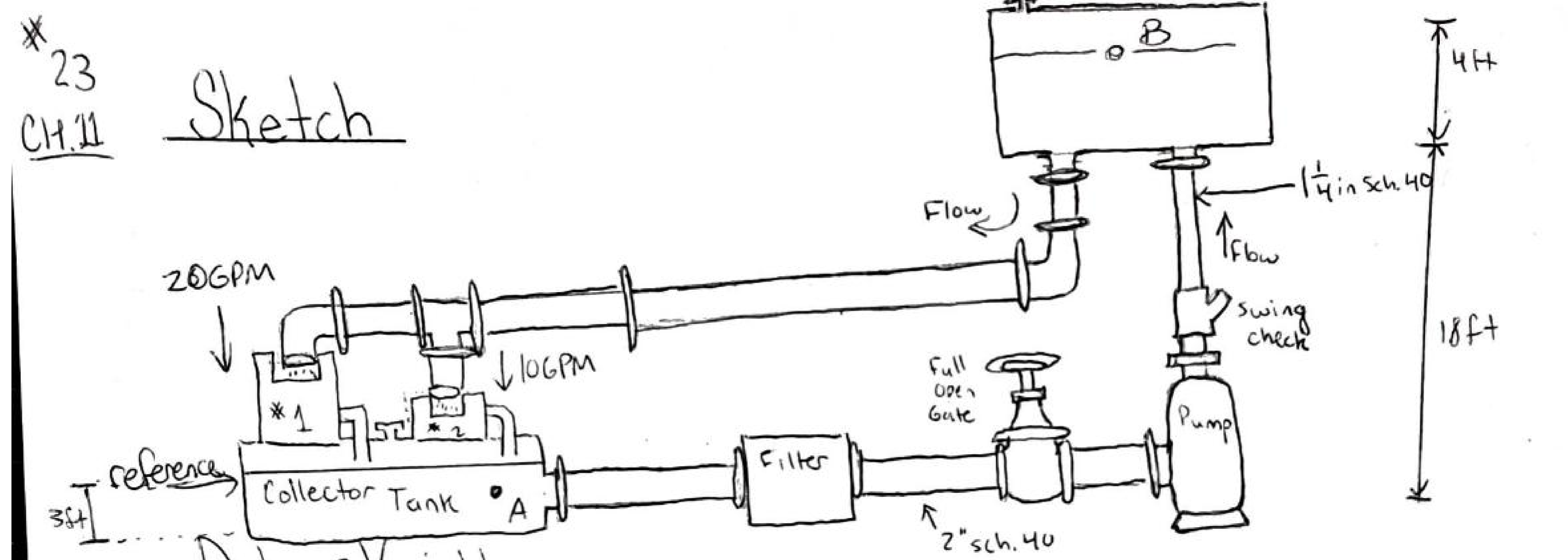
*23
CH.11

Sketch



Data & Variables

- $Q = 30\,\frac{gal}{min} \cdot \frac{1\,min}{60\,sec} \cdot \frac{1\,ft^3}{7.48052\,gal} = 0.06684\,\frac{ft^3}{sec}$
- $sg = 0.92 \therefore \gamma = 0.92(62.4\,\frac{lb}{ft^3}) = 37.408\,\frac{lb}{ft^3}$
- $\eta = 3.6\times10^{-5}\,\frac{lb\cdot s}{ft^2}$
- $\rho = 0.92(1.94\,\frac{slug}{ft^3}) = 2.86498\,\frac{slugs}{ft^3}$
- $\varepsilon_{steel} = 1.5\times10^{-4}\,ft$
- $L_{suct} = 10ft$, $L_{Disch} = 20ft$
- $D_{suct} = 0.1723ft$, $D_{Disch} = 0.1150ft$
  $A_{suct} = 0.02333ft^2$, $A_{Disch} = 0.01039ft^2$

Purpose

Find the total head on the pump & power delivered by the pump to the coolant

Calculations

$$\frac{P_{suct}}{\gamma} + z_{suct} + \frac{V_s^2}{2g} - h_L + h_A = \frac{P_{Disch}}{\gamma} + z_{disch} + \frac{V_D^2}{2g}$$

atm=0; large tank; atmosphere =0; 0, large tank

$\therefore \boxed{h_A = h_L + (z_2 - z_1)}$, $(z_2 - z_1) = (18ft + 4ft - 3ft) = 19ft$

$$h_L = h_{\substack{ent\\losses}} + h_{\substack{pipe\\suct}} + h_{filter} + h_{gate} + h_{\substack{swing\\check}} + h_{\substack{pipe\\disch}} + h_{\substack{exit\\losses}}$$

– $h_{\substack{ent\\losses}} = K\left(\frac{V_s^2}{2g}\right)$, $V = \frac{Q}{A} = \frac{0.06684\,ft^3}{sec} \cdot \frac{1}{0.02333\,ft^2} = 2.86498\,\frac{ft}{sec}$ $\therefore \frac{V_s^2}{2g} = \frac{(2.86498\,ft^2)}{sec^2} \cdot \frac{1}{2} \cdot \frac{sec^2}{32.2\,ft} = 0.12745513\,ft$

- K for square edge inlet = 0.5, $h_{\substack{ent\\loss}} = \frac{0.5 \cdot 2.86498\,ft^2 \cdot sec^2}{sec^2 \cdot 2(32.2)\,ft} = 0.063727\,ft$

– $h_{\substack{pipe\\suct}} = f \cdot \frac{L}{D} \cdot \frac{V_s^2}{2g}$, of from moody diag. = 0.025 $\left\{ N_R = \frac{VD\rho}{\eta} = \frac{2.86498\,ft \cdot 0.1723\,ft \cdot 1.784\,slug \cdot ft^2}{sec \cdot ft^3 \cdot 3.6\times10^{-5}\,lb\text{-}sec} = 2.44\times10^4;\ \frac{D}{\varepsilon} = \frac{0.1723ft}{1.5\times10^{-4}ft} = 1148.67 \right.$

$h_{\substack{pipe\\suct}} = 0.025 \cdot \left(\frac{10ft}{0.1723ft}\right) \cdot (0.12745513\,ft) = 0.184931994\,ft$

– $h_{\substack{pipe\\disch}} = f \cdot \frac{L}{D} \cdot \frac{V_D^2}{2g} = 0.0265 \cdot \frac{18}{0.115} \cdot 0.115 \cdot 0.642 = 2.66\,ft$

$K = f_T \cdot \frac{L}{D}$

– $h_{\substack{gate\\valve}}$ (full open) $\therefore \left(f_T \cdot \frac{L}{D}\right) \cdot \frac{V_s^2}{2g}$; $\frac{L}{D} = 8$, $\frac{V_s^2}{2g} = 0.12745513\,ft$, $f_T = \frac{0.25}{\left[\log\left(\frac{1}{3.7\frac{D}{\varepsilon}}\right)\right]^2} = 0.01898$

$h_{\substack{gate\\valve}} = 0.01898 \cdot 8 \cdot 0.12745513\,ft = 0.0193\,ft$

– $h_{\substack{swing\\check}} = f_T \cdot \frac{L}{D} \cdot \frac{V_D^2}{2g}$; $\frac{L}{D} = 100$, $\frac{V_D^2}{2g} = \left(\frac{0.06684}{0.01039}\right)^2 \div 2(32.2) = 0.6426$, $f_T = \frac{0.25}{\left[\log\left(\frac{1}{3.7\frac{D}{\varepsilon}}\right)\right]^2} = 0.022$

$\therefore h_{\substack{swing\\check}} = 1.4137\,ft$

– $h_{exit} = 1.0\left(\frac{V_D^2}{2g}\right) = 1.0 \times 0.642 = 0.642\,ft$

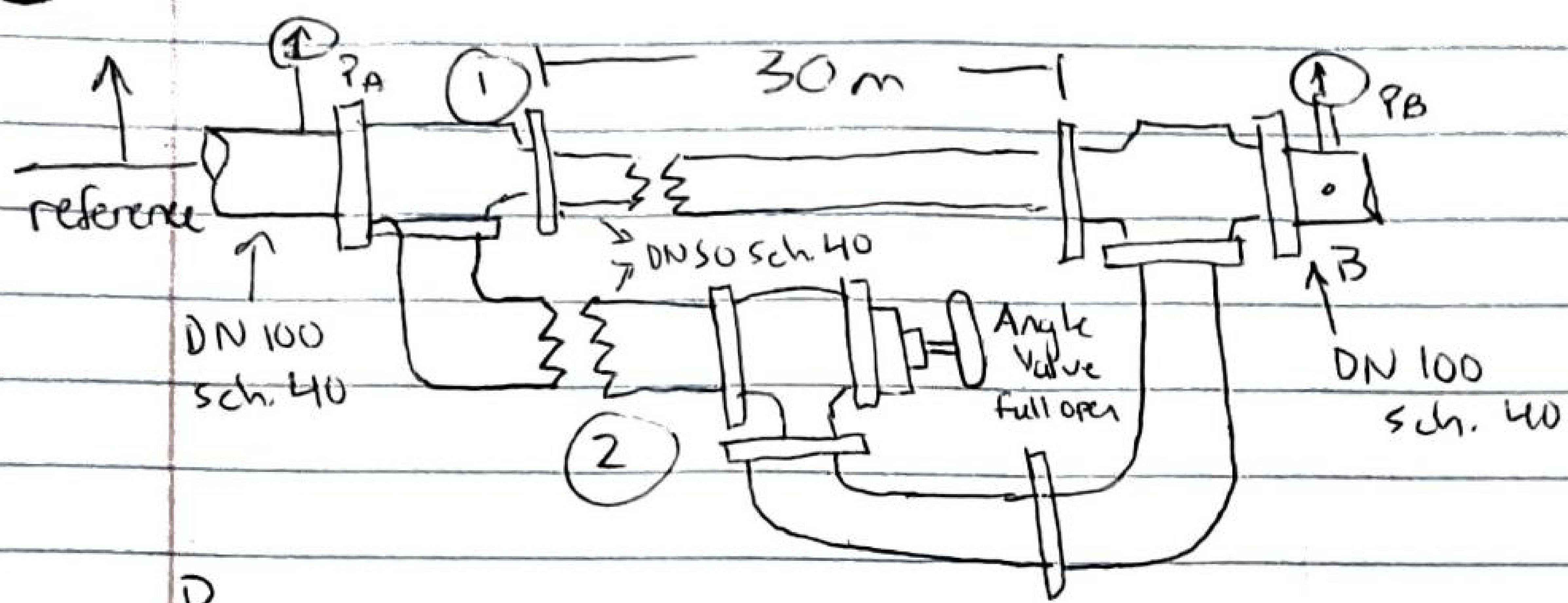
$\therefore h_A = 19ft + (0.642 + 1.4137 + 0.0193 + 2.66 + 0.185 + 0.0637)$

$\boxed{h_A = 23.9837\,ft}$

$$Power = Q\gamma h_A = 0.0668\,\frac{\cancel{ft}^3}{sec} \cdot 57.408\,\frac{lb}{\cancel{ft^3}} \cdot \frac{23.9837\,\cancel{ft}}{1} \cdot \frac{1\ ft \cdot lb/sec}{550\ Hp}$$

$$\boxed{Power = 0.167\ HP}$$

CH. 12 #3



Purpose
- Calculate flow rate in branch 1 & 2
- Calculate $P_A - P_B$

Data & Variables
$L_1 = 30m$, $L_2 = 60m$, $D_A = 0.01023m$, $D_{1/2} = 0.0525m$; $Q_A = 850 \frac{L}{min}$, $T_w = 10°C$ ∴ $\gamma = 9.81 \frac{kN}{m^3}$
$\nu = 1.30 \times 10^{-6} \frac{m^2}{sec}$, $\rho = 1000 \frac{kN}{m^3}$; $\frac{L}{D}_{valve} = 150$; $\varepsilon = 4.6 \times 10^{-5} m$, $A_{1/2} = 2.168 \times 10^{-3} m^2$

Branch 1
$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_{L_{AB}} \therefore \frac{P_A - P_B}{\gamma} = h_{L A,B}, \; h_{L A\text{-}B} = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g}, \; V = \frac{4Q}{\pi D^2}$$
$V_A = V_B$, $z_A = z_B = 0$

① $\therefore \frac{\Delta P}{\gamma} = f\left(\frac{L}{D}\right)\left(\frac{1}{2g}\right)\left(\frac{16Q^2}{\pi^2 D^4}\right)$

② $Q_1 = \sqrt{\frac{P_A - P_B}{\gamma} \cdot \frac{f L \pi D}{2g16}}$

Branch 2
① $\frac{\Delta P}{\gamma} = \left(f\left(\frac{L}{D}\right) + f_T\left(\frac{L}{D}\right)\right)\left(\frac{16Q^2}{\pi^2 D^4}\right)$

② $Q_2 = \sqrt{\frac{P_A - P_B \cdot \pi^2 D^4}{\gamma\left(f\left(\frac{L}{D}\right) + f_T\left(\frac{L}{D}\right)\right) \cdot 16}}$

Excel
- Use eq. ① & guess Q_1
- Calculate $\frac{\Delta P}{\gamma}$
- Use eq. ② & Iterate to find Q_2 & guess f.
- Compute N_R w/ $N_R = \frac{VD\rho}{\eta}$ where $V = \frac{Q_2}{A_2}$
- Find friction factor using moody diagram
- Find best f. using $\% diff = \frac{f_{old} - f_{new}}{f_{old}} \times 100\%$
- Calculate Q_1, $Q_1 = Q_A - Q_2$
- Calculate % diff $\frac{Q_{1\,old} - Q_{1\,new}}{Q_{1\,old}} \times 100\%$

- Calculate $P_A - P_B$ using eq. ①

Ch 12 HW 3.2 Melanie Cruz Cortez

6. For the system shown in Fig 12.11, the pressure at A is maintained constant at 20 psig. The total volume flow rate exiting from the pipe at B depends on which valves are open or closed. Use $K = 0.9$ for each elbow, but neglect the energy losses in the tees. Also, because the length of each branch is short, neglect pipe friction losses. The steel pipe in branch 1 is 2 in Sch 40, and branch 2 is 4 in Sch 40. Calculate the volume flow rate of water for each of the following conditions:

a) Both valves open
b) Valve in branch 2 only open
c) Valve in branch 1 only open

Purpose

Calculate the volume flow rate of water for various conditions of a 2-Branch system.

Data & Variables

$P_A = 20\,psig = $ conversion next pg. $A_1 = 0.02333\,ft^2$ (App F.1) $\gamma = 62.4\,lb/ft^3$

$K_{elb} = 0.9$ $A_2 = 0.08840\,ft^2$ (App F.1) $g = 32.2\,ft/s^2$

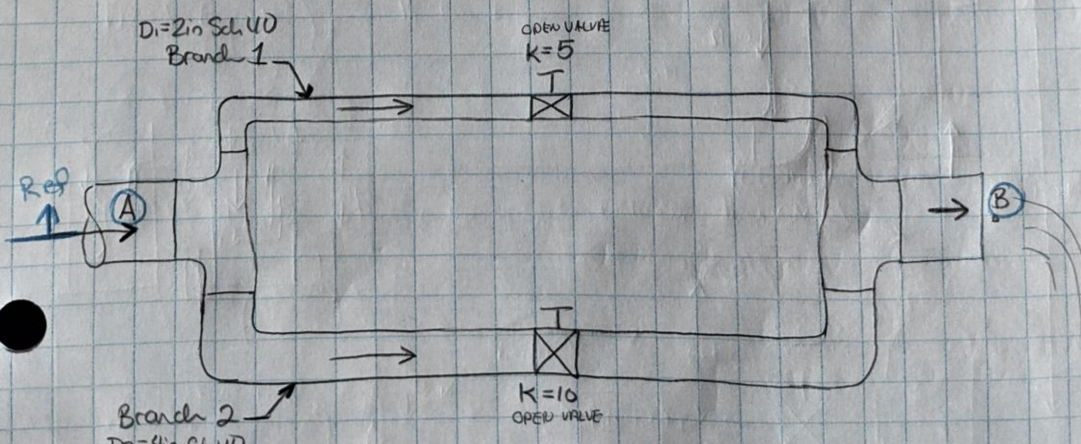
$D_1 = $ 2-in Sch 40 $\rightarrow 2.067\,in = 0.1723\,ft$ (App F.1)

$D_2 = $ 4-in Sch. 40 $\rightarrow 4.026\,in = 0.3355\,ft$ (App F.1)

$K_{v_1} = 5$ $f_{T_1} = 0.019$ (Table 10.5)

$K_{v_2} = 10$ $L_e/D = 8$ fully open gate valve

Drawing



Calculation:

$$\frac{P_A}{\gamma} + \cancel{\frac{v_A^2}{2g}} + \cancel{z_A} = \frac{P_B}{\gamma} + \cancel{\frac{v_B^2}{2g}} + \cancel{z_B} + h_{L_{AB}}$$

$$\frac{P_A - P_B}{\gamma} = h_{L_{AB_1}} \quad \text{or} \quad \frac{\Delta p}{\gamma} = h_{L_{AB_2}}$$

- same velocities bc same flow rate at points A+B and same pipe diameter.
- elevation is the same.
- neglect energy losses in the tees
- neglect pipe friction losses
- constant pressure at P_A

Branch 1

① $\frac{\Delta p}{\gamma} = 2 K_{elb} \frac{v_A^2}{2g} + K_{V_1} \frac{v_A^2}{2g}$

$\downarrow$ elbows $\quad \downarrow$ valve

* convert 20 psi to lb/ft^2 using Appendix K:

$$20\ psi \times \frac{144\ lb/ft^2}{1\ lb/in^2} = 2880\ lb/ft^2$$

$$h_{L_A} = 2(0.9)\frac{v_A^2}{2g} + 5\frac{v_A^2}{2g}$$

$h_{L_A} = 6.8 \frac{v_A^2}{2g}$ total head loss at A

② $\frac{\Delta p}{\gamma} = 6.8 \frac{v_A^2}{2g} \rightarrow 2g \cdot \frac{\Delta p}{\gamma} = 6.8\ v_A^2 \rightarrow \frac{2g \cdot \frac{\Delta p}{\gamma}}{6.8} = v_A^2 \rightarrow \sqrt{\frac{2g \cdot \frac{\Delta p}{\gamma}}{6.8}} = v_A$

$$\sqrt{\frac{2(32.2) \times \frac{2880}{62.4}}{6.8}} = v_A$$

$v_A = 20.9\ ft/s$ velocity flow in Branch 1

③ $Q_A = A_A V_A$ (A from App F)

$= (0.02333)(20.9)$

$Q_A = 0.488\ ft^3/s$ Volume flow rate in Branch 1

→ Continued

Branch 2

① $\frac{\Delta p}{\gamma} = 2 K_{elb} \frac{v_B^2}{2g} + K_{V_2} \frac{v_B}{2g}$

$\downarrow$ elbow $\qquad \downarrow$ valve

$h_{L_B} = 2(0.9) \frac{v_B^2}{2g} + 10 \frac{v_B^2}{2g}$

$h_{L_B} = 11.8 \frac{v_B^2}{2g}$ head loss at B

② $\frac{\Delta p}{\gamma} = 11.8 \frac{v_B^2}{2g} \rightarrow \sqrt{\frac{2g \cdot \frac{\Delta p}{\gamma}}{11.8}} = v_B$

$v_B = \sqrt{\frac{2(32.2) \cdot \frac{2880}{62.4}}{11.8}}$

$v_B = 15.87$ ft/s velocity flow at Branch 2

③ $Q_B = A_B V_B$ (A from App F)

$= (0.0884)(15.87)$

$Q_B = 1.403$ ft³/s Volume flow rate at Branch 2

Final Answer

Consideration A: Both Valves open (volume Flow Rate)

$Q_{TOT} = Q_A + Q_B$

$= 0.488 + 1.403$

$\boxed{Q_{TOT} = 1.891 \text{ ft}^3/s}$

Consideration B: Valve in branch 2 open

$Q_B = A_B V_B$

$= (0.0884)(15.87)$

$\boxed{Q_B = 1.403 \text{ ft}^3/s}$

Consideration C: Valve in branch 1 open

$Q_A = A_A V_A$

$= (0.02333)(20.9)$

$\boxed{Q_A = 0.488 \text{ ft}^3/s}$

I learned that in 2-branch systems velocities are usually unknown and friction factors are unknown. In parallel systems we use the continuity equation:

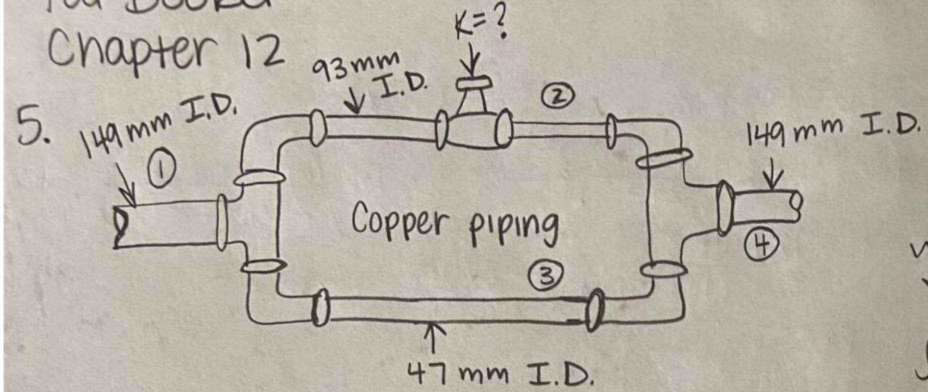
$Q_1 = Q_2 = Q_A + Q_B$.

The first part of the equation, $Q_1 = Q_2$, says that the volume flow rate is the same at any particular cross section when the total flow is considered. The second part defines that the branch flows, $Q_B + Q_A$, must sum to the total volume flow rate entering the first tee. For pressure drop across the system, there is a pressure at point 1. At point 2 there is a different pressure, so $p_1 - p_2$. We use the energy equation between points 1 & 2.

Tou Booker

Chapter 12

5.



water @ 10°C

$\gamma = 9.81\ kN/m^3$

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

$\eta = 1.3\times10^{-3}\ Pa.s$

$\nu = 1.3\times10^{-6}\ m^2/s$

$A_2 = 6.79\times10^{-3} m^2$

$A_3 = 1.735\times10^{-3} m^2$

$\frac{D^2}{\varepsilon} = 62,667 \qquad Re = \frac{V\times D_1}{\nu} = 8.7\times10^4 \quad f = 0.018 \quad f_T = 0.0085$

$\frac{D_3}{\varepsilon} = 31,333 \qquad Re = \frac{V\times D_2}{\nu} = 1.7\times10^5 \quad f = 0.016 \quad f_T = 0.0095$

$h_{L2} = h_{L elbows} + h_{L valve} + h_{L pipe}$

$h_{L2} = 2 f_T \frac{Le}{D}\times\frac{V_2^2}{2g} + K\frac{V_2^2}{2g} + f\frac{L}{D}\times\frac{V_2^2}{2g}$

$h_{L2} = 2(0.0085)(30)\frac{V_2^2}{2g} + K\frac{V_2^2}{2g} + (0.018)\left(\frac{30m}{0.094\,m}\right)\frac{V_2^2}{2g}$

$h_{L2} = (0.51 + K + 5.74)\frac{V_2^2}{2g} = (6.25 + K_{valve})\frac{V_2^2}{2g}$

$h_{L3} = h_{L elbows} + h_{L pipe}$

$h_{L3} = 2 f_T \frac{Le}{D}\times\frac{V_3^2}{2g} + f\frac{L}{D}\times\frac{V_3^2}{2g}$

$h_{L3} = 2(0.0095)(30)\frac{V_3^2}{2g} + (0.016)\left(\frac{30m}{0.047m}\right)\frac{V_3^2}{2g}$

$h_{L3} = (0.57 + 10.21)\frac{V_3^2}{2g} = 10.78\frac{V_3^2}{2g}$

Flip

5.

$$h_{L2} = h_{L3} \Longrightarrow (6.25 + K_{valve}) \frac{V_2^2}{2g} = 10.78 \frac{V_3^2}{2g}$$

$$(6.25 + K) \frac{(1.2 \text{ m/s})^2}{2(9.81 \text{ m/s}^2)} = 10.78 \frac{(4.8 \text{ m/s})^2}{2(9.81 \text{ m/s}^2)}$$

$$K = 10.78 \left(\frac{(4.8 \text{ m/s})^2}{(1.2 \text{ m/s})^2} \right) - 6.25 = 166.23$$

$$\boxed{K \cong 166}$$