# Unit 1 Exam



Labels on diagram: water, air, oil sg=0.90, B, A, 6in, 15in, 8in, 6in, 9in, mercury sg=13.54

## design considerations

- Incompressible fluids
- isothermal process

## data/variables
- distances in drawing
- sg mercury = 13.54
- sg oil = 0.90

## procedure

For this problem the formula used is $\Delta p = \gamma(h)$. Starting at point A we will move through the different fluids using a positive pressure moving down and a negative pressure moving upward.

## Calculations

Convert inches to ft.

new stage oil
$$\frac{5in}{} \cdot \frac{1ft}{12in} = 0.417ft$$

$$\frac{6in}{} \cdot \frac{1ft}{12in} = 0.5ft$$

$$\frac{10in}{} \cdot \frac{1ft}{12in} = 0.833ft$$

$$\frac{8in}{} \cdot \frac{1ft}{12in} = 0.666ft$$

$$P_A + \gamma_{oil}(.5ft) - \gamma_{merc}(.666ft) + \gamma_{air}(.833ft)$$
$$- \gamma_{merc}(.5ft) - \gamma_{water}(.5ft) = P_B$$

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

$\gamma_{oil} = SG_{oil}(\gamma_{water}) = 0.90(62.4 lb/ft^3) = 56.16 \, lb/ft^3$

$\gamma_{mercury} = SG_{Hg}(\gamma_{water}) = 13.54(62.4 lb/ft^3) = 844.896 \, lb/ft^3$

$\gamma_{air} \approx 0.075 \, lb/ft^3$

$P_A - P_B$
$$= -\gamma_{oil}(.5ft) + \gamma_{Hg}(.666ft) - \gamma_{air}(.833ft) + \gamma_{Hg}(.5ft) + \gamma_{water}(.5ft)$$
$$= -56.16(.5) + 844.896(.666) - 0.075(.833) + 844.896(.5) + 62.4(.5)$$
$$\boxed{= 988.21 \, lb/ft^3}$$

New stage calculations — oil 6in to 5in
Using the same initial equation but changing
the oil dimensions.

$P_A - P_B$
$$= -56.16(.417) + 844.896(.666) - 0.075(.833) + 844.8916(.5) + 62.4(.5)$$
$$\boxed{= 992.87 \, lb/ft^3}$$

## Summary

The pressure of the manometer with the
dimensions in the given image is 988.21 lb/ft3
The pressure once changing the dimension
of the oil to 5 inches changed the pressure
to 992.87 lb/ft² The pressure is based of
the material of the fluid and the vertical
length. Horizontal dimensions can be neglected.

2



support

gate, 0.6 m wide

28m   2.5m   2m

water

oil
sg=0.9

hinge
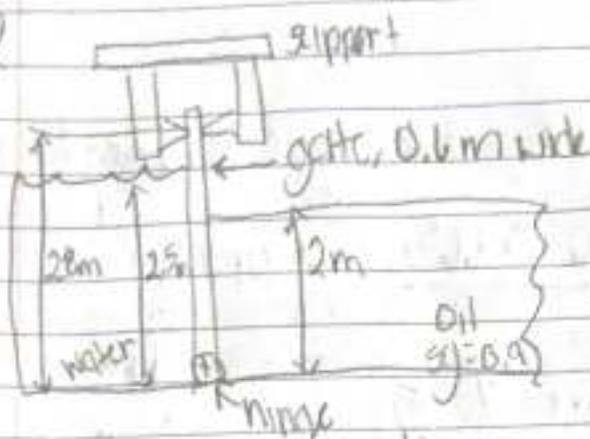
design considerations
incompressible fluid
isothermal process

data/variables
dimensions given
$\gamma_{water} = 9.81 \, kN/m^3$
$sg_{oil} = 0.90$        $\gamma_{oil} = 9.81(0.90) = 8.83 \, kN/m^3$

FBD   support

support right

2.5m

$f_{left}$
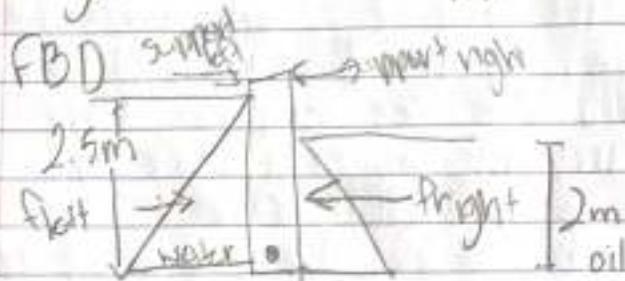
water

$f_{right}$   2m
oil

$F = \gamma_{fluid}(h_c)(A)$

$F_{left} = \gamma_{water}(h_c)(A) = (9.81 \, kN/m^3)(2.5/2 \, m)(2.5 \times .6)$

$= 18.39 \, kN$

$F_{right} = \gamma_{oil}(h_c)(A) = (8.83 \, kN/m^3)(2/2)(2 \times .6)$

$= 10.6 \, kN$

$F_{net} = 18.39 - 10.6 = 7.8 \, kN$

$\Sigma M = 0$

$F_{left}(2.5-5/3) = F_{right}(2-4/3) + F_{support}(2.8)$

$$= \frac{18.39(.833) - 10.6(0.667)}{2.8} = F_{support}$$

$F_{support} = 2.95 kN$

$\Sigma F_x = 0$

$F_{hinge} = F_{left} - F_{right} - F_{support}$

$= 18.39 - 10.6 - 2.95 = 4.85 kN$

## Summary

Starting with a free body diagrams, then finding the force of the fluid on the right the left the net force can be found by subtracting them. Then the sum of the moments allows for the support force to be found and lastly summing the forces in the x direction allows for the hinge force to be found. Once the data was inserted to an excel the same formulas worked out were inputted to the spreadsheet. Lastly a graph was produced for the force at the hinge and elevation of the oil on the right.

fluid

g

cylinder

L

d
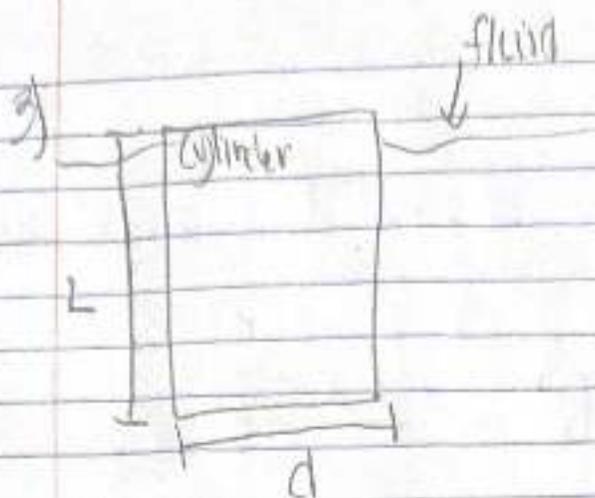
design considerations
- incompressible fluid
- isothermal process

$\sum F = 0$

$v = F_b = \gamma_{fluid} Vd = \gamma_{fluid} \frac{\pi d^2(x)}{4}$

$x = \dfrac{4v}{\pi d^2 \gamma_{fluid}}$

$y_{cb} = \dfrac{x}{2}$

$MB = \dfrac{I}{Vd} \qquad I = \dfrac{\pi d^4}{64} \qquad Vd = Ax$

$y_{mc} = y_{cb} + MB = xft$

## Summary

Starting with the sum of the forces the force buoyancy can be found. Next the center of buoyancy can be found. Lastly the metacenter location can be found. All the formulas were computed to the excel and random numbers were plugged in to get calculated values. A line graph was made to show relation between length, center of buoyancy, and metacenter location.

| depth on left side | depth on right side | specific gravity of left fluid | specific gravity of right fluid | Net force on gate | force on support | force on hinge | force on left side | force on right side |
|---|---|---|---|---|---|---|---|---|
| 2.5 | 2 | 9.81 | 8.83 | 7.8 | 2.95 | 4.85 | 18.39 | 10.60 |

| Diameter | Length | Weight(Specific Weight) of Cylinder | Specific Weight of Fluid | Area of Cylinder | Center of Gravity | Cylinder when floating | Center location of Bouyancy | MetaCenter location |
|---|---|---|---|---|---|---|---|---|
| 3 | 6 | 1550 | 56.16 | 42.39 | 3 | 5.79 | 1.5 | 3.76 |
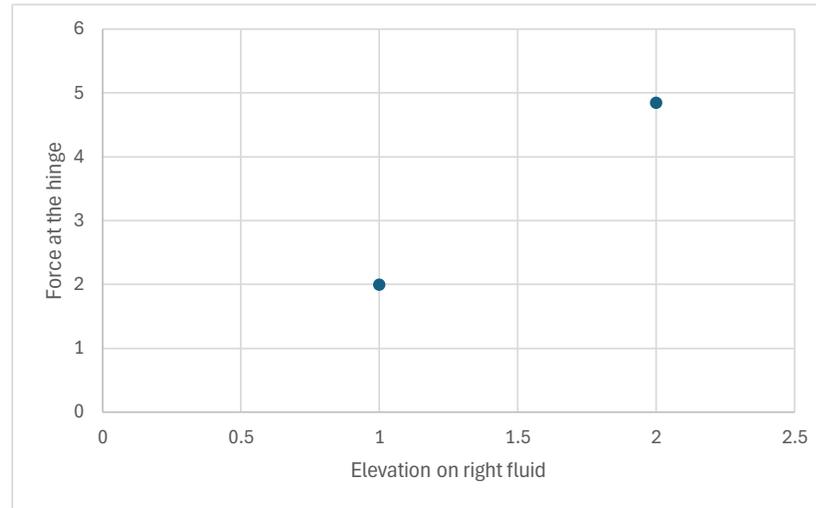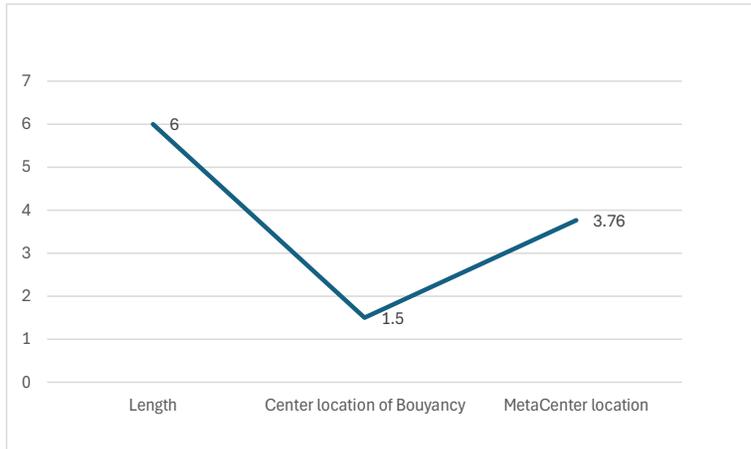
Name: _____.

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

Take home – Due Sunday June 2ᵗʰ 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. <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. The other eighty (90) points will come from the problem solutions.

3. There are 3 problems to solve, each worth (90/3) 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).

Air

Water

Oil (sg = 0.90)

B

A

6 in

8 in

10 in

6 in

6 in

Mercury (sg = 13.54)

1. For the compound differential manometer in the figure, calculate ($p_A$-$p_B$). Keep in mind that the pressure in the space with air is the same (it does not change with elevation).
   At some point of the operation of the system, the pressure at A drops. That makes the oil column to reduce from 6 in to 5 in and all other fluids will adjust to the change.
   calculate ($p_A$-$p_B$) for the new stage of the system.
   **Make sure you explain in detail the procedure you use.**



Support

Gate. 0.60 m wide

2.80 m

2.50 m

2.0 m

Oil
sg = 0.90

Water
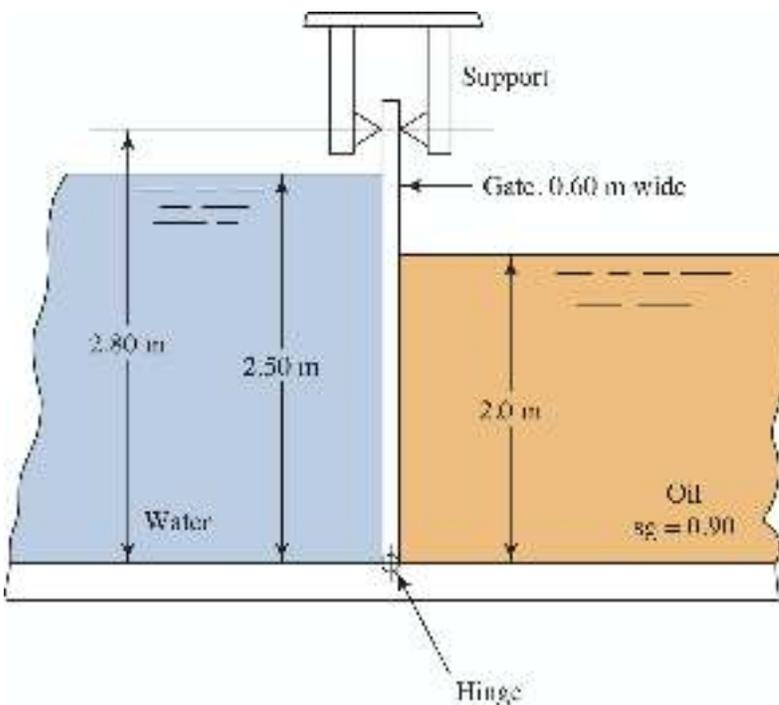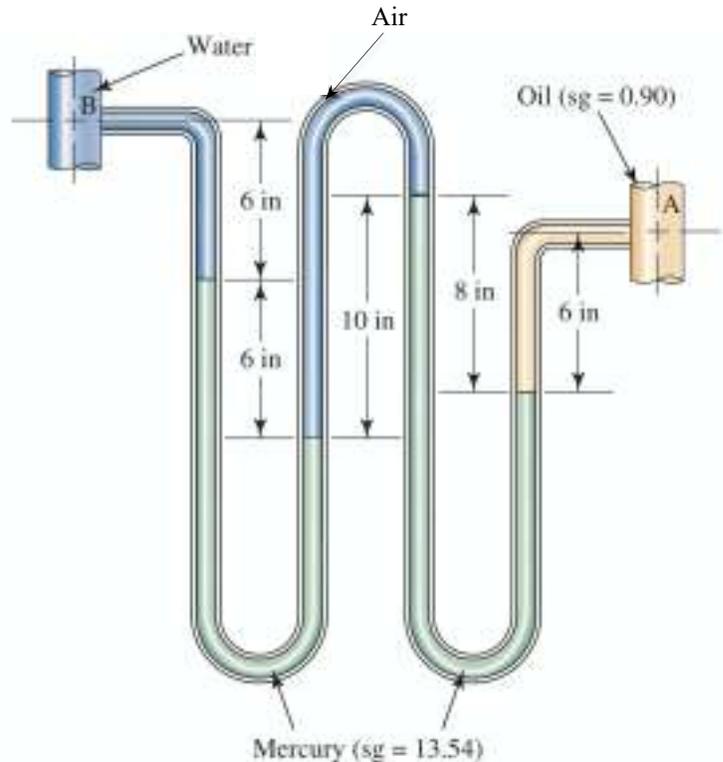
Hinge

2. The figure shows a gate hinged at its bottom and held by a simple support at its top. The gate separates two fluids. Create an Excel spreadsheet to compute the net force on the gate, the force on the hinge, and the force on the support due to the fluid on each side. Make the spreadsheet in such a way that you can input any combination of the depth on either side of the gate and any specific gravity of the fluids.
Produce a graph of force at the hinge versus the elevation of the liquid on the right. You will do this plot for different elevation of the liquid on the right.
**Make sure you explain in detail the procedure and set of equations you use.**

3. Create an Excel spreadsheet to evaluate the stability of a circular cylinder placed in a fluid with its axis vertical. Make the spreadsheet in such a way that you can input any combination diameter, length, and weight (or specific weight) of the cylinder, and specific weight of the fluid. The spreadsheet should provide the position of the cylinder when it is floating, the location of the center of buoyancy, and the metacenter location. Compare the location of the metacenter with the center of gravity to evaluate.
Produce a graph of the metacenter location and center of buoyancy location versus the cylinder length. You will do this plot for different cylinder diameter for fixed specific weights of cylinder and fluid.
**Make sure you explain in detail the procedure and set of equations you use.**

**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: _Meah Ferguson_

Student Signature: _Meah Ferguson_

Date: _6/2/24_