

Name: Bryant Teague

MET 330 Fluid Mechanics  
Dr. Orlando Ayala  
Fall 2018  
Test 3

Take home – Due Tuesday November 20<sup>th</sup> 2018 before class time (2:30 pm).

## 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). FOR THE “WORKFORCE” SYLLABUS STUDENTS: Ten (10) points are from your HW assignments. The other ninety (90) points will come from the problem solutions. FOR THE “OTHER” SYLLABUS STUDENTS: All hundred (100) points will come from the problem solutions. I will not require technical writing for this test. You could still do it following the attached rubric, however you are under no obligation to do so it as I will not grade it.
3. You will solve 5 problems and complete a questionnaire. The questionnaire is worth 10 points and the total amounts of points you get will depend on how many questions you get correct. The other points will be equally divided among all 5 problems you attempt to solve. You will HAVE to solve the very first problem. Then, solve 4 problems out of the other 6 problems. If you decide to solve them all, I will only grade the first 4 problems I find (in addition to the 1<sup>st</sup> one).
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 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

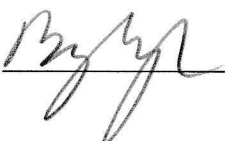
I pledge to follow the Honor Code and to obey all rules for taking exams and performing homework assignments as specified by the course instructor.

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.

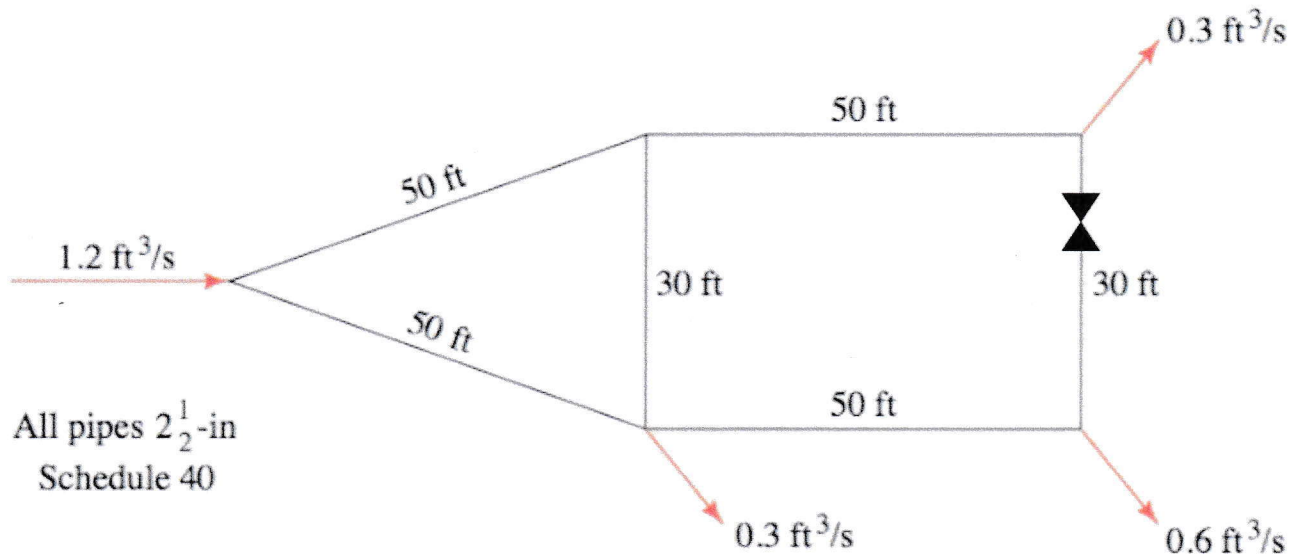
I understand that failure to follow this Honor Code imply that the professor will immediately report my case for academic dishonesty to the ODU Office of Student Conduct & Academic Integrity.

Student Name: Bryant Teagle

Student Signature: 

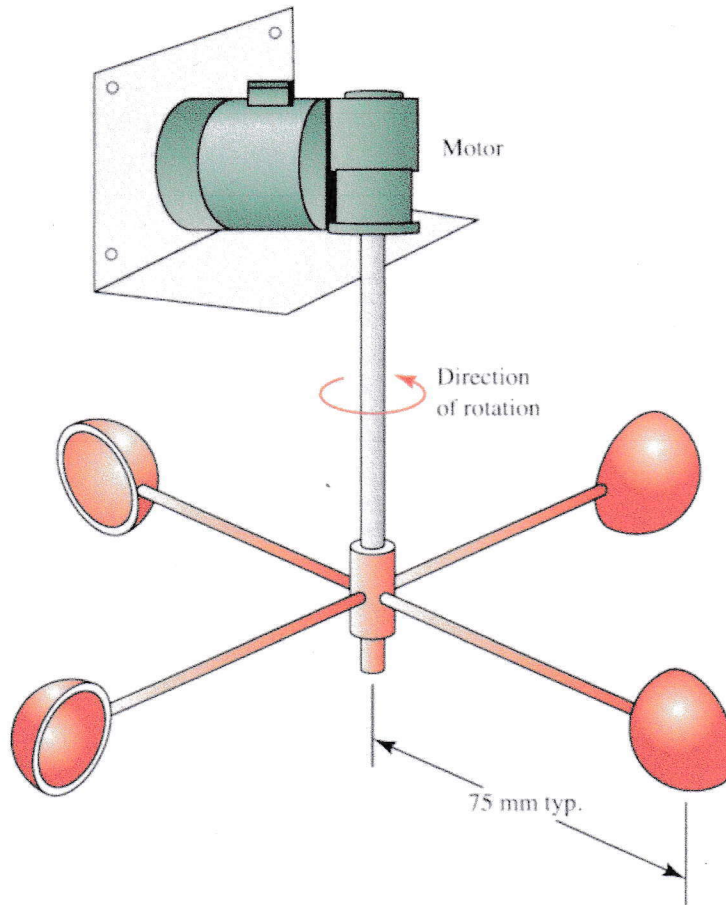
Date: 11-18-2018

1. Find the flow rate of water at 60F in each pipe. Please note the valve shown is completely closed. Neglect the minor losses.



2. At the end of a steel pipe ( $E=2 \times 10^7$  N/cm<sup>2</sup>) of internal diameter 600 mm, and thickness  $\delta=10$ mm, there is a valve. The water velocity in the pipe is 2.5 m/s and its compressibility module is  $E_o=2.03 \times 10^5$  N/cm<sup>2</sup>. What would be the required minimum pipe thickness so the pipe does not fail after the pressure increment when the valve closes all of the sudden. The operating pressure before closing the valve is 600 psi. Does the pipe fail? For the pipe thickness, use the equation in the last section of chapter 11 in our book (make any appropriate assumption when using this equation).
3. Design a triangular (half square) channel to be made of formed, unfinished concrete to carry 5.75 m<sup>2</sup>/s of water when laid on a 1.2-percent slope. The normal depth should be one-half the width of the channel bottom.
4. A pump draws propane at 45°C ( $sg = 0.48$ ) from a tank whose level is 1.84 m below the pump inlet. The energy losses in the suction line total 0.92 m and the atmospheric pressure is 98.4 kPa absolute. Determine the minimum required pressure above the propane in the tank to ensure that the fluid does not cavitate at the inlet of the pump.
5. Calculate the volume flow rate of water passing through a venturi meter with an inlet diameter of 100 mm and a throat diameter of 50 mm. The water is at 80°C, and a pressure difference of 55 kPa is observed between the inlet and the throat.
6. A 2-in nozzle is attached to a hose with an inside diameter of 4 in. The resistance coefficient  $K$  of the nozzle is 0.12 based on the outlet velocity head. If the jet issuing from the nozzle has a velocity of 80 ft/s, calculate the force exerted by the water on the nozzle.

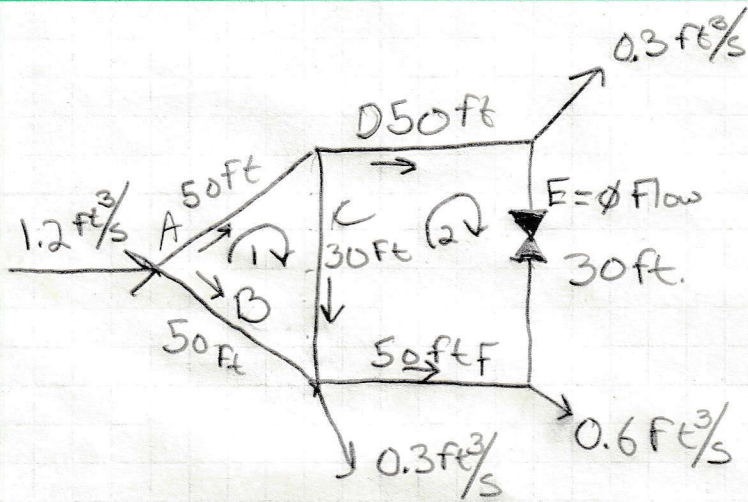
7. A type of level indicator incorporates four hemispherical cups with open fronts mounted as shown in the figure. Each cup is 25 mm in diameter. A motor drives the cups at a constant torque of  $2.85 \times 10^{-6}$  N.m. Determine the rotational speed (rpm) that the motor has when the cups are in oil at  $30^\circ\text{C}$ . What would be the torque if it rotates at the same rotational speed you just determined but rotating in the opposite direction.



- a. Please go to the following link to complete the 50 questions questionnaire:  
[https://odu.co1.qualtrics.com/jfe/form/SV\\_cNqRLBy59kr6TWd](https://odu.co1.qualtrics.com/jfe/form/SV_cNqRLBy59kr6TWd)

Complete

①



$$T = 60^\circ\text{F}$$

Pipe = 2 1/2" sch. 40

\* Pipe E has Zero Flow  $\rightarrow$  Therefore,  $Q_D$  and  $Q_F$  are known values. This becomes a 1 circuit solution.

\* Solved using Excel

$$Q_A = 0.5789 \text{ ft}^3/\text{s}$$

$$Q_B = 0.6211 \text{ ft}^3/\text{s}$$

$$Q_C = 0.2789 \text{ ft}^3/\text{s}$$

$$Q_D = 0.3 \text{ ft}^3/\text{s}$$

$$Q_E = 0 \text{ ft}^3/\text{s}$$

$$Q_F = 0.6 \text{ ft}^3/\text{s}$$



$$\textcircled{3} \quad Q = \frac{1.0}{n} A S^{1/2} R^{2/3}$$

$$Q = 5.75 \text{ m}^3/\text{s}$$

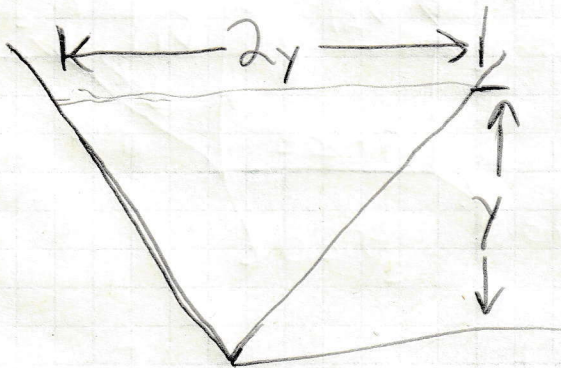
$$n = 0.017$$

$$S = 0.012$$

$$A = y^2$$

$$WP = 2.83y$$

$$R = 0.354y$$



\* Solved in Excel

$$y = 1.2422 \text{ m}$$

### EXAM 3 - Problem 3

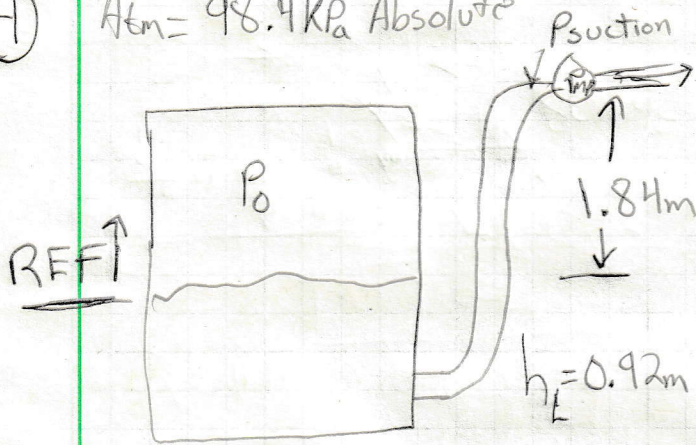
Q= 5.75 m<sup>3</sup>/sec

	Assumed Y (m)	Area (m <sup>2</sup> )	R (m)	Q (m <sup>3</sup> /sec)	Error (%)
Trial 1	1	1	0.354	3.2246101	43.92%
Trial 2	1.2	1.44	0.4248	5.2435716	8.81%
Trial 3	1.25	1.5625	0.4425	5.8466071	-1.68%
Trial 4	1.23	1.5129	0.43542	5.6004661	2.60%
Trial 5	1.24	1.5376	0.43896	5.7227095	0.47%
Trial 6	1.2422	1.543061	0.439739	5.7498248	0.00%

④

Atm = 98.4 kPa Absolute

Propane @ 45°C = 318 K



$$S_g = 0.48$$

$$\gamma = (0.48)(9.81)$$

$$\gamma = 4.7088 \text{ kN/m}^3$$

$$P_{\text{sat}} = 1538.3 \text{ kPa}_{\text{ABS}}$$

$$* P_{\text{suction}} + P_{\text{Atm}} > P_{\text{sat}} \quad * \frac{P_0}{\gamma} = \frac{P_{\text{suction}}}{\gamma} + Z_{\text{suction}} + \frac{V_{\text{suction}}^2}{2g} + h_L$$

\* No Flow Rate or Velocity or Pipe size were given.

\* The Velocity head will be neglected.

P<sub>sat</sub>

Interpolation

Temp °K	P <sub>kPa</sub>
300	997.4
318	P <sub>sat</sub>
320	1598.4

$$\frac{P_{\text{sat}} - 997.4}{1598.4 - 997.4} = \frac{318 - 300}{320 - 300}$$

$$P_{\text{sat}} = 1538.3 \text{ kPa}_{\text{ABS}}$$

$$P_{\text{suction}} = P_{\text{sat}} - P_{\text{atm}}_{\text{ABS}}$$

$$= (1538.3 - 98.4) \text{ kPa}$$

$$P_{\text{suction}} = 1439.9 \text{ kPa}$$

$P_0 > 1452.896 \text{ kPa}_{\text{gauge}}$

$$P_0 = \left( \frac{P_{\text{suction}}}{\gamma} + \Delta Z + h_L \right) \gamma$$

$$= \left[ \left( \frac{1439.9 \text{ kPa}}{4.7088 \text{ kN/m}^3} \right) + 1.84 \text{ m} + 0.92 \text{ m} \right] 4.7088 \text{ kN/m}^3$$

Table B-16, PC Model: Temperature Saturation Table, Propane ((C<sub>3</sub>H<sub>8</sub>))

SI Units  English Units

Saturation Temperature Table (PC Model) of Propane (C3H8)

Temp. K	Sat. Press. kPa	Spec. Volume m <sup>3</sup> /kg		Spec. Int. Energy kJ/kg		Spec. Enthalpy kJ/kg		Spec. Entropy kJ/kg·K	
		Sat. liquid	Sat. vapor	Sat. liquid	Sat. vapor	Sat. liquid	Sat. vapor	Sat. liquid	Sat. vapor
T	P <sub>sat@T</sub>	v <sub>f</sub>	v <sub>g</sub>	u <sub>f</sub>	u <sub>g</sub>	h <sub>f</sub>	h <sub>g</sub>	s <sub>f</sub>	s <sub>g</sub>
85.5	1.65 x 10 <sup>-7</sup>	0.001364	9.570 x 10 <sup>7</sup>	-495.72	50.78	-495.72	66.90	1.8813	8.4639
100	2.52 x 10 <sup>-5</sup>	0.001392	7.470 x 10 <sup>5</sup>	-467.82	61.30	-467.82	80.15	2.1826	7.6624
120	2.95 x 10 <sup>-3</sup>	0.001432	7.660 x 10 <sup>3</sup>	-428.94	77.05	-428.94	99.67	2.5370	6.9421
140	7.87 x 10 <sup>-2</sup>	0.001475	3.354 x 10 <sup>2</sup>	-389.60	94.10	-389.60	120.49	2.8402	6.4837
160	8.47 x 10 <sup>-1</sup>	0.001521	3.558 x 10 <sup>1</sup>	-349.68	112.31	-349.68	142.44	3.1067	6.1824
180	5.0	0.00157	6.69013	-308.95	131.56	-308.95	165.35	3.3465	5.9814
200	20.1	0.001624	1.84938	-267.18	151.68	-267.14	188.92	3.5665	5.8468
220	60.5	0.001684	0.66753	-224.06	172.47	-223.95	212.83	3.7719	5.7573
231.1	101.3	0.00172	0.41342	-199.50	184.18	-199.33	226.07	3.8808	5.7219
240	147.9	0.001752	0.29076	-179.27	193.72	-179.01	236.71	3.9668	5.6989
260	310.5	0.001831	0.14475	-132.45	215.19	-131.88	260.14	4.1542	5.6619
280	581.5	0.001925	0.07919	-83.17	236.52	-82.05	282.57	4.3369	5.6391
300	997.4	0.002043	0.04618	-30.84	257.10	-28.81	303.16	4.5176	5.6242
320	1598.4	0.0022	0.02793	25.38	275.78	28.90	320.42	4.6996	5.6106
340	2430.6	0.002433	0.01693	87.18	290.00	93.09	331.15	4.8883	5.5884
360	3554.0	0.002894	0.00949	160.40	291.07	170.69	324.79	5.1013	5.5293
369.9	4247.7	0.004535	0.00454	240.34	240.34	259.61	259.61	5.3376	5.3376

5

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

$$T = 80^\circ\text{C}$$

$$\gamma = 9.53 \text{ kN/m}^3$$

$$V_1 = 0.984 \sqrt{\frac{[2(9.81)(55)]/9.53}{\left(\frac{.0079}{.00196}\right)^2 - 1}}$$

$$\Delta P = 55 \text{ kPa or kN/m}^2$$

$$D_1 = .1 \text{ m}$$

$$A_1 = .0079 \text{ m}^2$$

$$D_2 = .05 \text{ m}$$

$$A_2 = .00196 \text{ m}^2$$

$$V_1 = 7.308 \text{ m/s}$$

$$Q = VA_1$$

$$= (7.308) \left(\frac{\text{m}}{\text{s}}\right) (.0079) \text{ m}^2$$

$$Q = 0.0577 \text{ m}^3/\text{s}$$

$$Re = \frac{V_1 D_1}{\nu} = \frac{(7.308)(.1)}{3.6 \times 10^{-7}}$$

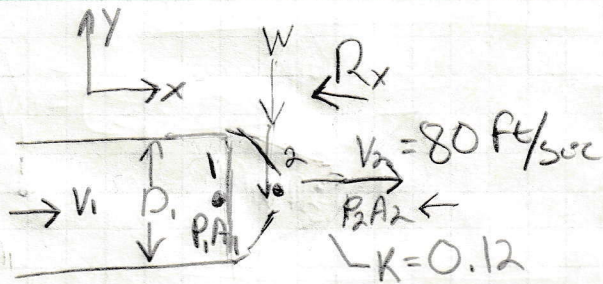
$$Re = 2,030,000$$

$$C_{\text{new}} = .984$$

$$\text{Error} = 0\%$$

$$T = 60^\circ F$$

⑥



$$D_1 = 4 \text{ in} = \phi.333 \text{ ft}$$

$$D_2 = 2 \text{ in} = \phi.167 \text{ ft}$$

$$A_1 = .0871 \text{ ft}^2$$

$$A_2 = .0219 \text{ ft}^2$$

$$\rho = 1.94 \text{ slugs}$$

$$\gamma = 62.4 \text{ lb/ft}^3$$

$$Q = V_2 A_2$$

$$= (80 \text{ ft/s})(.0219 \text{ ft}^2)$$

$$Q = 1.752 \text{ ft}^3/\text{sec}$$

$$V_1 = \frac{Q}{A_1}$$

$$= \frac{1.752 \text{ ft}^3/\text{sec}}{.0871 \text{ ft}^2}$$

$$V_1 = 20.115 \text{ ft/sec}$$

$$-R_x + \rho_1 A_1 \frac{\phi}{2} A_1 - \frac{\phi}{2} A_2 = \rho Q (V_2 - V_1)$$

$$R_x = \rho_1 A_1 \frac{\phi}{2} A_1 - \rho Q (V_2 - V_1)$$

$$V_1 = 20.115 \text{ ft/sec}$$

Solve  $P_1$

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + \frac{\phi}{2} A_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + \frac{\phi}{2} A_2 + h_L$$

$$P_1 = \left( \frac{V_2^2 - V_1^2}{2g} + h_L \right) \gamma$$

$$P_1 = \left[ \frac{80^2 - 20.115^2}{2(32.2)} + 11.925 \right] (62.4) \text{ lb/ft}^2$$

$$P_1 = 6553.315 \text{ lb/ft}^2$$

Solve  $h_L$

$$h_L = K \left( \frac{V_2^2}{2g} \right)$$

$$= 0.12 \left( \frac{80^2}{2(32.2)} \right)$$

$$h_L = 11.925 \text{ ft}$$

$$R_x = (6553.315 \text{ lb/ft}^2)(.0871 \text{ ft}^2) - (1.94 \text{ slugs})(1.752 \text{ ft}^3/\text{sec})(80 - 20.115) \text{ ft/sec}$$

$$R_x = 367.25 \text{ lbs.}$$

$R_y = W$   $P_1$  is Large

$W$  is Not Significant