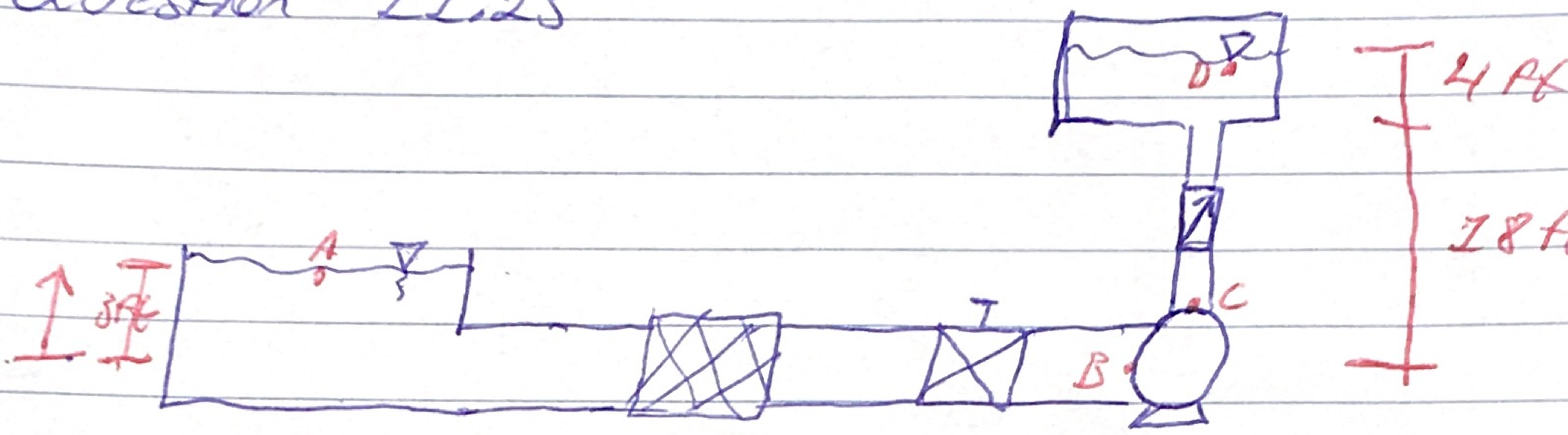
MET330 Team 5 HW3.2

Question 11.23



$$\cancel{\frac{P_A}{\gamma}} + \cancel{\frac{V_A^2}{2g}} + Z_A + h_A = \cancel{\frac{P_D}{\gamma}} + \cancel{\frac{V_D}{2g}} + Z_D + h_{L_{A-D}}$$

$\therefore Z_A + h_A = Z_D + h_{L_{A-D}}$

$h_A = Z_D - Z_A + h_{L_{A-D}}$

$K_{filter} = 1.85$

$K_{valve} = 8 \times 0.02 = 0.16$

$K_{check\ valve} = 100 \times 0.019 = 1.9$

$K_{entrance} = 0.5$

$K_{exit} = 1.0$

Length of suction pipe = 10 ft

Length of discharge pipe = 20 ft

Coolant: $SG = 0.92$

$\eta = 3.6 \times 10^{-5}\ lb \cdot s/ft^2$

$$Q = \frac{30\ gal}{min} \times \frac{1\ min}{60\ s} \times \frac{1\ ft^3}{7.48\ gal} = 0.067\ ft^3/s$$

Calculating energy losses before the pump

$$h_L = h_{L_{entrance}} + h_{L_{pipe}} + h_{L_{filter}} + h_{L_{valve}}$$

$$= K_{entrance}\frac{8Q^2}{g\pi^2 D^4} + f\frac{L}{D}\frac{8Q^2}{g\pi^2 D^4} + K_{filter}\frac{8Q^2}{g\pi^2 D^4} + K_{valve}\frac{8Q^2}{g\pi^2 D^4}$$

$D = 0.1723\ ft$

$$\therefore h_L = \frac{8Q^2}{g\pi^2 D^4}\left(K_{entrance} + f\frac{L}{D} + K_{filter} + K_{valve}\right)$$

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f_T valve $= 0.019$

$Q = AV \therefore V = \frac{Q}{A} = \frac{0.067\ ft^3/s}{0.02333\ ft^2} = 2.865\ ft/s$

$\rho = 0.92 \times 1.94\ slugs/ft^3 = 1.785\ slugs/ft^3$

$Re = \frac{\rho V D}{\eta} = \frac{1.785\ slugs/ft^3 \times 2.865\ ft/s \times 0.1723\ ft}{3.6 \times 10^{-5}\ lb \cdot s/ft^2}$

$= \cancel{2.448 \times 10^{-6}}\ 24604.2425\ slugs/ft \cdot s$

$\varepsilon = 4.6 \times 10^{-5}$

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7\left(\frac{0.1723}{4.6\times10^{-5}}\right)}\right)+\left(\frac{5.7}{(2.448\times10^{-6})^{0.9}}\right)\right]^2}$$

$= \cancel{7.413 \times 10^{-3}}\ 0.025$

$\therefore h_L = \frac{8Q^2}{g\pi^2 D^4}\left(0.5 + \cancel{7.413\times10^{-3}}\ 0.025 \frac{10\ ft}{0.1723\ ft} + 1.85 + 0.16\right)$

$= \cancel{0.377\ ft}\ 0.508\ ft$

Calculating energy losses after the pump.

$h_L = h_{L\,pipe} + h_{L\,check\,valve} + h_{L\,exit}$

$= \cancel{f\frac{L}{D}} \frac{8Q^2}{g\pi^2 D^4}\left(\frac{fL}{D} + K_{check\,valve} + K_{exit}\right)$

$D = 0.1150\ ft$

$Q = AV \therefore V = \frac{Q}{A} = \frac{0.067\ ft^3/s}{\cancel{0.02}\ 0.01039\ ft^2} = 6.449\ ft/s$

$Re = \frac{\rho V D}{\eta} = \frac{1.785\ slug/ft^3 \times 6.449\ ft/s \times 0.1150\ ft}{3.6 \times 10^{-5}\ lb \cdot s/ft^2}$

$= 36772.735$

$\varepsilon = 4.6 \times 10^{-5}$

$f_T = 0.021$

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7\left(\frac{0.1150}{4.6\times10^{-5}}\right)}\right)+\left(\frac{5.7}{(\cancel{2.448\times10^{-6}}\ 36772.735)^{0.9}}\right)\right]^2} = 0.042$$

$$h_L = \frac{8Q^2}{g\pi^2 D^4}\left(\frac{0.042 \times 20}{0.1150} + 1.9 + 1.0\right)$$

$$= 6.593 \text{ ft}$$

$$\therefore h_A = z_D - z_A + h_{L_{A-D}}$$

$$= 22 - 3 + (0.508 \text{ ft} + 6.593 \text{ ft})$$

$$= 26.101 \text{ ft}$$

$$P = \gamma Q h_A = 57.408 \text{ lb/ft}^3 \times 0.067 \text{ ft/s} \times 32.2 \text{ ft/s}^2 \times 26.101 \text{ ft}$$

$$= 3232.662 \text{ Hp.}$$

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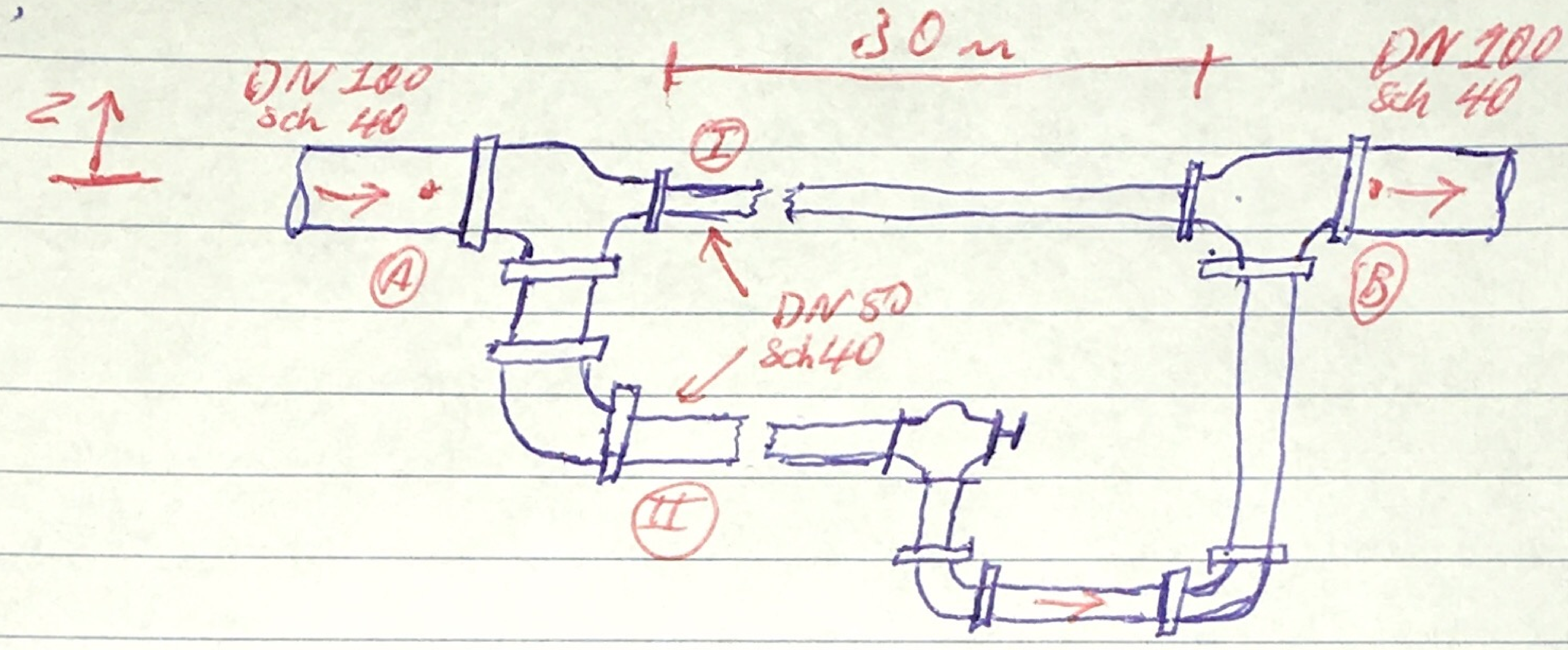
Question 12.3



Given

$Q = 850\ L/min$; $\frac{850\ L}{min} \times \frac{1\ min}{60\ s} \times \frac{1\ m^3}{1000\ L} = 0.142\ m^3/s$

$= 0.0142\ m^3/s$

$T = 10°C$

$$\frac{p_A}{\gamma} + \cancel{\frac{V_A^2}{2g}} + \cancel{z_A} = \frac{p_B}{\gamma} + \cancel{\frac{V_B^2}{2g}} + \cancel{z_B} + h_{L_{A-B}}$$

$$\therefore \frac{p_A - p_B}{\gamma} = h_{L_{A-B}} \quad \therefore \quad \frac{p_A - p_B}{\gamma} = h_{L_{A-B\,I}} \ \& \ \frac{p_A - p_B}{\gamma} = h_{L_{A-B\,II}}$$

$$h_{L_{A-B\,I}} = 2\, h_{L_{Tee\,I}} + h_{L_{pipe\,I}}$$

$$h_{L_{A-B\,II}} = 2\, h_{L_{Tee\,II}} + 3\, h_{L_{elbow\,II}} + h_{L_{valve\,II}} + h_{L_{pipe\,II}}$$

Consider Branch # I

$$h_{L_{A-B\,I}} = 2K_{Tee}\frac{V_I^2}{2g} + f\frac{L_I}{D_I}\frac{V_I^2}{2g} \qquad V^2 = \frac{16\,Q^2}{\pi^2 D^4}$$

$$= \frac{2K_{Tee}}{2g}\frac{16\,Q_I^2}{\pi^2 D_I^4} + f\frac{L_I}{D_I}\cdot\frac{1}{2g}\frac{16\,Q_I^2}{\pi^2 D_I^4}$$

$$= \frac{8\,Q^2}{g\pi^2 D_I^4}\left(2K_{Tee} + f\frac{L_I}{D_I}\right)$$

12-3 Consider Branch II

$$h_{L_{A-B\,II}} = 2K_{Tee}\frac{16Q_T^2}{g\,2\pi^2D^4} + \left(2K_{elbow_{II}} + K_{valve_{II}} + f\frac{L_{II}}{D_{II}}\right)\frac{8Q_{II}^2}{g\pi^2D_{II}^4}$$

$$Q_T = Q_I + Q_{II}$$

Solving for Q_I

$$Q_I = \sqrt{\frac{\frac{\Delta P}{\gamma} - \frac{2K_{Tee}}{2g}\frac{8Q_T^2}{\pi^2D_T^4}}{f\frac{L_I}{D_I}\frac{8}{g\pi^2D_I^4}}}$$

Solving for Q_{II}

$$Q_{II} = \sqrt{\frac{\frac{\Delta P}{\gamma} - 2K_{Tee}\frac{8Q_T^2}{g\,2\pi^2D^4}}{\left(2K_{elbow_{II}} + K_{valve_{II}} + f\frac{L_{II}}{D_{II}}\right)\frac{8\cancel{Q^2}}{g\pi^2D_{II}^4}}}$$

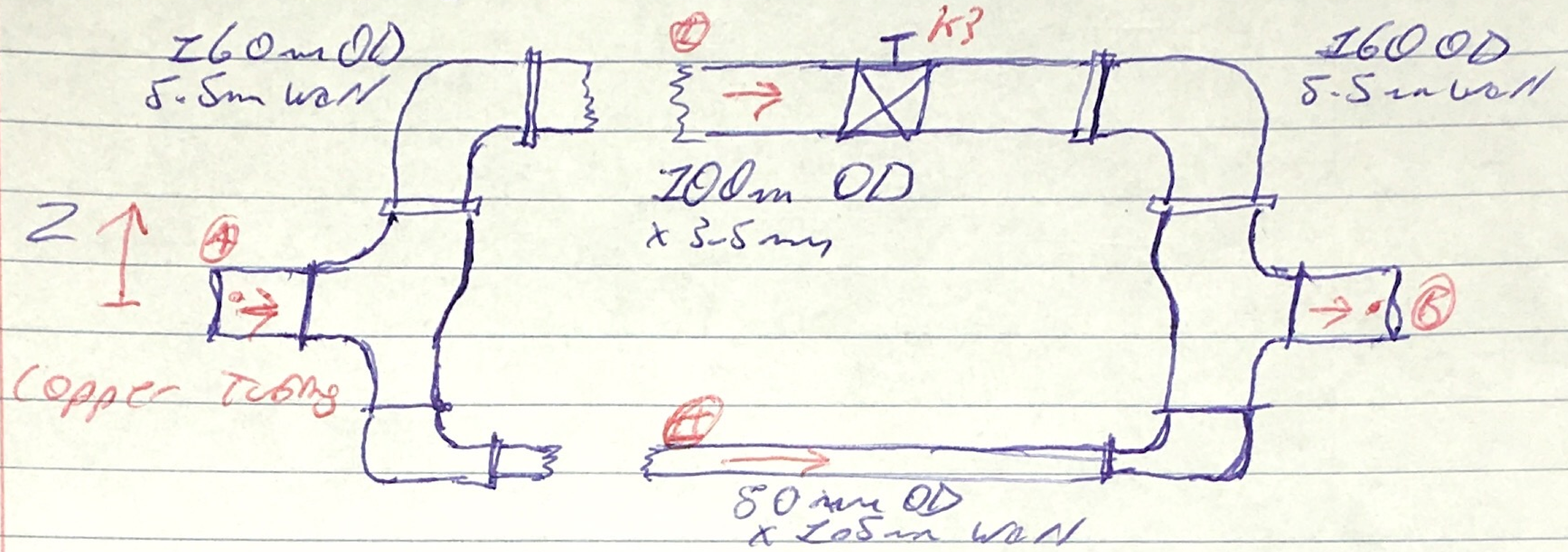
$$\therefore\ Q_T = \sqrt{\frac{\frac{\Delta P}{\gamma} - 2K_{Tee}\frac{8Q_T^2}{g\pi^2D_T^4}}{f\frac{L_I}{D_{II}}\frac{8}{g\pi^2D_I^4}}}$$

$$+ \sqrt{\frac{\frac{\Delta P}{\gamma} - 2K_{Tee}\frac{8Q_T^2}{g\,2\pi^2D^4}}{\left(2K_{elb_{II}} + K_{valve_{II}} + f\frac{L_{II}}{D}\right)\frac{8}{g\pi^2D_{II}^4}}}$$

$D_T = 0.1023$
$D_I = 0.0525$
$D_{II} = 0.0525$
$K_T = \cancel{20}\ 60$
$\gamma = \cancel{62.4\ lb}\ 9.81\ kN/m^3$

from Iterations
$Q_T = 0.01002\ m^3/s$
$Q_I = 0.0052\ m^3/s$
$Q_{II} = 0.00483\ m^3/s$

Question 12.5



Given:

$$Q_{I} = Q_{II} = \frac{500\,L}{min} \times \frac{1\,min}{60\,s} \times \frac{1\,m^3}{1000\,L} = 0.008\,m^3/s$$

T = 10°C water

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

$$\therefore \frac{\Delta P}{\gamma} = h_{L_{A-B}} \Rightarrow \frac{\Delta P}{\gamma} = h_{L_{A-B\,I}} \quad \& \quad \frac{\Delta P}{\gamma} = h_{L_{A-B\,II}}$$

Consider Branch I

$$h_{L_{A-B\,I}} = 2h_{L_{Tee}} + h_{valve} + h_{L_{pipe}} + 2h_{elbow}$$

$$= 2K_{Tee}\frac{V^2}{2g} + K_{valve}\frac{V^2}{2g} + \cancel{K} f\frac{L_I}{D_I}\frac{V^2}{2g} \qquad V^2 = \frac{16Q^2}{\pi^2 D^4}$$

$$= 2K_{Tee}\frac{16Q_T^2}{2g\,\pi^2 D^4} + K_{valve}\frac{16Q_I^2}{2g\,\pi^2 D^4} + f\frac{L_I}{D_I}\frac{16Q_I^2}{2g\,\pi^2 D^4} + K_{elbow}\frac{16Q^2}{2g\,\pi^2 D_I^4}$$

$$\frac{\Delta P}{\gamma} = \frac{2K_{Tee}\,8Q_T^2}{g\pi^2 D^4} + \left(K_{valve} + f\frac{L_I}{D_I} + K_{elbow}\right)\frac{8Q_I^2}{g\pi^2 D^4}$$

Question 22.5

Consider Branch (II)

$$h_{L_{A-B(II)}} = 2h_{L_{Tee}} + 2h_{L_{elbow}} + h_{L_{pipe}}$$

$$= 2K_{Tee}\frac{V^2}{2g} + 2K_{elbow}\frac{V^2}{2g} + f\frac{L_{(II)}}{D_{(II)}}\frac{V^2}{2g}$$

$$= \frac{2K_{Tee}}{2g}\frac{16Q_T^2}{\pi^2 D_T^4} + \frac{2K_{elbow}}{2g}\frac{16Q_{(II)}^2}{\pi^2 D^4_{(II)}} + \frac{fL_{(II)}}{D_{(II)}}\frac{16Q^2_{(II)}}{2g\pi^2 D^4_{(II)}}$$

$$\frac{\Delta P}{\gamma} = \frac{2K_{Tee}\,8Q_T^2}{g\pi^2 D_T^4} + \left(2K_{elbow} + \frac{fL_{(II)}}{D_{(II)}}\right)\frac{8Q^2_{(II)}}{g\pi^2 D^4_{(II)}}$$

$$Q_I = Q_{II}$$

$$\therefore \frac{2K_{Tee}\,8Q_T^2}{g\pi^2 D^4} + \left(K_{valve} + f\frac{L_{(I)}}{D_{(I)}}\right)\frac{8Q^2_{(I)}}{g\pi^2 D^4} = \frac{\Delta P}{\gamma}$$

$$Q_{(I)} = \sqrt{\frac{\frac{\Delta P}{\gamma} - \frac{2K_{Tee}8Q_T^2}{g\pi^2 D_T^4}}{\left(K_{valve} + f\frac{L_{(I)}}{D_{(I)}}\right)\frac{8}{g\pi^2 D^4_{(I)}}}}$$

$$Q_{(II)} = \sqrt{\frac{\frac{\Delta P}{\gamma} - 2K_{Tee}\frac{8Q_T^2}{g\pi^2 D_T^4}}{\left(2K_{elbow} + f\frac{L_{(II)}}{D_{(II)}}\right)\frac{8}{g\pi^2 D^4_{(II)}}}}$$

$$\therefore \sqrt{\frac{\frac{\Delta P}{\gamma} - \frac{2K_{Tee}8Q_T^2}{g\pi^2 D^4_{(I)}}}{\left(K_{valve} + 2K_{elbow} + f\frac{L_{(I)}}{D_{(I)}}\right)\frac{8}{g\pi^2 D^4_{(I)}}}} = \sqrt{\frac{\frac{\Delta P}{\gamma} - \frac{2K_{Tee}8Q_T^2}{g\pi^2 D_T^4}}{\left(2K_{elbow} + f\frac{L_{(II)}}{D_{(II)}}\right)\frac{8}{g\pi^2 D^4_{(II)}}}}$$

$$\therefore \left(K_{valve} + 2K_{elbow} + f\frac{L_{(I)}}{D_{(I)}}\right) = \left(2K_{elbow} + f\frac{L_{(II)}}{D_{(II)}}\right)$$

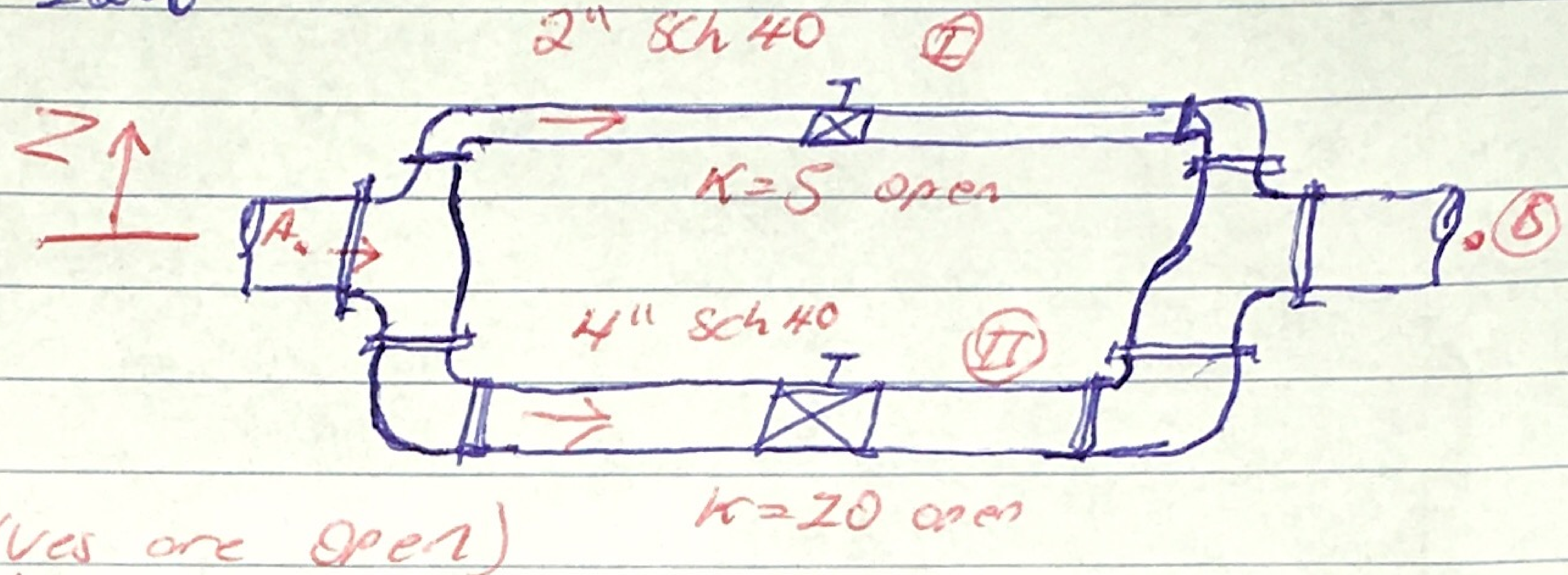
Question I2.5

$$K_{valve} + 2K_{elbow_{(I)}} + f\frac{L_{(I)}}{D_{(I)}} = 2K_{elbow_{(II)}} + f\frac{L_{(II)}}{D_{(II)}}$$

$$\therefore K_{valve} = 2K_{elbow_{(II)}} + f\frac{L_{(II)}}{D_{(II)}} - 2K_{elbow_{(I)}} - f\frac{L_{(I)}}{D_{(I)}}$$

$$= 2 \times 0.2925 + \qquad - 0.2582 -$$

Question 12-6



(Both valves are open)

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

$$\therefore \frac{P_A}{\gamma} + \frac{V_A^2}{2g} = h_{L_{A-B}}$$

$$\therefore h_{L_{A-B_{(I)}}} = \frac{P_A}{\gamma} + \frac{V_A^2}{2g} \quad \& \quad h_{L_{A-B_{(II)}}} = \frac{P_A}{\gamma} + \frac{V_A^2}{2g}$$

Consider Branch (I)

$$h_{L_{A-B_{(I)}}} = 2h_{L_{Tee}} + 2h_{L_{elbow}} + \cancel{2}h_{L_{valve}}$$

$$= 2K_{Tee}\frac{V^2}{2g} + 2K_{elbow}\frac{V^2}{2g} + \cancel{2}K_{valve}\frac{V^2}{2g} \qquad V^2 = \frac{16Q^2}{\pi^2 D^4}$$

$$= \frac{2K_{Tee}}{2g}\frac{16Q_T^2}{\pi^2 D_T^4} + \left(2K_{elbow} + K_{valve}\right)\frac{16Q_{(I)}^2}{\pi^2 D_{(I)}^4 2g}$$

$$\therefore \frac{P_A}{\gamma} + \frac{8Q_T^2}{g\pi^2 D_T^4} = \frac{2K_{Tee}8Q_T^2}{g\pi^2 D_T^4} + \left(2K_{elbow} + K_{valve}\right)\frac{8Q_{(I)}^2}{\pi^2 D_{(I)}^4 g}$$

$$Q_{(I)} = \sqrt{\frac{\frac{P_A}{\gamma} - 2K_{Tee}\frac{8Q_T^2}{g\pi^2 D_T^4} + \frac{8Q_T^2}{g\pi^2 D_T^4}}{\left(2K_{elbow} + K_{valve}\right)\pi^2 D_{(I)}^4 g}}$$

Question 12.6

Consider Branch (II)

$$h_{L_{A-B(II)}} = 2h_{L_{Tee}} + 2h_{L_{elbow}} + h_{L_{valve}}$$

$$= 2K_{Tee}\frac{V^2}{2g} + 2K_{elbow}\frac{V^2}{2g} + K_{valve}\frac{V^2}{2g}$$

$$= \frac{2K_{Tee}}{2g}\frac{16Q_T^2}{\pi^2D^4} + \frac{2K_{elbow}}{2g}\frac{16Q_{(II)}^2}{\pi^2D_{(II)}^4} + \frac{K_{valve}}{2g}\frac{16Q_{(II)}^2}{\pi^2D_{(II)}}$$

$$\therefore \frac{P_A}{\gamma} + \frac{8Q_T^2}{g\pi^2D^4} = 2K_{Tee}\frac{8Q_T^2}{g\pi^2D_T^2} + \left(2K_{elbow} + K_{valve}\right)\frac{8Q_{(II)}^2}{\pi^2D_{(II)}^4 g}$$

$$Q_{(II)} = \sqrt{\frac{\frac{P_A}{\gamma} + \frac{8Q_T^2}{g\pi^2D^4} - 2K_{Tee}\frac{8Q_T^2}{g\pi^2D_T^2}}{\left(2K_{elbow} + K_{valve}\right)\frac{8}{\pi^2D^4_{(II)}g}}}$$

$$Q_T = Q_{(I)} + Q_{(II)}$$

$$\therefore Q_T = \sqrt{\frac{\frac{P_A}{\gamma} + \frac{8Q_T^2}{g\pi^2D_T^4} - 2K_{Tee}\frac{8Q_T^2}{g\pi^2D_T^4}}{\left(2K_{elbow} + K_{valve}\right)\pi^2D_{(I)}^4 g}}$$

$$+ \sqrt{\frac{P_A + \frac{8Q_T^2}{g\pi^2D^4} - 2K_{Tee}\frac{8Q_T^2}{g\pi^2D_T^2}}{\left(2K_{elbow} + K_{valve}\right)\cancel{8}\pi^2D^4_{(II)}g}}$$

In the last few classes we worked on Solving Parallel Pipeline Systems. After reviewing the completed problems I have a better understanding of how to develop my equations before iterating in Microsoft Excel.