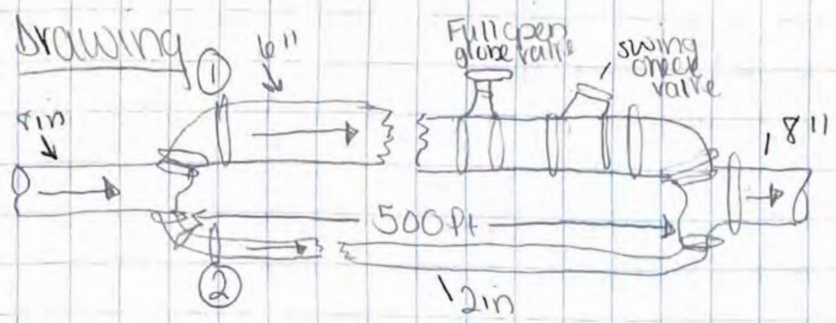
Amber Samm
MET330
Homework #6

12-7

Purpose: calculate the volume flow rate in the 6in and 2in pipes.

Drawing



Materials:
benzene, steel

Design Considerations
① Incompressible
② Isothermal
③ Steady state

Data:
$sg_{benzene} = 0.87$ $Q = 1350 gl/min = 3.01 m^3/s$
Fluid @ 140°F
Sche. 40 $D_{i_2} = 2.067in = 0.1723ft$, $A_p = 0.02333ft^2$, $\varepsilon = 1.5\times10^{-4}ft$
$D_{i_6} = 6.065in = 0.5054ft$, $A_p = 0.2006ft^2$, $\varepsilon = 1.5\times10^{-4}ft$
$D_{i8} = 7.981in = 0.6651ft$, $A_p = 0.3472ft^2$, $\varepsilon = 1.5\times10^{-4}ft$
$\nu = 4.45\times10^{-6} ft^2/s$ $f_{T(6)} = 0.015$ $f_{T2} = 0.019$

Procedure/Calculations: Express energy loss in each pipe: $h_L = KQ^2$

Branch 1 (6" pipe): L = 500ft
(2) 90° elbows: $2\times30f_T = 0.9$
(2) tees (flow thru): $20\times20f_T = 0.6$
(1) Full open globe valve: $340f_T = 5.1$
(1) swing valve: $50f_T = 0.75$
$\Sigma K = 7.35$

Branch 2: L = 500ft
(2) 90° elbows: $2\times30f_T = 1.14$
$\Sigma K_2 = 1.14$

Solve by iteration: (Excel) - (ROW 55)

Trial 6:

Branch	Pipe	Q (ft³/s)	D (ft)	ε	L	Le	D/ε	V
1	6in	2.807	0.5054	1.50E-04	500ft	7.35	3.37E+03	13.9896
2	2in	-0.201	0.1723	1.50E-04	500ft	1.14	1.15 E+03	8.64197

(cont)

Re	f	K	K·Q²	2·K·Q	ΔQ
1.59E+06	1.55E-02	8.74	68.83345	49.05249	0.00
3.35E+05	2.01E-02	1695.39	-68.83362	683.2411	
		sum	0.00	732.2936	

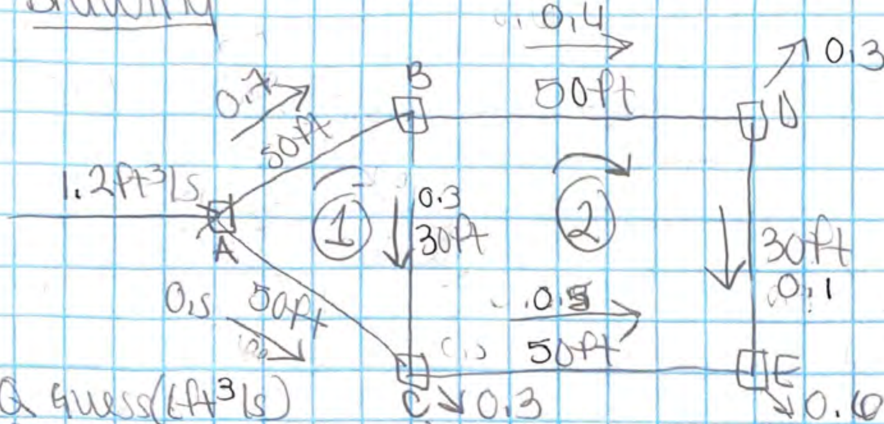
Summary: The flow rate for 6" pipe is 2.807 ft³/s, and the flow rate for 2" pipe is 0.201 ft³/s.

12-9

Purpose: Find the flow rate of water at 60°F in each pipe

Materials: water, steel

Drawing



Design Considerations

1. incompressible
2. isothermal
3. steady state
4. neglect minor losses

Q Guess (ft³/s)

Circuit One (Triangle)

AB + 0.7

BC + 0.3

AC − 0.5

Circuit Two (Rectangle)

BD + 0.4

DE + 0.1

CE − 0.5

BC − 0.3

Data:

2½ Sche 40:

$D_i = 0.2058$ ft

$A_f = 0.03326$ ft²

SW = 62.4 lb/ft³

$\nu = 1.21 \times 10^{-5}$ ft²/s

Solve by Iteration (Hardy Cross) - Excel (Row 101)

Trial 3:

Circuit	Pipe	Q (ft³/s)	ΔQ
1	AB	0.5007	
	BC	0.5374	
	CA	−0.6993	−0.01
2	BD	0.5120	
	DE	0.2120	
	CE	−3.880	
	BC	−0.5374	−0.01

Summary:

In circuit 1 the Q for AB = 0.5007 ft³/s, BC = 0.5374 ft³/s, and CA = −0.6993 ft³/s. In circuit 2 the Q for BD = 0.5120 ft³/s, DE = 0.2120 ft³/s, CE = −3.880, and BC = −0.5374 ft³/s.

14.15 Purpose: Determine the normal discharge for depths 3ft + 6ft.

Drawing

Materials: earth/grass, water

Design
1. incompressible
2. isothermal
3. solid state

Data

$n = 0.04$

$slope_{avg} = 0.00015\%$

$d_1 = 3ft$

$d_2 = 6ft$

$A = WD + XD$

$NP = W + 2L$

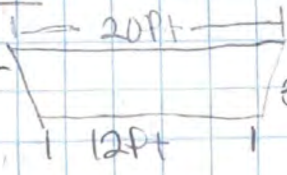
$R = \frac{A}{NP}$

Mannings Equation:

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

Procedure/Calculations

(A) 3ft depth:



$A = \frac{(12+3)}{} \times 3 = 45ft^2$

$NP = 12 + 2(3)\sqrt{2} = 20.49ft$

$R = 45.0ft^2 / 20.49ft = 2.196ft$

$Q = \frac{1.49}{0.04} 45 \cdot (2.196)^{2/3} \cdot (0.00015)^{1/2}$

$Q = 34.684 ft^3/s$

(B) 6ft depth: Rect + Triangle

$A = (4\times2) + (1/2 \times 2 \times 2) = 10ft^2$

$NP = 4 + \sqrt{2^2+2^2} = 6.83ft$

$R = 10ft^2 / 6.83ft = 1.46ft$

$Q = \frac{1.49}{0.04} \cdot 10(1.46)^{2/3} \times (0.00015)^{1/2}$

$Q = 5.87 ft^3/s \cdot 2 = 11.74 ft^3/s$

Lower trapezoid:

$A = \left(\frac{12+20}{2} \cdot 4\right) + (20(6-4)) = 104ft^2$

$NP = 12 + 2 \cdot (4\sqrt{2}) = 23.314ft$

$R = 104ft^2 / 23.314ft = 4.46ft$

$Q = \frac{1.49}{0.04} \cdot 104(4.46)^{2/3} \times (0.00015)^{1/2}$

$= 128.556 ft^3/s$

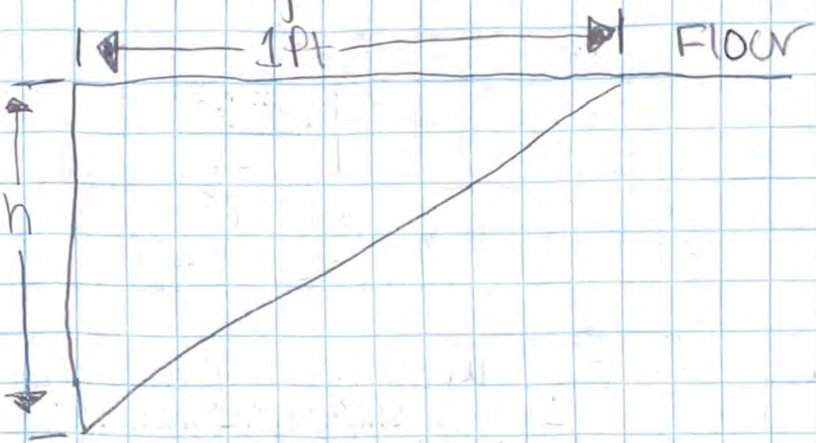
$\Sigma Q = 128.556 + 11.74 = 140.3 ft^3/s$

Summary: The normal discharge at 3ft is 34.7 ft³/s, and at a depth of 6ft is 140.3 ft³/s.

14.21 Purpose: Determine the size of tile required to carry the flow (500 gal/min) when running half full

Materials: water, clay tiles,

Drawing:



Design considerations:

① Incompressible fluid
② Isothermal
③ steady state

Data:

$Q = 500\,gal/min = 1.114\,ft^3/s$

$S = 0.01\%$

$n = 0.013$ (table 14.1)

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

$R = \frac{D}{4}$

Procedure/Calculations:

Manning's Equation

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

$Q = \frac{1.49}{n} \cdot \left(\frac{\pi D^2}{8}\right) \cdot \left(\frac{D}{4}\right)^{2/3} \cdot S^{1/2}$

$Q = \left(1.49 \cdot \frac{\pi}{8} \cdot \left(\frac{1}{4}\right)^{2/3}\right) \cdot \frac{1}{n} \cdot D^2 \cdot D^{2/3} \cdot S^{1/2}$

$Q = \frac{0.231}{n} \cdot D^{8/3} \cdot S^{1/2}$

$1.114 = \frac{0.231}{0.013} \cdot D^{8/3} \cdot (0.001)^{1/2}$

$1.114 = 0.5564 \cdot D^{8/3}$

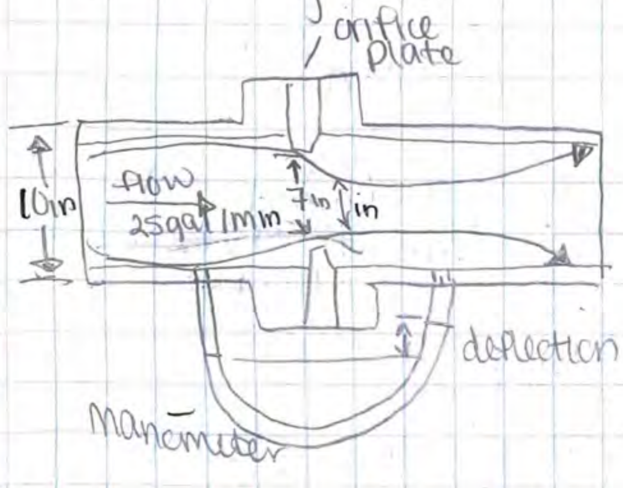
$D^{8/3} = 0.5564 / 1.114 = 1.975$

$D = (1.975)^{3/8} = \boxed{1.29\,ft}$

Summary: The diameter of the tile required to carry the 500 gal/min flow is 1.29 ft

15-4 Purpose: calculate the deflection of a water manometer (a) if orifice diameter is 1.0in an (b) if the orifice diameter is 7in.

Drawing:



Materials: ammonia, water

Data:

$d = 10in = 0.833ft$, $A = 0.5454ft^2$

$Q = 25 gal/min = 0.0557 ft^3/s$

$d_{orif} = 1 in = 0.0833ft$

$d_{orif} = 7in = 0.5833ft$

$sg = 0.83$

$V = 2.5 \times 10^{-6} lb \cdot s/ft^2$

$\rho_{ammon} = 0.83 \times 1.94 slugs/ft^3 = 1.61$

$SW_{amm} = 0.83 \times 62.4 = 51.792 lb/ft^3$

$SW_{water} = 62.4 lb/ft^3$

Procedure/Calculations

(a) Calculate R_e + Velocity

d=1.0in $V_1 = \frac{Q}{A} = \frac{0.0557 ft^3/s}{0.5454 ft^2} = 0.1021 ft/s$

$Re = \frac{\rho V D}{\mu} = \frac{(1.61)(0.1021)(0.833)}{2.5 \times 10^{-6} lb \cdot s/ft^2} = 54,800$

Re through orifice:

$Q = CA_0 \sqrt{\frac{2g \Delta p / \gamma_{amm}}{1-(A_0/A_1)^2}}$ $A = \frac{\pi}{4}\left(\frac{1}{12}ft\right)^2 = 0.005454 ft^2$ $C = 0.60$

$(A_0/A_1) = \beta^4$ $\beta = \frac{1}{10} = 0.10$

Pressure Head $\frac{\Delta p}{\gamma_{amm}} = \frac{1-\beta^4}{2g}\left(\frac{Q}{CA_0}\right)^2 = \frac{1-(0.10)^4}{2(32.2)}\left(\frac{0.0557}{0.60 \cdot 0.005454}\right) = 4.497$

Deflection: $\Delta p = h(\gamma_{water} - \gamma_{amm}) \Rightarrow h = \frac{\Delta p}{\gamma_{amm}}\left(\frac{\gamma_{amm}}{\gamma_{water} - \gamma_{amm}}\right)$

$h = 4.497\left(\frac{51.792}{62.4 - 51.792}\right) =$ **21.95ft or 263.4 in**

(b) $d = 7.0in$ $\beta = \frac{7}{10} = 0.70$ $A = \frac{\pi}{4}\left(\frac{7}{12}\right) = 0.2673 ft^2$ $C = 0.60$

Pressure Head:

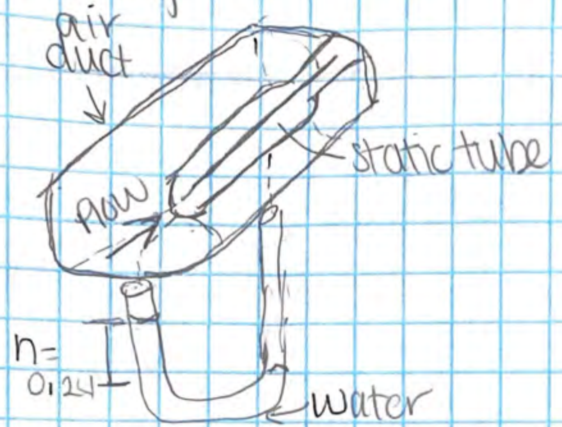
$\frac{\Delta p}{\gamma_{amm}} = \frac{1-(0.7)^4}{2(32.2)}\left(\frac{0.0557}{0.60 \times 0.2673}\right)^2 = 0.001378 ft$ ammonia

Deflection: $h = 0.001378 \times \left(\frac{51.792}{62.4 - 51.792}\right) =$ **0.00683 ft × 12 = 0.081 in**

Summary: With a 1in orifice diameter the deflection should be 21.95ft or 263.4in. With a 7in diameter orifice the deflection would be 0.00683ft or 0.081 in.

15-15 Purpose: Calculate the velocity of flow.

Drawing:



Materials: water

Design Considerations
1. steady state
2. incompressible
3. isothermal

Data: $h = 0.24 in = 0.02 ft$
$P_{atm} = 14.7 psi = 2116.2 lb/ft^2$
$\rho_{water} = 62.4 lb/ft^3$
$SW_{air} = 0.0765 lb/ft^3$

Procedure Calculation:

Apply Bernoulli's Equation

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

$$\frac{P_{stat}}{\gamma} + \frac{V_1^2}{2g} = \frac{P_{stag}}{\gamma}$$

$$\Delta p = \gamma_a \left(\frac{V^2}{2g}\right)$$

$$P_{stag} - P_{stat} = h_w(\gamma_w - \gamma_a)$$

$$\Delta p = 0.02 ft \times 62.4 lb/ft^3 = 1.248 lb/ft^2$$

Solve velocity:

$$V = \sqrt{\frac{2g(\Delta p)}{\gamma_a}} = \sqrt{\frac{2 \times 32.2 \times 1.248}{0.0765}} =$$

$$= \sqrt{1050.60} = 32.8 = \boxed{33.0 ft/s}$$

Summary:

The velocity of the flow is 33 ft/s

Network Pipeline EXAMPLE Problem 1

TRIAL 1

Circuit	Pipe	Q (l/min)	Q (m^3/s)	D (m)	e (m)	L (m)	Le (m)	D/e	V (m/s)	Re	f	k (s^2/m^5)	k*Q^2	2*k*Q	Column1	Error %
1	a	-1000	-0.0167	0.07384	1.50E-06	18.00	0.00	49226.67	3.8920	249901.77	0.015091	10224.974	-2.8403	340.8325		11.9%
	b	500	0.0083	0.07384	1.50E-06	15.00	0.00	49226.67	1.9460	124950.89	0.017201	9711.7888	0.6744	161.8631		-23.7%
	c	1000	0.0167	0.07384	1.50E-06	6.00	0.00	49226.67	3.8920	249901.77	0.015091	3408.3246	0.9468	113.6108	DeltaQ (m^3/s)	-11.9%
												SUM	-1.2191	616.3064	-0.00198	
2	c	-1000	-0.0167	0.07384	1.50E-06	6.00	0.00	49226.67	3.8920	249901.77	0.015091	3408.3246	-0.9468	113.6108		19.7%
	d	-2000	-0.0333	0.07384	1.50E-06	15.00	0.00	49226.67	7.7840	499803.55	0.013412	7572.587	-8.4140	504.8391		9.9%
	e	1000	0.0167	0.07384	1.50E-06	15.00	0.00	49226.67	3.8920	249901.77	0.015091	8520.8114	2.3669	284.027		-19.7%
	f	2000	0.0333	0.07384	1.50E-06	6.00	0.00	49226.67	7.7840	499803.55	0.013412	3029.0348	3.3656	201.9357	DeltaQ (m^3/s)	-9.9%
												SUM	-3.6283	1104.413	-0.00329	
3	f	-2000	-0.0333	0.07384	1.50E-06	6.00	0.00	49226.67	7.7840	499803.55	0.013412	3029.0348	-3.3656	201.9357		-22.9%
	g	2000	0.0333	0.07384	1.50E-06	18.00	0.00	49226.67	7.7840	499803.55	0.013412	9087.1044	10.0968	605.807		22.9%
	h	500	0.0083	0.07384	1.50E-06	15.00	0.00	49226.67	1.9460	124950.89	0.017201	9711.7888	0.6744	161.8631	DeltaQ (m^3/s)	91.7%
												SUM	7.4056	969.6058	0.00764	

Le (m) is for if you want to include minor losses

Calculate energy losses per branch:

$h_L = kQ^2$ where $k = 8(L + \text{Sum Le})f/ \text{pi}^2 g D^5$

v= 1.15E-06 **For kQ^2 we need to maintain pos/neg signs so formula ABS(k*Q)*Q**

Compute Flow Rate Correction: DeltaQ= SumkQ^2/sum2kQ

Q(new) = Q (old) - Delta Q Shared Branches: Q(new)= Q(old)- delta Q first + delta Q second

TRIAL 2

Circuit	Pipe	Q (l/min)	Q (m^3/s)	D (m)	e (m)	L (m)	Le (m)	D/e	V (m/s)	Re	f	k (s^2/m^5)	k*Q^2	2*k*Q	Column1	Error %
1	a	-1000	-0.0147	0.07384	1.50E-06	18.00	0.00	49226.67	3.430107	2.20E+05	0.01544	10461.94	-2.25722	307.3429		5.06%
	b	500	0.0103	0.07384	1.50E-06	15.00	0.00	49226.67	2.407929	1.55E+05	0.01650	9316.7291	0.990597	192.1367		-7.21%
	c	1000	0.0154	0.07384	1.50E-06	6.00	0.00	49226.67	3.586768	2.30E+05	0.01532	3459.0176	0.816029	106.2574	DeltaQ (m^3/s)	-4.84%
												SUM	-0.45059	605.737	-0.00074	
2	c	-1000	-0.0154	0.07384	1.50E-06	6.00	0.00	49226.67	3.586768	2.30E+05	0.01532	3459.0176	-0.81603	106.2574		-6.72%
	d	-2000	-0.0300	0.07384	1.50E-06	15.00	0.00	49226.67	7.016875	4.51E+05	0.01364	7700.8929	-6.95304	462.7944		-3.44%
	e	1000	0.0200	0.07384	1.50E-06	15.00	0.00	49226.67	4.659197	2.99E+05	0.01462	8253.3448	3.285478	329.3399		5.17%
	f	2000	0.0443	0.07384	1.50E-06	6.00	0.00	49226.67	10.3348	6.64E+05	0.01283	2897.8672	5.675829	256.4979	DeltaQ (m^3/s)	2.33%
												SUM	1.192233	1154.89	0.00103	
3	f	-2000	-0.0443	0.07384	1.50E-06	6.00	0.00	49226.67	10.3348	6.64E+05	0.01283	2897.8672	-5.67583	256.4979		-1.75%
	g	2000	0.0257	0.07384	1.50E-06	18.00	0.00	49226.67	6.000467	3.85E+05	0.01400	9483.7625	6.261772	487.3814		3.01%
	h	500	0.0007	0.07384	1.50E-06	15.00	0.00	49226.67	0.162431	1.04E+04	0.03065	17307.545	0.008374	24.07726	DeltaQ (m^3/s)	111.26%
												SUM	0.594316	767.9566	0.00077	

After 10 iterations the Answer is:

Pipe Branch	Flow rate (m^3/s)	Flow rate (L/min)
a	0.0141	847.53
b	0.0109	652.47
c	0.0173	1037.27
d	0.0314	1884.79
e	0.0186	1115.21
f	0.0442	2653.81
g	0.0244	1461.39
h	0.0006	38.61

12-7 Homework

v 4.45E-06 Af2 0.02333

Trial 1 g 32.2 A_{f6} 0.2006

Branch	Pipe	Q (l/min)	Q (ft^3/s)	D (ft)	e (ft)	L (ft)	Le (ft)	D/e	V (ft/s)	Re	f	k (s^2/ft^5)	k*Q^2	2*k*Q	Column1		Qnew1	Qnew2	
1	6 in	675	1.504	0.5054	1.50E-04	500	7.35	3.37E+03	7.497053	8.51E+05	1.58E-02	8.89	20.09859	26.72666			2.248		1008.819
2	2in	-675	-1.504	0.1723	1.50E-04	500	1.14	1.15E+03	64.50457	2.50E+06	1.92E-02	1620.45	-3665.53	4874.336	Delta Q			-0.760	-341.181
												SUM	-3645.43	4901.062	0.743803619				

Trial 2

Branch	Pipe	Q (l/min)	Q (ft^3/s)	D (ft)	e (ft)	L (ft)	Le (ft)	D/e	V (ft/s)	Re	f	k (s^2/ft^5)	k*Q^2	2*k*Q	Column1		Qnew1	Qnew2	
1	6 in	1008.819064	2.248	0.5054	1.50E-04	500	7.35	3.37E+03	11.2047	1.27E+06	1.56E-02	8.78	44.37801	39.48547			2.604		1168.846
2	2in	-341.1809357	-0.760	0.1723	1.50E-04	500	1.14	1.15E+03	32.60404	1.26E+06	1.93E-02	1633.54	-944.048	2483.66	Delta Q			-0.404	-181.154
												SUM	-899.67	2523.146	0.356566819				

Trial 3

Branch	Pipe	Q (l/min)	Q (ft^3/s)	D (ft)	e (ft)	L (ft)	Le (ft)	D/e	V (ft/s)	Re	f	k (s^2/ft^5)	k*Q^2	2*k*Q	Column1		Qnew1	Qnew2	
1	6 in	1168.846253	2.604	0.5054	1.50E-04	500	7.35	3.37E+03	12.98208	1.47E+06	1.55E-02	8.75	59.36981	45.59226			2.757		1237.147
2	2in	-181.1537471	-0.404	0.1723	1.50E-04	500	1.14	1.15E+03	17.31147	6.70E+05	1.96E-02	1654.85	-269.616	1335.924	Delta Q			-0.251	-112.853
												SUM	-210.247	1381.517	0.15				

Trial 4

Branch	Pipe	Q (l/min)	Q (ft^3/s)	D (ft)	e (ft)	L (ft)	Le (ft)	D/e	V (ft/s)	Re	f	k (s^2/ft^5)	k*Q^2	2*k*Q	Column1		Qnew1	Qnew2	
1	6 in	1237.147046	2.757	0.5054	1.50E-04	500	7.35	3.37E+03	13.74068	1.56E+06	1.55E-02	8.74	66.42974	48.19745			2.801		1257.144
2	2in	-112.8529537	-0.251	0.1723	1.50E-04	500	1.14	1.15E+03	10.78449	4.18E+05	1.99E-02	1679.94	-106.222	844.8567	Delta Q			-0.207	-92.8557
												SUM	-39.7919	893.0541	0.04				

Trial 5

Branch	Pipe	Q (l/min)	Q (ft^3/s)	D (ft)	e (ft)	L (ft)	Le (ft)	D/e	V (ft/s)	Re	f	k (s^2/ft^5)	k*Q^2	2*k*Q	Column1		Qnew1	Qnew2	
1	6 in	1257.144284	2.801	0.5054	1.50E-04	500	7.35	3.37E+03	13.96278	1.59E+06	1.55E-02	8.74	68.57163	48.96009			2.806		1259.489
2	2in	-92.85571635	-0.207	0.1723	1.50E-04	500	1.14	1.15E+03	8.873508	3.44E+05	2.01E-02	1693.40	-72.489	700.7231	Delta Q			-0.202	-90.5106
												SUM	-3.91739	749.6831	0.01				

Trial 6

Branch	Pipe	Q (l/min)	Q (ft^3/s)	D (ft)	e (ft)	L (ft)	Le (ft)	D/e	V (ft/s)	Re	f	k (s^2/ft^5)	k*Q^2	2*k*Q	Column1		Qnew1	Qnew2	
1	6 in	1259.489438	2.806	0.5054	1.50E-04	500	7.35	3.37E+03	13.98883	1.59E+06	1.55E-02	8.74	68.82504	49.04952			2.807		1259.567
2	2in	-90.51056192	-0.202	0.1723	1.50E-04	500	1.14	1.15E+03	8.6494	3.35E+05	2.01E-02	1695.33	-68.952	683.8022	Delta Q			-0.201	-90.4328
												SUM	-0.12696	732.8517	0.00				

Trial 7

Branch	Pipe	Q (l/min)	Q (ft^3/s)	D (ft)	e (ft)	L (ft)	Le (ft)	D/e	V (ft/s)	Re	f	k (s^2/ft^5)	k*Q^2	2*k*Q	Column1		Qnew1	Qnew2	
1	6 in	1259.56719	2.807	0.5054	1.50E-04	500	7.35	3.37E+03	13.98969	1.59E+06	1.55E-02	8.74	68.83345	49.05249			2.807		1259.569
2	2in	-90.43280962	-0.201	0.1723	1.50E-04	500	1.14	1.15E+03	8.64197	3.35E+05	2.01E-02	1695.39	-68.8362	683.2411	Delta Q			-0.201	-90.4311
												SUM	-0.00279	732.2936	0.00				

12-9 Homework:

v= 1.21E-05 **Q(new) = Q (old) - Delta Q** **Shared Branches: Q(new)= Q(old)- delta Q first + delta Q second**

Trial 1- g= 32.2

Circuit	Pipe	Q (l/min)	Q (ft^3/s)	D (ft)	e (ft)	L (ft)	Le (ft)	D/e	V (ft/s)	Re	f	k (s^2/ft^5)	k*Q^2	2*k*Q	Column1	Error %	Qnew
1	AB		0.7000	0.2058	1.50E-06	50.00	0.00	137200.00	21.0435	357912.95	0.014006	47.751549	23.3983	66.85217		-0.3%	0.60037
	BC		0.3000	0.2058	1.50E-06	30.00	0.00	137200.00	9.0186	153391.27	0.016424	33.598486	3.0239	20.15909		-0.7%	0.45566
	AC		-0.5000	0.2058	1.50E-06	50.00	0.00	137200.00	15.0311	255652.11	0.014893	50.775726	-12.6939	50.77573	DeltaQ (m^3/s)	0.4%	-0.59963
												SUM	13.7282	137.787	0.10		
2	BD		0.4000	0.2058	1.50E-06	50.00	0.00	137200.00	12.0248	204521.69	0.015533	52.957027	8.4731	42.36562		-0.8%	0.45602
	DE		0.1000	0.2058	1.50E-06	30.00	0.00	137200.00	3.0062	51130.42	0.020687	42.318159	0.4232	8.463632		-3.3%	0.15602
	CE		-0.5000	0.2058	1.50E-06	50.00	0.00	137200.00	15.0311	255652.11	0.014893	50.775726	-12.6939	50.77573		0.7%	-0.44398
	BC		-0.3000	0.2058	1.50E-06	30.00	0.00	137200.00	9.0186	153391.27	0.016424	33.598486	-3.0239	20.15909	DeltaQ (m^3/s)		-0.45566
												SUM	-6.8215	121.7641	-0.06		

Trial 2-

Circuit	Pipe	Q (l/min)	Q (ft^3/s)	D (ft)	e (ft)	L (ft)	Le (ft)	D/e	V (ft/s)	Re	f	k (s^2/ft^5)	k*Q^2	2*k*Q	Column1	Error %	Qnew
1	AB		0.6004	0.2058	1.50E-06	50.00	0.00	137200.00	18.0483	306969.96	0.0144	49.093816	17.6954	58.94857		-0.3%	0.50073
	BC		0.4557	0.2058	1.50E-06	30.00	0.00	137200.00	13.6980	232978.64	0.015154	30.99942	6.4362	28.25012		-0.4%	0.53739
	AC		-0.5996	0.2058	1.50E-06	50.00	0.00	137200.00	18.0262	306595.11	0.014403	49.104746	-17.6561	58.8897	DeltaQ (m^3/s)	0.3%	-0.69927
												SUM	6.4754	146.0884	0.04		
2	BD		0.4560	0.2058	1.50E-06	50.00	0.00	137200.00	13.7090	233166.07	0.015152	51.657886	10.7426	47.11428		-0.7%	0.51204
	DE		0.1560	0.2058	1.50E-06	30.00	0.00	137200.00	4.6904	79774.80	0.018776	38.409242	0.9350	11.98539		-2.1%	0.21204
	CE		-0.4440	0.2058	1.50E-06	50.00	0.00	137200.00	13.3469	227007.73	0.015228	51.918999	-10.2341	46.10177		0.7%	-0.38796
	BC		-0.4557	0.2058	1.50E-06	30.00	0.00	137200.00	13.6980	232978.64	0.015154	30.99942	-6.4362	28.25012	DeltaQ (m^3/s)		-0.53739
												SUM	-4.9927	133.4516	-0.04		

Trial 3-

Circuit	Pipe	Q (l/min)	Q (ft^3/s)	D (ft)	e (ft)	L (ft)	Le (ft)	D/e	V (ft/s)	Re	f	k (s^2/ft^5)	k*Q^2	2*k*Q	Column1	Error %	Qnew
1	AB		0.5007	0.2058	1.50E-06	50.00	0.00	137200.00	15.0531	256026.96	0.014889	50.761885	12.7277	50.83631		-0.4%	0.40110
	BC		0.5374	0.2058	1.50E-06	30.00	0.00	137200.00	16.1552	274771.24	0.014695	30.060946	8.6813	32.30908		-0.4%	0.53739
	AC		-0.6993	0.2058	1.50E-06	50.00	0.00	137200.00	21.0214	357538.11	0.014008	47.760503	-23.3537	66.79468	DeltaQ (m^3/s)	0.3%	-0.79890
												SUM	-1.9446	149.9401	-0.01		
2	BD		0.5120	0.2058	1.50E-06	50.00	0.00	137200.00	15.3931	261810.45	0.014827	50.551608	13.2541	51.76933		-0.6%	0.56807
	DE		0.2120	0.2058	1.50E-06	30.00	0.00	137200.00	6.3745	108419.18	0.017612	36.027078	1.6199	15.27868		-1.5%	0.26807
	CE		-0.3880	0.2058	1.50E-06	50.00	0.00	137200.00	11.6628	198363.35	0.015624	53.26757	-8.0173	41.33091		0.8%	-0.33193
	BC		-0.5374	0.2058	1.50E-06	30.00	0.00	137200.00	16.1552	274771.24	0.014695	30.060946	-8.6813	32.30908	DeltaQ (m^3/s)		-0.53739
												SUM	-1.8246	140.688	-0.01		

Le (m) is for if you want to include minor losses

Calculate energy losses per branch:

$h_L = kQ^2$ where $k = 8(L + \text{Sum Le})f/ \text{pi}^2 g D^5$

v= 1.15E-06 **For kQ^2 we need to maintain pos/neg signs so formula ABS(k*Q)*Q**