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MET 330 Fluid Mechanics
Dr. Orlando Ayala
Spring 2021
Test 2

Take home – Due Tuesday March 23rd, 2021 before midnight.

READ FIRST

1. RELAX!!!! DO NOT OVERTHINK THE PROBLEMS!!!! There is nothing hidden. The test was designed for you to pass and get the maximum number of points, while learning at the same time. <u>HINT:</u> THINK BEFORE TRYING TO USE/FIND EQUATIONS (OR EVEN FIND SIMILAR PROBLEMS)

2. The total points on this test are one hundred (100). Ten (10) points are from your HW assignments, and ten (10) other points are based on the basis of technical writing. The other eighty (80) points will come from the problem solutions. For the technical writing I will follow the attached rubric.

3. There are 7 main different parts, each one is worth 80/7 points.

4. What you turn in should be only your own work. You cannot discuss the exam with anyone, except me. Call me, skype me, text me, email me, come to my office, if you have any question.

5. I do not read minds. You should be explicit and organized in your answers. Use drawings/figures. If you make a mistake, do not erase it. Rather use that opportunity to explain why you think it is a mistake and show the way to correct the problem.

6. You have to turn in your test ON TIME and ONLY through BLACKBOARD. You must submit the test solution in only one file, and it has to be a pdf file. You must also submit the <u>excel spreadsheet</u>. For the ePortfolio (which is optional) you are supposed to upload this artifact to your Google drive. I will provide more instructions later.

7. Do not start at the last minute so you can handle anything that could happen. Late tests will not be accepted. Test submitted through email will not be accepted either.

8. Cheating is completely wrong. The ODU Student Honor Pledge reads: "I pledge to support the honor system of Old Dominion University. I will refrain from any form of academic dishonesty or deception, such as cheating or plagiarism." By attending Old Dominion University, you have accepted the responsibility to abide by this code. This is an institutional policy approved by the Board of Visitors. It is important to remind you the following part of the Honor Code:

    IX. PROHIBITED CONDUCT

    A. Academic Integrity violations, including:

    1. *Cheating*: Using unauthorized assistance, materials, study aids, or other information in any academic exercise (Examples of cheating include, but are not limited to, the following: using unapproved resources or assistance to complete an assignment, paper, project, quiz or exam; collaborating in violation of a faculty member's instructions; and submitting the same, or substantially the same, paper to more than one course for academic credit without first obtaining the approval of faculty).

With that said, you are NOT authorized to use any online source of any type, unless is ODU related.

The company that hired you to design the system in the figure is happy with your work. The want to hire you again to check few more things. Let us remember that the system is to deliver 60 ^{o}F water from the lower open channel to the upper open channel at a rate of 3.387 ft^3/s. They want you to complete the following tasks:

a. For a good working system, the amount of pumped water should not be too much to dry the lower open channel. The company wants to know whether the amount of pumped water is negligible compare to the total flow rate running through the lower open channel. Please note that this is a natural channel with light brush and its average slope is 0.00015.

b. The discharge pipe needs to be supported. Your civil engineer colleague requires to know the relevant forces for the support design. Calculate the total horizontal and vertical forces in the **WHOLE** discharge pipe-elbows-valve system (IMPORTANT: this is from the pump outlet to the elevated open channel inlet – not just the elbow or elbows). Note: you might need to compute the pump outlet pressure and the elevated channel inlet pressure for this task.

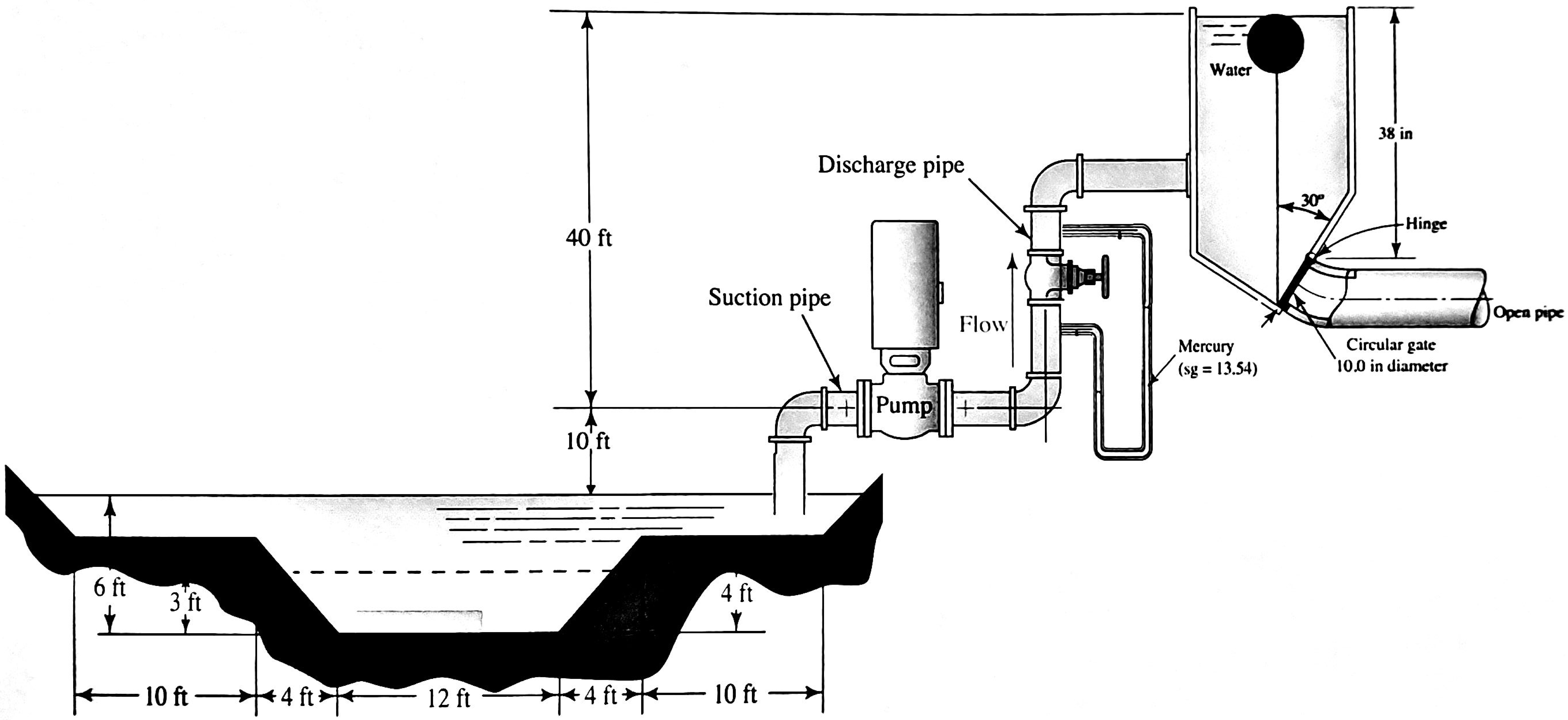
c. Your client also proposes to use a flow nozzle to measure the flow. For a nozzle diameter to pipe diameter ratio of 0.5, what is the pressure drop across the nozzle? With this addition to the system (which is an additional energy loss), by how much (show it in percentage) should the pump power increase?

d. The company wants you to verify your design in case of the occurrence of water hammer and/or cavitation. If the valve in the pipe closes suddenly, what is the pressure increment after the sudden closing? If the modulus of elasticity of steel is 200 GPa, would the pipe fail? To answer this question, you must use equation 11-9 in the book. The idea is to compare the thickness you get out of that equation to the actual thickness of the pipe you selected. Also, verify that there is no cavitation in the system.

e. In order to avoid spillage in the elevated channel, your client proposes to use a system as depicted in the picture. A circular gate seals the open pipe to prohibit the flow. When the water level reaches 38 inches, the fully submerged spherical buoy opens the gate. How large should the buoy be for this to happen? Neglect the weight of the circular gate and the buoy. Is the buoy stable when pulling the gate? Why?

f. If there is an object at the bottom of the lower open channel, what is the maximum object weight so the fluid flow around it slides it along the bottom surface? Assume the object does not tumbles and that the coefficient of friction is 0.60. The object has a shape of a 5 feet long square cylinder (1-foot side) and the flow is perpendicular to the flat front face. Make any additional reasonable assumption.

g. The company would like you to do all your work by hand but also, they need you to create an excel spreadsheet to run automatically all calculations. You must make sure the excel solutions match the hand calculations above. Now, use the pumped flow rate corresponding to half of the required pump power you computed on the 1st test (you can use the solutions), and with the spreadsheet you have developed, review your calculations to determine:
    i. Whether the amount of pumped water is negligible compare to the total flow rate in the lower open channel.
    ii. The total horizontal and vertical forces in the whole discharge pipe-elbows-valve system.
    iii. By how much (show it in percentage) you should increase the pump power if adding the flow nozzle.
    iv. Whether the pipe would fail under a water hammer problem
    v. When the water level reaches 38 inches in the upper open channel, how large the buoy should be for the mechanism to work.
    vi. The maximum object weight at the bottom of the lower open channel, so the fluid flow slides it at the bottom.



Water
38 in
30°
Hinge
Open pipe
Circular gate
10.0 in diameter
Mercury
(sg = 13.54)
Discharge pipe
Flow
Suction pipe
Pump
40 ft
10 ft
6 ft
3 ft
4 ft
10 ft
4 ft
12 ft
4 ft
10 ft

Problem solution rubric

	Exceeds Standard	Meets Standard	Approaches Standard	Needs Attention
	4	3	2	1
	10 points	7 points	4 points	0 points
Purpose **5%**	The purpose of the section to be answered is clearly identified and stated.	The purpose of the section to be answered is identified, but is stated in a somewhat unclear manner.	The purpose of the section to be answered is partially identified, and is stated in a somewhat unclear manner.	The purpose of the section to be answered is erroneous or irrelevant.
Drawings & Diagrams **10%**	Clear and accurate diagrams are included and make the section easier to understand. Diagrams are labeled neatly and accurately.	Diagrams are included and are labeled neatly and accurately.	Diagrams are included and are labeled.	Needed diagrams are missing OR are missing important labels.
Sources **5%**	Several reputable background sources were used and cited correctly.	A few reputable background sources are used and cited correctly.	A few background sources are used and cited correctly, but some are not reputable sources.	Background sources are cited incorrectly.
Design considerations (assumptions, safety, cost, etc) **10%**	Design is carried out with applicable assumptions and full attention to safety and cost, etc.	Design is generally carried out with assumptions and attention to safety, cost, etc.	Design is carried out with some assumptions and some attention to safety, cost, etc.	Assumptions, safety and cost were ignored in the design.
Data and variables **5%**	All data and variables are clearly described with all relevant details.	All data and variables are clearly described with most relevant details.	Most data and variables are clearly described with most relevant details.	Data and variables are not described OR the majority lack sufficient detail.
Procedure **25%**	Procedure is described in clear steps. The step description is in a complete and easy to understand short paragraph.	Procedure is described in clear steps but the step description is not in a complete short paragraph.	Procedure is described in clear steps. The step description is in a complete short paragraph but it is difficult to understand.	Procedure is not described in clear steps at all.
Calculations **20%**	All calculations are shown and the results are correct and labeled appropriately. The units of all values are shown.	Some calculations are shown and the results are correct and labeled appropriately.	Some calculations are shown and the results labeled appropriately.	No calculations are shown OR results are inaccurate or mislabeled.
Summary **5%**	Summary describes the design, the relevant information and some future implications.	Summary describes the design and some relevant information.	Summary describes the design.	No summary is written.
Materials **5%**	All materials used in the design are clearly and accurately described.	Almost all materials used in the design are clearly and accurately described.	Most of the materials used in the design are clearly and accurately described.	Many materials are described inaccurately OR are not described at all.
Analysis **10%**	The design is discussed and analyzed. Argumentative predictions are made about what might happen in case of change in the operation and how the design could be change.	The design is discussed and analyzed. Argumentative predictions are made about what might happen in case of change in the operation.	The design is discussed and analyzed. No argumentative predictions are made about what might happen in case of change in the operation and how the design could be change.	The design is not discussed and analyzed.

TEST 2

Purpose

A) Calculate if the amount pumped out of the lower channel is negligible.

B) Calculate the total forces in the discharge pipe.

C) Calculate the pressure drop across a new nozzle. Calculate how much the pump power should increase due to the new nozzle.

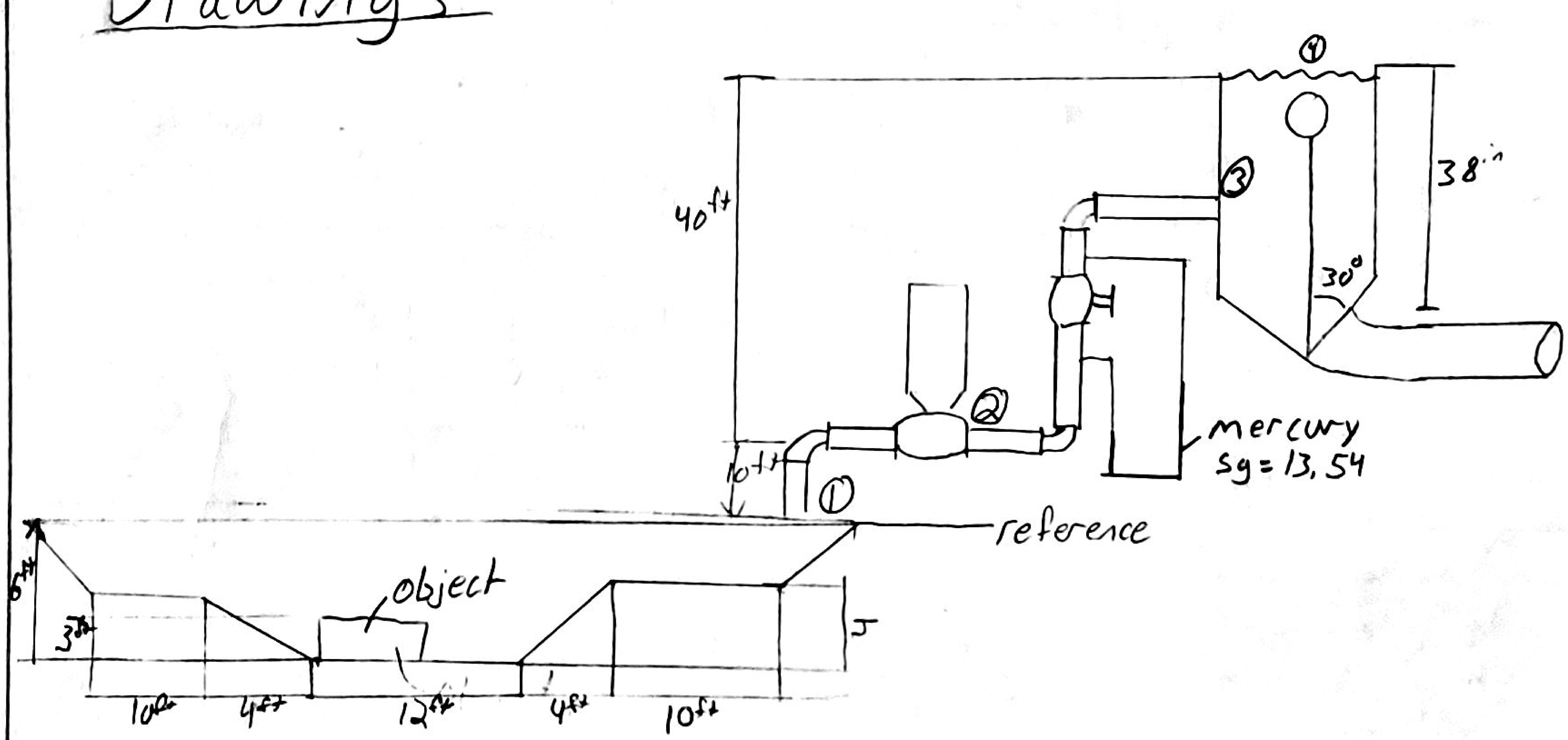
D) Calculate the pressure increment after sudden valve closing and determine if the pipe would fail

E) Calculate how large the buoy needs to be in order to open the gate and determine if the buoy is stable.

F) Calculate object weight so that fluid flow will slide it along bottom of channel.

G) Create excel spreadsheet to calculate all previous questions when the pump power is at 50% of pump power calculated in the first test.

Drawings



Sources

- Mott, R., Untener, J. A., "Applied Fluid Mechanics", 7th edition, Pearson Education, Inc (2015)
- ANSI/ASME B31.3 Process Piping

Design Considerations

- Constant tempature
- Incompressible fluid
- Steady state
- Constant properties

Data & Variables

$T_{water} = 60°F$

$L_{discharge} = 2500\ ft$

$L_{suction} = 11\ ft$

D_{pipe} = 8 in schedule 40

$Q = 3.387\ \frac{ft^3}{s}$

$\gamma = 62.4\ lb/ft^3$

$\gamma_{Hg} = 844.9\ lb/ft^3$

$V = 9.842\ ft/s$

average slope of chanel = 0.00015°

Materials

- Water
- pump
- pipe
- Valves
- gate
- bouy
- object
- manometer

Procedure

A) Compute total flow in open channel using open flow channel flow equation $Q = \frac{1.49}{n} A S^{\frac{1}{2}} R^{\frac{2}{3}}$

Next, Compare Q_{chanel} to Q_{pipe} and determine if amount is negligible.

B) Use bernoulli's equation to find pressure at pump outlet and upper chanel inlet. Create FBD of water and use force equations to find total horizontal and vertical forces.

Procedure

C) Use minor loss for valve to find energy loss due to new valve. Use bernolli's equation to compute new head pressure for pump.

$h_L = k \frac{v^2}{2g}$

D) Use water hamer equation $\Delta P = \rho \cdot C \cdot V$ to find the change in pressure. Then use basic wall thickness equation $t = \frac{P \cdot D}{2(S \cdot E + PY)}$ (11-9)

to determine if the pipe will fail. Use thermo tables to determine if there is a phase change due to drop in pressure.

E) Calculate the weight on the gate $F_R = \gamma \cdot h_c \cdot A$
Calculate the location of the weight $L_p =$

$L_p = \frac{I_c}{L_c A} + L_c$ $h_p = h_c + \frac{I_c \sin^2\theta}{h_c A}$ Take moment of gate and find force to lift it.
Use $F_b = \gamma \cdot V_D$ to find Volume of buoy.

F) Use Q of lower channel to determine force on the face of the object. $F = C_D\left(\frac{\rho \cdot V^2}{2}\right)A$
Then use force and coefficient of friction (0.6) to determine the weight of object.

G) Transfer all calculations to excel. Then use excel to calculate results for half pump power

Calculations

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

$n = 0.05$

$A = 148^{ft^2}$

$R = \frac{A}{\text{wetted perimeter}} = \frac{148^{ft^2}}{48.96^{ft}} = 3.02^{ft}$

$S = \tan\theta = \tan 0.00015 = 0.000002618$

$Q = \left(\frac{1.49}{0.05}\right)(148^{ft^2})(0.000002618)^{\frac{1}{2}} \cdot (3.02^{ft})^{\frac{2}{3}}$

$Q = \underline{14.909 \frac{ft^3}{s}}$

$Q_{pipe} = 3.387 \frac{ft^3}{s}$

% of flow leaving $= \frac{3.387}{14.909} \times 100 = 22.76\%$

This amount of flow is not negligible.

B) Find pressure at pump outlet

$h_a + \frac{P_1}{\gamma}^0 + \frac{v_1^2}{2g}^0 + z_1^0 = \frac{P_2}{\gamma} + \frac{v_2^2}{2g}^0 + z_2 + h_L$

$P_2 = \gamma(h_a - z_2 - h_L)$

$h_a = 147.53^{ft}$ (from first test)

$z_2 = 10^{ft}$

$h_L = h_{elbow} + h_{pipe}$

$h_{elbow} = k\frac{v^2}{2g} = 0.422 \cdot \frac{(9.842 \frac{ft}{s})^2}{2 \cdot 32.2 \frac{ft}{s^2}} = 0.634^{ft}$

$h_{pipe} = f\frac{L}{D} \cdot \frac{v^2}{2g} = 0.016 \cdot \frac{11}{0.665} \cdot \frac{(9.84 \frac{ft}{s})^2}{2 \cdot 32.2 \frac{ft}{s^2}}$

$h_{pipe} = 0.398^{ft}$

$h_L = 0.634 + 0.398 = 1.03^{ft}$

$P_2 = 62.4 \frac{lb}{ft^3}(147.53^{ft} - 10^{ft} - 1.03^{ft})$

$P_2 = 8517.6 \frac{lb}{ft^2}$

B) find pressure at discharge pipe exit

$$h_a + \frac{p_1}{\gamma}^{0} + \frac{v_1^2}{2g}^{0} + z_1^{0} = \frac{p_3}{\gamma} + \frac{v_3^2}{2g}^{0} + z_3 + h_{L\,1\to3}$$

$$P_3 = \gamma(h_a - z_3 - h_{L\,1-3})$$

$h_a = 147.53\,ft$

$z_3 = 50\,ft$

$h_{L\,1-3} = h_{pipe} + 3h_{elbow} + h_{valve}$

$h_{pipe} = 86.36\,ft$

$3h_{elbow} = 1.86\,ft$

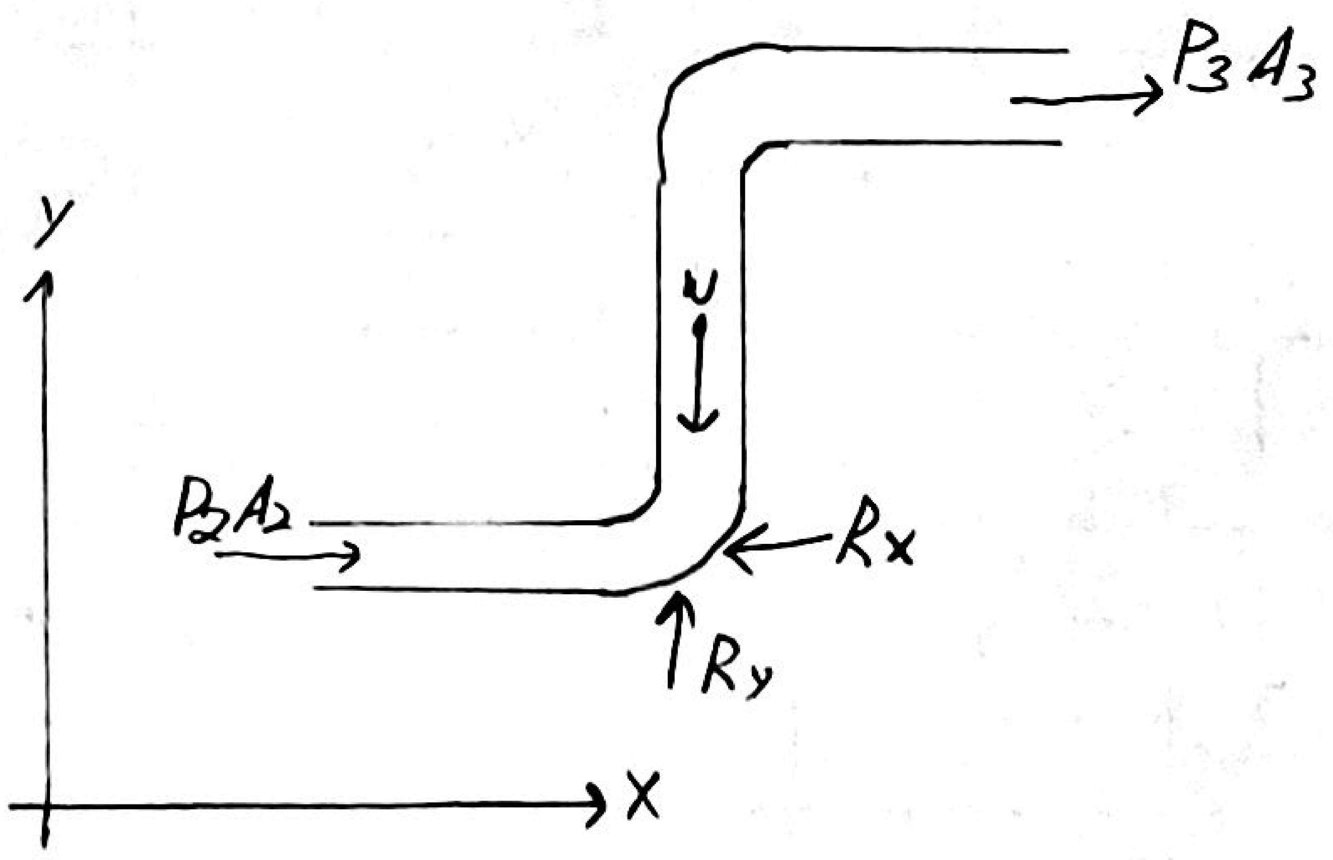
$h_{valve} = 7.83\,ft$

$h_{L\,1-3} = 86.36 + 1.86 + 7.83 = 96.05\,ft$

$P_3 = 62.4\frac{lb}{ft^3}(147.53\,ft - 50\,ft - 96.05\,ft)$

$\underline{P_3 = 92.35\frac{lb}{ft^2}}$

FBD of the water in the pipes



$$\Sigma F_x = (P_2A_2) + (P_3A_3) - R_x = \rho \cdot Q \cdot \Delta v_x^{0}$$

$R_x = P_2 \cdot A_2 + P_3 \cdot A_3$

$R_x = (8517.6 \cdot 0.34722) + (92.35 \cdot 0.34722)$

$\underline{R_x = 2987.37\,lb}$

$$\Sigma F_y = -W + R_y = \rho \cdot Q \cdot \Delta v_y^{0}$$

$R_y = W = \gamma \cdot A \cdot L = 62.4 \cdot 0.3472 \cdot 2500$

$\underline{R_y = 54163.2\,lb}$

c)

$$V_1 = C\sqrt{\frac{\frac{2g\Delta P}{\gamma}}{\left(\frac{A_1}{A_2}\right)^2 - 1}}$$

$$Re = \frac{V \cdot D}{\nu} = \frac{9.842 \cdot 0.662}{1.21\times10^{-5}} = 5.38\times10^5$$

using table 15.5 $C = 0.984$

$$\left(\frac{V}{C}\right)^2 = \frac{\frac{2g\Delta P}{\gamma}}{\left(\frac{A_1}{A_2}\right)^2 - 1} \Rightarrow \left[\left(\frac{A_1}{A_2}\right)^2 - 1\right]\cdot\left(\frac{V}{C}\right)^2 = \frac{2g\Delta P}{\gamma}$$

$$\Delta P = \frac{\left[\left(\frac{A_1}{A_2}\right)^2 - 1\right]\cdot\left(\frac{V}{C}\right)^2\cdot\gamma}{2g}$$

$$\Delta P = \frac{\left[\left(\frac{0.344\,ft^2}{0.086\,ft^2}\right)^2 - 1\right]\cdot\left(\frac{9.842\,\frac{ft}{s}}{0.984}\right)^2\cdot 62.4\,\frac{lb}{ft^3}}{2\cdot 32.2\,\frac{ft}{s^2}}$$

$$\Delta P = 1481.77\,\frac{lb}{ft^2}$$

Bernoulli's to find energy loss

$$\frac{P_1}{\gamma} + z_1^{\,0} + \frac{V_1^2}{2g} - h_L = \frac{P_2}{\gamma} + z_2^{\,0} + \frac{V_2^2}{2g}$$

$$\frac{P_1 - P_2}{\gamma} = \frac{V_2^2 - V_1^2}{2g} + h_L \qquad V_2 = V_1$$

$$\frac{P_1 - P_2}{\gamma} = h_L \Rightarrow \frac{\Delta P}{\gamma} = h_L$$

$$h_L = \frac{1481.77\,\frac{lb}{ft^2}}{62.4\,\frac{lb}{ft^3}}$$

$$\underline{h_L = 23.73\,ft}$$

c) new energy loss for the system

$h_{L1-4} = h_{elbows} + h_{valve} + h_{nozzle} + h_{exit} + h_{pipe}$

$h_{elbows} = 1.86^{ft}$

$h_{valve} = 7.83^{ft}$

$h_{nozzle} = 23.73^{ft}$

$h_{exit} = 1.48^{ft}$

$h_{pipe} = 86.36^{ft}$

$h_{L1-4} = 1.86 + 7.83 + 23.73 + 1.48 + 86.36$

$h_{L1-4} = 121.26^{ft}$

Using bernoulli's to find new pump head

$h_a + \frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_4}{\gamma} + \frac{V_4^2}{2g} + z_4 + h_{L1-4}$

$h_a = z_4 + h_{L1-4}$

$h_a = 50^{ft} + 120.89^{ft}$

$h_a = 171.26^{ft}$

$\text{pump power} = \frac{\gamma \cdot Q \cdot h_a}{\eta} = \frac{62.4 \cdot 3.387 \cdot 170.89}{0.6}$

$P_{power} = 60328.39 \frac{lb \cdot ft}{s}$

$\% \text{ Power increase} = \frac{60328.39}{51967.147} \cdot 100 = 116.08\%$

the pump power needs to increas by 16.08%

D) $P_{max} = P_{op} + \Delta P$

$\Delta P = \rho \cdot C \cdot V$

$$C = \frac{\sqrt{\frac{E_0}{\rho}}}{\sqrt{1 + \frac{E_0 D}{E \delta}}}$$

$E_0 = 45504000 \frac{lb}{ft^2}$

$\rho = 1.94 \frac{slug}{ft^3}$

$D = 0.662 ft$

$E = 4177086846.63 \frac{lb}{ft^2}$

$\delta = 0.322 in = 0.026 ft$

$$C = \frac{\sqrt{\frac{45504000}{1.94}}}{\sqrt{1 + \frac{45504000 \cdot 0.662 \cdot 0.0}{4177086846.63 \cdot 0.026}}}$$

$C = 4285.42$

$\Delta P = 1.94 \cdot 4285.4 \cdot 9.842$

$\Delta P = \underline{81818.3 \frac{lb}{ft^2}}$

P_{op} = p at pump outlet $= 8517.6 \frac{lb}{ft^2}$

$P_{max} = 8517.6 + 81818.3021$

$P_{max} = \underline{90335.65 \frac{lb}{ft^2}}$

Thickness of Pipe using P_{max}

$$t = \frac{P \cdot D}{2(S \cdot E + PY)}$$

$S = 2188800 \frac{lb}{ft^2}$ assuming A672 grade A45 (reference 2)

$E = 1$

$Y = 0.4$

$$t = \frac{90335.65 \cdot 0.718}{2(2188800 \cdot 1 + 90335.65 \cdot 0.4)}$$

$t = 0.0145^{ft} = 0.174^{in}$

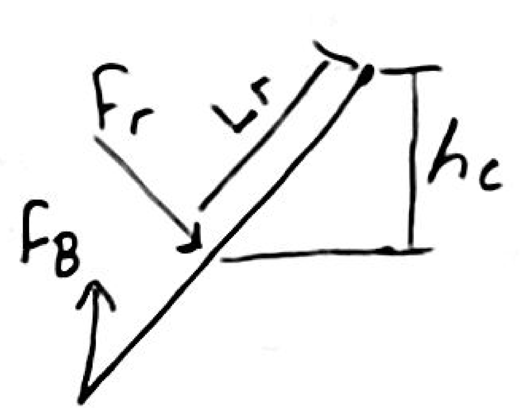
0.174^{in} is less than 0.325^{in} therefore, the pipe will not fail due to water hammer effect.

Cavitation

$P_{op} = 8517.6 \frac{lb}{ft^2}$ $P_{sat@60°F} = 36.9187 \frac{lb}{ft^2}$

Pop is greater than Psat therefore there will be no cavitation will occure.

E)



$F_r = P \cdot A$

$P = \gamma_{water} \cdot (h + h_c)$

$h_c = 5 \cos 30 = 4.33$

$P = 62.4 \cdot (\frac{38}{12} + \frac{4.33}{12}) = 220.1 \frac{lb}{ft^2}$

$A = \pi (\frac{10}{2})^2 = 78.53^{in^2} = 0.54^{ft}$

$F_r = 220.1 \cdot 0.54 = 119.95^{lb}$

Take moment at hinge

$\Sigma M_h = (F_r \cdot L_r) - (F_B \cdot 10^{in}) = 0$

$$F_B = \frac{F_r \cdot L_r}{10}$$

$L_r = L_{face} - \frac{L_{face}}{3}$

$L_{face} = \frac{10}{\cos 30} = 11.54^{in}$

$L_r = 11.54^{in} - \frac{11.54}{3} = 7.69^{in}$

$$F_B = \frac{119.95^{lb} \cdot 7.69^{in}}{10^{in}}$$

$F_B = 92.24^{lb}$

$F_B = \gamma_{water} \cdot V_D$

$V_D = \frac{F_B}{\gamma_{water}}$

$V_D = \frac{92.24^{lb}}{62.4 \frac{lb}{ft^3}}$

$V_D = 1.478^{ft^3}$

$V_D = \frac{4}{3} \cdot \pi \left(\frac{D}{2}\right)^3$

$D = 2 \cdot \sqrt[3]{\frac{3 V_D}{4 \pi}}$

$D = 1.41^{ft}$

Stability of the buoy

$L_{cb} + MB > L_{cg}$

$L_{cg} = \frac{1.41}{2} = 0.705^{ft}$

$L_{cb} = \frac{1.41}{2} = 0.705^{ft}$

$MB = \frac{I}{V_D}$

$I = \frac{2}{3} m \cdot r^2$

$I = \frac{2}{3} \cdot \left(\frac{1.41}{2}\right)^2$

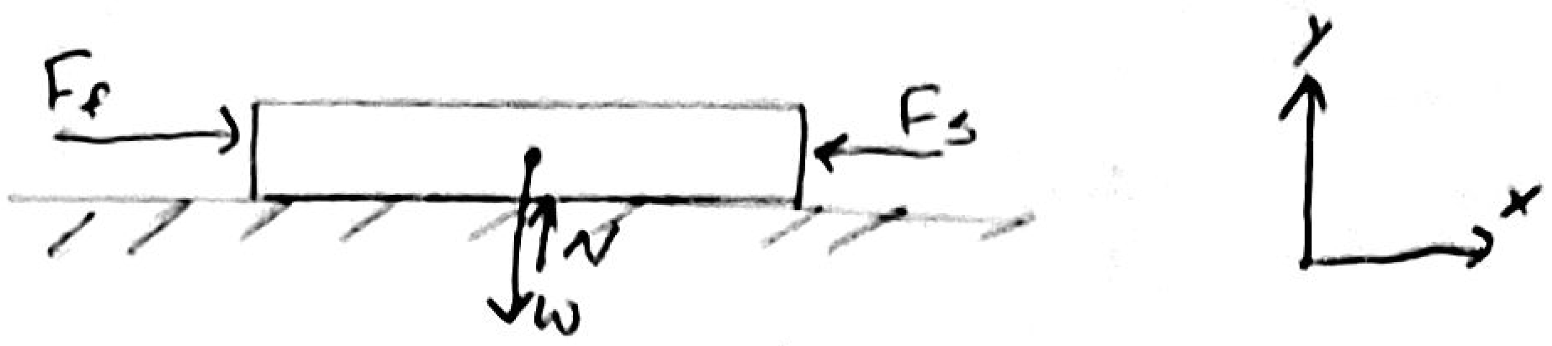
$I = 0.331^{ft^2}$

$MB = \frac{0.331^{ft^2}}{1.478^{ft^3}}$

$MB = 0.223^{ft}$

$0.705 + 0.223 > 0.705$ ∴ buoy will be stable

F)



$$F_f = C_D\left(\frac{\rho \cdot v^2}{2}\right)$$

$$F_f = 1.6\left(\frac{1.94 \cdot \frac{14.74\,\frac{ft}{s}}{148\,ft}}{2}\right)\cdot(5^{ft}\cdot 1^{ft})$$

$$F_f = 0.078^{lb}$$

$$\Sigma F_y = -W + N = 0 \;\therefore\; N = W$$

$$\Sigma F_x = F_f - F_s = 0 \;\therefore\; F_f = F_s$$

$$F_s = U_s \cdot N$$

$$F_f = U_s \cdot W$$

$$W = \frac{F_f}{U_s}$$

$$W = \frac{0.78}{0.6}$$

$$\underline{W = 0.131^{lb}}$$

Summary

The flow in the lower channel is $14.904\,\frac{ft^3}{s}$ and the flow into the system is $3.387\,\frac{ft^3}{s}$. 22.7% of the flow is removed from the lower channel. This is not a neglectable amount of water.

The horizontal force in the discharg pipe is 2987.37^{lb}. The vertical force in the discharge pipe is 54163.2^{lb}.

The pressure drop due to a new flow nozzle is $1481.17\,\frac{lb}{ft^2}$. The increase to energy loss is 23.73^{ft}. This increase in energy loss requires that the pump power be increased by 16.09%

The pressure increment due to the watter hammer effect is 81818.3 lb/ft². This makes the maximum pressure equal to 90335.65 lb/ft². The required pipe thickness for this p_{max} is 0.174 in but the slected pipe has a thickness of 0.322 in therefore the pipe will not fail due to the water hammer effect. The operational pressure is 8517.6 lb/ft² and the saturation pressure at 60°F is 36.91 lb/ft² therefore there will be no cavation.

The force on the gate is 119.95 lb and the required bouyance force is 92.24 lb. The buoy needs to have a diameter of 1.41 ft to supply this force. The metacenter of the buoy is above the center of gravity therefore the buoy is stable.

The maximum weight of the object, so that the flow will make it slide, is 0.131 lb

Analysis

Calculating how much weigh the discharg. pipe supports need to hold is critical to the opperation of the system. While the civil engineers will make the specs, it is my job to provide support to them.

Knowing the flow rate in the discharge pipe is important to be able to monitor the pump performance. The nozzele to pipe diameter of 0.5 causes a lot of energy loss. It would be beneficial to run calculation on a variety of different ratios.

Preventing both water hammer and cavation is essential to ensuring the longevity of the system. Part g, showed that lowering the velocity of the fluid lowers the effect of water hammer.