TEXAS TECH UNIVERSITY

DEPARTMENT OF CIVIL, ENVIRONMENTAL AND CONSTRUCTION ENGINEERING

Lab Report #2: Forces on Plane Surfaces and Archimedes' Principle

Section:

Group Number: _

Instructor:

Members:

Date Of Experiment: July 13, 2022

Date of Submission: July 19,2022

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Theory

The objective of this lab is to understand how fluid statics and outside forces affect the body. Measure buoyancy force on several objects and determine the hydrostatic acting on a plane surface in water. Archimedes' principle is to measure the fluid displaced by the volume of the object. An upward buoyant force from the fluid will equal the weight of the fluid displaced. If an object sinks to the bottom of a container a buoyant force is acting on it.

Equations:

$$(1)B = w_f = \rho_f \times V_f \times g$$
$$(2)B - w_o = (\rho_f - \rho_o)V_o g$$

$$(3)B - W_0 = 0$$

$$(4)\rho f \times Vf \times g = \rho_o \times V_o \times g$$

$$(5)\frac{V_o}{V_f} = \frac{\rho_f}{\rho_o}$$

$$(6)\delta F = \gamma_w(y\cos\theta - h)W\delta y$$

$$(7)\delta M = \gamma w W(y \cos\theta - h) y \delta y$$

$$(8)M = \gamma wW \int (\cos\theta y^2 - hy) dy$$

(9)
$$M = \frac{\gamma wW cos\theta}{3} (R_2^3 - R_1^3) - \frac{(\gamma wW)}{3} (R_2^2 - R_1^2)h$$

$$(10)M = \frac{\gamma wW \sec^2 \theta h^3}{6} + \frac{\gamma wW \cos\theta R_2^3}{3} - \frac{\gamma wW R_2^2 h}{2}$$

Apparatus

Figure 1: Pictured below is a graduated cylinder(mL), concrete block, wood.

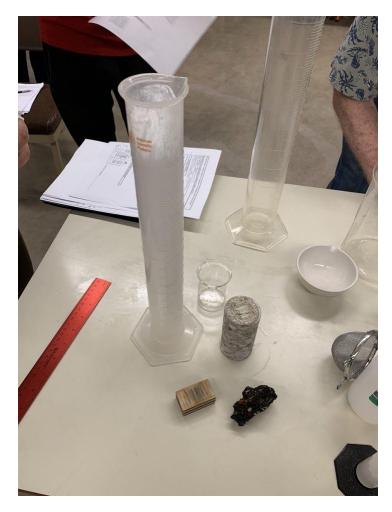


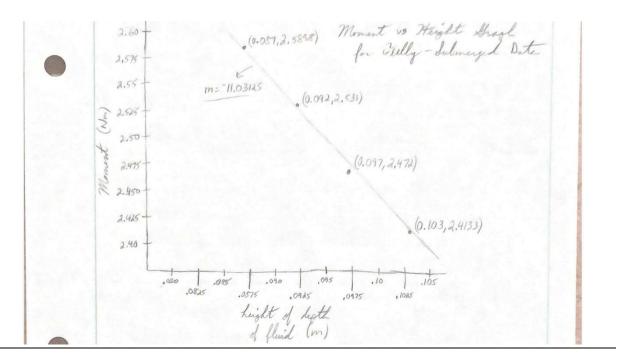
Figure 2: Pictured below is for a demonstration for fluids on a plane surface



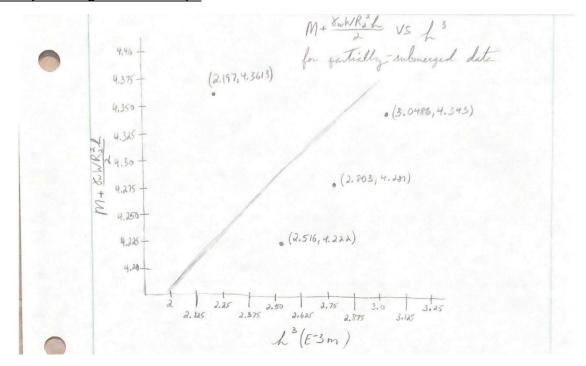
Results

Object	Initial	Final	Change in	Measured	Calculated	Mass of	Submerged?	Buoyant
	Volume	Volume	Volume	Volume of	Volume	Object		Force (N)
	(mL)	(mL)	(mL)	Object	(cubic cm)	(grams)		
				(cubic cm)				
Asphalt	800	828	28	Irregular	32.40	70.83	Yes	0.2747
Wood	800	815	15	21.46	25.42	15.57	No	0.1527
Concrete	2001.22	2232.13	230.91	196.35	181.71	485.3	Yes	2.2652

Fully Submerged Dataset Graph



Partially Submerged Dataset Graph



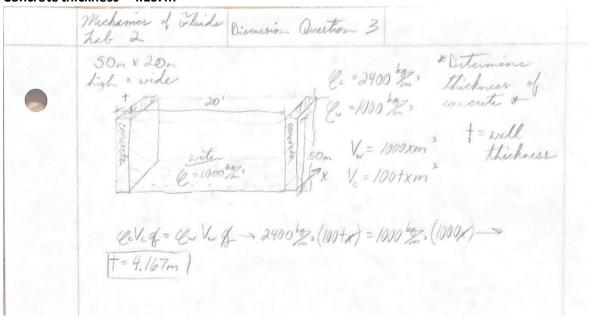
Discussion

1. What is Archimedes' Principle?

Archimedes' Principle states that an object that is fully or partially submerged in a fluid will exert its weight on the fluid, and in return, the fluid will exert an upward buoyancy force equal to the weight of the volume of fluid displaced by the object.

- 2. A rock is thrown in a beaker of water, and it sinks to the bottom. Is the buoyant force on the rock greater than, less, or equal to the weight of the rock?
 The buoyant force exerted on the rock is equal to the weight of the volume of water that the rock displaced. Since the rock is denser than the water, the buoyant force would be less than the weight of the rock
- 3. An embankment that is 50 m high x 20 m wide is to be constructed to hold water. Assuming the embankment is to be constructed using concrete of density 2400 kg/m³, what is the minimum thickness necessary to withhold the water when full such that there is no over-turning. Assume the embankment is a cuboid.

Concrete thickness = 4.167m



Data Appendix

CE3105 Mechanics of Fluids Laboratory, Depart Experiment:Forces on Plane Surfaces, Archimeter			versity
Date of Experiment:			
Name: Team 1			
Temperature of water, T= 20 °C Celsi	us Water density,ρ =	1000 kg/ms	
R3 = 200 mm, R2 = 200 mm, R1 = 100 mm			

Arci	nimedes' Princ	cipie		2	3			
	mL	ML	mL	cm ³	cm-	9		
	Wat	er		Volume of Object	Volume			-/
Object	V (Initial)	V (Final)	ΔV	(measured)	Calculated	Mass of Object	Submerged	FB(N)
Asphalt 1	800	828	28		32.40	70.83	V	1000000
Asphalt 2	1-11	_	_		-	-	1	0.27468
Wood 1	800	815	15	21.46	25.424	15.57	X	0.15274
Wood 2						#1 <u>—</u> — — —	At .	0.15219
Concrete 1			-		_	11-	V	1 1/512
Concrete 2	2001 22	2232 13	230 01	196.35	18171	400 300	17	2.26523

Forces on Plane Surfaces -Partially Submereged

		mn	min
Trial	Weight	h	b
Initial	1540	145	136
1	1060	141	1/41
2	1080	136	145
3	1160	130	150
4	- =	_	-
5		_	-

Forces on Plane Surfaces -Fully Submereged

b= 180 mm

- hu

	7	14/11/
Trial	Weight	h
Initial	1230	103
1	1260	97
2	1290	92
3	1320	87
4	-	-
5		-

Error Analysis

Object	Volume Error
Asphalt	15.71%
Wood	43.07%
Concreate	21.31%

Calculations

Went of Displaced Water V ₄ - V ₁ = ∆V → ∆V = 828nL - 800mL = 2BmL Buoyency voice (F6) (1) F ₈ = (P ₄ ∆ V ₄ g (von Concrete) (V ₆ = 1000 ½ 5 d d d d d d d d d d d d d d d d d d	
Buoyeney voice (Fe) (1) $F_{E} = U_{E} \circ V_{E} g$ (For Concerts) $U_{w} = 1000 \frac{k_{gg}}{m^{3}} \text{SV}_{F} = 230.9 \text{Im} L$ $F_{E} = 1000 \frac{k_{gg}}{m^{3}} \left[230.9 \text{Im} L \left(\frac{1E \cdot 6m^{3}}{mL} \right) \right] \left(9.81 \frac{m_{g}}{s^{2}} \right) \Rightarrow F_{E} = 2.265 \text{N}$ Volume of Object (Eq. 5) (5) $\frac{V_{o}}{V_{E}} = \frac{U_{E}}{U_{e}}$ (For Word) $V_{F} = 15mL = 15E \cdot 6m^{3} U_{E} = 1000 \frac{k_{gg}}{s^{3}} U_{wood} = 590 \frac{k_{gg}}{s^{3}}$ Volume of Object (Veing mass & desirty) (For Vood) $V_{wood} = 0.0155 \text{ Tkg} U_{wood} = 25.42 \text{cm}^{3}$ Volume of $U_{e} = 0.0155 \text{ Tkg} U_{wood} = 26.39 \text{cm}^{3}$ Volume of Object (Eq. 2) (2) $V_{e} = V_{e} = U_{e} \cdot U_{e} \cdot U_{e} \cdot U_{e}$	
(1) $F_{B} = (P_{E} \otimes V_{E} q)$ (For Correct) $U_{W} = 1000 \frac{kg}{m^{3}} $ $V_{E} = 230.9 \text{Im} L$ $F_{B} = 1000 \frac{kg}{m^{3}} \left[230.9 \text{Im} L \left(\frac{1E^{2} \text{Gm}^{3}}{\text{mL}} \right) \right] \left(9.81 \frac{\text{M}}{\text{S}^{2}} \right) \Rightarrow F_{B} = 2.265 \text{N}$ Volume of Object (Eq. 5) (5) $\frac{V_{0}}{V_{E}} = \frac{P_{E}}{Q_{0}}$ (500 Wood) $V_{E} = 15mL = 15E^{2} \text{Gm}^{3} (P_{E} = 1000 \frac{\text{kg}}{\text{ph}^{3}}) \text{ fund} = 590 \frac{\text{kg}}{\text{m}^{3}}$ $V_{wed} = 15E^{2} \text{Gm}^{3} \left(\frac{1000}{590} \right) \Rightarrow V_{wood} = 25.42 \text{cm}^{3}$ Volume of Object (Nainy mass & desirty) (500 Vood) must = .01557 kg (wood = 590 \text{kg}) $V_{wood} = \frac{m}{Q} = \frac{01557 \text{kg}}{590 \text{kg}} \Rightarrow V_{wood} = 26.39 \text{cm}^{3}$ Volume of Object (Eq. 2) $V_{wood} = \frac{m}{Q} = \frac{01557 \text{kg}}{590 \text{kg}} \Rightarrow V_{wood} = 26.39 \text{cm}^{3}$	
(For Concrete) $Q_{w} = 1000 \frac{kg}{m^{3}} \text{ SV}_{4} = 230.9 \text{Im L}$ $F_{B} = 1000 \frac{kg}{m^{3}} \left[230.9 \text{Im L} \left(\frac{1E^{6}m^{3}}{mL} \right) \right] \left(9.81 \frac{m}{s^{2}} \right) \rightarrow F_{B} = 2.265 \text{N}$ Volume of Object (Eq. 5) (5) $\frac{V_{0}}{V_{4}} = \frac{Q_{4}^{4}}{Q_{0}^{4}}$ (For Word) $V_{4} = 15mL = 15E^{6}m^{3} Q_{4} = 1000 \frac{kg}{m^{3}} \text{ Quod} = 590 \frac{kg}{m^{3}} \text{ Visible}$ Volume of Object (Using mass & desirty) (For Vood) $m_{verd} = .01557 \text{kg} \text{ Quod} = 590 \frac{kg}{m^{3}} \text{ Visible}$ Varied = $\frac{m}{Q} = \frac{01557 \text{kg}}{590 \text{kg}} \rightarrow \frac{v_{verd}}{2} = 26.39 \text{cm}^{3}$ Volume of Object (Eq. 2) (2) $F_{B} - W_{0} = (Q_{4} - Q_{0}) V_{0} Q_{4}$	
(For Concrete) $C_{w} = 1000 \frac{kg}{m^{3}}$ $SV_{f} = 230.9 \text{Im} L$ $F_{E} = 1000 \frac{kg}{m^{3}} \left[230.9 \text{Im} L \left(\frac{1E^{2}6m^{3}}{mL} \right) \right] \left(9.81 \frac{m}{s^{2}} \right) \rightarrow F_{E} = 2.265N$ Volume of Object (Eq 5) (5) $\frac{V_{o}}{V_{f}} = \frac{C_{f}}{C_{o}}$ (For Word) $V_{f} = 15mL = 15E^{2}6m^{3}$ $C_{f} = 1000 \frac{kg}{m^{3}}$ $C_{word} = 590 \frac{kg}{m^{3}}$ $V_{word} = 15E^{2}6m^{3} \left(\frac{1000}{590} \right) \rightarrow V_{wood} = 25.42em^{3}$ Volume of Object (Using mass & density) (For Vood) $F_{wood} = 0.01557 \text{kg}$ $F_{wood} = 26.39 \text{cm}^{3}$ $V_{wood} = \frac{m}{C} = \frac{0.1557 \text{kg}}{590 \frac{kg}{m^{3}}} \rightarrow V_{wood} = 26.39 \text{cm}^{3}$ Volume of Object (Eq 2) (2) $F_{G} - W_{o} = (C_{f} - C_{o}) V_{o} g$	
For \$1000 \frac{1}{m^3} \(230.9\lm L \left(\frac{16 \text{ 6m}}{mL} \right) \right) \left(9.81\frac{1}{5^2} \right) \rightarrow \int_B = 2.265N \\ \begin{align*} \text{Volume of Object (Eq 5)} \\ \(\text{(5)} \frac{V_0}{V_4} = \frac{9}{400} \\ \(\text{(5)} \frac{V_0}{V_4} = \frac{9}{400} \\ \(\text{(5)} \frac{V_0}{V_4} = \frac{15mL}{570} \right) \rightarrow \int_{Wood} = \frac{1000^{\text{kg}}}{25.42cm^3} \\ \text{Vwood} = \frac{15E}{6m^3} \left(\frac{10000}{570} \right) \rightarrow \text{Vwood} = 25.42cm^3 \\ \text{Volume of Object (Nainy mass & density)} \\ \(\text{Vood} = \frac{M}{400} = \frac{01557\text{kg}}{590\text{kg}} \rightarrow \text{Vwood} = 590\text{kg}^2 \\ \text{Vwood} = \frac{M}{4000} = \frac{01557\text{kg}}{590\text{kg}} \rightarrow \text{Vwood} = 26.39\text{cos}^3 \\ \text{Volume of Object (Eq 2)} \\ \(\text{(2)} \) \(\text{Fo} - \text{Vo} = \left(\text{(2)} + \chi_0 \right) \text{Vog} \\ \end{align*}	
(5) $\frac{V_0}{V_4} = \frac{Q_4}{Q_0}$ (For Word) $V_4 = 15mL = 15E - 6m^3 Q_4 = 1000 kg/3 Qwood = 590 kg/3 Vwood = 15E 6m^3 (590) >> Vwood = 25.42em^3 Volume of Object (Viny mass & density) (For Vood) mond = .01557kg Qwood = 590 kg/3 Vwood = \frac{m}{Q} = \frac{01557kg}{590 kg/3} >> Vwood = 26.39cm^3 Volume of Object (Eq 2) (2) F_6 - W_0 = (Q_4 - Q_0)V_0 q_0$	
(5) $\frac{V_0}{V_4} = \frac{\ell_4}{\ell_0}$ (For Word) $V_4 = 15mL = 15E-6m^3$ $\ell_4 = 1000 \frac{k_0}{lm^3}$ $\ell_{wood} = 590 \frac{k_0}{lm^3}$ $V_{word} = 15E-6m^3(\frac{1000}{590}) \Rightarrow V_{wood} = 25.42em^3$ Volume of Object (Vainy mass & density) (For Vood) $m_{word} = .01557kg$ $\ell_{wood} = 590 \frac{k_0}{lm^3}$ $V_{wood} = \frac{m}{\ell} = \frac{.01557kg}{.590 \frac{k_0}{lm^3}} \Rightarrow V_{wood} = 26.39cm^3$ Volume of Object (Eq 2) (2) $F_6 - W_0 = (\ell_4 - \ell_0)V_0 g$	
Volume of Object (Viny mass & denity) (For Vood) Much = .01557kg (wood = 25.42em ³ Vwood = M = .01557kg (wood = 590 bg); Vwood = M = .01557kg -> Vwood = 26.39cm ³ Volume of Object (Eq 2) (2) Fe-Wo = (Q+-Qo)Vo g	
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(For Vood) Mund = .01557kg (wood = 590 kg) 3 Vwood = M = .01557kg -> Vwood = 26.39cm 3 Volume of Object (Eq 2) (2) Fo-Wo = (Q+-Qo)Vog	
Vwood = M = 01557kg -> Vwood = 26.39cm ³ Volume of Object (Eq 2) (2) Fe-Wo = (Q+-Qo)Vog	
Volume of Object (Eq 2) (2) Fo-Wo = (C+-Co)Vog	
(2) Fo-Wo=(C+-Co)Vog	
(Vor Concrete) Womerte = 4.7608N Gangle = 2400 kg, Qc = 1000	
Committee	023
Fo= 2,2652N	
2.26521V-4.7608TV=(1000-2400) (Veoneste) (9.87 752)	
Vionerate = 230.91cm3	

Moment

EM = 0 = . 2W - Wneter (36b)

W = 12.0663N &= . 180m

0 = . 2 (12.0663N) - Wneter (3/2 (.18m)) = Wneter = 35.752N

Enor Analysis (asplet)

Va (measured) = 28cm³ Vascout (experimental) = 32.40cm³

28-32.40 × 100 = 15.71%