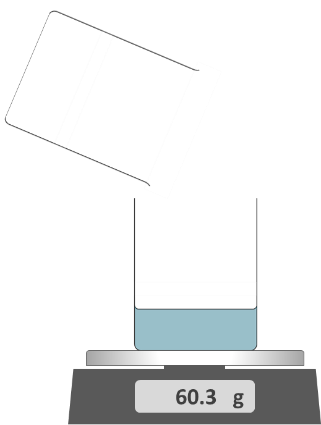
**Clay boat**

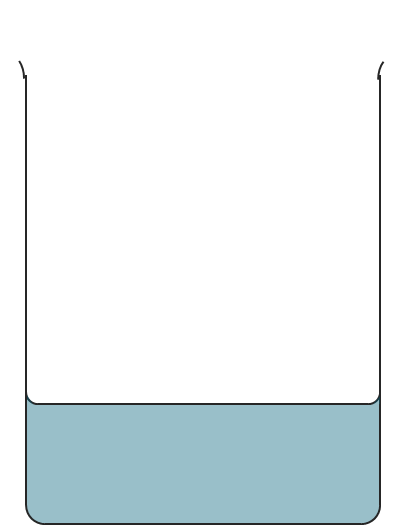
Modelling clay can float if it is shaped like a boat.

When it is put onto the water, how much water does a boat push out of the way?

**Apparatus**

* modelling clay boat
* displacement can
* ****beaker (x2)
* balance

**Diagram**



**Method**

1. Fill a displacement can with water.
2. Catch any drips in a beaker.
3. Empty the beaker.
4. Slowly place the clay boat in the displacement can.

*Do not dip fingers into the water.*

1. Collect all the water pushed out of the way in a beaker.
2. Place an empty beaker on a balance.
3. Press the **tare** button to set the balance to zero.
4. Pour in the water that was pushed out of the way by the clay boat.
5. Measure the mass of this water.
6. Measure the mass of the clay boat. *Remember to set the balance to zero first.*

*Take measurements for more clay boats. Use boats of different sizes and shapes.*

**Results**

|  |  |
| --- | --- |
| **Mass of water / g** | **Mass of clay boat / g** |
|  |  |
|  |  |
|  |  |
|  |  |

**To answer**

1. Are the results what you expected?
2. What is the rule for the mass of the water pushed out of the way by a boat that is put onto the water? *Give as much detail as you can.*
3. What do you think the mass of water is that is pushed out of the way by a boat that sinks?

*Physics > Big idea: PMA Matter > Topic PMA2: Floating and sinking > Key concept PMA2.1: Floating, sinking and density*

|  |
| --- |
| **Response activity** |
| **Water and sand** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | An object that is surrounded by a fluid (liquid and/or gas) floats if its overall density is less than the density of the fluid. |
| Observable learning outcome: | Describe how the shape of an object affects how well it floats.  Explain how the density of an object determines how well it floats. |
| Activity type: | Application and practice - practical |
| Key words: | Floating, sinking, weight, volume, density |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic questions

* Diagnostic question: Flipping iceberg
* Diagnostic question: Block float

**What does the research say?**

Paik et al. (2017) describe a learning progression for buoyancy that begins with the basic concepts of weight and volume, before starting to develop the scientific concepts of density and buoyancy. In their progression, the density of an object is introduced as the object being *heavy (or light) for its size*. This working definition of density allows students to develop understanding of how volume and weight combine to give an object its buoyancy, and provides descriptive tools that help explain why boat-shaped objects (that are filled with air) are more buoyant than other more compact shapes. This idea is also linked to the understanding that buoyancy increases as the volume of liquid (or gas) displaced increases. Buoyancy is defined as the resultant upward force of the liquid (or gas) around an object on the object.

When an object sinks in a liquid, Cepni and Şahin (2012) found that most 13- to 14-year-olds (n=48) did not think that the object had buoyancy. In some cases students labelled the buoyancy of a sinking object as downward: they thought that the liquid was pushing it downward. Conversely some students may think that a floating object has no weight (Allen, 2014). Buoyancy always acts vertically upward; the resultant force is determined by comparing the force of the water pushing the object up, with the force of gravity pulling the object down.

It is appropriate to teach students how to calculate buoyancy only after they have developed a good qualitative understanding how it works (Gao et al., 2018). Students can use a displacement can to measure the weight of water displaced by an object and compare this to the weight of the object. Buoyancy is equal to the weight of the water (or other fluid) displaced. Objects that float displace their own weight of water. If the weight an object is greater than the weight of the water the object displaces, then the object will sink. In other words: if an object is less dense than the liquid (or gas) that it is placed in it will float; if it is denser it will sink.

**Ways to use this activity**

This practical activity gives students the opportunity to practise applying their understanding and to clarify their thinking through discussion. To support this, students should complete the practical in pairs or small groups.

Listening to individual groups as they work often highlights any difficulties they might have. These can often be overcome, through a whole class clarification or redirection part way through the activity.

Asking students to report their findings at end of the practical work is a useful check. After a group has fed back, it might be helpful to model an even better answer. You could do this, for example, by asking another group to add to, or clarify, the first observation. Then ask another group to sum up the important part of the observation, and so on.

*Differentiation*

Providing suitable recording sheets can help some students organise their observations so they can more easily focus on the science. If some students are working with a teaching assistant, then a list of prompt questions for the TA could help to make this activity more purposeful. Some students may benefit from being challenged to plan and organise their own record keeping.

**Equipment**

For each student/pair/group:

* modelling clay boat
* displacement can
* beaker (x2)
* balance
* water

**Technician notes**

Each group will need a piece of modelling clay of about 100 g, such as Plasticine™.

**Health and safety**

The main risk is spilled water that can cause floors to become slippery.

Water may be spilled onto balances.

Practical work should be carried out in accordance with local health and safety requirements, guidance from manufacturers and suppliers, and guidance available from CLEAPSS.

**Expected answers**

The mass of water pushed out of the way (displaced) is equal to the mass of the boat.

A boat that sinks is not big enough to push its own mass of water out of the way. This means the water cannot push up on it with enough force to support its weight.

N.B. The latter of theses answers can be easily demonstrated.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

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