LAB 11. BUOYANCY AND DISPLACEMENT

Introduction

Some things float. Some things sink.

Activities

These are in different stations around the room. They can be done in any order. Unfortunately, they don't all take the same amount of time, so practice patience.

1. Fountain

Materials

Bucket, water, tin cans or plastic bottles with holes in the sides

Procedure

Fill a can or bottle with water. Observe the streams of water from the holes in the side. Describe how the streams behave as the water drains from the bottle or can. Explain your observations.

2. Displacement and Buoyancy

A submarine dives and surfaces by pumping water into or out of its bilge tanks, thereby changing its overall mass and density. To maintain a constant depth, upward buoyant forces due to pressure differences must balance the force due to gravity on the submarine (i.e., its weight). The buoyant force is equal to the weight of the sea water displaced.

Materials

Test tube boat, graduated cylinder, metal balls, forceps or needle-nosed pliers, lump of clay, container (beaker) of water, overflow can

Procedure

1. Place the test tube boat in a graduated cylinder that contains some water (the boat's sea). Record the level of the sea in mL. Carefully load the boat by adding 1-gram metal balls one at a time and record in Table 1 the new levels of the sea with each addition.

2. Complete the columns in Table 1. Calculate the mass of additional water displaced with each metal ball loaded. The density of water is 1 g/cm^3, and 1 cm^3 = 1 mL.

Table 1. Balls in a test tube

Number of balls	Mass of balls (g)	Sea level (mL)	Sea level change (mL)	Water displaced (g)
0	**0**		0	0

Question

Compare the mass of water displaced with the mass of the metal balls. How do they relate to each other?

3. Displacement and Sinking

Materials

Density cubes, Vernier calipers, overflow can, water, spring force meter, clamp stand and rod, graduated cylinder

Procedure

1. Set an overflow can on a stable, level surface. Fill it with water. Catch the water that overflows.
2. Measure and record the dimensions of the density cube with the Vernier calipers. (Is it cubical?)
3. Calculate and record the volume of the density cube.
4. Hang the force meter from a rod. Hang the density cube from the hook of the force meter. Record its hanging weight.
5. Place the overflow can under the density cube. Hold the graduated cylinder to catch the water that will flow from the spout of the overflow can. Slowly lower the rod supporting the force meter and cube until the cube is submerged beneath the surface of the water.
6. Catch the water that flows from the overflow can into the graduated cylinder. Record its volume.
7. Record the hanging weight of the cube that is now under water.
8. Repeat with the remaining density cubes.

Table 2. Density cubes

Material or description	Dimensions $l \times w \times h$	Volume	Weight in air	Weight under water	Volume displaced

Questions

1. How does the volume displaced relate to the volume of the cubes?

2. What determines the difference between the weight of a cube in air and its weight under water?

4. Sinking and Floating

Materials

Plasticine lump, glass beaker, graduated cylinder, ruler or tape measure, hook mass, spring force meter, overflow can, water

Procedure

1. Select a lump of plasticine to use for this activity. Measure and record the mass of the lump. For the rest of the activity, do not add or remove any plasticine from the lump.
2. Roll the lump into a ball. Fill an overflow can to the brim with water, so that water overflows from its spout. Allow the water to overflow until it is finished. *Gently* place the ball into the overflow can and collect the water that overflows into a graduated cylinder. Record the volume of water collected below.
3. Retrieve the plasticine and mold it into a shape that floats. (Make a plasticine boat.) Sketch or describe this shape.

4. Refill the overflow can with water. Gently float the plasticine boat on the surface of the water and collect the water that overflows into a graduated cylinder. Record the volume of water collected below. (If the "boat" sinks, keep trying.)

Mass of lump: _____

Overflow volume: Lump: _____ Boat: _____

Questions

1. Which displaced more water: the lump or the boat?

2. What determines the volume of water displaced by the boat?

5. Diver

Materials

Plastic 2-L bottle with cap, test tube, water

Procedure

1. Fill a 2-L bottle with water. Also fill the test tube with water. Smoothly invert the test tube into the mouth of the 2-L bottle so that a small bubble of water is trapped in the test tube. If you wish, allow more air into the test tube by briefly lifting it above the surface of the water and then lowering it back down. You want a big enough air bubble to make the test tube float. Let go of the test tube. If it sinks, take it out of the bottle (as tidily as possible) and repeat the process, this time allowing a larger air bubble into the test tube.
2. With the test tube floating in the 2-L bottle, top off the bottle so that it is as full of water as possible. Cap the bottle tightly.
3. Squeeze the bottle in your hands. If you squeeze hard enough, you should be able to make the test tube sink. If you cannot, remove the test tube, refill it with water, and again float it in the bottle using a smaller air bubble.
4. Figure out how it works. Be prepared to explain it.

Lab report

This lab's report won't have "Abstract," "Purpose," "Theory," or "Experimental" sections. Your "Observations and Data" (15 points) are recorded on this paper.

Analysis and Discussion (30 points)

Explain what each of the stations of this laboratory demonstrate about buoyancy in a fluid. Address the questions asked in these instructions.

Conclusion (10 points)

Do your activities confirm that the buoyancy force acting on an object is equal to the weight of fluid displaced?