Will it sink or float?

Have you ever noticed that some objects float on water while others sink? Surprisingly, sometimes heavier objects float while lighter ones sink. Can you figure out why this happens?

Q 1. What happens when you try to lift something underwater?

Q 2. What will happen if you push a floating object, like a tennis ball or an empty bottle, underwater and then let go?

Do it yourself! - Task 1: Exploring forces underwater

Materials

Bucket (with water), empty plastic bottle or a container

Take a bucket filled with water and try to push the sealed (with closed cap/ air tight) empty plastic bottle into the bottom of the bucket.

Q 3. What did you observe? What forces do you think are acting on the object? Try to explain this using a diagram.

Note that buoyancy isn't just in water—air is also a fluid, and the same principle applies to objects like birds and aeroplanes, which experience buoyant/ upthrusts in the air.

So far, we have explored the concept of buoyant/ upthrusts in fluids and understood its origin. Now, let us consider the factors that influence the buoyant/ upthrust.

Q.4. What do you think are some of the properties of the object or the fluid that can change and influence the buoyant/ upthrust force?

Let us explore these questions and try to do some experiments to understand more about the buoyant/ upthrust force and why some objects float and some sink.

Materials

For Task 2, 3, 4, 5 and 6: (i) Bucket/Beaker (ii) Water, (iii) Spring balance (for weight) (iv) Same-sized small plastic containers with lid (v) Thread (vi) Small stones, (vii) Marbles viii) Clay *(for Task 3)* (ix) Objects of different shape that will sink in the water (e.g. keys, magnets etc) *(for Task 3)* (x) Aluminium foil *(for Task 5)* (xi) Salt *(for Task 6)*,

Task 2: Does the buoyant/ upthrust force depend upon the weight of the object?

A small stone sinks immediately whereas a large ship floats. This raises the question, 'Whether the buoyant/ upthrust force on an object depends upon the weight of that object or not? Let us find out.

To begin with, we need objects that have the same volume but different weights. This can be done by collecting containers of the same size and adding sand/stones/marbles so that each container has a different weight (but the same volume). *Add enough sand, stones, or marbles to each container so that they all sink completely in water, except for one container, which should float.*

Measure the weight of each of the containers with the help of a spring balance. Now submerge each of these containers in a beaker filled with water and measure their weights in water. Note down your readings in Table 1.

	Weight outside water	**Weight inside water**	**Observations**
Container 1			
Container 2			
Container 3			
Container 4 (floating)			

Table 1

While performing the task, it is important to realise that for any object there are two quantities that could be varied; **the weight** and **the volume** of that object. To study how one quantity impacts the buoyant/ upthrust, **we need to change one quantity and keep the other one constant.** In the above case, **we kept the volume of the object constant** by using the same containers and changed the weight by adding and removing different materials to the containers.

Q 5. What happened to the weights outside and inside the water?

Q 6. Why did this happen? What can you conclude from the above observation?

Q 7. What is the relationship between the weight of objects in air and underwater for all the containers with the same volume but different weights? What conclusions can you draw from your observations?

____
____
____
____

Q 8. Do your observations change when measuring the weight of the object in water at different depths? What conclusions can you draw from this?

____
____
____

Task 3: Does the buoyant/ upthrust depend upon the volume of an object?

In the previous case, we explored how the buoyant/ upthrust force relates to the weight of the object. Now, let's investigate **whether the buoyant/ upthrust force changes with the volume of the object** by observing its variation for objects of different volumes.

We begin by selecting objects of the **same weight but different volumes**, then follow the same procedure as in Task 2 to measure the buoyant/ upthrust force. We can use various objects with similar weights but different shapes, adding clay to adjust their weights and make them as equal as possible.

	Weight outside water	Weight inside water	Observations
Object 1			
Object 2			
Object 3			
Object 4			

Table 2

Q 9. What is the relation between the weights of the objects *in the air and underwater* for containers with different volumes but the same weight? Is it different from the previous task where you varied the weight of the container but kept its volume constant?

____
____
____
____

Q 10. With the help of the buoyant/ upthrust force acting on the objects in the water, explain your observations.

____
____
____
____

Task 4: Does the buoyant/ upthrust depend upon the density of an object?

Let's explore how the density of an object affects whether it will float or sink. **In this case, we will keep the volume constant and vary the weight, this changes the average density of the object with each weight adjustment.**

Before that let us calculate the volume of the container:
Shape of the container is: ________________________________

Volume of the container: ________________________________

Take a container and standard weight measures, such as marbles. Initially as expected the empty container floats on the water. Add marbles to the container and at each stage, record the total weight of the container outside the water and calculate its density. Continue this until the container sinks.

Note here that we are only changing the weight in this case, but since the volume is not changing, the real factor influencing whether the container floats or sinks is its density.

	Weight (outside water)	**Density (Weight/ Volume)**	**Observation**
Case 1			
Case 2			
Case 3			

Table 3

Q 11. How does the change in weight affect the density of the object?

____
____
____

Q 12. What do you observe from the table?

____
____
____

Task 5: But when does it float?

Take a stone or marble wrapped in a 15 × 15 cm piece of aluminium foil and place it in a beaker filled with water.

Q 13. What happens to the stone or marble wrapped in aluminium foil? Why does this occur? Explain it in terms of the forces acting on the object.

Now, take the same stone or marble, but instead of covering it with foil, shape the foil into a boat-like structure and place it in the water.

Q 14. What forces are acting on this object? How does the force acting on it compare to the previous arrangement with the stone or marble wrapped in foil? Discuss and explain your observations.

Q 15. In both cases presented in Task 5, the materials used are the same, but the outcomes differ. Reflecting on the results from previous tasks (the dependence of buoyant/ upthrust on weight, volume, and density), consider which properties of the object affect whether it sinks or floats. Given the properties of the objects involved, which specific property is changing to produce these different results?

Now, fill this boat with some more stones/marbles.

Q 16. Will the boat sink or float? Discuss and explain your reasoning.

What is the origin of Buoyant forces?

Fluids take the shape of the container where they are stored. If you imagine the fluid to be divided into various layers (see Fig. 1), each layer exerts a force on the layer below and also the sides of the container. Also, each layer encloses an equal area of the container.

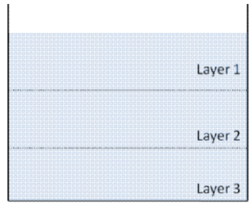

Figure 1

Q 17. Assume the mass of layers 1, 2 and 3 as m_1, m_2, and m_3 respectively. Determine the force exerted by (i) Layer 1 on layer 2 (ii) Layers 1 and 2 on layer 3. Label and illustrate these forces in Figure 1.

Q 18. If you were to measure the *pressure* at the boundary of these layers, how do you think it would change? How could this pressure difference contribute to the buoyant/ upthrust force on the object?

Extended (Task 7): Does the buoyant/ upthrust depend on the liquid used?

Having explored the relationship between the buoyant/ upthrust force and the properties of the material, let's now examine how it relates to the nature of the liquid.

Do you know that scuba divers carry more weight on them when they dive in saltwater compared to when they dive in freshwater? Why do you think scuba divers do this? What is the difference between saltwater and freshwater?

Figure 2
Gibb, Natalie. (2019)

Let's try to find out.
Take two different vessels: one filled with regular water and the other with salt water (prepared by dissolving two tablespoons of salt in a glass of water). Select at least three objects and weigh them. Next, measure the weight of these objects when submerged in both liquids. This will help us determine the buoyant/ upthrust force acting on the objects in each liquid.

	Weight outside water	**Weight when submerged in normal water**	**Weight when submerged in saltwater**	**Observations (1) (for normal water)**	**Observations (2) (for Saltwater)**
Object 1					
Object 2					
Object 3					

Table 4

Q 19. What did you observe? Explain your observation.