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MET 330 Fluid Mechanics
Dr. Orlando Ayala
Spring 2017
Test 1

Take home – Due Tuesday February 07th 2017 before class time.

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, 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 "OTHER" SYLLABUS STUDENTS: Ten (10) other points are based on the basis of technical writing. The other eighty (90) points will come from the problem solutions. For the technical writing I will follow the attached rubric.
3. There are 3 problems to solve, each worth (80/3) points for "Workforce" syllabus students and (90/3) for the "Other" syllabus students.
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 o 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. I 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 (Exampl cheating include, but are not limited to, the following: using unapproved resources or assistance to complete an assignme 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).

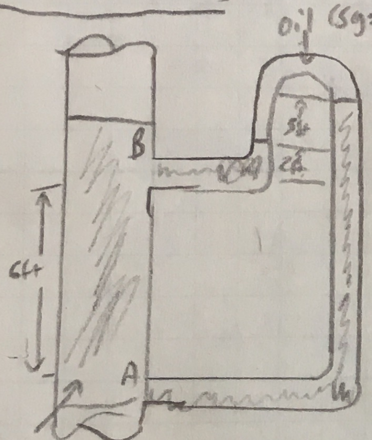
1

- Purpose

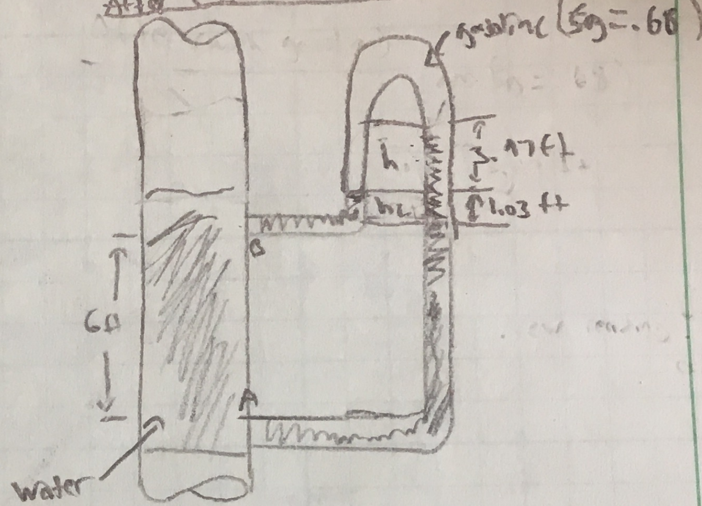
Determine the new distance of gasoline after the change of switching oil in the manometer to gasoline.

- Drawing and diagrams

Before (with oil):



After (with gasoline)



- Sources - Mott R., Untener J.A., "Applied fluid mechanics", 7th edition Pearson Education, Inc, (2015)
- Blackboard notes MET 330 #3.69 Solution from Dr. Ayala.

- Design Considerations
- Constant properties
- Incompressible fluids
- pressure in manometer.
- specific gravity of fluids

- Data and Variables
- $\gamma_{water} = 64.1 \frac{lb}{ft^3}$ $P_A - P_B = 2.73$ psi
- $Sg_{oil} = .68$

Procedure - The pressure-elevation equation $\Delta P = \gamma h$ is important for solving this problem. Because we know the distance from point A to B is 2.73psi we can use that for the ΔP. Also we know γ_{water} is 62.4 lb/ft^3 and we solve the change in elevation for water. We also know Sg_{oil} is .68 from appendix B.1 in our book now we solve for the elevation change for oil.

- Calculations

$\Delta P = \gamma h$

$2.73\ psi = 393.12\ lb/ft^2$

$P_A - P_B = \gamma_{water} \cdot (6ft + 2ft + 3ft) - \gamma_{gas}\, h\,ft - \gamma_{water} \cdot 2ft$

$P_A - P_B = \gamma_{water}(9ft - Sg_{gas} \cdot h\,ft)$

$393.12\ lb/ft^2 = 62.4\ lb/ft^3 (9ft - .68\,h\,ft)$

$393.12\ lb/ft^2 = 561.6\ lb/ft^2 - 42.4\,h\ lb/ft^3$

$-561.6\ lb/ft^2 = -561.6\ lb/ft^2$

$-168.5\ lb/ft^2 = -42.4\,h\ lb/ft^3$

$\frac{-168.5\ lb/ft^2}{-42.4\ lb/ft^3} = \frac{-42.4\,h\ lb/ft^3}{-42.4\ lb/ft^3}$

$3.97\ ft = h$

$h - h_{mercury} = h_2$

$3.97ft - 5ft = 1.03ft\ h_2$

- Summary

The distance in the monometer would be different if we used gas with specif gravity of .68 and would be $h = 3.97\ ft$

- Materials

- Manometer
- water
- gas

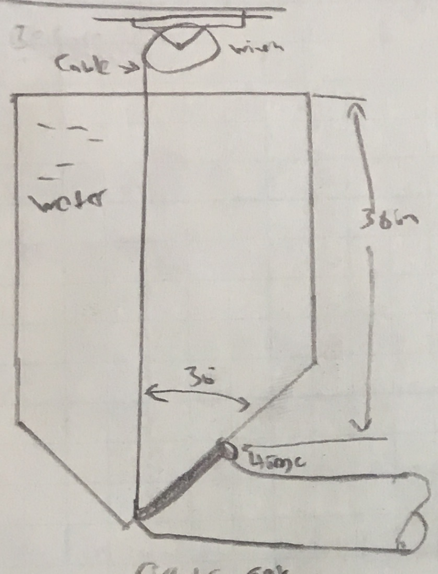
- Analysis

The key to this problem is to realice that when using the $\Delta P = \gamma h$ equation, if we change specific gravity from a $Sg_{oil} = .90$ to a $Sg_{gas} = .68$ then the height elevation will also change. The smaller the Sg the larger the height in the manometer. Refer to the diagram after using Sg_{gas}. This will also affect the original 2ft height of water and with the speific gravity of gasoline it will be less than 2ft.

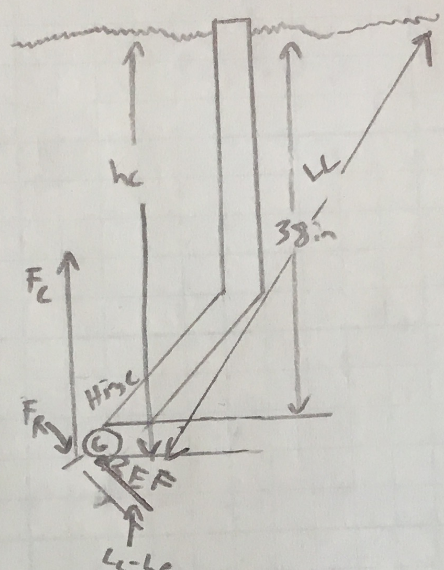
• Purpose

Figure out water elevation measured from the centroid of the gate with a winch cable force of 100 lbf therefore the system can perform its job properly.

• Drawing and diagrams



Circular gate
D= 10 in



• Sources

- Mott, R, Untener J.A, "Applied fluid mechanics", 7th edition. Pearson education, Inc. (2015)
- MET 330 blackboard notes, Ch.4

• Design considerations

- Water elevation
- Centroid of gate
- water elevation
- Incompressible fluid
- Resultant Forces

• Data and variables

$\gamma_{water} = 62.4 lb/ft^3$ $F_c = 100 lbf$

• Procedure

- We have the force in cable but we need to find Resultant Force by applying $\Sigma M = 0$ at the hinge. After obtaining the Resultant force we can use the use the $F_R = \gamma h_c A$ equation. We solve for the unknown which is the h_c, water elevation measured from centroid gate

• Calculations

• Area of circular gate $= A = \frac{\pi D^2}{4} = \frac{\pi\, 10^2}{4}$ • Height of gate (vertical) $= Y = \frac{10\,in}{2} = 5\,in$

$A = 78.54\ in^2$

Moment of inertia of gate (circle) $= I_c = \frac{\pi D^4}{64} = \frac{\pi\, 10^4}{64}$

$I_c = 490.87\ in^4$

$h_c = 36 + \left(\frac{10}{2}\cos 30^\circ\right)$

$h_c = 42.33\ in$

$L_c = \frac{h_c}{\cos\theta} = \frac{42.33\ in}{\cos(30^\circ)}$

$L_c = 48.87\ in$

• Plug in values into Location of center of pressure equation $L_p - L_c = \frac{I_c}{L_c A}$

$L_p - L_c = \frac{490.87\ in^4}{(48.87\ in)(78.54\ in^2)} = L_p - L_c = .128\ in$

• use $\Sigma M_H = 0$, find F_R.

$\Sigma M_H = 0$

$= F_R \cdot [5 + (L_p - L_c)] - [F_c \cdot 5\ in] = 0$

$F_R \cdot [5\ in + .128\ in] - [100\ lbf \cdot 5\ in] = 0$

$5.128\ in\ F_R - 500\ in\ lb = 0$

$\frac{5.128\ in\ F_R}{5.128\ in} = \frac{500\ in\ lb}{5.128\ in}$

$F_R = 97.5\ lb$

• Plug in values for $F_R = \gamma_w h_c A$

$97.5\ lb = (62.4\ lb/ft^3)\left(\frac{h_c}{12\ in}\right)\left(\frac{78.54\ in^2}{12\ in^2}\right)$

$\frac{97.5\ lb}{2.84\ lb/in} = \frac{2.84\ lb/in\ h_c}{2.84\ lb/in}$

$h_c = 34.3\ in$

· Summary

The water elevation measured from the centroid of the gate would be 34.3 in. with the new cable force exerted of 100 lbf.

· Materials

: water (actually less water than original cable force of 123.2 lbf)

· Analysis

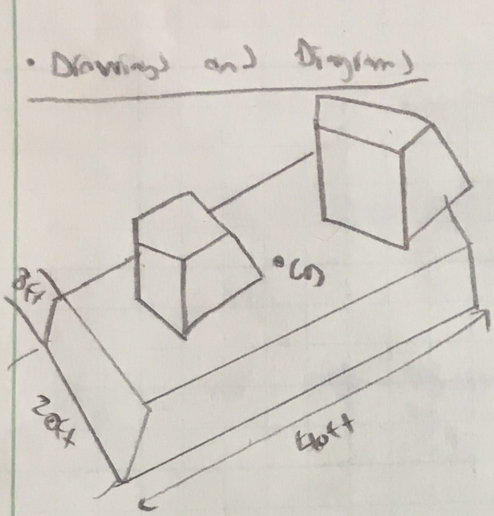
The water elevation is now 34.3in which makes sense since we used a lower cable force of 100lbf. Less cable force equals less water so the result I got is realistic. Originally the cable force was 123.2 lbf and resulted in a larger water elevation so we can compare these two results / ratios for a design that would work.

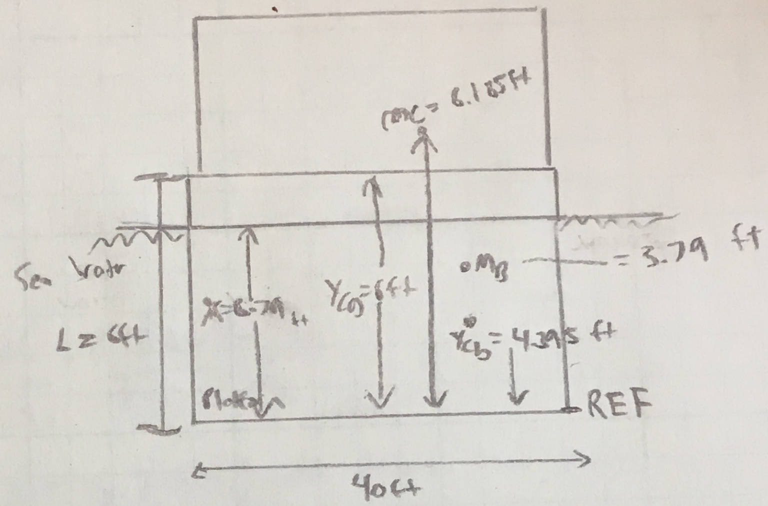
3

Purpose

Determine if the system would be stable if the platform is 40ft long instead of 50ft long.

Drawings and Diagrams





Sources

- Mott, R, Untener, J.A, "Applied fluid mechanics", 7th edition, Pearson education, Inc (2015)
- Blackboard notes, MET 330 Ch. 5
- Appendix B.2, Seawater value.
- Appendix L, moment of inertia (I) for rectangle

Design Considerations

- Incompressible fluids
- Sea water values
- Center of gravity of platform
- loads on top of platform.

Materials

- Sea water — loads
- platform

Data and Variables

- See diagram
- $\gamma_{sw} = 64 lb/ft^3$

W = 450,000 lb

H = 6ft

B = 20ft

L = 40 ft

y_{cg} = 8ft

Procedure

Overall we need $Y_{mc} > Y_{cg}$ or else the platform won't be stable. We need to solve for $Y_{mc} = Y_{cb} + M_B$ using the appropriate equations for the appropriate figures. We know Y_{cg} (center of gravity is) even with the top of the platform. Refer to diagram.

Calculations

- Buoyant Force $= F_b = W = \gamma_{sw} V_d$

- $V_d = LBH = 40\,ft \cdot 20\,ft \cdot X$

  $V_d = 800(X)\,ft^3$

  - $F_b = 64\,lb/ft^3 \cdot 800\,(x)\,ft^3$

    $F_b = 51200(x\,ft)\,lb$

- $F_b = W \Rightarrow \dfrac{450{,}000\,lb}{51200\,lb} = \dfrac{51200(x\,ft)\,lb}{51200\,lb}$

  $X = 8.79\,ft$ (displaced distance from box)

- $Y_{cb} = \dfrac{X}{2} = \dfrac{8.79\,ft}{2}$

  $Y_{cb} = 4.395\,ft$ (center of buoyancy)

- Moment of inertia (I) for rectangle

  $I = \dfrac{LB^3}{12} = \dfrac{(40\,ft)(20\,ft)^3}{12}$

  $I = 26.67 \times 10^3\,ft^4$

– Plug x back in for F_b

$F_b = 51200\,(\overset{x}{8.79\,ft})$

$F_b = 450{,}046\,lb$

– plug x back in for V_d (volume displaced)

$V_d = 800\,ft^2(8.79\,ft)$

$V_d = 7032\,ft^3$

- metacenter from buoyancy

  $M_B = \dfrac{I}{V_d} = \dfrac{26.67 \times 10^3\,ft^4}{7032\,ft^3}$

  $M_B = 3.79\,ft$

$Y_{mc} = Y_{cb} + M_B$

$Y_{mc} = 4.395\,ft + 3.79\,ft$

$Y_{mc} = 8.185\,ft$

$= Y_{mc} > Y_{cg}$

$= 8.165\,ft > 8.00\,ft$

· Summary

The System is still stable even with the changed length of 40 ft. But it is close, 8,165ft > 8.00 ft. We should try not to impliment this length if possible.

· Analysis

Refer to drawings and diagrams. The metacenter is located above center of buoyancy which means it is stable. The differace between the 40 ft length and 50 ft length did not vary much because its the length. If we changed the height it would affect the metacator and center of gravity more. overall the system would still be stable.