WOW Lab
Science Education R&D

a WOW Lab BLUEPRINT

Buoyancy

Inquiry Approaches

Some of the following questions will only be relevant if all three parts of the activity are performed.

Experimental Procedure Inquiry

What are the forces acting on an object in water?

Gravitational force (F_g) and buoyant force (F_b).

Why does the test tube float on the surface of the water in the pop bottle?

When the test tube is floating on the surface of the water, the buoyant force (F_b) and the gravitational force (F_g) are equal and opposite, resulting in a net force (F_{NET}) of zero.

What happens to the density of air inside the test tube when you stop squeezing?

The air bubble inside the test tube is allowed to increase in size but the amount of air remains constant, so the density of the air decreases.

What happens with the forces acting on the test tube once you release the pressure on the bottle? What happens to the test tube?

When the bottle is released, the volume of fluid (water) displaced by the test tube increases and therefore the weight of the displaced fluid increases, resulting in a greater F_b. If F_{NET} is then calculated by adding F_g and F_b, the resultant force (F_{NET}) will point upwards. The test tube will rise until it reaches equilibrium ($F_g + F_b = F_{NET} = 0$).

What happens to F_b when the volume of the balloon increases after the antacid is added to the water?

F_b increases because a greater volume of surrounding fluid (air) is displaced.

What can be concluded about the volume of the surrounding fluid (air) displaced in relation to F_b?

The volume of the surrounding fluid (air) which is displaced is directly proportional to F_b. This means that F_b will continue to increase as more surrounding fluid (air) is displaced, and vice-versa.

What happens to F_g throughout the experiment?

F_g remains constant.

What does the change in mass correspond to?

The change in mass is equal to the mass of the surrounding fluid (air) which is displaced by the expanded balloon (from Archimedes' principle: $w/g - w'/g = F_b/g$ and F_b/g = mass of displaced air).

What happens if F_b exceeds F_g?

F_{NET} will be directed upwards and the water bottle and balloon will rise. This phenomenon occurs in hot air balloons.

What happens to F_g and F_b when the can of diet pop floats statically before and after salt is added to the water?

F_g and F_b are in equilibrium ($F_{NET} = 0$) before and after adding salt. In terms of Archimedes' principle, the apparent weight of the can is zero at this point.

What happens to F_g and F_b when the can of pop is moving upwards?

F_b exceeds F_g, which causes the can of pop to move upwards until the forces reach equilibrium at the surface of the water.

What happens to the volume of fluid displaced by the can before and after it reaches the surface? What happens to the mass of the fluid displaced?

When the can is moving upward, F_b exceeds F_g (F_{NET} points upwards), until it reaches the surface and floats, with F_b and F_g now in equilibrium ($F_{NET} = 0$). The volume of fluid displaced by the can is greater when the can is under the surface of the fluid compared to when it is floating. The mass of the displaced fluid begins to decrease as the can floats back up because the volume decreases.

In-Depth Inquiry

How could you relate this activity to how a submarine functions?

Submarines have ballast tanks which are filled with water to allow the submarine to descend. In order to rise, gas is pumped into the tank and the water is expelled. When the test tube is filled with water (when the bottle is squeezed), the density of the air increases, which makes the entire test tube more dense than the water and causes it to sink.

How can this activity be used to determine the density of the surrounding air after the antacid is added to the water?

If the volume of the balloon increases, then the volume of surrounding air which is displaced increases. We can estimate the volume of air that has been displaced by the volume of the expanded balloon. The change in mass, before and after the addition of antacid, corresponds to the mass of the surrounding air which was displaced. The density can be calculated by dividing the mass by the volume.