Lab 10: Archimedes’ Principle

- Please omit Part B (‘unloading a boat’).
- Basic point: A new force, called the buoyant force \( B \), which will 1.) act upwards, when fluid is being displaced, and 2.) specifically, that the size of this force is exactly equal to the weight of the fluid displaced (Archimedes Principle).
- For the purposes of simplifying things, I will follow along with the result sheet. Please note that I have used less weird notation than they have. A good idea is to change notation in manual to this notation.
- PART A:

  (1) \( B \) theory. Theory says it should be equal to the following: (Please note ‘fd’ stands for fluid displaced.)
  \[
  B_{\text{theory}} = \text{Weight fd} = \text{mass fd} \times g = (\text{density of fluid} \times \text{volume fd}) \times g \\
  = (\text{density of fluid} \times \text{volume of submerged object}) \times g.
  \]

  The last step follows since we will submerge object completely.

  density of water = 1000 kg/m\(^3\)
  volume of obj is easily computed \((l \times w \times h)\) since we will use rectangular object in this part.

  N.B.: MOST COMMON MISTAKE IN THIS STEP IS INCORRECT CONVERSION FROM cm\(^3\) TO m\(^3\). for simplicity, convert all distances
to m before computing volume.

(2) \( mg \). Get mass from normal scale reading, multiply by \( g \).

(3) Apparent weight (\( T_{\text{theory}} \)). If object weighed while submerged, then by the simple fact it is at rest:
\[
F_{\text{net}} = T + B - mg = 0, \text{ so } T = mg - B.
\]
Simply subtract \#2-\#1 to yield theoretical apparent weight (T).

(4) Apparent weight (\( T_{\text{actual}} \)). Actually weigh object while submerged to get actual apparent weight. Do \% error with \#3 (theoretical apparent weight).

(5) \( B_{\text{actual}} \). Working backwards from \#3, \( B = mg - \text{actual } T \). Subtract \#2 - \#4 to get \( B_{\text{actual}} \), compute \% error with \#1 (\( B_{\text{theory}} \)).

(6) \( B_{\text{actual}} \), second way. Directly confirm that \( B \) is equal to weight of fluid displaced. Using spigotted cup, dip your mass into water (with a string), and catch water displaced in a separate cup. The weight of this water displaced should be \( B \), so should agree with \#1 also.

To get best results for \#6:

- weight cup catching water BEFORE experiment, so it can be easily subtracted out to leave only weight of water.
- Before beginning the experiment, make sure the spigotted cup is filled up ALL the way, meaning overfill it and let excess come out.

• PART B (’unloading boat’): OMIT
• PART C:
Now that everything is confirmed from part A, we know the following is valid for our experiment:

\[ T - mg = B = \text{density fluid} \times \text{volume of object} \times g \]

- \( T = \text{apparent weight, can be measured, as above. (Part A, #4)} \)
- \( mg = \text{weight, can be measured, as above. (Part A, #2)} \)
- \( \text{density of fluid, } g \text{ are known.} \)

so can solve for object’s volume. This can be used to find the exact volume of an unknown, irregular object. (You can pick whichever one you want; there are several provided).

- Once volume of object is known, plug into density = mass/volume to get density, and identify what object is made out of. A chart of various densities is provided in the lab manual. Generally, results on this lab are pretty good.