Lab Background

Purpose

To explore the effects of fluids on objects submerged within it, both partially and fully.

Theory

When you step into a pool with water in it, the water level within the pool appears to rise. The increase in volume of the water is equal to the volume of your body that is in the water or submerged in the water. You might also notice that when you are in a swimming pool, you feel lighter than before you entered the pool. The weight you feel in the pool is your apparent immersed weight, or apparent weight F_B.

This apparent weight change is described by Archimedes' principle. When an object is placed in a fluid, the object will experience a buoyant force F_B upward, and this force is equal to the weight of the fluid displaced, or

$$F_B = m_{\text{fluid}}g$$

Eq. 1

The mass of the fluid m_{fluid} can be replaced with the displaced volume V_{disp} by using the fluid's density $\rho = m/V$, resulting in

$$F_B = \rho V_{\text{disp}}g$$

Eq. 2

One way of determining whether an object will float or sink is to directly compare the density of the object to the density of the fluid. If the object floats, $\rho_{\text{fluid}} > \rho_{\text{obj}}$; if it sinks, $\rho_{\text{fluid}} < \rho_{\text{obj}}$; if equal, you can position the object anywhere in the fluid and it will stay put. We can also examine each density as *specific gravity*, which compares the density of an object to the density of water, or 1000 kg/m^3.

Experiment

Equipment

- Hydrometer
- Scale
- Water
- Solid metal
- Mystery fluid
- Wooden block

Data Collection

1. Using the scale, determine the mass of the solid metal in air. Record this in the data collection table below.
2. Submerge the solid completely in water *without letting the solid touch the bottom of the container*, then use the scale to determine the apparent mass of the mystery solid. Record this in the data collection table below. *Don't forget to include units!*
3. Submerge the solid completely in the mystery fluid *without letting the solid touch the bottom of the container*, then use the scale to determine the apparent mass of the mystery solid. Record this in the data collection table below.
4. Using the scale, determine the mass of the wooden block. Record this in the data collection table below.

5. Attach the solid to the wooden block, then submerge *just* the solid in the same way as step 2. Use the scale to determine the combined mass of the block and submerged solid and record this in the data collection table below.
6. Submerge both the block and solid in the same way as step 2, then use the scale to determine the mass of the pair. Record this in the data collection table below.

Material + Environment	m
Solid metal in air	
Solid metal in water	
Solid metal in fluid	
Wooden block in air	
Wooden block in air, solid metal in water	
Wooden block and solid metal in water	

Data Analysis

7. We will start with determining the relationship between the mass of the object in air, the apparent mass of the object in a fluid, and the mass of the displaced fluid. Starting with a free-body diagram and Newton's Second Law, examine an object that is submerged in a fluid, *but not touching the bottom of the container*. Solve for the mass of the displaced fluid.

8. The specific gravity of a material (SG) compares the material's density to that of water. Using this with the definition of density and the relation of masses you found in #7, determine the equation for specific gravity of the solid metal from step 2, then use this to calculate the specific gravity of your metal.

9. Determine the accepted value of your metal's specific gravity, then calculate a percent error.

10. Repeat #8 with the case in step 3.

11. Record the specific gravity of the fluid from the hydrometer, then calculate a percent error using the hydrometer reading as the theoretical value.

12. Using the formula below, determine the specific gravity of the wood.

$$\mathrm{SG}_{\mathrm{wood}} = \frac{m_{\text{wood in air}}}{m_{\text{wood in air and metal in water}} - m_{\text{wood and metal in water}}}$$

13. What during your **data collection** (NOT data analysis) may have caused your percent errors?

Questions

14. Explain how you can obtain the volume of an irregular solid that is insoluble in water.

15. You have a pure copper sphere with a radius of 2.00 cm. You wish to find the buoyant force on it when submerged in water. Find the weight of the fluid displaced by the sphere when you submerge it. What is the buoyant force?

16. A piece of cork has a mass of 15 g in air and a specific gravity of 0.25. The cork is attached to a lead sinker whose mass is 230 g in air. What will be the apparent mass of the pair when they are both submerged in water?

17. An iceberg is floating in the Arctic Ocean. What percentage of its volume is above the surface? Density of ice is 0.917 g/cm^3 and the density of salt water is 1.024 g/cm^3.