Florida International University
CWR 3201 Fluid Mechanics, Fall 2018
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TA: Thao Do, CEE Undergraduate

Mid-term # 1

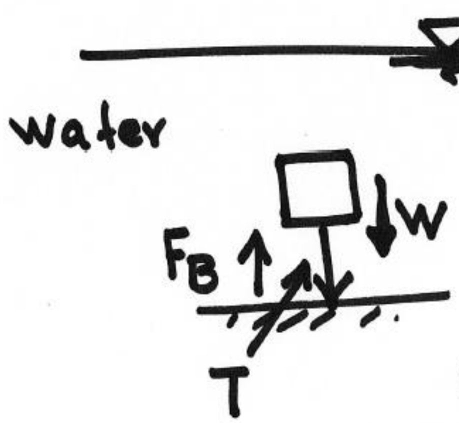
Student Name: ____ **Date:** 09/26/2018

✓ **You will have 1h 15 minutes to complete the exam. The exam is closed book and closed notes.**

Only one page (front and back) with handwritten equations are allowed (no photocopies or artificially reduced text will be allowed.

1. **(20 points)** An object is constructed of a material lighter than water. It weighs 50 N in air and a force of 10 N is required to hold it under water. What is its density, specific weight, and specific gravity?

Because object is lighter than water:



$W = 50N$

$T = 10N$

$F_B = 50 + 10 = 60\ N$

$60 = \gamma_w \forall ol$

$60 = 9810 \forall ol$

$\forall ol = 0.00612\ m^3$

<u>In air</u>

$\rho_{object} \times g \forall ol = W$

$\rho_o \times 9.81 \times 0.00612 = 50$

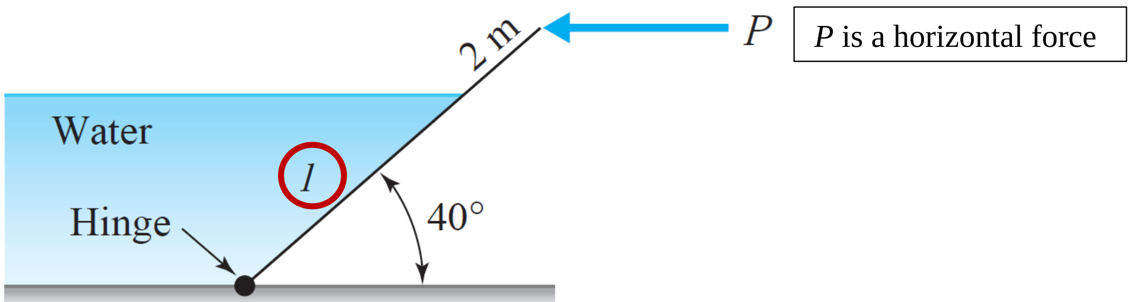
$\rho_{object} = 833.3\ kg/m^3$

$S = \frac{833.3}{1000}$

$S = 0.833$

$\gamma_{object} = \rho_o \times g = 8174.7\ N/m^3$

2. **(20 points).** Find the force *P* needed to hold the 3-m-wide rectangular gate as shown below if l = 5 m

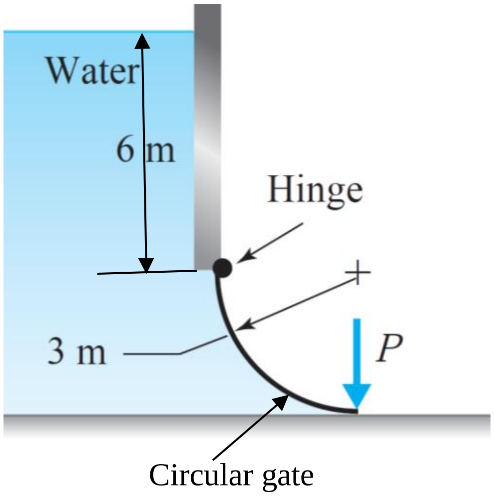


$$F = \gamma \frac{1}{2} l \sin 40^\circ \times 3l. \quad F \times \frac{l}{3} = (l+2) P \sin 40^\circ. \quad \therefore \gamma l^3 = 2(l+2)P.$$

$$9810 \times 5^3 = 2(5+2)P$$

P = 87600 N

3. **(30 points)** What force P is needed to hold the 10-m-wide gate shown in the figure below closed?



(3) Place the resultant force at the circular arc center. F_H passes thru the hinge, so $P = F_V$. Use the water that could be contained above the gate, it produces the same distribution and hence the same F_V.

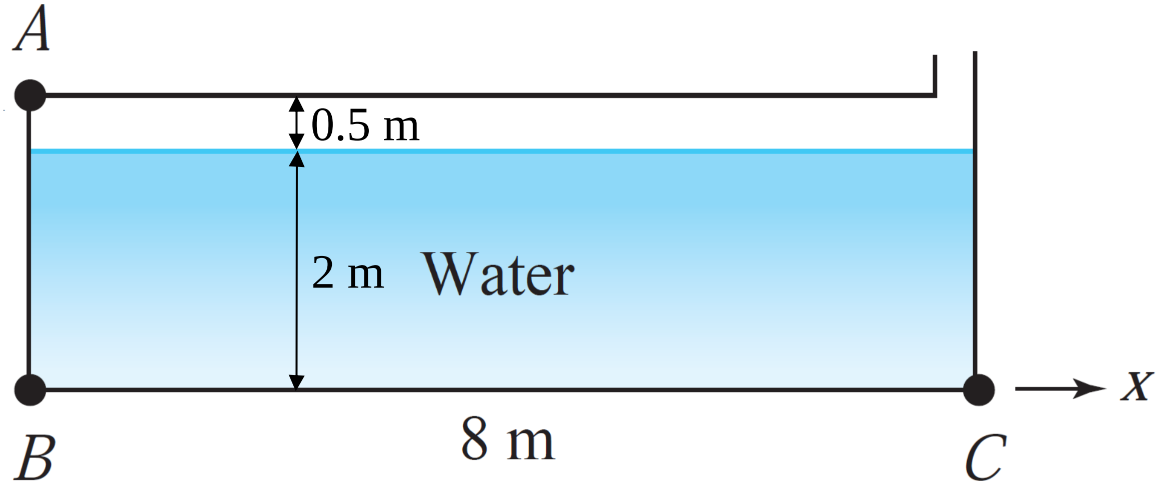
$$P = F_V = \gamma \, \text{Volume}$$

$$P = 9810\left(6 \times 3 \times 10 + \frac{\pi \times 3^2}{4} \times 10\right)$$

$$P = 2'459{,}228 \text{ N}$$

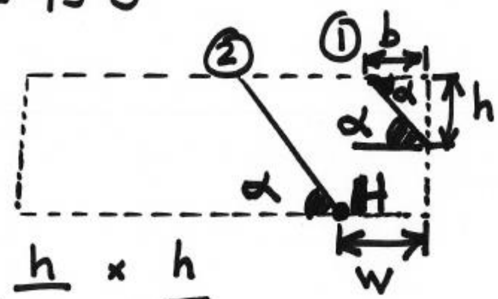
$$\boxed{P = 2459.2 \text{ kN}}$$

4. **(30 points)** The tank shown in the figure shown below is accelerated to the right at 10 m/s^2. If the tank is 4 meters wide, find the force acting on the wall AB.



(4) The air volume is the same before and after

$\tan\alpha = \frac{10}{9.81}$ $\alpha = 45.5°$



$\tan 45.5° = \frac{h}{b}$

$0.5 \times 8 = \frac{bh}{2} \rightarrow 4 = \frac{h}{\tan 45.5°} \times \frac{h}{2}$

$h = 2.856$ m

Because $h > 2.5$, air-water surface will look like (2)

$0.5 \times 8 = w \times 2.5 + \frac{2.5}{2} \times \frac{2.5}{\tan\alpha}$

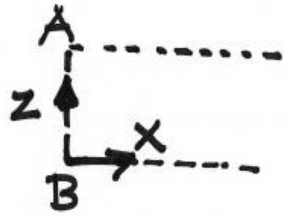
$\tan\alpha = \frac{2.5}{x}$

$x = \frac{2.5}{\tan\alpha}$

$\boxed{w = 0.374 \text{ m}}$

Note in the figure above that $P_H = 0$. To calculate the force on the wall AB, we can relate the pressures on the wall AB to point H.

$$dp = -\rho a_x\,dx - \rho g\,dz \qquad a_z = 0$$



$$p_z - \cancel{p_H}^{\,0} = -\rho(10)(x_z - x_H) - \rho \times 9.81 \times (z - 0)$$

$$p_z = -10000\,(0 - 7.626) - 9810\,z$$

$$\boxed{p_z = 76260 - 9810\,z}$$

$$F_{AB} = \int p_z\,dA \qquad dA = b\,dz$$

$$dA = 4\,dz$$

$$F_{AB} = \int_0^{2.5} (76260 - 9810\,z)\,4\,dz$$

$$F_{AB} = 305040\,z - 39240\,\frac{z^2}{2}\Bigg|_0^{2.5}$$

$$F_{AB} = 639975\ \text{N} = 640\ \text{kN}.$$