Will it sink or float?

Introduction:

In your daily life, you would have seen that some objects float on water while others sink. **Take a beaker filled with water, drop some everyday objects around you and test whether they float or sink.**
It's also interesting to note that sometimes heavy objects float in water while light ones sink. For example, things like big wooden logs, ships/ boats, etc float on water while tiny pebbles, iron nails, and pins sink. Can you think about why this happens?

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

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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 with your hands and then let it go? Will it stay there, sink, or come back up?
What forces do you think are acting on it? Try to draw a simple diagram to show all the forces involved. You can use arrows to show the direction of the forces.

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Task 1: Measuring the weight of an object underwater:

Materials: (i) Object/ Stones (roughly the size of half the palm) (ii) Any objects that float (eg. small plastic container with some stones, see Figure. 1) (iii) Spring balance (for weighing) (iv) 2 Beakers (v) Water (vi) Salt (for salt-water)
[A] Take at least 3 objects (e.g. stones) of various sizes (roughly the size of half of your palm), tie them with a thread and measure their weight outside and inside water using a spring balance (see, Figure 1). Make sure each stone is tied to a separate thread and labelled properly. Now repeat the process by taking any two objects that float in water.

Figure 1

[B] Prepare a salt-water solution by mixing salt into the same quantity of water similar to the beaker above, until the solution is saturated. Repeat the weight measurements of all the objects in a saturated salt-water solution.

Fill in your observations for the weights obtained in Table 1.

No.	Condition	Object's weight (m* g) outside water (N)	Object's weight (m* g) inside water (N)	Object's weight (m* g) inside salt-water (N)		Difference in weight (outside v/s inside)	
						For water	For salt-water
1	Sinking						
2	Sinking						
3	Sinking						
4	Floating						
5	Floating						

Table 1

Q 3. For a given object, is the weight in air different from its weight in water? Which physical property do you think explains this difference?

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For an object in water, the 'weight of the object' is the downward **force** caused by Earth's gravitational pull. We observe that the weight of the stone decreases inside water. The decrease in weight (downward force) can be explained if we consider that there must be an upward force acting on the object, which is partially balancing its weight (or fully in the case of floating objects). *This upward force is called the* ***buoyant force or in general buoyancy****.*

Note that buoyancy isn't just in water—air is also a fluid. The same principle applies to balloons, birds, and airplanes, which experience buoyant force in the air.

Q 4. How does the buoyant force compare to the actual weight of the object (for both cases, sinking and floating)? Write the relation between them. Looking at this relation, when will an object float, and when will it sink?

Q 5. Compare the weight of any given object under water and salt-water. Are they same or different? Also, compare the buoyant force in water and in saltwater for each object.

Let us now check if the buoyant force varies with different heights inside a liquid.

Q 6. Take one of the stones and measure its weight at different depths in the water. What do you observe? What conclusions can you draw from this?

Task 2: 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 2).

Figure 2

Q 7. Why does the water from the bottom hole travel the farthest?

Q 8. What does this tell us about the pressure in a fluid at different depths?

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.”

In Task 1 (Q5), we already saw that the density of a liquid affects the buoyant force. Now, let us consider other factors that influence the buoyant force.

Q.9. 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 some of the properties affecting the buoyant force that you have listed.

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 3), each having a volume of 100 cm^3. We added different number of marbles to each container, so that the weight of each container was different. Then, we measured the weight of the container both outside and inside the water using a spring balance, just like you did in Task 1. (Here, we are not performing the task but only using the already obtained readings)

Figure 3

Object no.	Volume of the container (cm^3)	Object's Weight (m* g) outside water (N)	Object's Weight (m* g) inside water (N)	Buoyant Force
1	100	110*9.8= 1078	35*9.8= 343	
2	100	125*9.8= 1225	50*9.8= 490	
3	100	135*9.8=1323	60*9.8= 588	
4	100	150*9.8= 1470	75*9.8= 735	
5	100	220*9.8= 2156	145*9.8= 1421	

Table 2

Q 10. What relationship do you observe between the magnitude of buoyant force and the weight of objects (note that every object has the same volume)?

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Now, we will check if the buoyant force depends on the volume of the object.

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.

We will start by taking objects of the same weight but different volumes, then follow the same procedure as in Task 2 to calculate the buoyant force. In the table below, we provide the weight 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, weight, and volume of these objects are listed in the table below.

Object no.	Material	Radius (cm)	Height (cm)	Volume of the object (cm^3)	Object's Weight (m * g) outside water (N)	Object's Weight inside water (N)	Buoyant Force
1	Iron	1.5	3.8	27	100*9.8= 980	73*9.8= 715.4	
2	Clay	2.0	3.6	45	100*9.8= 980	55*9.8= 539	
3	Plastic	2.2	4.0	60	100*9.8= 980	40*9.8= 392	
4	Wood	2.5	4.1	80	100*9.8= 980	20*9.8= 196	
5	Foam	2.8	4.1	100	100*9.8= 980	0*9.8= 0	

Table 3

Q 11. What relationship do you observe between the magnitude of the buoyant force and the volume of objects (note that every objects has the same weight)?

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From Tasks 1, 2, and 3, 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 weight of the object that is submerged.**

Task 5 (Extended Task):
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 1, 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 3) 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.

(If the time is not sufficient, then this task can also be done by observing the result from Figure 3. The figure has 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).

Q 12. When objects are added to the plastic container, does the weight or the volume of the container change? How?

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Also, it's important to understand that an object can either float (when the buoyant force balances the gravitational force) or sink. It cannot do both at the same time—there's no such thing as an object being partly floating and partly sinking.

Q 13. How does adding the marbles in the container affect its density? When do you think the container will sink?

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WHY LARGE SHIPS FLOAT?

Think of large cargo ships. Even though they are made of heavy materials like iron and steel (which are denser than water), they don't sink. This is because their average density is kept low by having large hollow spaces inside. These spaces reduce the overall density, allowing the ship to float. So, it's not just the material's density that matters, but the average density of the whole object.

References

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