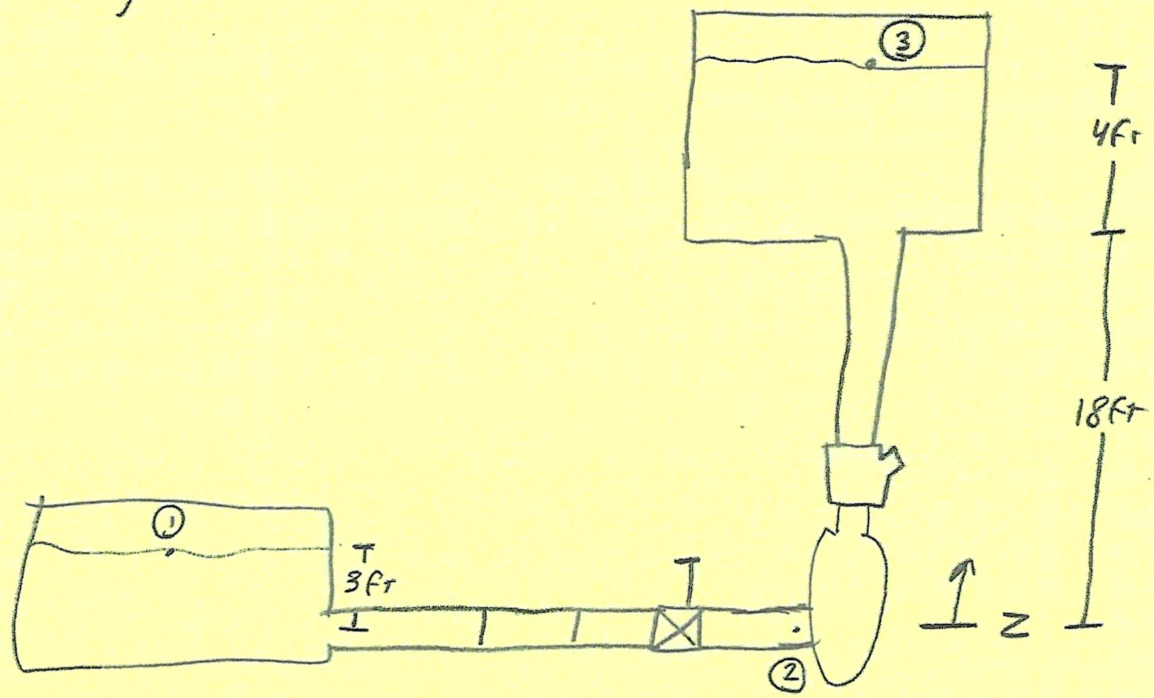
MET 440 Group 4 HW 3.2

The main takeaway from the problems for this week was to follow the procedure. Whether the system was parallel or series the procedure is fairly similar. Select points based on where the most information is known and then draw a reference. Then write however many Bernoulli's equations are needed depending on the problem. Write out the energy losses fully and convert the velocities to be in terms of flow rate and pipe diameter. Put the known terms on one side, and the unknowns on the other. Guess the friction factor and the unknown then do iterations within Excel to find the solution. The solutions should be less than 1% of error. I found on some of the problems I had to rework how I was approaching within excel. Some the flow rate can be guessed and then iterations use, others it was easier to "solve" for flow rate and then look at the relationship between total flow rate and the different branched.

11-23)



$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_{L\,1\to2}$$

$$h_{L\,1\to2} = f\frac{L}{D}\frac{V_2^2}{2g} + k_{inlet} + k_{valve}$$

$$\frac{P_2}{\gamma} = z_1 - \frac{V_2^2}{2g} - f\frac{L}{D}\frac{V_2^2}{2g} - k_{inlet} - k_{valve}$$

$$Re = \frac{VD}{\nu} = \frac{D\left(\frac{Q4}{g\pi D^2}\right)}{\nu} = \frac{(0.1723\text{ ft})\left(\frac{(0.0668\text{ ft}^3/\text{s})(4)}{32.2\text{ ft/s}^2 \cdot \pi \cdot 0.1723^2}\right)}{1.05\times10^{-5}\text{ ft}^2/\text{s}}$$

$Re = 1460.01$ $\qquad \varepsilon = 1.5\times10^{-4}$ ft

$f = 0.0189$

$$\frac{P_2}{\gamma} = 3\text{ft} - \left(\frac{0.089\text{ ft/s}}{2(32.2\text{ ft/s}^2)}\right) - 0.0189\left(\frac{10\text{ ft}}{0.1723}\right) - 0.5 - 0.0189(8)$$

$\frac{P_2}{\gamma} = 1.399$ $\qquad P_2 = 87.17\text{ lb/ft}^2$

$$\frac{P_2}{\gamma} + \frac{V_2^2}{2g} + \cancel{z_2} + h_A = \cancel{\frac{P_3}{\gamma}} + \cancel{\frac{V_3^2}{2g}} + z_3 + h_{L\,2\to3}$$

$$\frac{P_2}{\gamma} + \frac{V_2^2}{2g} + h_A - z_3 = f\frac{L}{D}\frac{V^2}{2g} + K_{crea} + K_{isler}$$

$1.399 + \cancel{0.0889} - 22 = -20.4013$

$D = 0.1150\ ft$

$Re = 2187.477$

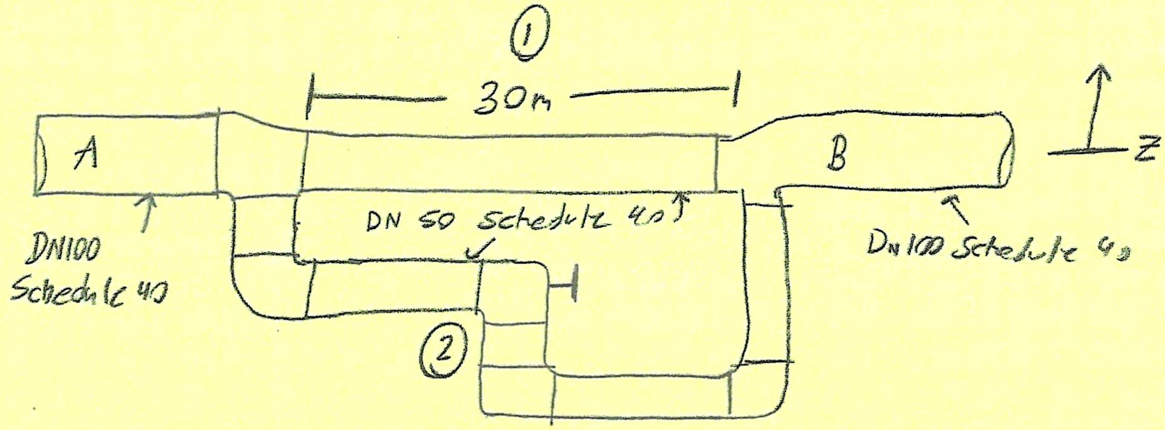
$f = 0.210$

$V = 0.1997\ ft/s$

$$-20.4013\ h_A = 0.210\left(\frac{20}{0.1150}\right)\left(\frac{0.1997^2}{2(32.2)}\right) + 8(0.210)$$

$h_A = 0.08345\ ft$

12-3)



$Q_T = 850\ L/min = 0.0142\ m^3/s$ $\qquad L_2 = 60m$

$$\frac{P_A}{\gamma} + \cancel{\frac{V_A^2}{2g}} + \cancel{z_A} = \frac{P_B}{\gamma} + \cancel{\frac{V_B^2}{2g}} + \cancel{z_B} + h_{L\,A\to B}$$

$$\frac{P_A - P_B}{\gamma} = h_{L\,A\to B}$$

$$h_{L\,A\to B\,I} = f_1 \frac{L_1}{D_1}\frac{V_1^2}{2g} = f_1 \frac{L_1}{D_1}\frac{8}{g\pi^2 D_1^4} Q_1^2 \qquad ①$$

$$h_{L\,A\to B\,II} = f_2 \frac{L_2}{D_2}\frac{V_2^2}{2g} + K_{valve}\frac{V_2^2}{2g} + 3K_{elbow}\frac{V_2^2}{2g}$$

$$h_{L\,A-B\,II} = \frac{V_2^2}{2g}\left(f_2 \frac{L_2}{D_2} + K_{valve} + 3K_{elbow}\right)$$

$$\text{''} = Q_2^2 \frac{8}{g\pi^2 D_2^4}\left(f_2 \frac{L_2}{D_2} + K_{valve} + 3K_{elbow}\right) \qquad ②$$

$$Q_T = Q_1 + Q_2 \qquad ③$$

$$Q_1 = \sqrt{\frac{\Delta P}{\gamma f_1 \frac{L_1}{D_1} \frac{8}{g\pi^2 D_1^4}}} \quad (1)$$

$$Q_2 = \sqrt{\frac{\Delta P}{\gamma \frac{8}{g\pi^2 D_2^4}\left(f_2 \frac{L_2}{D_2} + k_{valve} + 3k_{elbow}\right)}} \quad (2)$$

$$Q_T = Q_1 + Q_2 \quad (3)$$

using excel iterations

$f_1 = 0.021$ $f_2 = 0.0217$

$Re_1 = 157271.8$ $Re_2 = 107629.2$

$\Delta P = 91.19$ Pa

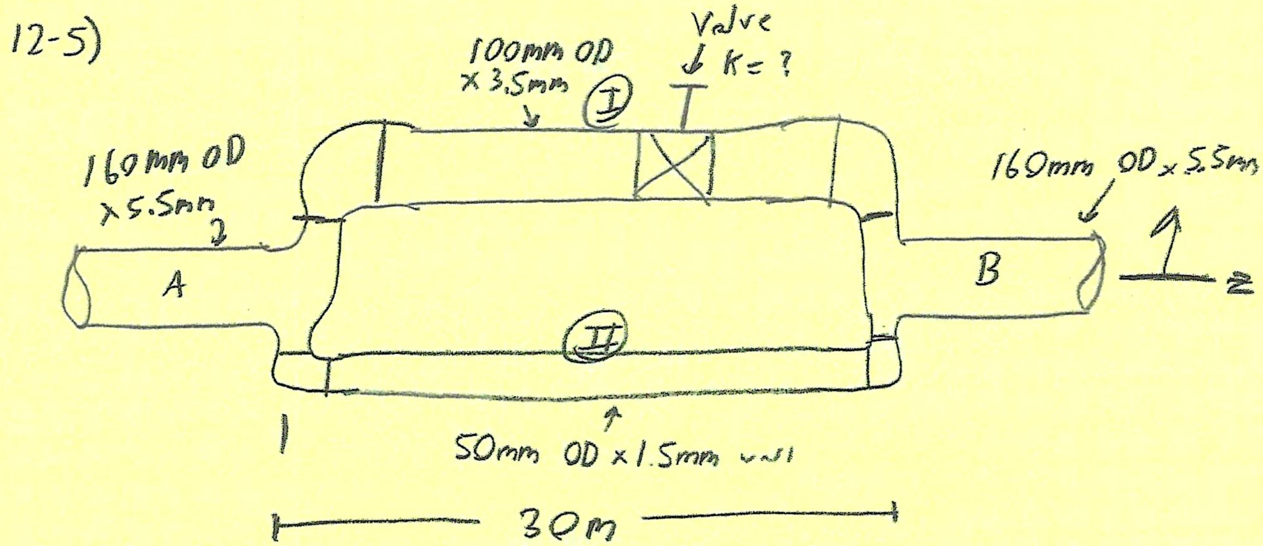
$Q_1 = 0.00843\ m^3/s$

$Q_2 = 0.005769\ m^3/s$

QT	0.0142	m^3/s
L1	30	m
L2	60	m
D1	0.0525	m
D2	0.0525	m
g	9.81	m/s^2
e	0.000046	m
rho	1	kN/m^3
nu	0.0000013	m^2/s

delta P	f1	f2	Kelbow	Kvalve	Q1	Q2	Re1	Re2	Qt calc	%diff
50	0.0200	0.0200	0.6000	0.1600	0.0064	0.0045	119459	83100	0.0109	-23.54%
100	0.0215	0.0223	0.6701	0.1787	0.0087	0.0060	162813	111208	0.0147	3.44%
99	0.0210	0.0217	0.6503	0.1734	0.0088	0.0060	164083	112318	0.0148	4.34%
98	0.0210	0.0217	0.6497	0.1733	0.0088	0.0060	163299	111802	0.0147	3.85%
97	0.0210	0.0217	0.6500	0.1733	0.0087	0.0060	162435	111206	0.0147	3.30%
96	0.0210	0.0217	0.6503	0.1734	0.0087	0.0059	161564	110603	0.0146	2.74%
95	0.0210	0.0217	0.6506	0.1735	0.0086	0.0059	160687	109997	0.0145	2.18%
94	0.0210	0.0217	0.6510	0.1736	0.0086	0.0059	159807	109388	0.0144	1.62%
93	0.0210	0.0217	0.6513	0.1737	0.0085	0.0058	158921	108776	0.0143	1.05%
92	0.0210	0.0217	0.6517	0.1738	0.0085	0.0058	158031	108161	0.0143	0.48%
91	0.0210	0.0217	0.6520	0.1739	0.0084	0.0058	157136	107542	0.0142	-0.09%
91.9	0.0210	0.0217	0.6524	0.1740	0.0085	0.0058	157877	108043	0.0143	0.38%
91.8	0.0210	0.0217	0.6521	0.1739	0.0085	0.0058	157820	108008	0.0142	0.35%
91.7	0.0210	0.0217	0.6521	0.1739	0.0085	0.0058	157731	107948	0.0142	0.29%
91.6	0.0210	0.0217	0.6522	0.1739	0.0085	0.0058	157642	107886	0.0142	0.23%
91.5	0.0210	0.0217	0.6522	0.1739	0.0084	0.0058	157553	107824	0.0142	0.18%
91.4	0.0210	0.0217	0.6522	0.1739	0.0084	0.0058	157463	107762	0.0142	0.12%
91.3	0.0210	0.0217	0.6523	0.1739	0.0084	0.0058	157373	107700	0.0142	0.06%
91.2	0.0210	0.0217	0.6523	0.1739	0.0084	0.0058	157284	107638	0.0142	0.01%
91.19	0.0210	0.0217	0.6523	0.1740	0.0084	0.0058	157272	107629	0.0142	0.00%

12-5)



$Q_1 = 500 L/min = 0.0083 m^3/s$

$Q_2 = 500 L/min = 0.0083 m^3/s$

$Q_T = Q_1 + Q_2 = 1000 L/min = 0.01667 m^3/s$

$$\frac{P_A}{\gamma} + \cancel{\frac{V_A^2}{2g}} + \cancel{z_A} = \frac{P_B}{\gamma} + \cancel{\frac{V_B^2}{2g}} + \cancel{z_B} + h_{L\,A\to B}$$

$$\frac{\Delta P}{\gamma} = h_{L\,A\to B}$$

$$h_{L\,A\to B(I)} = f_1 \frac{L_1}{D_1}\frac{V_1^2}{2g} + 2k_{elbow}\frac{V_1^2}{2g} + k_{valve}\frac{V_1^2}{2g}$$

$$h_{L\,A\to B(I)} = \frac{V_1^2}{2g}\left(f_1 \frac{L_1}{D_1} + 2k_{elbow} + k_{valve}\right)$$

$$h_{L\,A\to B(I)} = Q_1^2 \frac{8}{g\pi^2 D_1^4}\left(f_1 \frac{L_1}{D_1} + 2k_{elbow} + k_{valve}\right) \quad (1)$$

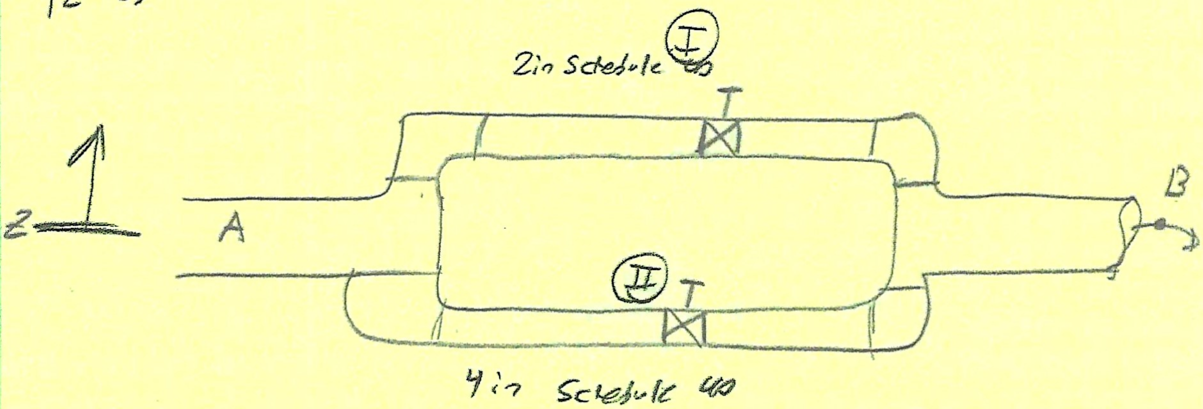
$$h_{L\,A\to B(II)} = Q_2^2 \frac{8}{g\pi^2 D_2^4}\left(f_2 \frac{L_2}{D_2} + 2k_{elbow}\right) \quad (2)$$

using excel $K = 167.5$

Q1	0.0083	m^3/2
Q2	0.0083	m^3/2
L1	30	m
L2	30	m
D1	0.093	m
D2	0.047	m
DT	0.149	m
QT	0.01667	M^3/2
kelbow	30	
e	0.0000015	m
ReT	109576.17	
nu	0.0000013	m^2/s
ft	0.0175913	
Re1	87410.159	
Re2	172960.53	
f1	0.0184671	
f2	0.0162469	

equivalent	Kvalve	LHS	RHS	%diff
5000	92.33529	7.561693	13.28122	-43.06%
6000	110.8023	8.96691	13.28122	-32.48%
7000	129.2694	10.37213	13.28122	-21.90%
8000	147.7365	11.77734	13.28122	-11.32%
9070	167.4962	13.28093	13.28122	0.00%

12-6)



$P_A = 20\,psig$ $\qquad k_{elbow} = 0.9$

$P_B = 0\,psig$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_{L\,A\to B}$$

$$\frac{P_A}{\gamma} = h_{L\,A\to B}$$

$$h_{L\,A\to B\,(I)} = 2K_{elbow}\frac{V_1^2}{2g} + K_{valve_1}\frac{V_1^2}{2g}$$

$$h_{L\,A\to B\,I} = Q_1^2 \frac{8}{g\pi^2 D_1^4}\left(2K_{elbow} + K_{valve_1}\right)$$

$$Q_1 = \sqrt{\frac{P_A/\gamma}{\frac{8}{g\pi^2 D_1^4}\left(2K_{elbow} + K_{valve_1}\right)}}$$

$$Q_2 = \sqrt{\frac{P_A/\gamma}{\frac{8}{g\pi^2 D_2^4}\left(2K_{elbow} + K_{valve_2}\right)}}$$

$$Q_T = Q_1 + Q_2$$

D1	0.0525	m
D2	0.1023	m
Pa	137.895	kPa
gamma	9.81	kN/m^3
Kelbow	0.9	
nu	0.0000013	m^2/s

Kvalve1	Kvalve2	Re1	Re2	Q1	Q2	QT
5	10	499819.9	970492.3	0.026792	0.101368	0.12816
0	10	499883.7	970492.3	0.026795	0.101368	0.128163
5	0	499819.9	974059.1	0.026792	0.101741	0.128533

$$Q_1 = Q_2 + Q_3$$