Florida International University
CWR 3201 Fluid Mechanics, Fall 2019
Mid-term # 1

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Student Name: Arturo Leon **Date:** 09/27/2019

✓ **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/graphics will be allowed.**

1. **(15 points)** The velocity distribution in a 4-cm-diameter pipe transporting 20°C water is given by $u(r) = 10(1 - 2500r^2)$ m/s. What is the shear stress at the pipe wall in Pascals? Assume $\mu = 10^{-3}$ N.s/m^2

Solution

$\tau = \mu \left| \frac{du}{dr} \right|$ ... (1)

$\frac{du}{dr} = -10 \times 2500(2r) = -50{,}000r$

$r = \frac{1}{2}\left(\frac{4}{100}\right) = 0.02$ m

$\therefore \frac{du}{dr} = -1000 \left(\frac{m}{s \cdot m}\right)$

$\left|\frac{du}{dr}\right| = 1000 \left(\frac{1}{s}\right)$

In (1)

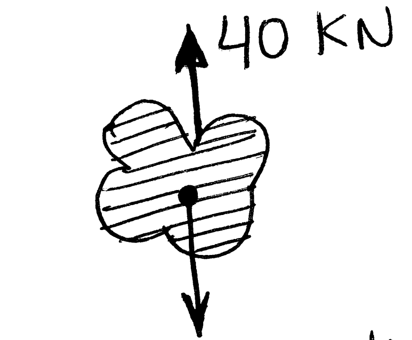
$\tau = 10^{-3} \times (1000) = 1$ Pa

$\frac{N \cdot s}{m^2} \times \frac{1}{s}$

$1 \text{ Pa} = 1 \frac{N}{m^2}$

2. **(15 points)** A body, with a volume of 2 m^3, weighs 40 kN in the air. Determine its weight when submerged in a liquid with $S = 1.59$.

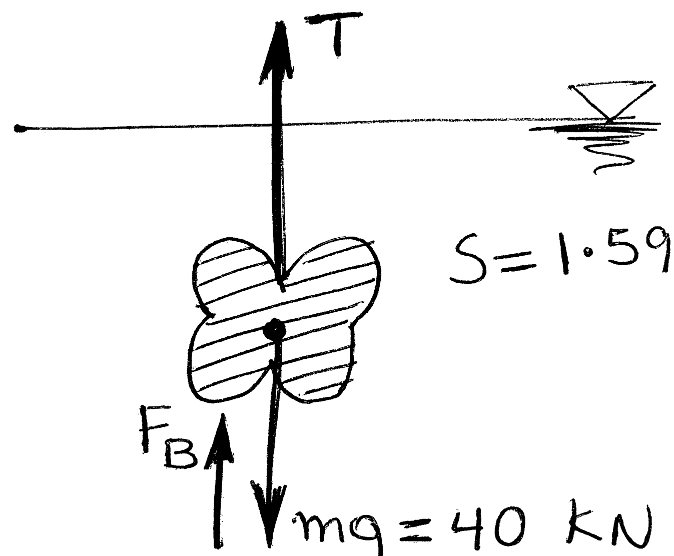
<u>Air</u>



$W = mg = 40$ KN

Volume $= 2$ m^3

<u>Liquid</u>



For equilibrium:

$$F_B + T = 40{,}000 \text{ N} \quad \cdots (1)$$

$$F_B = S \rho_w g V_s$$

$$F_B = 1.59 \times 1000 \times 9.81 \times 2$$

$$\boxed{F_B = 31{,}195.8 \text{ N}}$$

In (1)

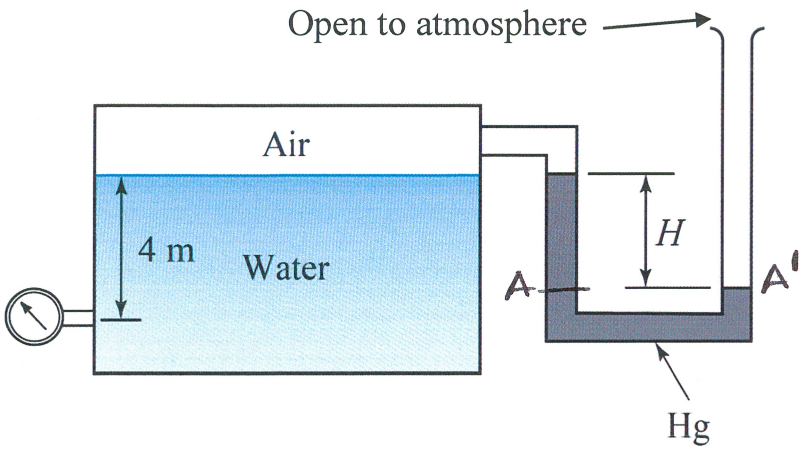
$$T = 40{,}000 - 31{,}195.8$$

$$T = 8804.2 \text{ N}$$

or $T = 8.804$ kN

This will be the measured weight

3. **(20 points).** In the figure below, the initial H is 16 cm. If the air pressure in the tank is increased by 10 kPa, what is the magnitude of the new H?



Before pressurization

$$P_A = P_{air} + 13.6\,\rho_w g\,(0.16) = 0$$

$$\therefore\ P_{air} = -13.6 \times 1000 \times 9.81 \times 0.16$$

$$P_{air_{initial}} = -21{,}346.6 \text{ Pascals}$$

After pressurization

$$P_{air_{after}} = -21{,}346.6 + 10{,}000$$

$$P_{air_{after}} = -11{,}346.6 \text{ Pa}$$

$$P_A = P_{air_{after}} + 13.6\,\rho_w g\,H \qquad P_A = P_{A'}$$

$$P_{A'} = 0$$

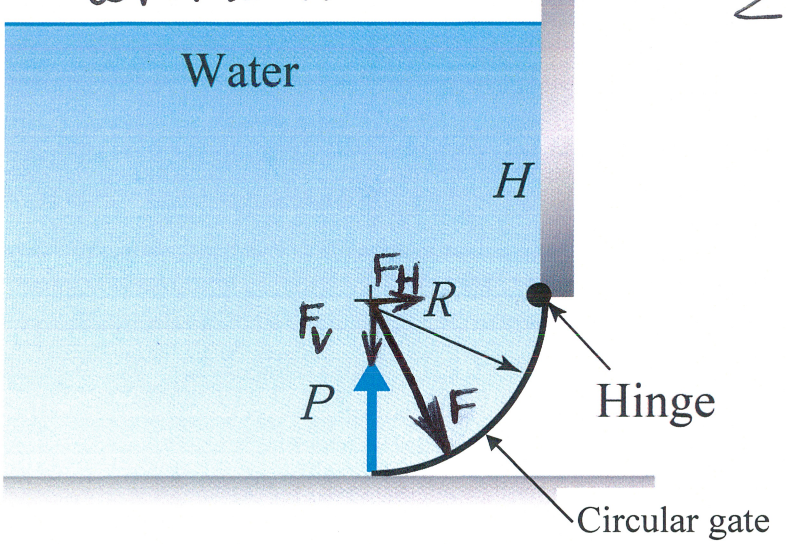
$$\therefore\ -11{,}346.6 + 13.6 \times 1000 \times 9.81\,H = 0$$

$$H = 0.0851 \text{ m}$$

or $H = 8.51$ cm

4. **(25 points)** A force $P = 300$ kN is needed to just open the circular gate below with $R = 1.2$ m and $H = 4$ m. How wide is the circular gate?

width = W



$$\sum M_{Hinge} = 0$$

$$F_V (R) = P (R)$$

$$F_V = P \cdots (1)$$

F_V = weigh of water $= \gamma V$

$$F_V = 1000 \times 9.81 \left[4W \times 1.2 + W \times \frac{\pi \times 1.2^2}{4} \right]$$

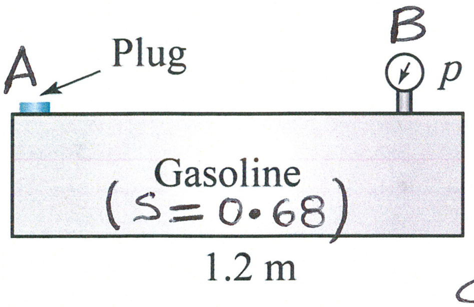
In (1)

$$9810 (4.8 W + 1.131 W) = 300{,}000$$

$$5.931 W = 30.581$$

$$W = 5.16 \text{ m}$$

5. **(25 points)** The gasoline tank below, with an initial pressure of $p = 20$ kPa, is accelerated to the right at the rate of 5 m/s^2. What is the force on the 4-cm-diameter plug?



$S = 0.68$

$a = 5\ m/s^2$

Solution

$$dp = -\rho a_x dx - \rho(a_z + g)\,dz \quad (a_z = 0)$$

Between points (A) and (B)

$$P_A - P_B = -S\rho_w a_x (x_A - x_B) - S\rho_w g (z_A - z_B) \quad (z_A - z_B = 0)$$

$z_A = z_B$

$$P_A - 20{,}000 = -0.68 \times 1000 \times 5\,(0 - 1.2)$$

$$P_A = 24{,}080 \text{ Pa}$$

This is the pressure at the plug.

* Force = P. A

$$\text{Force} = 24{,}080 \times \frac{\pi \times 0.04^2}{4}$$

$$\text{Force} = 30.26 \text{ N}$$

This is the force acting on the 4-cm-diameter plug.