Sink or Swim

Introduction

Density is the mass of a substance or object relative to the amount of space it takes up. To calculate the density of an object or substance, we need to know the mass of the item and the volume it occupies.

If two substances differ enough, their relative densities are easy to determine. For example, a piece of lead, which is a dense metal, feels much heavier than a piece of cork of about the same size. An analysis of the densities of the two objects shows that one cubic centimeter of lead, about the size of a small marble, has a mass of more than 11 grams, while one cubic centimeter of cork has a mass of about one-quarter of a gram.

When materials have such different densities, it is easy to predict which will sink and which will float in water, which has a density of one gram per cubic centimeter. But what about other substances? Is there a way to predict whether or not a substance will sink or float in water (or any other fluid of known density)?

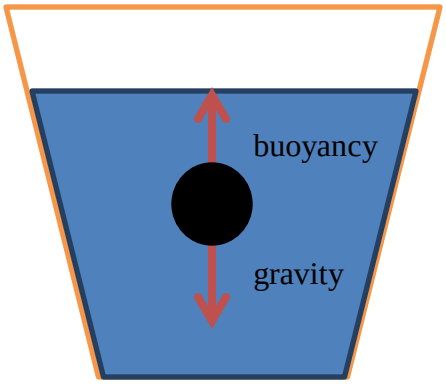

Figure 1: Forces acting on a floating object

When an object is floating in a fluid there are two forces acting on it. One force, gravity, is pulling the object down. The other force, buoyancy, is pushing up on the object. The force of buoyancy is caused by a difference in the densities of the object and the fluid. If the overall density of the object is lower than the density of the fluid surrounding it, buoyant forces pushing on the object from below will be strong enough to make the object float. Likewise, if the overall density of the object is greater than the density of the liquid, the object will sink. If the density of the object and the fluid are the same then the object is neutrally buoyant. A neutrally buoyant object can remain suspended in the fluid.

A submarine can be made neutrally buoyant. Its overall density will vary depending on how much air it contains at any given time. As a result, a submarine can be made to float or sink by allowing water to enter or leave tanks called ballast tanks. To make a submarine submerge, vent valves at the top of the ballast tanks open, allowing air to escape and water to fill the tanks through holes in the bottom. To make a submarine surface, the vent valves are shut and high pressure air is released into the tanks, forcing the water out through the holes in the bottom.

Materials

- Modified plastic water bottle
- 225 g weight
- Electrical or duct tape
- 5 gallon bucket

Procedure

1. Obtain a water bottle, 225 g weight, and some tape. Tape the weight to the bottom of the bottle. **Do not cover the hole in the bottom of the bottle**.
2. Make sure the cap is tightly screwed on to the bottle.
3. Place your thumb over the end of the tubing and place the bottle in the 5 gallon bucket.
4. Remove your thumb and watch as the bottle fills with water. You should feel air rushing out of the tubing.
5. When the bottle has sunk to the bottom, blow into the tubing, and watch the bottle come back to the surface.
6. Experiment with filling and emptying the bottle. Try to make the bottle neutrally buoyant.

Discussion

1. Why do you need to tape the 225 g weight on to the bottle?

2. Why do you need to put your thumb over the end of the tube to keep water from flowing into the bottle?

3. How is what you did in this activity similar to how a submarine submerges and surfaces?