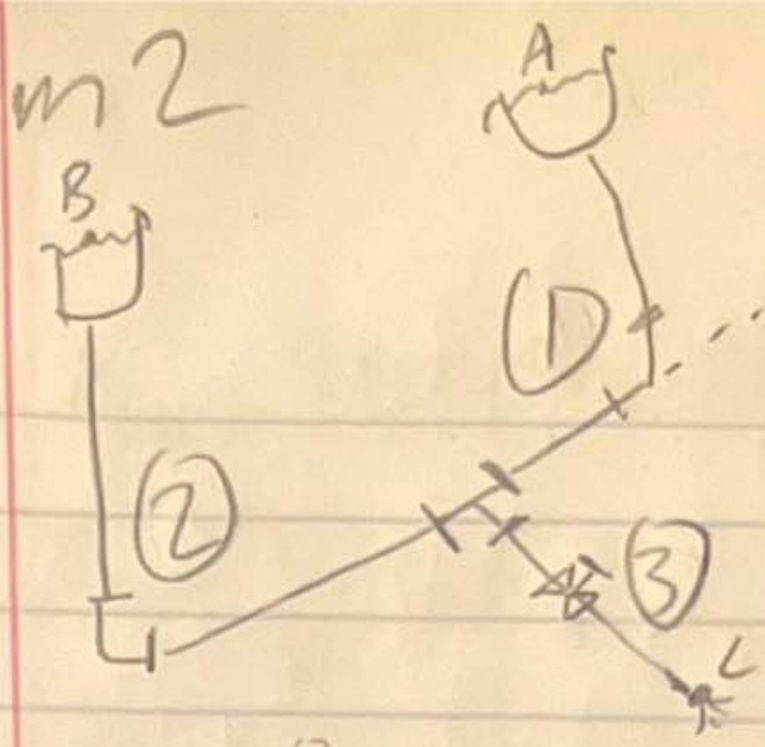
Exam 2



$Z_A = 4m$
$Z_B = 3m$
$Z_L = 0m$
$L_A = 10_m$
$L_B = 9m$
$L_L = 10m$

Assume $T = 15°C$
$P_A = P_B = P_C = 0 atm$
$D = 3/4'' \times \frac{.0254m}{1in}$
$D = .01905m$
$\nu = 1.15 \times 10^{-6} m^2/s$
$\varepsilon = 4.6 \times 10^{-5} m$
$\gamma = 9.81 kN/m^3$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A = \frac{P_L}{\gamma} + \frac{V_L^2}{2g} + Z_L + h_{LAC}$$

$$Z_1 = \frac{V_3^2}{2g} + h_{LAL} \qquad V = \frac{Q}{A} \qquad A = \frac{\pi}{4} D^2 \quad A = \frac{\pi}{4}(.01905m)^2$$
$$A = 2.85 \times 10^{-4} m^2$$

$$h_{LAL} = f_1 \frac{L_A}{D} \frac{V_1^2}{2g} + K_{ent} \frac{V_1^2}{2g} + K_{elb} \frac{V_1^2}{2g} + K_{Tee} \frac{V_1^2}{2g} + K_V \frac{V_3^2}{2g} + f_3 \frac{L_L}{D} \frac{V_3^2}{2g}$$

$Q_L = Q_A + Q_B$

$$h_{LAL} = f \frac{L_A 8 Q_1^2}{g D^5 \pi^2} + K_{ent} \frac{8 Q_1^2}{\pi^2 g D^4} + \frac{K_{elb} 8 Q_1^2}{g \pi^2 D^4} + K_{Tee} \frac{8 Q_1^2}{g \pi^2 D^4} + \frac{K_V Q_3^2 8}{\pi^2 g D^4} + f_L \frac{L_L 8 Q_3^2}{g \pi^2 D^5}$$

$K_{ent} = .5$
$K_{Tee} = 60 f_T$
$K_{elb} = 30 f_T$
$K_V = 160 f_T$

Since f only depends on relative roughness, $f_1 / f_2 / f_3 = f_T$

$$f_T = \frac{.25}{\left[\log\left(\frac{1}{3.7 \times \left(\frac{.01905m}{4.6 \times 10^{-5} m}\right)}\right)\right]^2}$$

$f_T = .0246$

$$h_{LAC} = \frac{Q_1^2 8}{\pi^2 g D^4}\left(\frac{f_1 L_A}{D} + K_{ent} + K_{elb} + K_{Tee}\right) + \frac{Q_3^2 8}{g \pi^2 D^4}\left(K_V + f_3 \frac{L_C}{D}\right)$$

$$h_{LAC} = 9804549.1 Q_1^2 + 10571227.2 Q_3^2$$

$$Z_A = \frac{V_3^2}{2g} + h_{LAC} \qquad 4 = \frac{8 Q_3^2}{\pi^2 g D^4} + h_{LAC}$$

$$4 = 9804549.1 Q_1^2 + 11198622.6 Q_3^2$$

$$Z_B = \frac{V_3^2}{2g} + f\frac{L_B}{D}\frac{V_2^2}{2g} + K_{ent}\frac{V_2^2}{2g} + K_{cb}\frac{V_2^2}{2g} + K_{Tee}\frac{V_2^2}{2g} + K_V\frac{V_3^2}{2g} + f\frac{L_L}{D}\frac{V_3^2}{2g}$$

$$3 = 11198622.6 Q_3^2 + 8994370.1 Q_2^2$$

$$Q_1 = \sqrt{\frac{4 - 11,198,622.6 Q_3^2}{9,804,549.1}} \qquad Q_3 = Q_1 + Q_2$$

$$Q_2 = \sqrt{\frac{3 - 11,198,622.6 Q_3^2}{8,994,370.1}}$$

$Q_3 = 5 \times 10^{-4} m^3/s$ or $30 L/min$
$Q_2 = 1.49 \times 10^{-4} m^3/s$ or $8.94 L/min$
$Q_1 = 3.5 \times 10^{-4} m^3/s$ or $21 L/min$

$V_{max} = 3 m/s$

$V = \frac{Q}{A}$

$A = 2.85 \times 10^{-4} m^2$

$V_3 = 5 \times 10^{-4} / 2.85 \times 10^{-4}$

$V_3 = 1.75 m/s$
$V_2 = .523 m/s$ $\Rightarrow$ Does not exceed V_{max}
$V_1 = 1.23 m/s$

$$\frac{P_A}{\gamma}^{0} + \frac{V_A^2}{2g}^{0} + Z_A = \frac{P_I}{\gamma} + \frac{V_3^2}{2g} + Z_L^{0} + h_{LA-Tee}$$

$$h_{LA-Tee} = f_T \frac{L_A}{D} \frac{V_1^2}{2g} + K_{ent} \frac{V_1^2}{2g} + K_{elb} \frac{V_1^2}{2g} + K_{Tee} \frac{V_1^2}{2g}$$

$$h_{LA-Tee} = .0246 \times \frac{10m}{.01405m} \times \frac{(1.23\frac{m}{s})^2}{2 \times 9.81 \frac{m}{s^2}} + .5\frac{(1.23\frac{m}{s})^2}{2 \times 9.81 \frac{m}{s^2}} + 30(.0246)\frac{(1.23\frac{m}{s})^2}{2 \times 9.81 m/s^2} + 60(.0246)\frac{(1.23 m/s)^2}{2 \times 9.81 m/s^2}$$

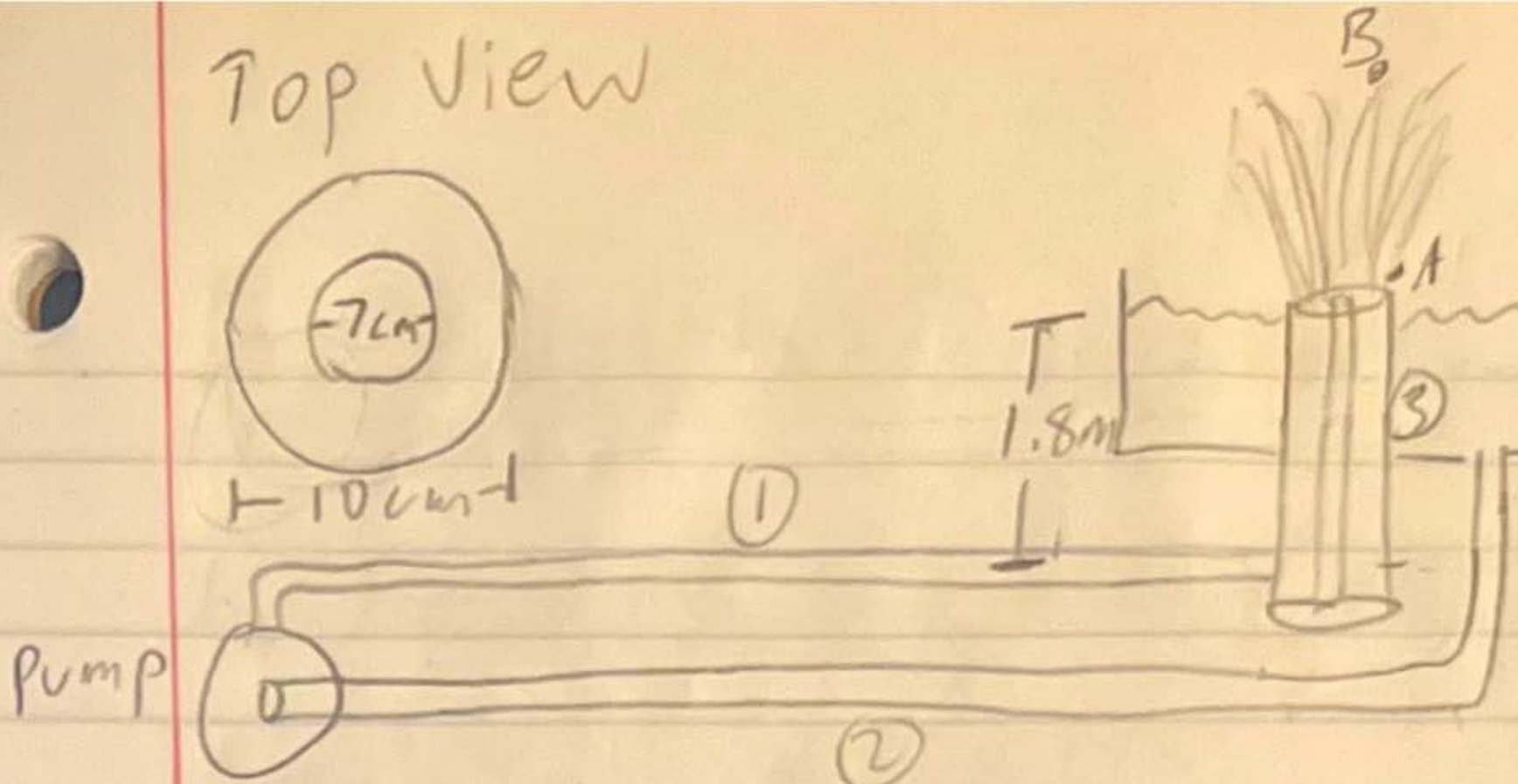
$$h_{LA-Tee} = 1.205 m$$

$$\frac{P_I}{\gamma} = Z_A - \frac{V_3^2}{2g} - h_{LA-Tee}$$

$$P_T = 9.81 \frac{kN}{m^3}\left(4m - \frac{(1.75\frac{m}{s})^2}{2 \times 9.81 \frac{m}{s^2}} - 1.205m\right)$$

$$\boxed{P_T = 25.89 kPa}$$

Top View



$A = \frac{\pi}{4}(D_o^2 - D_i^2)$

$P_A = h_A \gamma Q$

$e_m = \frac{P_A}{P_I}$

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

$\frac{P_A}{\gamma}^{Atm} + \frac{V_A^2}{2g}^{0} + z_A^{0} + h_A = \frac{P_B}{\gamma}^{Atm} + \frac{V_B^2}{2g}^{0} + z_B + h_L^{0}$

$Q = V \cdot A$

$V_A = \sqrt{z_B \cdot 2g}$ $\quad V_A = \sqrt{1m \cdot 2 \cdot 9.81 \frac{m}{s^2}}$ $\quad V_A = 4.43 m/s$

$A = \frac{\pi}{4}(.1\,m^2 - .07\,m^2)$ $\quad A = 4.006 \times 10^{-3} m^2 \times 4.43 m/s$

$Q = .0177 m^3/s$

$V_{max} = 3m/s$ $\quad A_{pipe} = \frac{\pi}{4} D^2$

$D = \sqrt{\frac{Q}{V} \frac{4}{\pi}}$ $\quad D = \sqrt{\frac{.0177 \frac{m^3}{s}}{3 m/s} \times \frac{4}{\pi}}$ $\quad D = .0868m = 7$

Diameter must be <u>Larger</u>

Choose <u>125mm Pipe</u> with ID of <u>110.2mm</u>

$\Rightarrow V_{pipes} = \frac{.0177 m^3/s}{\frac{\pi}{4}(.1102m)^2}$ $\quad V_{pipes} = 1.86 m/s$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A + h_A = \frac{P_A}{\gamma} + \frac{V_A}{2g} + Z_A + h_L \Rightarrow h_A = h_L$$

$$h_A = f\frac{L}{D}\frac{V^2}{2g} + f_{Ann.4R}\frac{L}{4R}\frac{V_A^2}{2g} + 3k_{elb}\frac{V^2}{2g} + k_{Ann}\frac{V^2}{2g} + k_{en}\frac{V^2}{2g}$$

$K_{elb} = 30 f_T$ $\quad f = .0155$

$K_{en} = .5$ $\quad f_T = .0066$ (excel)

$K_{Ann} = 2$

Equivelent Diameter Annulus $= D_e = 4R$

$R = \frac{A}{WP}$ $\quad WP = \pi(D_o + D_i)$ $\quad WP = .534m$

$R = \frac{4.006\times10^{-3}m^2}{.543m}$ $\quad R = 7.5\times10^{-3}m \times 4 = .03m = De$

(excel) $f_{ann} = .017$

$$h_A = .0155 \times \frac{38m}{.1102m} \times \frac{(1.86\frac{m}{s})^2}{2\times9.81\frac{m}{s^2}} + .017\times\frac{1.8m}{.03m}\times\frac{(4.43\frac{m}{s})^2}{2\times9.81\frac{m}{s^2}} + 3\times30\times.0066\times\frac{1.86^2}{2\times9.81}$$
$$+2\times\frac{(1.86\frac{m}{s})^2}{2\times9.81\frac{m}{s^2}} + .5\frac{(1.86\frac{m}{s})^2}{2\times9.81\frac{m}{s^2}}$$

$h_A = 2.505m$

$P = \gamma h_A Q$ $\quad P = 2.505m \times 9.79\frac{KN}{m^3} \times .0177\frac{m^3}{s}$

$P = .434KW \times \frac{HP}{.7457KW}$

$\boxed{P = .582HP}$

$P_{in} = \frac{P}{e_M}$ $\quad P_{in} = \frac{.582HP}{.92}$

$\boxed{P_{in} = .633HP \text{ or } .472KW}$

HONOR CODE

I pledge to follow the Honor Code and to obey all rules for taking exams and performing homework assignments as specified by the course instructor.

I understand that when asked to follow the Honor Code on exams or homework assignments I must follow the rules below.

1. When following the Honor Code a student must work entirely alone on exams.

2. When following the Honor Code a student may not share information about any aspect of the exam with other members of the class, other faculty members, or other people who has not already taken the exam this year, or its equivalent in future years.

3. When following the Honor Code a student must direct all questions concerning the exam or homework assignment to the course instructor or teaching assistant.

4. When following the Honor Code it is the student's responsibility to obtain clarification from the instructor if there are questions concerning the requirements of the Honor Code.

5. When following the Honor Code a student can only access websites related to ODU (such as Blackboard, etc.) while taking the test.

6. When following the Honor Code a student cannot access, neither ask for help, from websites such as coursehero, chegg, and any other similar website, while taking the test.

I understand that failure to follow this Honor Code imply that the professor will immediately report my case for academic dishonesty to the ODU Office of Student Conduct & Academic Integrity.

Student Name: Logan Kooy

Student Signature: L Kooy

Date: 6/29/22