

- On this problem you will compute the moment at the base of a vertical pole. The moment is due to a 80 mi/h wind. The pole is composed by two cylinders connected to each other end to end. The lowest cylinder is of 4 in nominal schedule 40 steel pipe with a length of L_{bottom} . The other cylinder is made of 3 1/2 in nominal schedule 40 steel pipe with a length of L_{top} . The temperature of the air is 71 F. Use the table below to get the values for L_{bottom} and L_{top} . Use the 1st (from right to left) digit of your UIN to use the table.

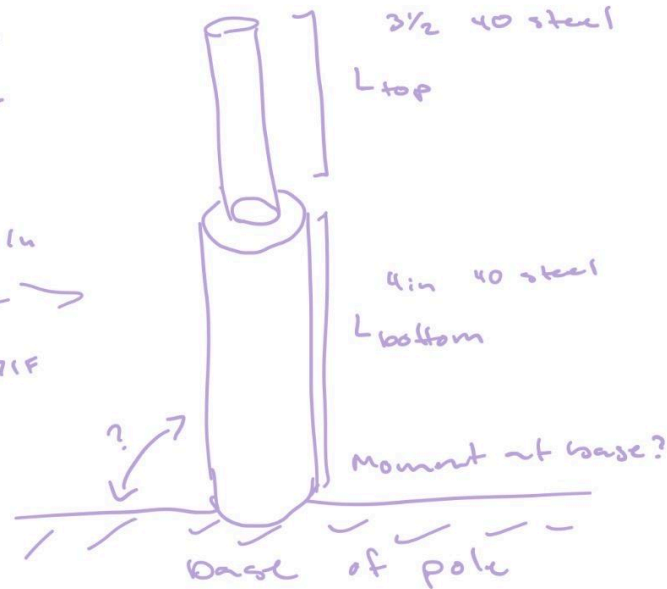
UIN digit 2

$L_{\text{bottom}} = 3 \text{ ft}$

$L_{\text{top}} = 3 \text{ ft}$

Wind: 80 mi/h

Air temp: 71 F



Step 1

$$V = 80 \text{ mph} \cdot \left(\frac{44 \text{ ft/s}}{30 \text{ mph}} \right) = 117.33 \text{ ft/s}$$

L_{Bottom}

$$\text{OD}_1 = 4.5 \text{ in} = 0.3750 \text{ ft}$$

L_{top}

$$\text{OD}_2 = 4 \text{ in} = 0.3333 \text{ ft}$$

Step 2 air at 71 F

$$P: 0.00233 \text{ slug/ft}^3$$

$$V: 1.60 \times 10^{-4} \text{ ft}^2/\text{s}$$

Step 3

bottom

$$D_1 = 0.3750 \text{ ft}$$

$$L_1 = 3 \text{ ft}$$

$$R_{e1} = \frac{v \cdot D_1}{\nu} = \frac{117.33 \text{ ft/s} \cdot 0.3750 \text{ ft}}{1.60 \times 10^{-4} \text{ ft}^2/\text{s}} \approx 2.75 \times 10^5$$

$$C_{D1} = 1.20$$

$$A_1 = D_1 \cdot L_1 = 0.3750 \text{ ft} \cdot 3 \text{ ft} = 1.125 \text{ ft}^2$$

$$F_{D1} = C_{D1} \cdot \left(\frac{1}{2} \rho v^2 A_1 \right)$$

$$F_{D1} = 1.20 \cdot \left(\frac{1}{2} \cdot 0.00233 \cdot (117.33)^2 \cdot 1.125 \right) = 21.68 \text{ lb}$$

$$\text{Moment Arm}_1 = \frac{L_1}{2} = \frac{3 \text{ ft}}{2} = 1.5 \text{ ft}$$

Step 4 top section

$$D_2 = 0.3333 \text{ ft}$$

$$L_2 = 3 \text{ ft}$$

$$R_{e2} = \frac{v \cdot D_2}{\nu} = \frac{117.33 \text{ ft/s} \cdot 0.3333 \text{ ft}}{1.60 \times 10^{-4} \text{ ft}^2/\text{s}} \approx 2.44 \times 10^5$$

$$C_{D2} = 1.20$$

$$A_2 = D_2 \cdot L_2 = 0.3333 \text{ ft} \cdot 3 \text{ ft} = 1.0 \text{ ft}^2$$

$$F_{D2} = C_{D2} \cdot \left(\frac{1}{2} \rho v^2 A_2 \right)$$

$$F_{D2} = 1.20 \cdot \left(\frac{1}{2} \cdot 0.00233 \cdot (117.33)^2 \cdot 1.00 \right) = 19.27 \text{ lb}$$

$$\text{Moment Arm}_2 = L_1 + \frac{L_2}{2} = 3 \text{ ft} + 1.5 \text{ ft} = 4.5 \text{ ft}$$

Step 5

$$M_{\text{base}} = (F_{D1} \cdot \text{Moment Arm}_1) + (F_{D2} \cdot \text{Moment Arm}_2)$$

$$= (21.68 \text{ lb} \cdot 1.5 \text{ ft}) + (19.27 \text{ lb} \cdot 4.5 \text{ ft})$$

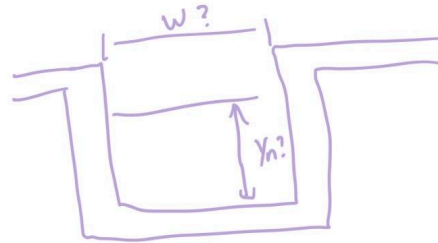
$$= 32.52 \text{ lb} \cdot \text{ft} + 86.72 \text{ lb} \cdot \text{ft} = 119.24 \text{ lb} \cdot \text{ft}$$

2. On this problem you will compute the liquid height in an open channel with a slope of 0.001. The channel has a rectangular shape and it is made of cement. The width of the channel is W and water runs through it at a flow rate of Q . Is the flow supercritical or subcritical? Use the table below to get the values for W and Q . Use the 2nd (from right to left) digit of your UIN to use the table.

UIN digit 5

$$W = 18 \text{ ft}$$

$$Q = 150 \text{ ft}^3/\text{s}$$



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Step 1

$$S: 0.001$$

$$n: 0.12$$

Step 2:

$$A = W \cdot y = 18y$$

$$WP = W + 2y = 18 + 2y$$

$$R_h = \frac{A}{WP}$$

$$Q = \frac{1.486}{n} A R_h^{2/3} S^{1/2}$$

Step 3

$$y = 1.68 \text{ ft}$$

$$V = \frac{Q}{A} = \frac{150 \text{ ft}^3/\text{s}}{30.24 \text{ ft}^2} = 4.96 \text{ ft/s}$$

$$F_r = \frac{V}{\sqrt{g \cdot y}} = \frac{4.96}{\sqrt{32.2 \cdot 1.68}} = 0.67$$

$$F_r = 0.67 < 1.0 \text{ subcritical}$$

Prob 2						
Trial	Assumed Depth y (ft)	Area $A = 18y$ (ft ²)	$WP = 18 + 2y$	Hydraulic Radius $R_h = A/WP$	$R_h^{2/3}$	Calculated Q (ft ³ /s)
1	1	18	20	0.9	0.93	65.71
2	2	36	22	1.64	1.39	195.76
3	1.5	27	21	1.29	1.18	125.02
4	1.7	30.6	21.4	1.43	1.27	152.09
5	1.68	30.24	21.36	1.42	1.26	149.30

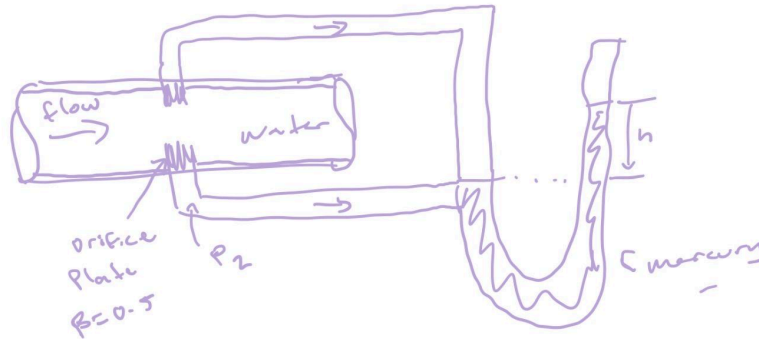
$$\text{Percent Error} = \left| \frac{149.3 - 150}{150} \right| \times 100\% = 0.5\%$$

3. On this problem you will compute the reading of a mercury manometer when an orifice plate of $\beta=0.5$ is used to measure a water flow rate of Q running through a pipe with a diameter D nominal, schedule 40 pipe. Use the table below to get the values for Q and D . Use the 3rd (from right to left) digit of your UIN to use the table.

UIN: 3

$Q: 6000 \text{ gpm}$

$D = 12''$



Step 1

$$D = 24 \text{ in} = 2 \text{ ft}$$

$$A_1 = \frac{\pi}{4} D^2 = \frac{\pi}{4} (2 \text{ ft})^2 = 3.1416 \text{ ft}^2$$

$$\beta = 0.5 \rightarrow d = 0.5 \times D = 1.0 \text{ ft}$$

$$A_2 = \frac{\pi}{4} d^2 = \frac{\pi}{4} (1 \text{ ft})^2 = 0.7854 \text{ ft}^2$$

$$Q = 6000 \text{ gpm} = \frac{6000}{448.8} = 13.37 \text{ ft}^3/\text{s}$$

$$\gamma_m (\text{Mercury}) = 844.9 \text{ lb/ft}^3, \gamma_w (\text{water}) = 62.4 \text{ lb/ft}^3$$

Step 2

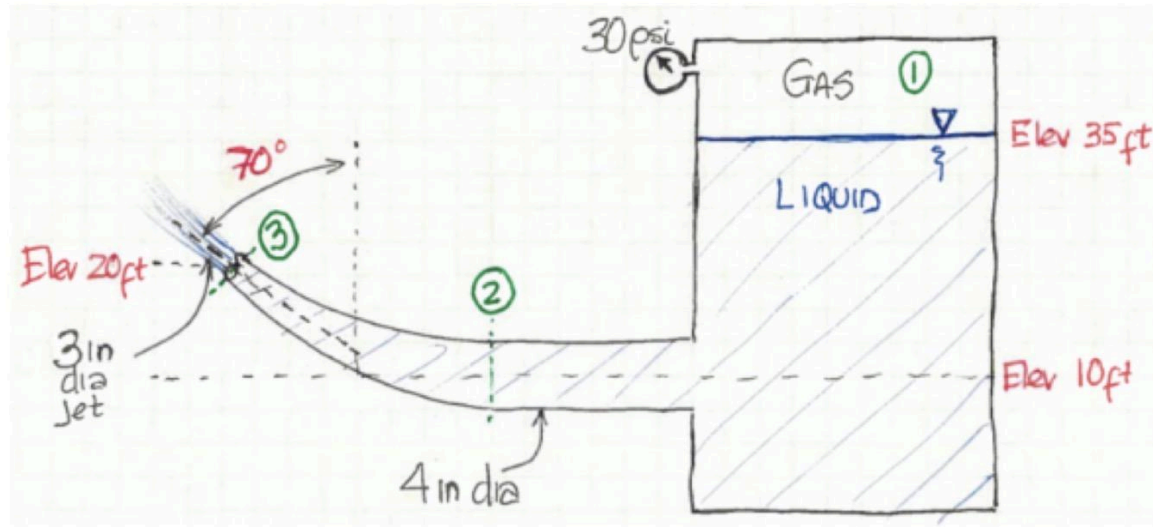
$$Q = A_1 C \sqrt{\frac{2gh \left(\frac{\gamma_m}{\gamma_w} - 1 \right)}{\left(\frac{A_1}{A_2} \right)^2 - 1}}$$

$$h = \frac{\left(\frac{Q}{A_1 C} \right)^2 \times \left[\left(\frac{A_1}{A_2} \right)^2 - 1 \right]}{2g \left(\frac{\gamma_m}{\gamma_w} - 1 \right)} = \frac{\left(\frac{13.37}{3.1416 \times 0.61} \right)^2 \cdot \left(\frac{3.1416}{0.7854} \right)^2 - 1}{2(32.2) \left(\frac{844.9}{62.4} - 1 \right)}$$

$$= 9.04 \text{ ft} \approx 10.85 \text{ in}$$

estimated $C: 0.61$

4. On this problem you will compute the force on the curved pipe section shown in the figure. The length of that section is L_{curved} . For the force you will provide its magnitude and direction. Neglect any energy losses. The specific weight of the liquid is $\gamma = 55 \text{ lb/ft}^3$. Use the table below to get the values for L_{curved} . Use the 4th (from right to left) digit of your UIN to use the table.



$$L_{\text{curved}} = 50 \text{ ft}$$

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2.

$$1. \quad \gamma : 55 \text{ lb/ft}^3$$

$$A_2 : D = 4 \text{ in} = 0.333 \text{ ft} \rightarrow A_2 = \frac{\pi}{4} (0.333)^2 = 0.0873 \text{ ft}^2$$

$$A_3 : D = 3 \text{ in} = 0.25 \text{ ft} \rightarrow A_3 = \frac{\pi}{4} (0.25)^2 = 0.0491 \text{ ft}^2$$

$$2. \quad P_1 (\text{psf}) = 30 \frac{\text{lb}}{\text{in}^2} \times 144 \frac{\text{in}^2}{\text{ft}^2} = 4320 \text{ lb/ft}^2$$

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

$$\frac{4320}{55} + 35 = 0 + 20 + \frac{V_2^2}{2(32.2)}$$

$$V_2^2 = 77.60 \text{ ft/s}$$

$$Q : V_2 \times A_2 = 77.60 \times 0.0873 = 3.81 \text{ ft}^3/\text{s}$$

$$\frac{Q}{A_2} = 3.81 / 0.0873 = 43.64 \text{ ft/s}$$

$$3. \quad \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g} = \frac{P_3}{\gamma} + z_3 + \frac{V_3^2}{2g}$$

$$\frac{P_2}{55} + 0 + \frac{43.64^2}{64.4} = 0 + 20 + \frac{77.60^2}{64.4}$$

$$P_2 = 4066.7 \text{ lb/ft}^2 \quad (28.24 \text{ psi})$$

$$4. \quad \dot{m} : \frac{\gamma}{g} Q = \frac{55}{32.2} \times 3.81 = 6.51 \text{ slugs/s}$$

$$V_{3x} = -77.6 \cos(20^\circ) = -72.72 \text{ ft/s}$$

$$V_{3y} = +77.6 \sin(20^\circ) = +26.54 \text{ ft/s}$$

$$P_2 A_2 - R_x = \dot{m} (V_{3x} - V_{2x})$$

$$4066.7 \times 0.0873 - R_x = 6.51(-72.92 - 43.64)$$

$$R_x = 1113.82 \text{ lb}$$

s/s

$$R_y - W = \dot{m} (V_{3y} - 0)$$

$$R_y - 240.08 = 6.51(26.54) = 172.78$$

$$R_y = 412.86 \text{ lb}$$

$$\text{Magnitude: } \sqrt{1113.82^2 + 412.86^2} = 1187.97 \text{ lb}$$

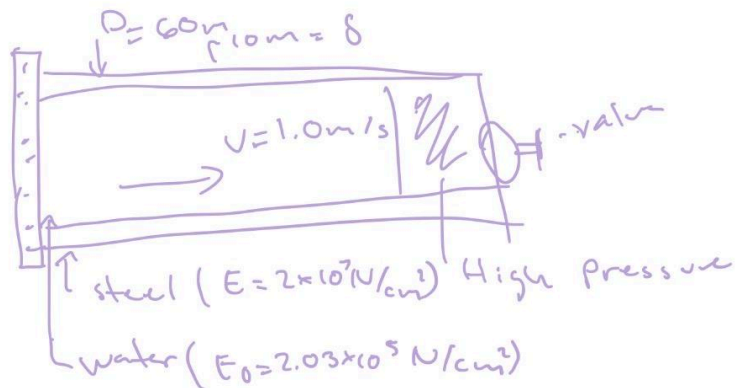
$$\text{Direction: } \tan^{-1}(412.86/1113.82) = 20.3^\circ \text{ Up \& to the left}$$

5. At the end of a steel pipe ($E=2 \times 10^7 \text{ N/cm}^2$) of internal diameter D , and thickness $\delta=10\text{mm}$, there is a valve. The water velocity in the pipe is V . Calculate the pressure increment when the valve closes all of the sudden. Water compressibility module is $E_0=2.03 \times 10^5 \text{ N/cm}^2$. Use the table below to get the values for D and V . Use the 5th (from right to left) digit of your UIN to use the table.

UIN: 0

$$D = 600 \text{ mm}$$

$$V = 1.0 \text{ m/s}$$



1. E_0 (Bulk Modulus): $2.03 \times 10^9 \text{ N/m}^2$

E (Elastic Modulus): $2.0 \times 10^{11} \text{ N/m}^2$

$D = 0.6 \text{ m}$

$\delta = 0.01 \text{ m}$

$\rho = 1000 \text{ kg/m}^3$

$V = 1.0 \text{ m/s}$

$$C = \sqrt{\frac{E_0 / \rho}{1 + \frac{E_0 D}{E \delta}}} = \sqrt{\frac{(2.03 \times 10^9) / 1000}{1 + \frac{(2.03 \times 10^9)(0.6)}{(2.0 \times 10^{11})(0.01)}}} = 1123.2 \text{ m/s}$$

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

$$= 1000 \cdot 1123.2 \cdot 1.0$$

$$\Delta P = 1,123,200 \text{ Pa}$$

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MET 330 Fluid Mechanics
Dr. Orlando Ayala
Test 3

Take home – Due before midnight on the date shown in CANVAS.

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. The other ninety (90) points will come from the problem solutions.
3. There are 5 problems to solve, each worth (90/5) 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 CANVAS. You must submit only one file and it has to be a pdf file. For the ePortfolio you are also supposed to upload this artifact to your Google drive. When you are done solving the test, please go ahead and upload it now before you forget.
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 it is ODU related.

HONOR CODE

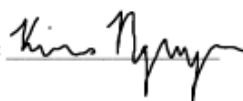
I pledge to follow the Honor Code and to obey all rules for taking exams and performing homework assignments as specified by the course instructor.

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: Kim T. Nguyen

Student Signature: 

Date: 7/5/2026