Will it sink or float?

Have you ever seen that some objects float on water while others sink? It's interesting that sometimes heavy objects float and light ones sink. Can you think about why this happens?

Q 1. What do you feel when you try to lift something from under the water? Does it feel heavier or lighter than when it's outside the water?

Q 2. What do you think will happen if you push a floating object—like a tennis ball or an empty bottle—under the water and then let it go? Will it stay there, sink, or come back up?

Do it yourself! - Task 1: Exploring forces underwater

Materials: Bucket/ beaker (with water) and an empty plastic bottle or plastic container

Take a bucket or a beaker and fill it with water. Now take an empty plastic bottle or container that is sealed tightly with a cap. Try to push it down to the bottom of the bucket. What do you observe?

Q 3. What did you notice when you pushed the bottle underwater? What forces do you think are acting on it? Try to draw a simple diagram to show these forces. You can use arrows to show the direction of the forces.

Now we know why objects feel lighter in water or sometimes float up on their own. This happens because of a force called buoyant force. Let's now try to measure this force using a simple activity.

Task 2: Measuring the weight of an object underwater:

Materials: (i) Stones (roughly the size of half the palm) (ii) Any objects that float (iii) Spring balance (for weighing) (iv) Glass beaker with water

No.	**Condition**	**Object's weight outside water (N)**	**Object's weight inside water (N)**	**Object's weight inside salt-water (N)**		**Buoyant force**	
						For water	**For salt-water**
1	Sinking						
2	Sinking						
3	Sinking						
4	Floating						
5	Floating						

Table 1

Q 4. For a given object, how is its weight in air different from its weight in water? Which physical property do you think explains this difference?

Q 5. How can you find out how strong the buoyant force is in each case using the weights you observed? (Hint: Think about the difference between the object's weight in air and its weight in water.)

Q 6. What is the value of the buoyant force for objects that float? When will an object float, and when will it sink?

Q 7. How does the buoyant force in water compare to the buoyant force in saltwater for each object?

Q 8. Take one of the stones and measure its weight at different depths in the water. What do you observe? What conclusions can you make from this?

Task 3: What is the origin of buoyant forces?

Take an empty plastic bottle and make small holes at different levels, from the bottom to the top. Then, fill the bottle with water. Observe how far the water stream from each hole falls (Figure 1).

Figure 1

Q 9.Why does the water from the bottom hole travel the farthest?

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Q 10. What does this tell us about the pressure in a fluid at different depths?

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PART II: So far, we have explored the concept of buoyant force in fluids. We conducted an activity to measure its magnitude and examined the concept behind its origin.
"The buoyant force arises from the pressure difference in fluids. The pressure on the bottom of an object submerged in the fluid is greater than the pressure on the top, creating a net upward force. This upward force is what we refer to as the buoyant or upthrust force."

Now, let us consider the factors that influence the buoyant force.
Q.11. What do you think are some properties of the object and the fluid that can change or influence the buoyant force? Write your answers separately for the object and the fluid.

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Let's explore these questions to understand more about the buoyant force and why some objects float while others sink.

Task 3: Does the buoyant force depend upon the weight of the object?

A small stone sinks right away, while a large ship floats. This makes us wonder, "Does the buoyant force on an object depend on its weight?" Let's find out.

To test if buoyant force depends on weight, we need to consider objects with different weights but keep other factors the same so we only test one variable. In this case, we will keep the volume the same. In the table below, we provide the weight measurements of 5 different plastic containers with closed lids (Figure 1), each having a volume of 100 cm^3. We add a different number of marbles to each container, so the weight of each container is different. Then, we measure the weight of the container both outside and inside the water using a spring balance, just like we did in task 2.

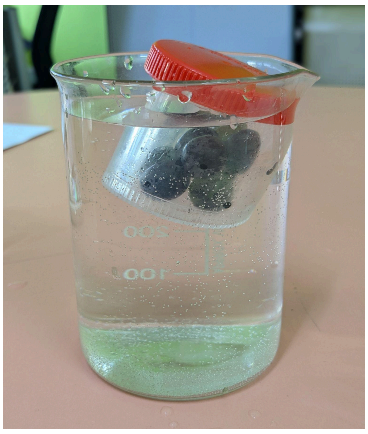

Figure 2

Object no.	Volume of the container (cm^3)	Weight of the container- outside water (N)	Weight of the container- inside water (N)	Buoyant force
1	100	110	35	
2	100	125	50	
3	100	135	60	
4	100	150	75	
5	100	220	145	

Table 2

Q 12. What relationship do you observe between the buoyant force and the weight of objects that have the same volume?

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Task 4: Does the buoyant force depend on the volume of an object?

In the previous task, we explored how the buoyant force relates to the weight of the object. Now, let's investigate whether the buoyant force changes with the volume of the object by observing how it varies in objects with different volumes.

We will start by taking objects of the same weight but different volumes, then follow the same procedure as in Task 3 to calculate the buoyant force. In the table below, we provide the mass and volume measurements of 5 objects. These objects are cylindrical in shape and made from different materials: iron, ceramic, plastic, wood, and foam. The dimensions, mass, and volume of these objects are listed in the table below.

Object no.	Material	Radius (cm)	Height (cm)	Vol of the object (cm^3)	Object's mass outside water (mg)	Object's mass inside water (mg)	Buoyant force
1	Iron	1.5	3.8	27	100	73	
2	Clay	2.0	3.6	45	100	55	
3	Plastic	2.2	4.0	60	100	40	
4	Wood	2.5	4.1	80	100	20	
5	Foam	2.8	4.1	100	100	0	

Table 3

Q 13. What relationship do you observe between the magnitude of the buoyant force and the volume of objects that have the same weight?

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From Tasks 2, 3, and 4, it is clear that the buoyant force depends on the density of the fluid and the volume of the object. It does not depend on the mass of the object that is submerged.

Extended Task 5: Density--Sinking & Floating:

In the previous tasks, we explored how weight and volume affect the buoyant force.
If we change the weight of an object while keeping its volume constant, the buoyant force for these objects ______________ changes/ does not change.
If we change the volume of an object while keeping its weight constant, the buoyant force for these objects ______________ changes/ does not change.

From Task 2, recall that for a floating object, the magnitude of the buoyant force is ___________ (more/ less/ equal) to its weight in air. So, to keep an object floating, the magnitude of the buoyant force should always be ___________ (more/ less/ equal) to the weight of the object. An object will sink if the magnitude of the buoyant force is ___________ (more/ less/ equal) than the object's weight outside water.

Let us now explore how the density (ϱ) of an object affects whether it will float or sink.
Unlike in Tasks 3 and 4, where we studied how weight and volume affect the buoyant force, in this task we will focus on how the density of an object affects floating or sinking.

Place an empty sealed plastic container (like the one shown in Figure 2) in water. At first, the container floats on the surface of the water. Now, add some objects into the container—these could be marbles, small stones, sand, or even water. As you keep adding objects, the container starts to submerge. Keep adding and observe how the position of the container in water changes.

Q 14. When objects are added to the plastic container, does the mass or the volume of the container change? How?

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Q 15. How does this affect the density of the container? When do you think the container will sink?

The figure below, there are six panels. Each panel shows a plastic container with marbles placed in a beaker filled with water. The same container is used in all six panels, but the number of marbles inside the container varies. Consequently, the weight of the container changes across panels, while its volume remains constant. As a result, the average density of the container differs in each case.

Q 16. For each container in the figure (or next to the panels), indicate whether its density (ϱ) is = 1, > 1, or < 1 (remember, the density of water is 1).

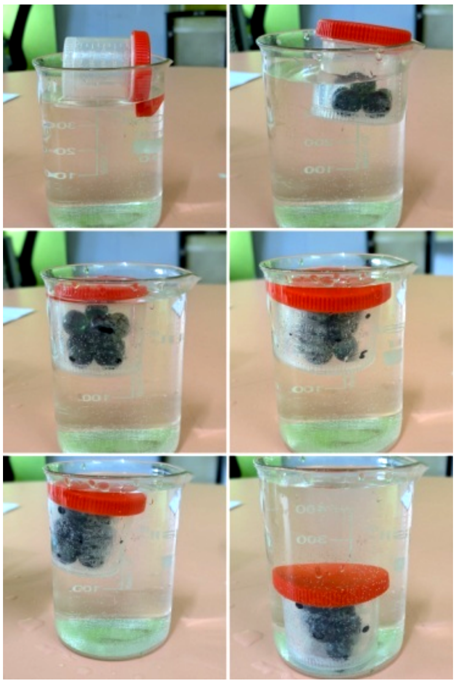

Figure 3

The results from all the tasks above show that an object floats in water when the buoyant force is equal to or greater than the downward gravitational force. In simple terms, this happens when the object's average density is less than the density of the fluid it is in.

References

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