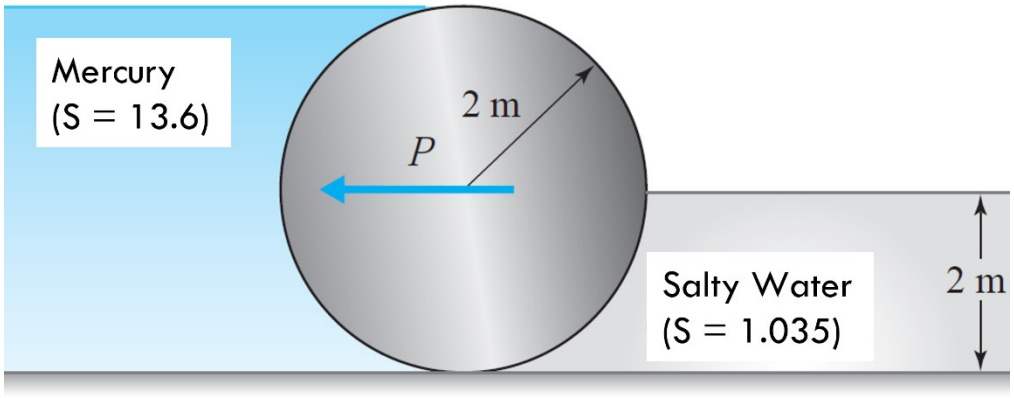
Florida International University
CWR 3201 Fluid Mechanics, Fall 2022
Mid-term # 1

Instructor: Arturo S. Leon, Ph.D., P.E., D.WRE

Student Name: _____Arturo Leon_____ **Panther ID:** _____

- ✓ **You will have 1 h 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**

1. **(30 points).** Find the force "*P*" needed to hold the 5-m-long cylinder in position as shown in the figure below.



At equilibrium: $\sum F_x = 0$ horizontal forces

$F_{Hg} = P + F_{salty\ water}$ .. (1)

$F_{Hg} = \gamma \bar{h} A = 13.6 \times 9800 \times \left(\frac{4}{2}\right)(4 \times 5) = 5'331,200\ N$

$F_{salty\ water} = \gamma \bar{h} A = 1.035 \times 9800 \times \left(\frac{2}{2}\right) \times (2 \times 5)$

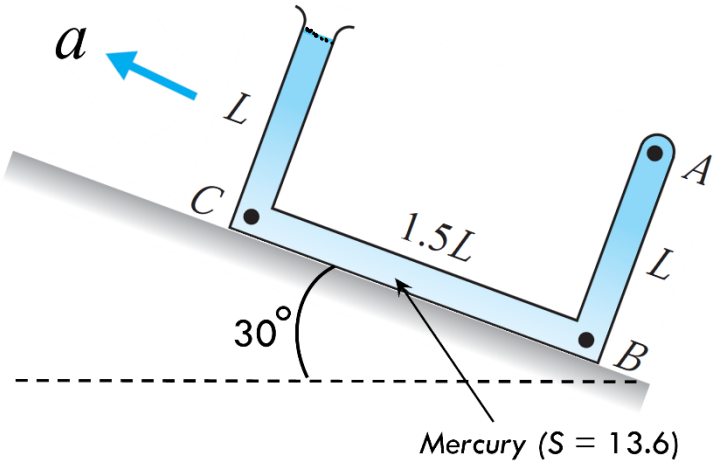
$= 101,430\ N$

In (1)

$P = 5'229,770\ N$

$P = 5,229.8\ kN$

2. **(30 points)** The U-tube shown in the figure below is filled with mercury and accelerated. Find the pressure at point *B* if the acceleration $\boldsymbol{a}$ = 20 m/s^2 and L= 1 m.

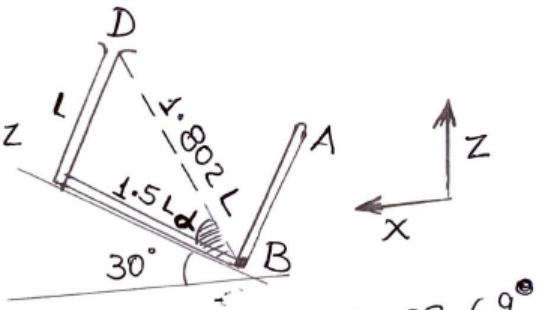


$P_B = ?$

$dp = -\rho a_x dx - \rho(a_z + g)dz$ ... (1)

$P_D = 0$

↑ open to atmosphere



$\tan\alpha = \frac{L}{1.5L} \rightarrow \alpha = 33.69°$

$a_x = a\cos 30° = 17.32\ m/s^2$

$a_z = a\sin 30° = 10\ m/s^2$

$P_B - P_D = -13.6 \times 1000 \times 17.32 (X_B - X_D)$

$-13.6 \times 1000 \times (10 + 9.8)(Z_B - Z_B)$ (2)

$X_B - X_D = (0 - 1.802 \times 1 \cos 63.69 = -0.799$

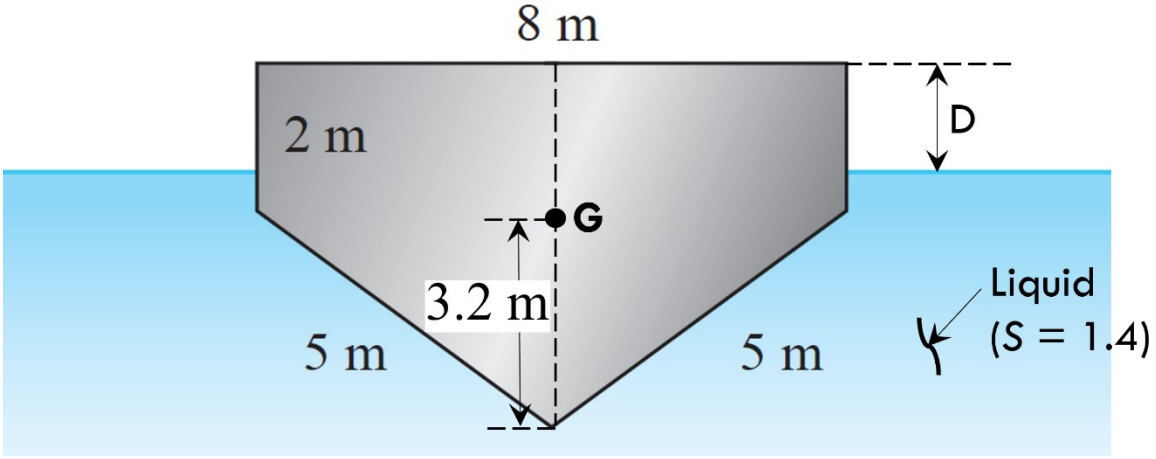
$Z_B - Z_D = 0 - 1.802 \times 1 \sin 63.69 = -1.615$

In (2)

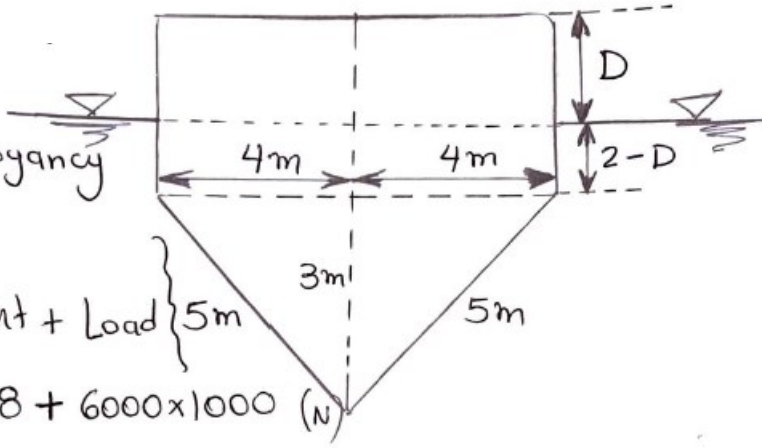
P_B = 623,093 Pa

P_B = 623 kPa

3. **(40 points)** A 30-m-long vessel, with a cross-section shown in the figure below, carries a load of 6000 kN.
   (a) **(20 points)** Find the distance (**D**) from the top of the vessel to the liquid top level if the vessel mass is 120000 kg and the liquid has a specific gravity (*S*) of 1.4.
   (b) **(20 points)** Is the vessel stable? The center of gravity (**G**) of the vessel and load is located as shown below.



a) D = ?



Total Weight
= Buoyancy

* Total weight
= Vessel weight + Load

$= 120{,}000 \times 9.8 + 6000 \times 1000$ (N)

$= 7{,}176$ KN

* Buoyancy $= \gamma \forall_{submerged} = 1.4 \times 9800 \forall_{submerged}$

$\forall_{submerged} = 30\left[(2-D)8 + 4 \times 3\right]$

$\therefore 7{,}176 \times 1000 = 1.4 \times 9800 \times 30\left[(2-D)8 + 12\right]$

$D = 1.32$ m

b) Stable? $GM = \frac{I_o}{\forall_s} - GC \quad \ldots (1)$

$$\forall_s = 30\left[(2-1.32)8 + 12\right] = 523.2\ m^3$$

$$I_o = \frac{bh^3}{12} = \frac{30 \times 8^3}{12} = 1280$$

* We need to find the position of the centroid of the submerged volume. Use as reference the bottom of the vessel.

$2 - 1.32 = 0.68$

$$y_c \cdot A = \Sigma y_{ci} A_i$$

$$17.44\, y_c = (2-1.32)8\left(3 + \frac{0.68}{2}\right) + \frac{2}{3}(3)(12)$$

$$y_c = \frac{18.17 + 24}{17.44} = 2.42\ m \text{ (from the vessel bottom)}$$

$$GC = 3.2 - 2.42 = 0.78\ m.$$

In (1) $$GM = \frac{1280}{523.2} - 0.78$$

$$GM = 1.67\ m > 0$$

Vessel is Stable.