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MET 330 Fluid Mechanics
Dr. Orlando Ayala
Spring 2024
Test 1

Take home – Due Tuesday February 9th 2024 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. HINT: 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 is only one problem with 3 different parts, each one is worth 80/3 of the total grade.
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 only one file and it has to be a pdf file. 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 accepte 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 o 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).

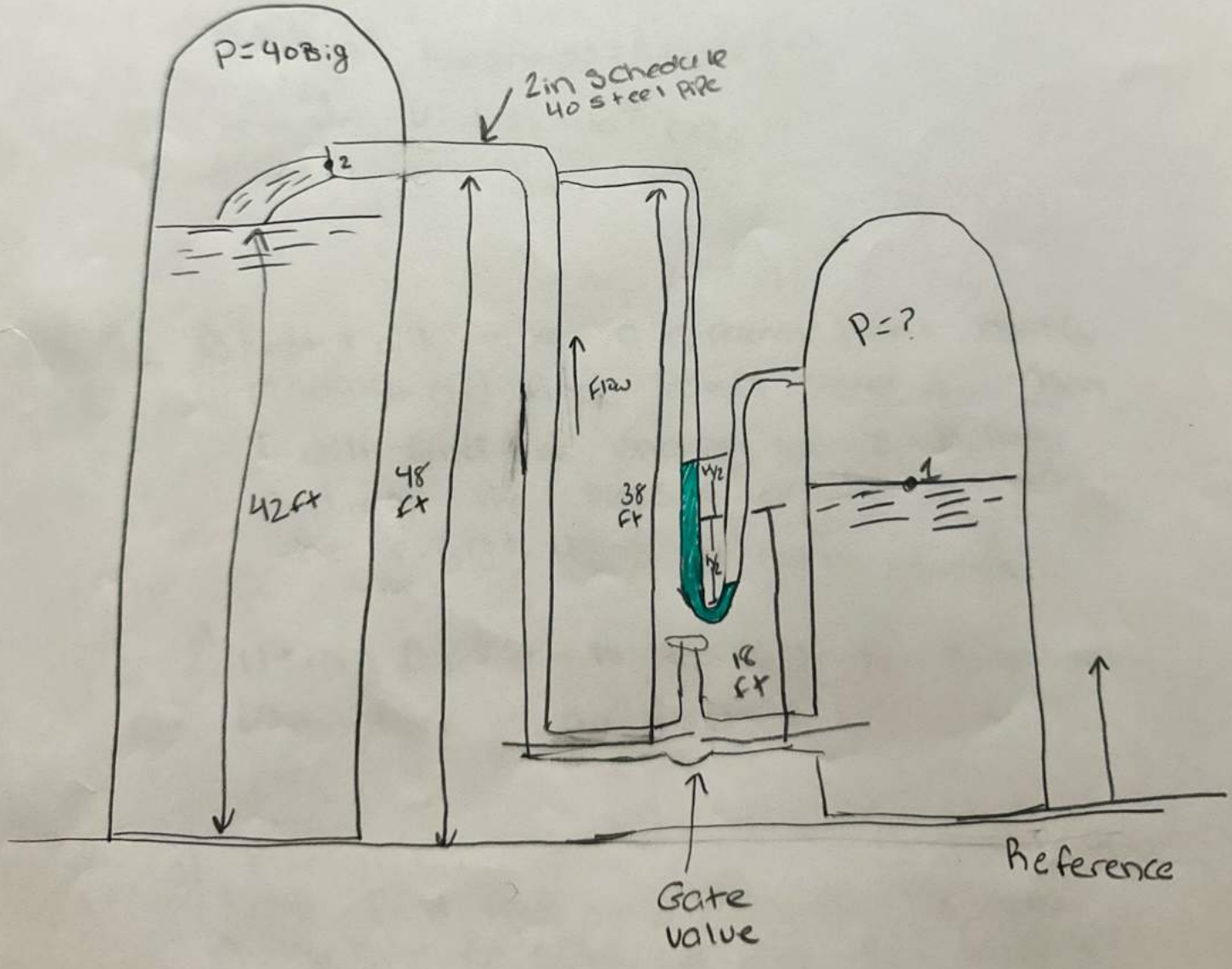
With that said, you are NOT authorized to use any online source of any type, unless is ODU related.

Purpose: 1) Determine the required air Pressure in the tank on the right in order to deliver 250gpm of ethyl alcohol.

2) Determine the air pressure when the flow of ethyl alcohol in the system stops.

3) Determine the flow rate when the air pressure is 75 psi. Determine the air pressure in the tank on the right for several flow rates

rawings and Diagrams:



Sources:

Mott, Robert, Untener Joseph, Applied Fluid Mechanics 7th edition, Pearson Education

Design Considerations:

Incompressible Fluids
Isothermal Process

Data and Variables:

1) $T = 77F$ $P = 40\ Psig$ $L = 36ft$
$D = 0.1723\ ft$ $Q = 250gpm = 0.557\ ft^3/s$
$\gamma_{mercury} = 844.9\ lb/ft^3$ $Roughness = 5.0 \times 10^{-6}\ ft$
$\rho = 1.53\ Slugs/ft^3$
$\gamma_{ethylalcohol} = 49.01\ lb/ft^3$ $\nu = 1.37 \times 10^{-5}\ ft^2/s$
2) $h = 18ft$ $L = 38ft$

3) 75 Psi

Procedure:

1) First I will make a reference point on the drawing and find points 1 and 2. Then I will find the energy losses befor finding the pressure of the tank on the right. using Bernoulli's Equation

2) using $\Delta P = \gamma * h$ to find the pressure when there is no flow.

3) I will first find air pressure for the tank on the right for serval flow rates. Then make a Plot of Pressure vs flowrate. And finding the flow rate at 75 Psi

1) Calculations.

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L \qquad h_L = f\frac{L}{D}\frac{V^2}{2g} + 4 \times K\frac{V^2}{2g}$$

$$\frac{P_2}{\gamma} = z_1 - \frac{V_2^2}{2g} - h_L \qquad \frac{P_2}{\gamma} = z_1 - \frac{V_2^2}{2g} - f\frac{L}{D}\frac{V^2}{2g} + 4 \times K\frac{V^2}{2g}$$

$$V_1 = \frac{Q}{A} = \frac{0.557\ ft^3/s}{\frac{\pi}{4} * 0.1723^2 ft} = 23.89\ ft/s$$

$$Re = \frac{23.89\ ft/s * 0.1723\ ft}{1.37 \times 10^{-5}\ ft^2/s} = 3 \times 10^5$$

$$\frac{\varepsilon}{D} = \frac{5.0 \times 10^{-6}\ ft}{0.1723\ ft} = 2.90 \times 10^{-5}$$

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7(0.1723/5.0\times10^{-6})} + \frac{5.74}{(3.37\times10^{-6})^{0.9}}\right)\right]^2} = 0.0167$$

$$f_T = \frac{0.25}{\left[\log\left(\frac{1}{3.7(0.1723/5.0\times10^{-6})}\right)\right]^2} = 0.00398$$

$$K = 0.6775$$

$$\frac{P_1}{\gamma} = z_1 - \frac{V_1^2}{2g}\left(1 + f\frac{L}{D} + 2K\right)$$

$$\frac{P_1}{\gamma} = 46 - \frac{(23.89)^2}{2(9.81)}\left(1 + 0.0167\,\frac{36 ft}{0.1723\ ft} + 2 \times 0.6775\right)$$

Using Specific weight of ethyl alchol

$\gamma_{ethanol\ alchol} = 49.01\ lb/ft^2$

$$7249.28\ lb/ft^2 = 50.34\ psig$$

Summary: The Pressure in the right tank is 50.31 Psig.
The monometer reading is 18 Ft.

Materials:
Mercury and Ethyl alchol

Analysis: The energy losses were considered and the Pressure between the two tanks decreased.

2) Calculations:

$\Delta P = \gamma * h$

$P_1 = \gamma_f + h + P_2$

$\gamma_{ethyl\ alcohol} = 49.01\ lb/ft^2$

$\gamma_{Hg} = 844.9\ lb/ft^2$

$P_1 = (49.01)(9.81)(36ft) - (844.9)(18ft)$

$= 2100.171\ lb/ft^2 + 50.34\ psig$

$= 2150.51\ lb/ft^2$

$= 14.93\ Psig$

$P_1 + h(\gamma_{ethyl\ alcohol} + 2\gamma_{Hg}) = 0$

$h = \frac{P_1}{\gamma_{ea+2Hg}} = \frac{14.93\ lb/in^2}{(-49.01 + 2 \times 844.9)\left(\frac{1ft^3}{12^3 in^3}\right)}$

$= 15.72\ ft = 1.31\ ft$

$= 18ft + 2(1.31ft) = \boxed{20.62\ ft}$

Summary: The air pressure at 14.93 Psig the flow of ethyl alcohol in the system stops. The new manometer reading is 20.62 ft at the moment there is no flow.

Materials: ethyl alcohol and mercury

Analysis: The Pressure changed to cause the Flow of the System to stop. When the Pressure changed it cause the height of the manometer to change.

Calculations:

$$\frac{P_1}{\gamma} + \frac{V_1^2}{g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2$$

$$P_1 = P_2 + \frac{\gamma Q^2}{2g} + V_1^2 + V_2^2$$

$$V = \frac{Q}{A} = \frac{0}{\frac{\pi}{4}(0.1723)^2} = 0 \text{ ft/s}$$

$$P_1 = 40 \text{ psig} + 49.01 \times \frac{0^2}{2(9.81)} * \left(0 \text{ ft/s} + 23.29 \text{ ft/s}\right) + 49.01$$

$$(36 - 0)$$

$$= 1804.36 \text{ lb/ft}^2 = \boxed{12.5 \text{ psig}}$$

$$V = \frac{Q}{A} = \frac{0.0557}{\frac{\pi}{4}(0.1723)} = 2.39 \text{ ft}^3/\text{s}$$

$$P_1 = 40 \text{ psig} + 49.01 \times \frac{2.39^2}{2(9.81)} \times \left(2.39 + 23.29\right) + 49.01$$

$$(36 - 0)$$

$$= 2170.78 \text{ lb/ft}^2 = \boxed{15.09 \text{ psig}}$$

$$= \frac{Q}{A} = \frac{0.111}{\frac{\pi}{4}(0.1723)^2} = 4.762 \text{ ft}^3/\text{s}$$

$$= 40 \text{ psig} + 49.01 \times \frac{4.762^2}{2(9.81)} \times \left(4.762 + 23.29\right) + 49.01 (36 - 0)$$

$$= 3391.93 \text{ lb/ft} = \boxed{123.66 \text{ psig}}$$

$V = \frac{Q}{A} = \frac{0.167}{\frac{\pi}{4}(0.1723)^2} = 7.16\ ft^3/s$

$P_1 = 40\ psig + 49.01 \times \frac{7.16^2}{2(9.81)} \times (7.16 + 23.29) + 49.01(36-0)$

$= 5763.7\ lb/ft^2 = \boxed{36.61\ psig}$

$V = \frac{Q}{A} = \frac{0.223}{\frac{\pi}{4}(0.1723^2)} = 9.56\ ft^3/s$

$P_1 = 40 + 49.01 \times \frac{9.56^2}{2(9.81)} \times (9.56 + 23.29) + 49.01(36-0)$

$= 9303.9\ lb/ft^2 = \boxed{64.61\ psi}$

$V = \frac{Q}{A} = \frac{0.279}{\frac{\pi}{4}(0.1723^2)} = 11.97\ ft^3/s$

$= 40 + 49.01 \times \frac{11.97^2}{2(9.81)} \times (11.97 + 23.29) + 49.01(36-0)$

$= 14434.3\ lb/ft^2 = \boxed{100.23\ psig}$

$V = \frac{Q}{A} = \frac{0.334}{\frac{\pi}{4}(0.1723^2)} = 14.32\ ft^3/s$

$= 40 + 49.01 \times \frac{14.32^2}{2(9.81)} \times (14.32 + 23.29) + 49.01(36-0)$

$= 21069\ lb/ft^2 = \boxed{146.31\ psi}$

$V = \frac{Q}{A} = \frac{0.390}{\frac{\pi}{4}(0.1723^2)} = 16.73\ ft^3/s$

$= 40 + 49.01 \times \frac{16.73^2}{2(9.81)} \times (16.73 + 23.29) + 49.01(36-0)$

$= 29784.8\ lb/ft^2 = \boxed{206.84\ psi}$

$V = \frac{Q}{A} = \frac{0.44}{\frac{\pi}{4}(0.1723^2)} = 19.13 \text{ ft}^3/\text{s}$

$P_1 = 40 + 49.01 \times \frac{19.13^2}{2(9.81)} \times (19.13 + 23.29) + 49.01 (36-0)$

$= 40582.44 \text{ lb/ft}^2 = 281.85 \text{ psig}$

$V = \frac{Q}{A} = \frac{0.501}{\frac{\pi}{4}(0.1723^2)} = 21.48 \text{ ft}^3/\text{s}$

$P_1 = 40 + 49.01 \times \frac{21.48}{2(9.81)} \times (21.48 + 23.29) + 49.01 (36-0)$

$= 53403.38 \text{ lb/ft}^2 = 370.86 \text{ psig}$

$V = \frac{Q}{A} = \frac{0.557}{\frac{\pi}{4}(0.1723^2)} = 23.29$

$= 40 + 49.01 \times \frac{23.29}{2(9.81)} \times (23.29 + 23.29) + 49.01 (36-0)$

$= 64918.14 \text{ lb/ft}^2 = 450.82 \text{ psig}$

Summary: Different flow rates were found and graphed. The flowrate at 75 psi is around 105 ft^3/s

Materials:
Ethyl alchol

Analysis: With different flow rates, different Pressures needed to be found to be able to Plot the graph to find the flowrate for Certain Pressures.