



*Illustration © John Joyce, 2009*

## THE CARTESIAN DIVER EXPERIMENT

### **Aim / Description:**

Students can learn about the physics of buoyancy.

### **Materials:**

- cap off a pen / plastic tube – open at one end (acts as “diver”)
- small lump of blue-tac or Plasticene / Marla
- cup of water
- 2 litre bottle and cap
- Water

## Explorer Education Programme

### Activity: The Cartesian Diver experiment



#### Background:

#### What is Buoyancy?

**Buoyancy** is the upward force that keeps objects afloat. The upward buoyancy force is equal to the amount of the weight of fluid displaced by the body of the object. This force enables an object to float.

**Neutral buoyancy** is achieved when the mass of an object equals the mass it displaces in a surrounding medium. This offsets the force of gravity that would otherwise cause the object to sink. An object that has neutral buoyancy will neither sink nor rise.

**Negative** buoyancy is achieved by either increasing the object's own weight or decreasing its displacement, so that it sinks.

**Positive buoyancy** is when the total weight of an object is less than the total weight of water it displaces, so that the object rises to the surface.

#### Buoyancy and Submarines

Submarines can control their buoyancy by pumping air in and out of water-filled tanks (ballast tanks) on the outside of their hulls. Pumping air (which is lighter than water) into the ballast tanks increases the submarine's buoyancy and allows it to float to the surface (by giving the submarine positive buoyancy). Releasing air and allowing water to fill the ballast tanks decreases the submarine's buoyancy and allows it to sink (by giving it negative buoyancy).

When travelling underwater, a submarine captain will aim to achieve neutral buoyancy, so that the submarine neither floats nor sinks. In this state, a submarine can be "flown" underwater like an aircraft is flown in air, by using short "wings" called hydroplanes that can be angled up or down. In fact, the controls of a modern submarine look very similar to those of an aircraft, with a 'joystick' that controls movement up, down, left and right.

## Explorer Education Programme



### Activity: The Cartesian Diver experiment

#### Activity: Cartesian Diver Experiment

Step 1. Discuss with students what sinks and floats (see other lesson plans and activities). Introduce the language of buoyancy, positively buoyant and neutrally buoyant etc.

Step 2. Complete the Cartesian diver experiment to demonstrate buoyancy.

- Place a small ring of blu-tac around the opening of the "diver" (a small rigid tube, such as a cap off a pen or a pill container etc) without blocking it,
- Float the cap in a cup of water to test its buoyancy. If it is floating more than 5mm above the water line, the "diver" is too light – therefore, add some more blu-tac. If the diver sinks to the bottom, it is too heavy. Therefore, remove some of the blu-tac.
- Fill the 2 litre bottle with water right to the top. Gently drop the cap into the water with its open end downwards. Put the lid on the bottle. Note that the bottle must be airtight when closed.
- The "diver" should be partially filled with a small amount of water, but has enough air in it to be neutrally buoyant.
- Press the bottle inward and watch the "diver" sink to the bottom. When the pressure is released watch the "diver" float to the top.

Step 3. How does it work?

The "diver" is an open-ended object, which contains a small amount of air placed in an airtight container of water. The bubble of air in the diver makes it buoyant.

When the container is squeezed, the water pressure squeezes the bubble of air inside the "diver". As the bubble gets smaller its buoyancy is reduced until the "diver" becomes negatively buoyant and sinks.

When the pressure on the container is released, the bubble expands, increases in buoyancy, the "diver" becomes positively buoyant and floats.

#### Outcome:

Students will have developed skills:

- understanding the language associated with buoyancy.
- understanding the science of buoyancy by analysing, making inferences and coming up with their own conclusions.

Also, see lesson plans on "What Boats sink AND float" highlighting the history of submarines and making a DIY submarine.