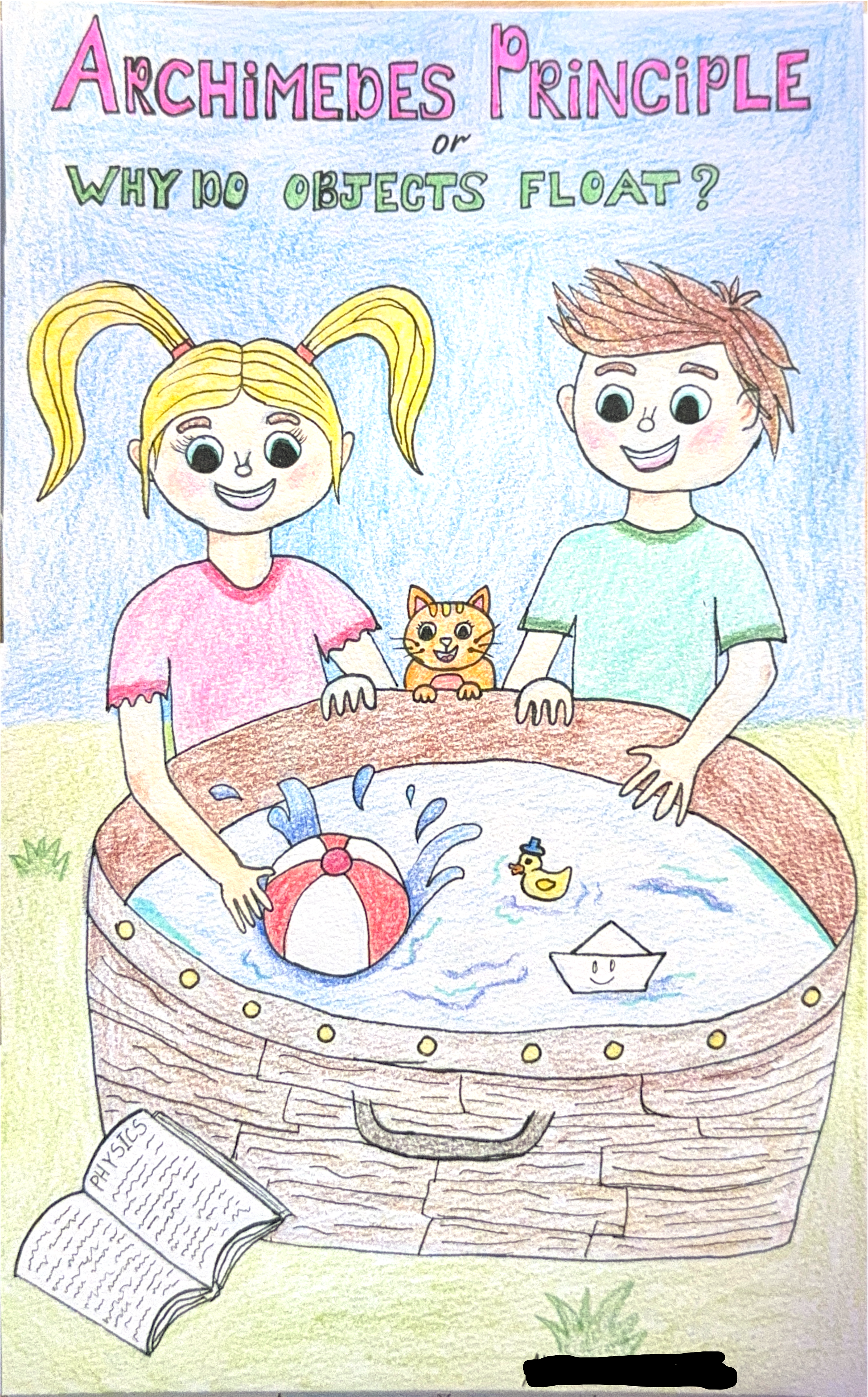
ARCHIMEDES PRINCIPLE

or

WHY DO OBJECTS FLOAT?



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EUREKA!

A moment of history!

Archimedes' principle, named after an inventor and a mathematician who lived in Ancient Greece, states that the buoyant force on a submerged object is equal to the weight of the fluid that is displaced by the object. Buoyancy is the ability of an object to float in water or air.

How did he come up with this idea?

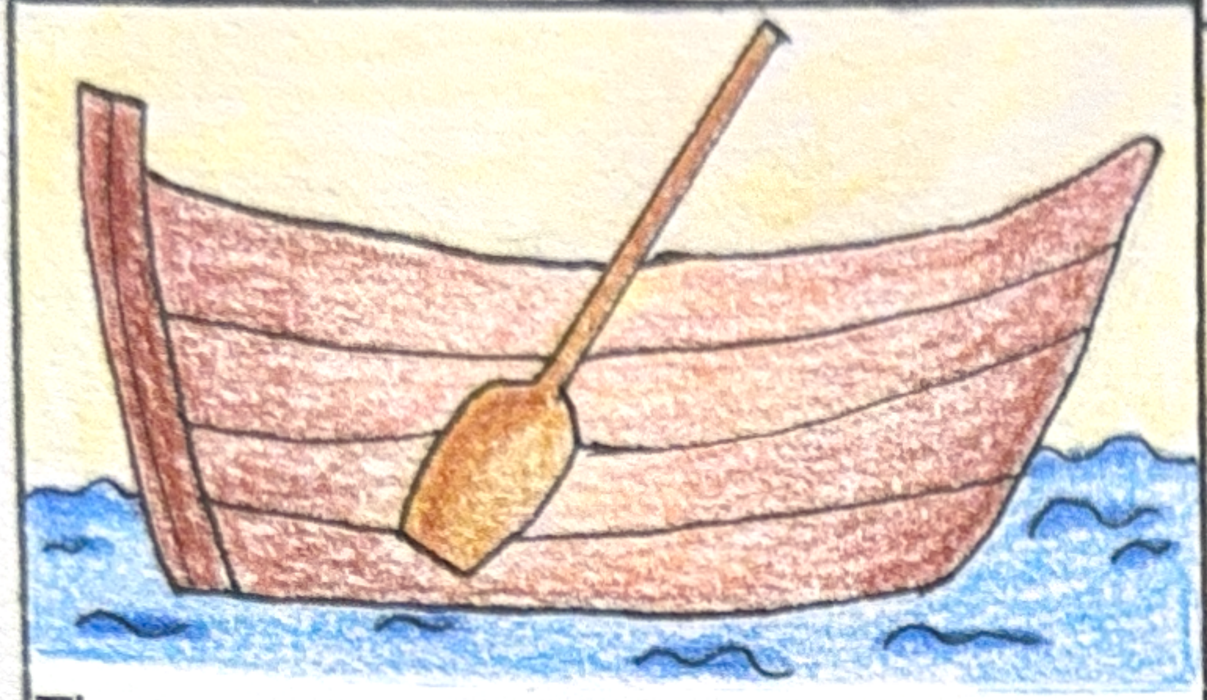
According to legend, while bathing, Archimedes suddenly realized that a body immersed in water displaces a volume of liquid equal to its own volume. Delighted with the discovery, he ran out shouting: "Eureka!"

A moment of physics!

What is the gravitational pull, all objects are pulled by the Earth?

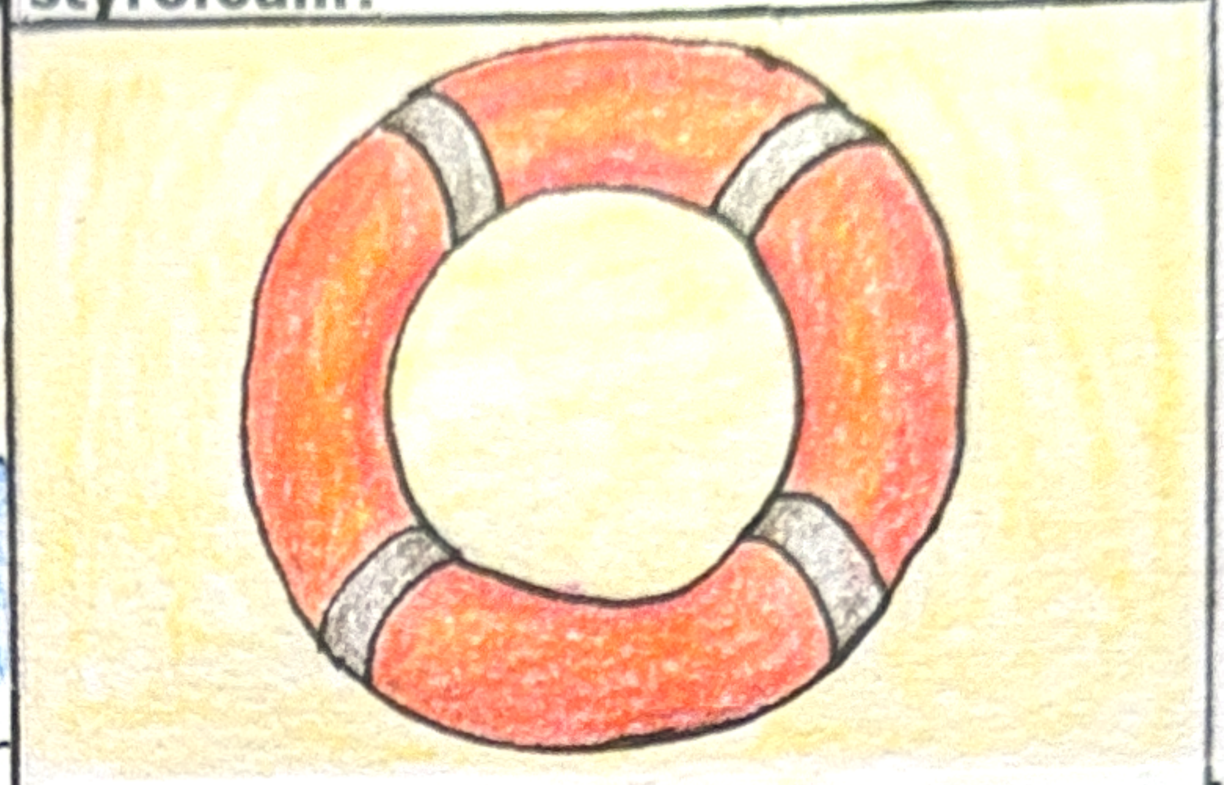
Gravity is an invisible force that attracts all objects to the Earth. For example, if you throw a ball up in the air, it will always fall back to the ground. This is because the Earth "holds" everything around it like a magnet. It's gravity that keeps us from flying when we walk or jump!

Why do you think boats are made out of wood?

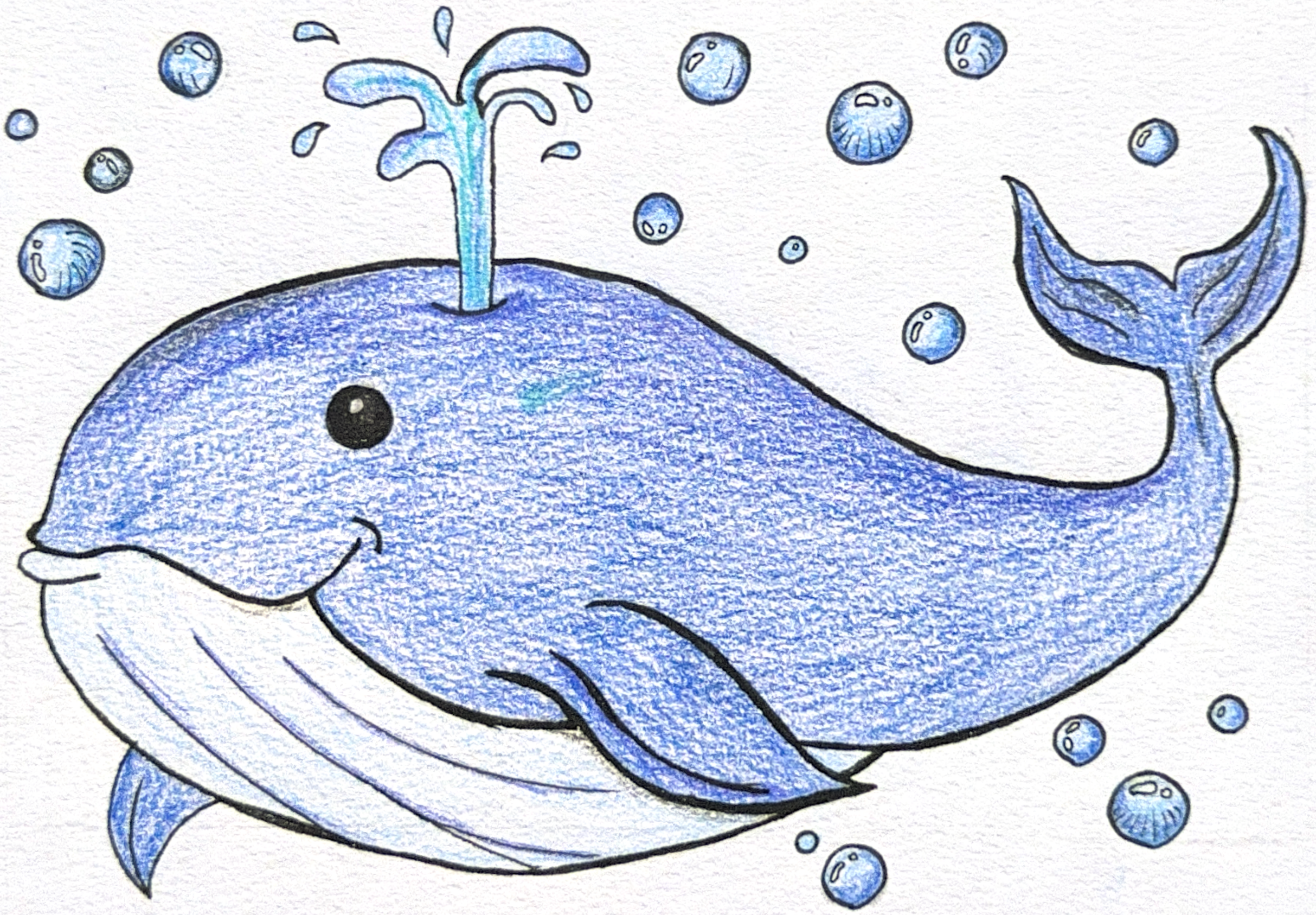


The reason is that wood has layers of air in it. Air is lighter than water and the boat does not sink.

Why do you think life-saving devices are made of cork wood or styrofoam?



These materials are very light and have many tiny air bubbles inside.



How can whales go up to the surface of the water and then back down?

To rise to the ocean surface, a whale fills its lungs with air, which increases its volume. This, in turn, increases the buoyant Archimedes' force. When diving deeper down, the whale exhales air from its lungs.

Let's investigate!

What do you need? Three empty 0.5L bottles, a bucket filled with water.

What to do? Fill the first bottle with water up to the top, fill the second bottle halfway with water, and leave the third one empty!

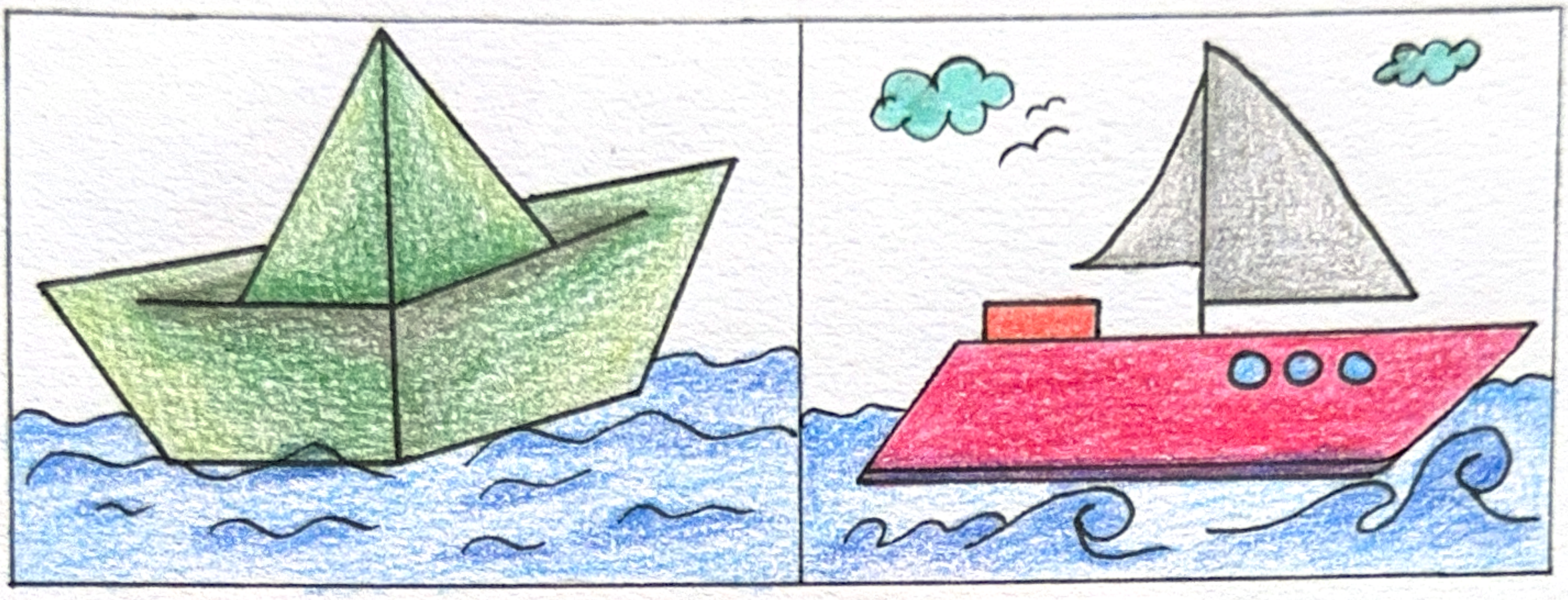
<u>Can you guess what's going to happen to each of the bottles after they're submerged in water?</u> Submerge all of the bottles into the basket with water. Observe and write down the results.

	Sank	Floated	Stayed on the surface
Full Bottle			
Half filled bottle			
Empty bottle			

Output: If the gravitational force is greater than the buoyant(Archimedes') force, the object sinks; if the forces are equal, it floats in the liquid; if the gravitational force is less, the object stays on the surface of the liquid.

Have you noticed that anything immersed in a liquid experiences a buoyant force? Some objects sink, some float in the liquid, and some stay on the surface — all of these work according to Archimedes' principle.

Both the paper ship and the heavy ship float on water due to the buoyant force!

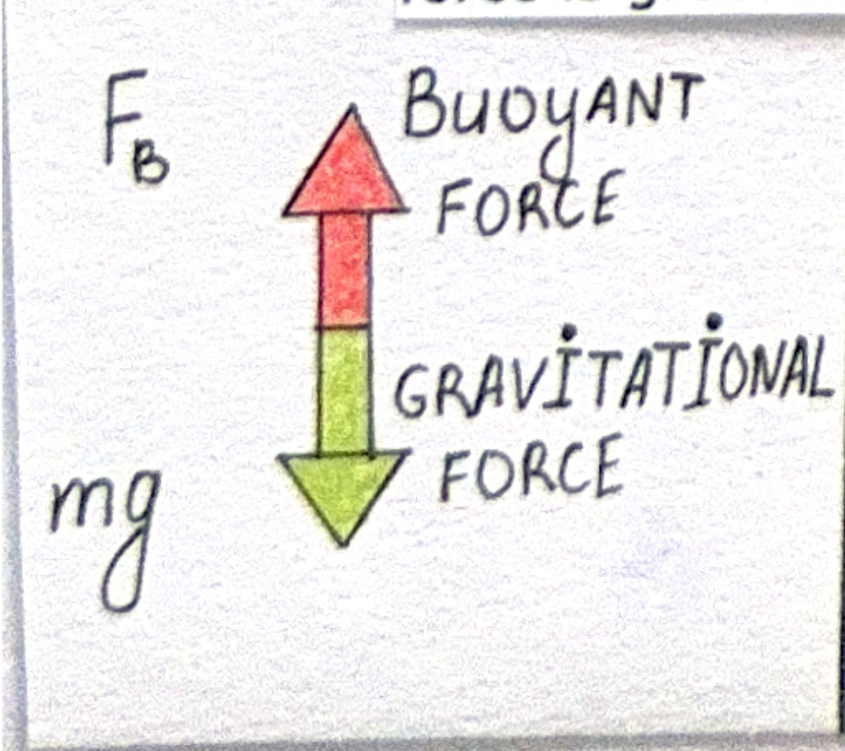


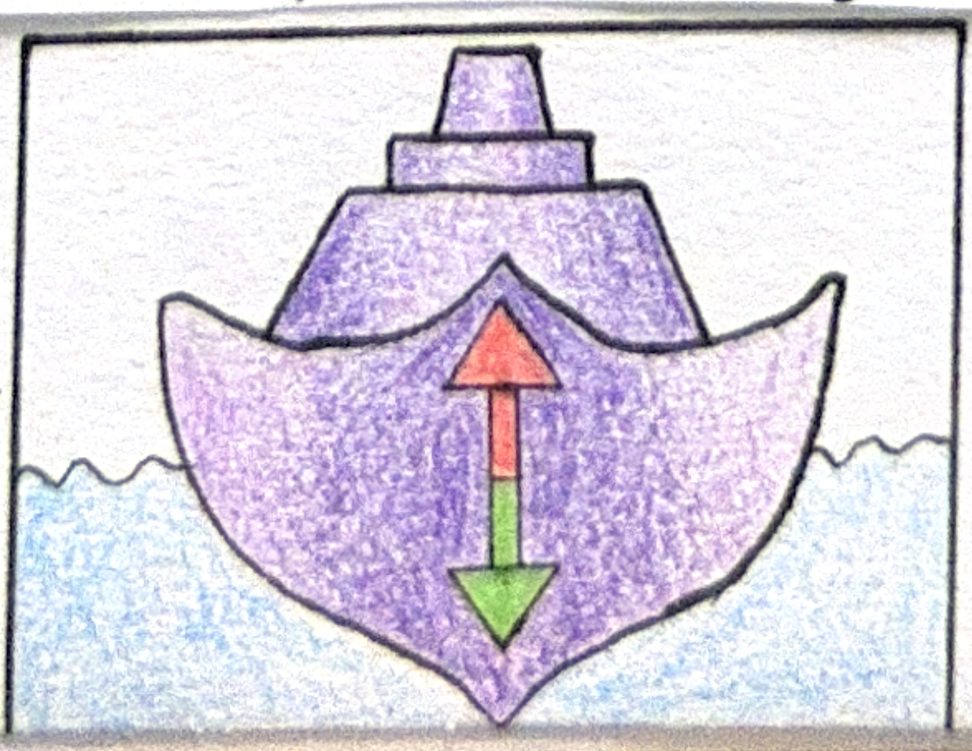
- A paper ship is lightweight, but its shape allows it to displace a lot of water. - Because it is lightweight and occupies a large volume, it displaces water, whose weight is sufficient to counteract gravity. The buoyant force is equal to the weight of the displaced water, and this allows the ship to stay on the surface of the water.

- A heavy ship has a lot of mass, but its shape and design allow it to occupy a large volume, displacing a lot of water. Although the mass of the ship is large, its volume and shape allow it to displace enough water that the buoyant force is greater than or equal to the pull of gravity and the ship will remain on the surface of the water.

Why don't large ships drown?

Although a large ship weighs a lot, its shape allows it to displace a huge amount of water. The ship has a large volume, but this volume is not completely filled with material - there are cavities that allow more water to be displaced than the ship itself weighs. The force of gravity pulling the ship down is balanced with the buoyant force acting from the water. The ship will remain on the surface as long as the buoyant force is greater than or equal to the force of gravity.





$F_B = \rho g V$

ρ : density of fluid

g : gravity, $-9.81\ m/s^2$

V : volume

Let's investigate!

What do you need? A container with water, one egg, and salt.

What to do?

- Put the egg in the water.
- Dissolve 4 spoons of salt in the water. Lower the egg into the water.
- Observe and write down the results.

	Sank	Floated	Stayed on the surface
Egg in water			
Egg in salty water			

Research question: does the action of the buoyant force depend on the liquid in which the body is placed?

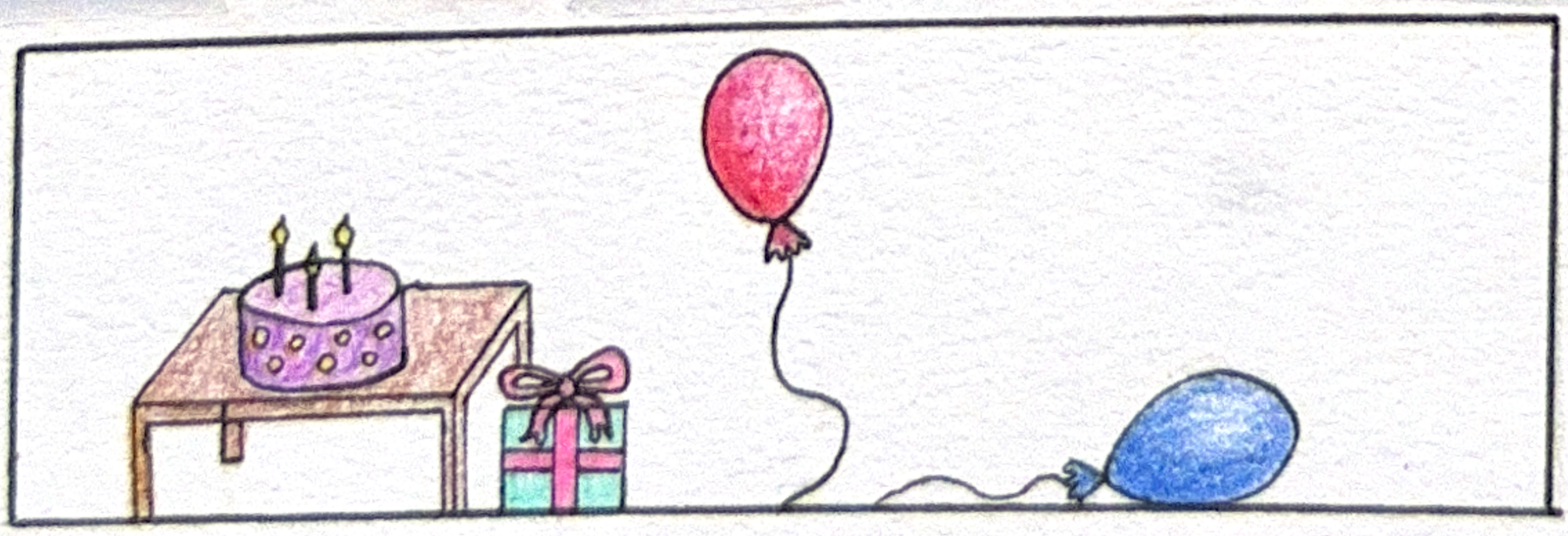
Results: when we add salt to the water, we increase the density of the water. Gravitational force becomes equal to the buoyant force.

A moment of geography!

It is easier for people to swim in the Dead Sea or salt lakes because of the high density of the water, which is caused by the high salt content. The buoyant force depends on density. In ordinary fresh water, the density is about 1000 kg/m³, and in saline water bodies such as the Dead Sea, this density is much higher (it can reach 1200-1300 kg/m³).

Does this only apply in water?

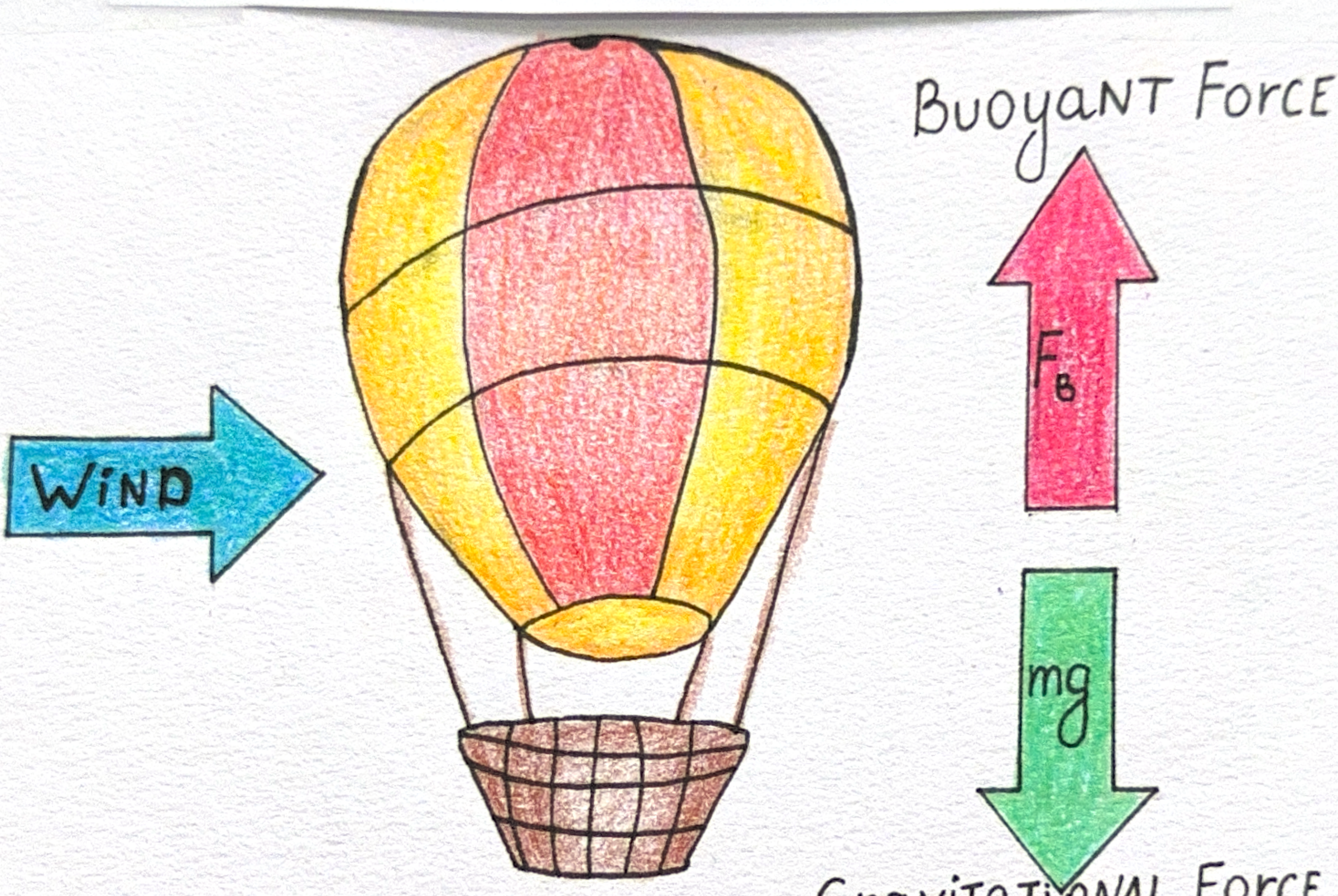
Think about the most recent birthday party you've been to.



Compare the two. Why does the red one stay in the air, and the blue one lies on the ground?

One balloon is filled with helium and the other one with air. Helium is lighter than air, which makes it easy for the balloon filled with it to fly up, with the help of buoyant force. Since the other one is filled with air, it stays in the same position, because there's no buoyant force.

Archimedes' Principle works in the air just like in the water!
You can observe it with an example of a hot air balloon.



A balloon moves easily in the air. The warm air inside the balloon is lighter than the cold air outside. Therefore, the balloon rises upwards under the action of Archimedes' force.

Now you know that:

1) If the force of gravity is greater than Archimedes' force, the body sinks; if the forces are equal, the body floats in the liquid; if the force of gravity is less, the body stays on the surface of the liquid;
2) Objects with the same mass and different volume have different buoyant forces acting upon them.
3) Liquid density in which the object is present influences the buoyant force.
4) Archimedes' force acts in water and in air.