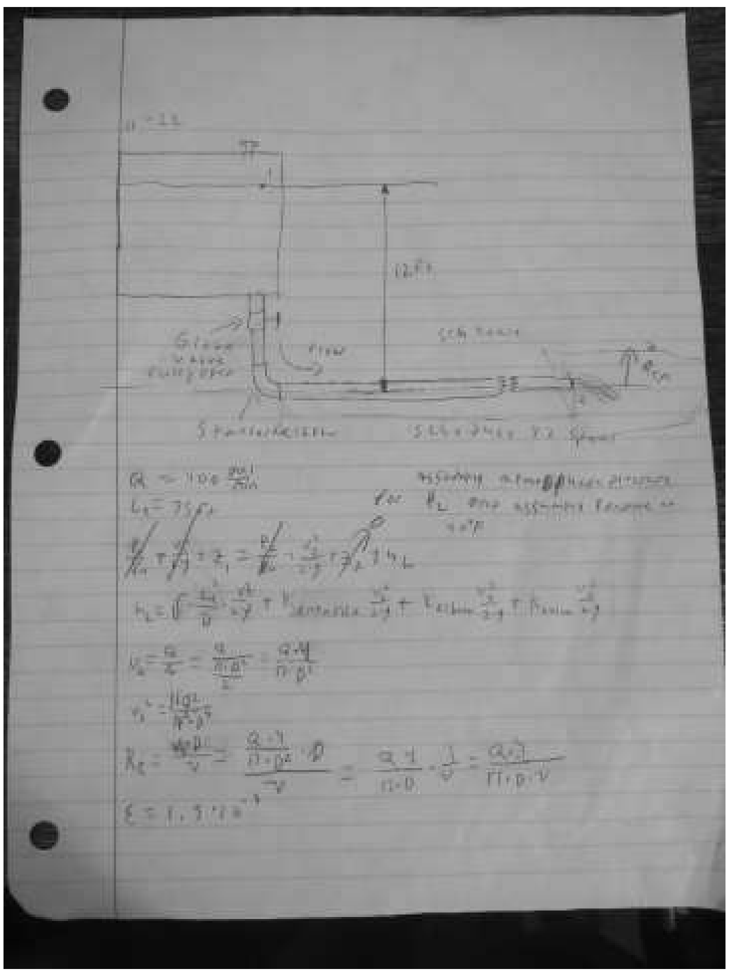
- guess f
- calc Diam from f
- compute R_e and D/ε
- find f again
- compare f_{new} and f_{old}

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

Excel Below!

Gamma	62.4	lb/ft^3			**Top**	18.39057	**Bot.**	21.15385
Visc	1.21E-05	ft^2/s				11.03434		21.15385
PA	80	psig	11520	lb/ft^2		7.356227		21.15385
PB	60	psig	8640	lb/ft^2		3.678113		21.15385
ZB	25	ft				9.195284		
L	600	ft	**Delta P**	2880		8.09185		
Q	0.5	ft^3/s				9.162181		
e	0.00015	ft						
g	32.2	ft/s^s						
Itteration	**f**	**D**	**V**	**Re**	**D/e**	**f(new)**	**%diff**	
1	0.05	0.972392		5.41E+04	6482.61	2.38E-02	52.47421725	
2	0.03	0.877953		6.00E+04	5853.022	2.44E-02	18.57799204	
3	0.02	0.809568		6.50E+04	5397.118	2.50E-02	-24.86708559	
4	0.01	0.70477		7.47E+04	4698.464	2.60E-02	-159.5167258	
5	0.025	0.846516		6.22E+04	5643.44	2.47E-02	1.319047597	
6	0.022	0.825148		6.38E+04	5500.985	2.48E-02	-12.92382639	
7	0.02491	0.845906		6.22E+04	5639.371	2.47E-02	0.943018233	

11.22



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

$$f_T = \frac{0.25}{\left[\log\left(\frac{\varepsilon}{3.7D}\right)\right]^2}$$

$K_{entrance} = 0.5$

$K_{elbow} = 30 f_T$

$K_{valve} = 340 f_T$

$\nu = 1.63\cdot10^{-5}\ \frac{ft^2}{s}$

$$z_1 = \frac{1}{2g}\cdot\frac{16Q^2}{\pi^2 D^4} + f\cdot\frac{L_e}{D}\cdot\frac{1}{2g}\cdot\frac{16Q^2}{\pi^2 D^4} + 0.5\cdot\frac{1}{2g}\cdot\frac{16Q^2}{\pi^2 D^4} + 30 f_T\cdot\frac{1}{2g}\cdot\frac{16Q^2}{\pi^2 D^4} + 340 f_T\cdot\frac{1}{2g}\cdot\frac{16Q^2}{\pi^2 D^4}$$

$$z_1 = \left(1 + f\frac{L_e}{D} + 0.5 + 30 f_T + 340 f_T\right)\frac{1}{2g}\frac{16Q^2}{\pi^2 D^4}$$

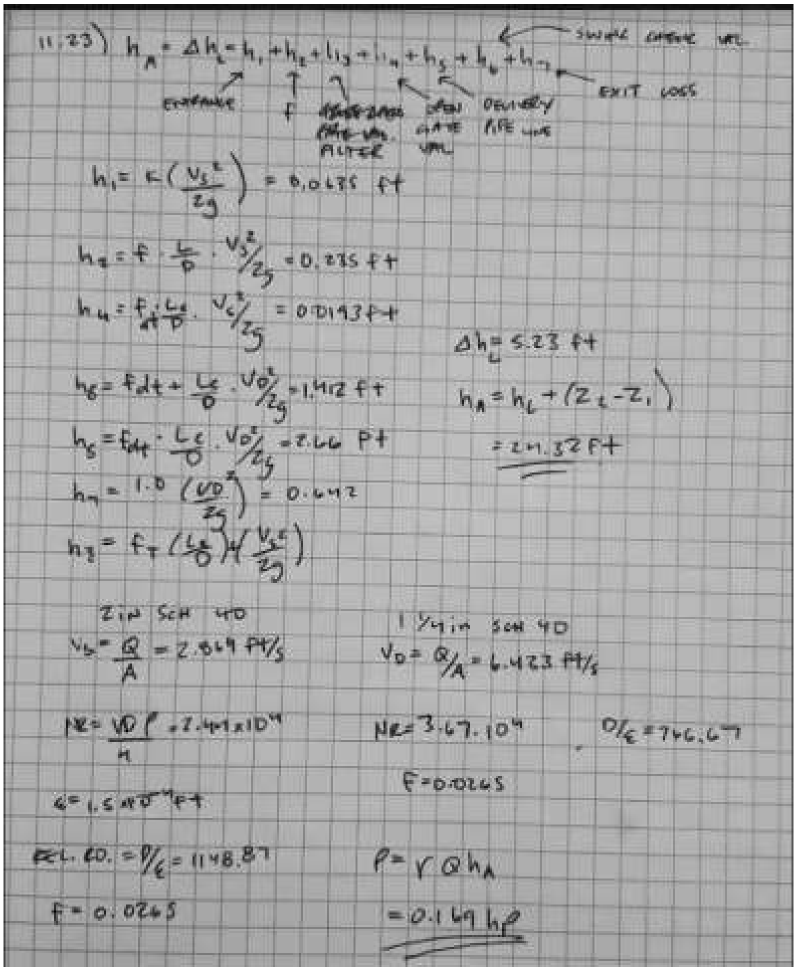
using interation

By guessing for D

$D = 0.775$ ft

z1	12	ft								
Q	400	gal/min	0.890868597	ft3/s						
RHS1	1									
RHS3	0.5									
υ	1.67E-05	ft2/s								
ε	1.50E-04	ft								
LHS	12	ft								
Le	75	ft								
Interation	D	F	Ft	Re	RHS2	RHS4	RHS5	RHS6	RHS	%diff
1	0.5	8.875617	0.01493702	4.537157	1331.342596	0.448110602	5.078586827	0.319655	427.8166	3465%
2	0.2	6.910428	0.018329405	11.34289	2591.410658	0.549882138	6.231997563	12.48653	32461.13	270409%
3	1	1.29875	0.012959657	2.268578	97.40628449	0.388789703	4.406283304	0.019978	2.071792	-83%
4	0.6	4.373506	0.014375183	3.780964	546.6882334	0.431255494	4.88756227	0.154155	85.32569	611%
5	0.9	1.581742	0.013233966	2.520643	131.811798	0.397018987	4.49954852	0.03045	4.208487	-65%
6	0.8	2.023156	0.013551056	2.835723	189.6708578	0.406531676	4.607358991	0.048775	9.569009	-20%
7	0.7	2.790145	0.013924523	3.240826	298.9441591	0.417735701	4.734337941	0.083209	25.42831	112%
8	0.75	2.348046	0.013729659	3.024771	234.8046093	0.411889785	4.66808423	0.063142	15.24145	27%
9	0.76	2.275278	0.013692718	2.984971	224.5339907	0.410781537	4.655524081	0.059884	13.8391	15%
10	0.77	2.206728	0.013656405	2.946206	214.9409916	0.409692155	4.643177759	0.056833	12.58811	5%
11	0.78	2.142056	0.013620703	2.908434	205.966884	0.408621075	4.631038852	0.053974	11.46979	-4%
12	0.775	2.173927	0.013638479	2.927198	210.3799933	0.409154362	4.637082768	0.05538	12.01343	0%

11.23



11.23) $h_A = \Delta h_L = h_1 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7$

ENTRANCE; f; ~~ANGLE~~ ~~BASS~~ ~~GATE VAL.~~ FILTER; OPEN GATE VAL; DELIVERY PIPE LINE; SWING CHECK VAL; EXIT LOSS

$h_1 = K\left(\frac{V_S^2}{2g}\right) = 0.0635$ ft

$h_2 = f \cdot \frac{L}{D} \cdot V_S^2/2g = 0.235$ ft

$h_4 = f_{dt} \cdot \frac{L_e}{D} \cdot V_D^2/2g = 0.0193$ ft

$h_6 = f_{dt} + \frac{L_e}{D} \cdot V_D^2/2g = 1.412$ ft

$h_5 = f_{dt} \cdot \frac{L_e}{D} \cdot V_D^2/2g = 2.66$ ft

$h_7 = 1.0\left(\frac{V_D^2}{2g}\right) = 0.642$

$h_3 = f_T\left(\frac{L_e}{D}\right)\left(\frac{V_S^2}{2g}\right)$

$\Delta h_L = 5.23$ ft

$h_A = h_L + (z_2 - z_1)$

$= 24.32$ ft

2 in SCH 40

$V_S = \frac{Q}{A} = 2.869$ ft/s

$N_R = \frac{VD\rho}{\mu} = 2.44 \times 10^4$

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

REL. RO. $= D/\epsilon = 1148.87$

$f = 0.0265$

1 1/4 in SCH 40

$V_D = Q/A = 6.423$ ft/s

$N_R = 3.67 \cdot 10^4$

$D/\epsilon = 746.67$

$f = 0.0265$

$P = \gamma Q h_A$

$= 0.169$ hp

Paragraph:

We learned that the two equations given in the book to determine flow rate and to determine pipe diameter should not be used under any circumstances. Series pipeline systems are when fluid flows through a single continuous path. Therefore, the flow rate is equal throughout the system, and energy losses are equal to the sum of all the losses in the system. For the critical velocity of water in pipes, we are using three meters per second for this class when determining pipe diameter.

In parallel pipeline systems, the total flow rate is found by adding the flow rates of different parts of the system together. The energy losses of all parts of the system are equivalent and equal to the total energy losses of the system.