What happens when objects are floated in water?

In this experiment you will investigate how the volume and density of the liquid displaced by an object affects the upthrust that the object feels.

We will:

- Describe how the volume of water displaced changes as the volume/mass of the displacing object increases.
- Use a graph to investigate the relationship between these quantities.
- Compare the volume displaced for tap water and concentrated salt water.
- Make deductions about the relationship between upthrust and the weight of the fluid displaced.

Equipment

- Large plastic beaker or jug, 1 L, with graduations
- A compact mass of ~ 50 g
- Two additional plastic containers, ≥ 0.5 L
- 0.5 L concentrated salt water
- Objects to measure the mass of (optional)
- Medium sized plastic cup
- Blu-tac
- Graduated measuring tube
- Food colouring (optional)

Method

1. Start with the larger beaker/jug partially filled with water (~ 500 ml).
2. Carefully take the pre-prepared cup, with a mass stuck to the bottom, and float it in the large beaker/jug.
3. Record the volume measurement on the outside of the large beaker, this is your measurement for 0 ml in the cup.
4. Use the graduated measuring tube to measure out 50 ml, then carefully add that water to the cup floating in the large beaker/jug and record the volume measurement of the large beaker/jug and the volume of water added.
5. Keep adding water to the cup in 50 ml amounts, stop before the cup sinks, recording the volume measurement for each added volume of water.
6. Repeat the experiment with concentrated salt water in the large beaker/jug (still tap water in the floating cup). Use your results to calculate the density of salt water.
7. (Extension) Take an object of unknown mass and add it to an empty cup floating in the beaker, use what you have learnt to work out the mass of the object.

Results

Use the following two tables to write down the results for your experiment.

The density of pure water is 1.0 g/cm^3 (you may assume tap water is reasonably pure) and the density of a liquid is the mass of the liquid divided by its, volume

$$\text{density} = \frac{\text{mass}}{\text{volume}}, \quad \text{or in symbols} \quad \rho = \frac{m}{V}. \tag{3}$$

Tap water

Volume of water add to cup (ml)	Mass of added water (g)	Beaker/jug volume reading (ml)	Volume increase in the beaker/jug (ml)
0	0		0
50			
100			

Salt water

Volume of water add to cup (ml)	Mass of added water (g)	Beaker/jug volume reading (ml)	Volume increase in the beaker/jug (ml)
0	0		0
50			
100			

Plotting your graph

Two sheets of graph paper are provided at the end of the handout for you to plot your graphs. It is good practice to plot each point as you collect your data in the tables above.

Once you have plotted your data then you will need to draw a **line of best fit**. This is a straight line that agrees with your data as well as you can make it. You should not "join the dots", but instead draw a single straight line with a ruler. Do not worry if your line does not go through all of the data points (but it should be close to most of them). You may find you can only draw a sensible line of best fit for part of your data.

Discussion

1 Look at the shape of your graph from the experiment using tap water in the beaker. Describe the shape of your graph.

2 Look at the shape of your graph from the experiment using salt water in the beaker. Describe the shape of your graph.

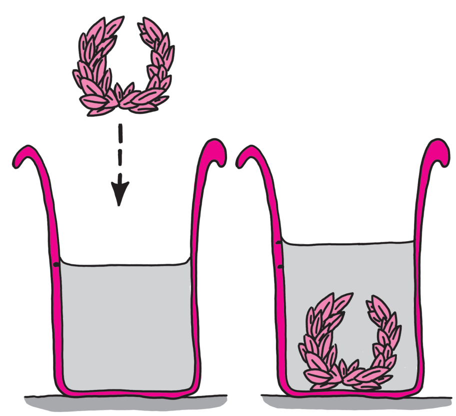
3 Compare the results you obtained using water and concentrated salt water. What do you notice? (fill in the blanks)

(a) Volumes of added and displaced fluids are related ____________. In the first experiment the slope of the line is ____________; in the second experiment it is ____________ in the first experiment.

(b) Thus to obtain the same upthrust with the salt solution ____________ liquid must be displaced; the difference between the salt solution and the tap water is the density, the density of salt solution being ____________ than that of tap water.

(c) Any object, totally or partially immersed in a liquid, is buoyed up by a force ____________ the ____________ of the liquid ____________ by the object.

The principle at which you have arrived at the end of question 3 is called *Archimedes' principle* and was first discovered by the ancient Greek philosopher Archimedes when he was tasked by the king to determine whether a crown was made of pure gold.



If you have time you could use Archimedes' principle to estimate the mass of an object by placing it in the floating cup and looking at how much water is displaced.

Calculations

4 (a) If you add 150 ml of water to the cup, what mass are you adding to the cup?

(b) What mass of (tap or salt) water must be displaced by the cup to create enough upthrust to compensate for the increased weight of the cup?

(c) What volume of tap water does this correspond to?

(d) What volume of salt water does this correspond to? Is that volume more, less, or the same as the volume of tap water added to the cup?

5 Given that the density of pure water is 1.0 g/ml use your graph for the concentrated salt water to calculate the density of the salt water.

Conclusions

6 To finish the experiment, write a sentence or two to answer the following questions.

(a) Does the same volume of salt water have a smaller, larger, or the same mass, as tap water?

(b) What is the relationship between the volume and the mass and weight of a liquid?

(c) Does salt water have the same or a different density to tap water?

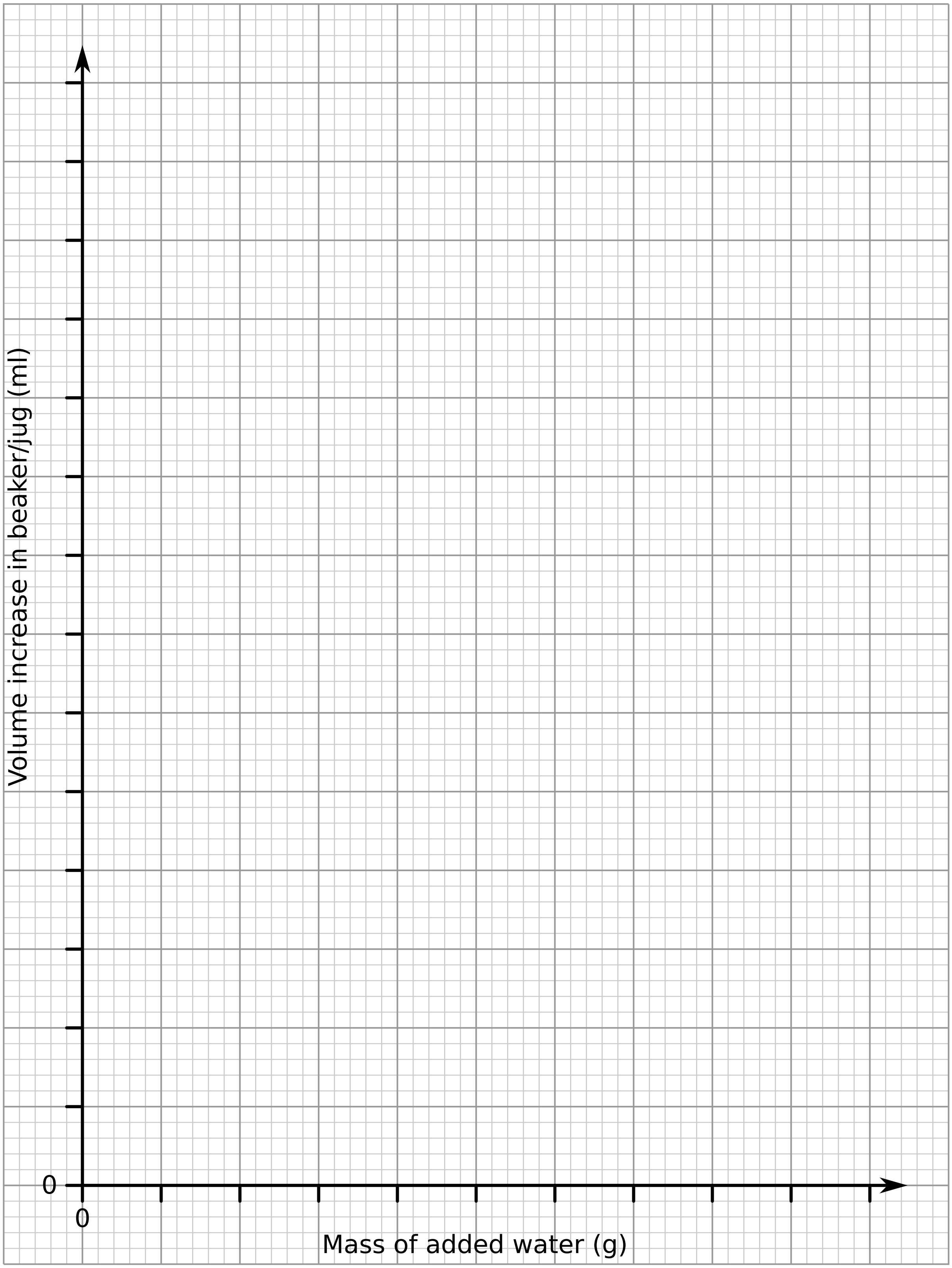
(d) How is the upthrust related to the volume of water displaced by an object?

(e) How could you use this knowledge to measure the mass of unknown objects?

(f) Can you think of any ways you might change the experiment, in order to improve it, if you were to perform it again?

Use this graph paper to plot your data for tap water. You will have to **choose an appropriate scale** for your axes. Depending on your data you may not use all the available space.

Title: A graph of the displaced volume against the mass added to the cup



Use this graph paper to plot your data for salt water. You will have to **choose an appropriate scale** for your axes. Depending on your data you may not use all the available space.

Title: A graph of the displaced volume against the mass added to the cup