**ACTIVITY: Buoyancy in water**

**Activity idea**

In this activity, students make a Cartesian diver to demonstrate the relationship between volume, mass and density. A similar principle is used in Argo scientific floats.

By the end of this activity, students should be able to:

* describe some of the factors that affect what makes an object float or sink
* understand how volume, mass and density are related
* understand how Argo floats rise and sink in the ocean.

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**Introduction/background**

It might be helpful to do some preliminary work on floating and sinking before doing this activity. You could use the activity as part of an exploration of some common misconceptions about floating and sinking:

* Small objects float better than large ones.
* Soft objects float better than hard ones.
* All floating objects have air in them somewhere.
* An object floats or sinks because of its weight.

***Science explanation***

The Cartesian diver has been a popular science toy for many years. It is named after René Descartes, a French scientist in the 17th century.

The Cartesian diver students make has a pocket of air sealed in a flexible container (a plastic pipette). This floats in a sealed plastic bottle full of water. When you squeeze the sides of the bottle, the diver sinks. When you release the bottle sides, the diver rises.

When you set up the demonstration, you create an object that has neutral buoyancy in water. The air in a plastic pipette has lower density than the water – on its own, it would float to the top. Modelling clay has a higher density than water – on its own, it would sink. You add modelling clay to the pipette to achieve a balance so that the object neither sinks to the bottom nor floats to the top.

When you squeeze the sides of the bottle, watch the bulb of the pipette – you will see the sides move inwards slightly. Squeezing the bottle increases the pressure inside, and because air compresses more easily than water, the air inside the pipette is compressed. This means that the mass of the air, which hasn’t changed, takes up less volume. Since density is calculated as density = mass/volume, if mass stays the same and volume goes down, density increases.

With the air in the diver now denser, the object is less buoyant than the water, so it sinks. When you release the sides of the bottle, the reverse happens. The air expands back to its original volume and becomes less dense, so it floats up through the water.

***Argo float buoyancy***

Argo floats drift 1500 m down in the ocean. Every 10 days. they rise to the surface, collecting temperature and salinity measurements as they go. After transmitting data via a satellite, they sink again and repeat the cycle.

The floats contain a mechanism that allows them to sink or rise in the ocean. This is based on the same principle as the Cartesian diver, although changes of volume are made by an internal pump rather than by squeezing the ocean.

Floats spend most of their time at 1500 m depth, with neutral buoyancy. When a float is programmed to rise, a pump pushes hydraulic fluid from inside the float into a flexible bladder on the outside. This increases the volume of the float. Since the mass is the same, the density decreases and the float rises. When data has been sent at the surface, the hydraulic fluid is withdrawn from the bladder back inside the float. The volume of the float is therefore less, the density increases and the float sinks.

**What you need**

* Empty clear plastic drink bottle (1.5–2 L size)
* Pipette (or dropper) – one made all of soft plastic is easiest to use, but a glass one with a soft bulb would do
* Modelling clay (such as plasticine)
* Open container of water to set up neutral buoyancy of diver

**What to do**

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| 1. Seal the pipette with a piece of modelling clay. Start with a ball of clay about 3cm in diameter. 2. Put the diver in the container of water – add or take away clay until the diver floats with the top just below the surface of the water. 3. Fill the drink bottle with water. |  |
| 1. Put the diver in – it should float at the top of the bottle. 2. Make sure the water in the bottle comes to the very top and screw the top on tight. 3. Squeeze the sides of the bottle. The diver should sink. 4. Release the bottle. The diver should rise. 5. Try and get the diver to sit half way down. 6. Get students to explain what they think makes the diver sink and rise. (Watching the bulb of the pipette as you squeeze the sides of the bottle should give a clue.) |  |

**Extension ideas**

* Replace the water in the bottle with salty water. Salt water is denser than normal water – what happens to the buoyancy of the diver?
* Surround the bottle with ice to cool the water inside – watch what happens to the diver. What does this tell you about the density of cold water?