ScienceCube

Weight in Water

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1. **Be able to measure and compare the weight of an object in water and in air.**
2. **Be able to measure and compare the weight of an object submerged in water based on its orientation, volume, and depth.**

Fundamental Concept

1. Archimedes

Greek scholar Archimedes discovered the principle of buoyancy and the relationship between buoyancy and the displaced fluid when he observed water spilling over when he got into a full bathtub. This principle applies not only to liquids but also to gases..

2. Buoyancy

① Buoyancy is the upward force exerted by a fluid that opposes the weight of an object immersed in it.

② The pressure exerted on the bottom of an object submerged in fluid is greater than the pressure on the top, causing the object to float.

3. Relationship between the Densities of Objects and Fluids

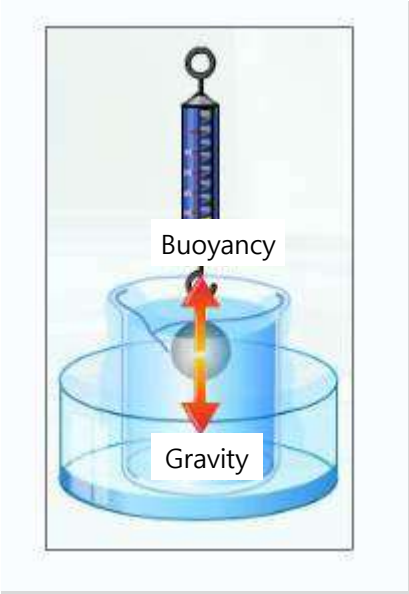
If the density of an object > density of the fluid: the object sinks.

If the density of an object = density of the fluid: the object remains suspended in the fluid.

If the density of an object < density of the fluid: the object floats. (The greater the difference in density, the more the object will float.)

4. Weight Measurement in Air and Water

In the air, only gravity acts on the object, so its weight is shown on a spring scale. In water, both gravity and buoyancy act on the object. Therefore, the weight shown on the spring scale in water is the net force of gravity and buoyancy..



5. **Applications of Buoyancy**

Ad balloons: Filled with a gas lighter than air, ad balloons rise because the buoyancy from the air is greater than the weight of the gas.

Life vests: Containing gas lighter than water, life vests provide great buoyancy, keeping people afloat.

Fish swim bladders: When fish inflate their swim bladders, buoyancy increases, causing them to rise.

Experiment

Materials

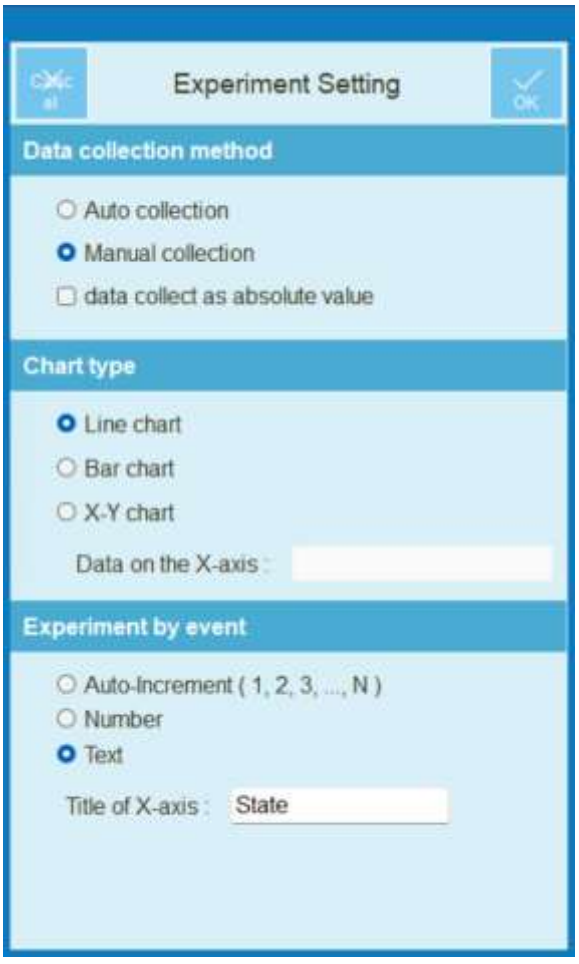
Interface, Science# program, force sensor, electronic scale, stand, transparent cup, petri dish, 200g weight, string, clip, scissors, water tank, glass bottle, dropper

Experiment Setup

1. Connect a clamp to the stand and securely attach the force sensor as shown in the diagram.
2. Tie a string to the hook of the force sensor and attach a clip to the other end.

Interface Settings

1. Run the Science# program.
2. Connect the force sensor to the interface..
3. Press the button to zero the force sensor.
4. Press the button to configure the experimental environment as shown below or press the button to auto-configure.



[Auto Configuration]

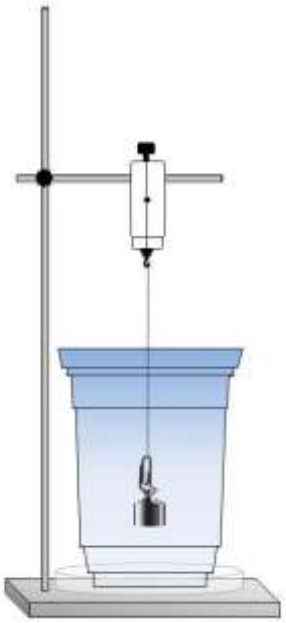
Data Collection

[Experiment 1] Comparing the Weight of Objects in Water and Air

1. Place a petri dish on the electronic scale and zero it.
2. Press the button, attach a weight to the clip on the force sensor, and measure

and record the weight of the object in the air..

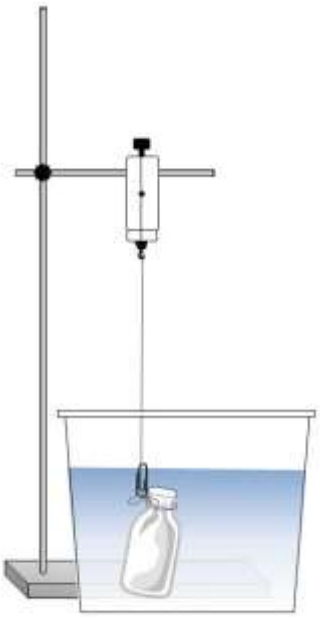
3. Place a transparent cup filled to the brim with water on the petri dish on the electronic scale. (Use a dropper to ensure the water is as full as possible without spilling over.)
4. Slowly lower the clamp so that the weight is submerged in the water, ensuring it doesn't touch the bottom of the cup, and measure and record the weight.
5. Lift the weight out of the water and carefully remove the transparent cup from the electronic scale.
6. Measure and record the mass of the overflowed water.



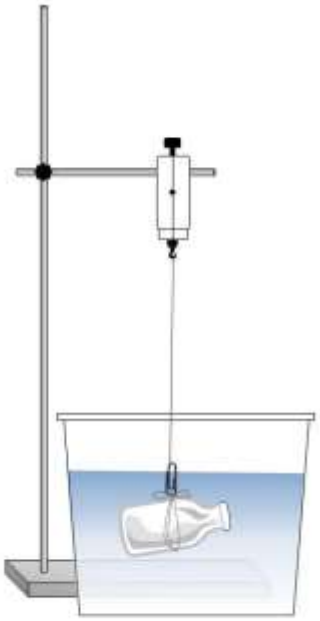
[Experiment 2] Factors Affecting Weight in Water

■ Weight Based on Submersion Orientation

7. Tie a string around the middle and neck of the glass bottle several times to create a loop.
8. Fill the water tank with water so that the glass bottle can be fully submerged (at least 3/4 full).
9. Attach the clip on the force sensor to the loop at the neck of the bottle and hang it upright.
10. Slowly lower the clamp to submerge the glass bottle deeply in the water, then measure and record the weight.
11. Lay the glass bottle horizontally in the water and measure and record the weight..



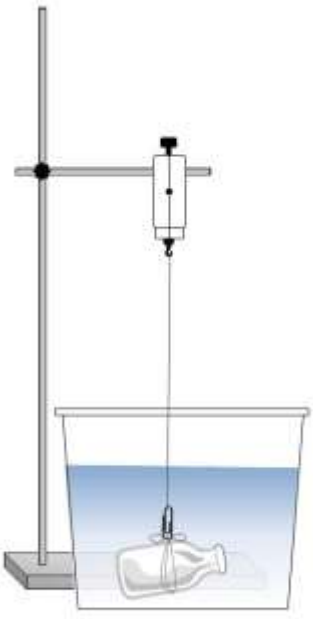
Vertically upright state



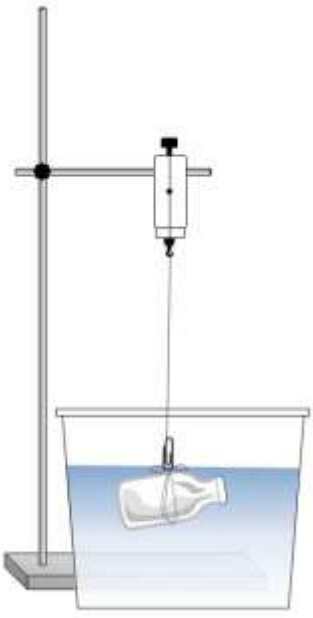
Horizontally laid state

■ Weight Based on Submersion Depth

12. Lay the glass bottle horizontally and submerge it deeply in the water, just before it touches the bottom of the tank. Measure and record the weight.
13. Keep the glass bottle horizontal and submerge it shallowly in the water. Measure and record the weight.



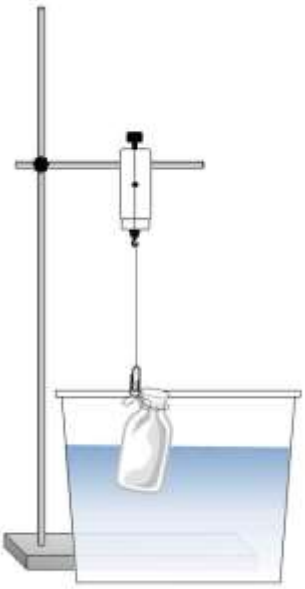
Deeply submerged state



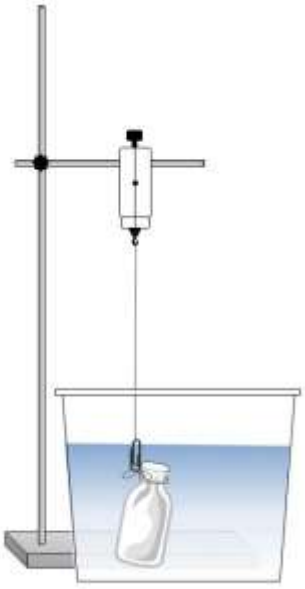
Shallowly submerged state

■ Weight Based on Submerged Volume

14. Attach the clip to the loop at the neck of the glass bottle and stand it upright. Submerge the bottle halfway in the water, then measure and record the weight.
15. Submerge the entire glass bottle in the water, then measure and record the weight.



Half-submerged state



Fully submerged state

Data Analysis

Recording Results

1. Record and plot the weights measured in air and water on a bar graph and in the table below.
   [Bar Graph]

   [Table]

Weight in Air (N)	Weight in Water (N)	Change (N)

2. Measure and record the mass and weight of the overflowed water..

Mass of Overflowed Water (g)	Weight of Overflowed Water (N)

3. Record and plot the weights of the glass bottle under different conditions on a bar graph and in the table below.

[Bar Graph]

[Table]

Submersion Orientation	Weight (N)
Upright Position	
Horizontal Position	

Submersion Depth	Weight (N)
Deep	
Shallow	

Submerged Volume	Weight (N)
Half	
Full	

Applying Data

1. Explain the difference in weight when measured in air and in water.

2. Express the relationship between the change in weight of the object and the amount of overflowed water in a mathematical equation.

3. Explain why the weight changes when measured in air and in water.

4. Identify the variables that do not affect the weight measured in water.

5. Identify the variables that do affect the weight measured in water.

6. Explain how to make an object weigh less in water..

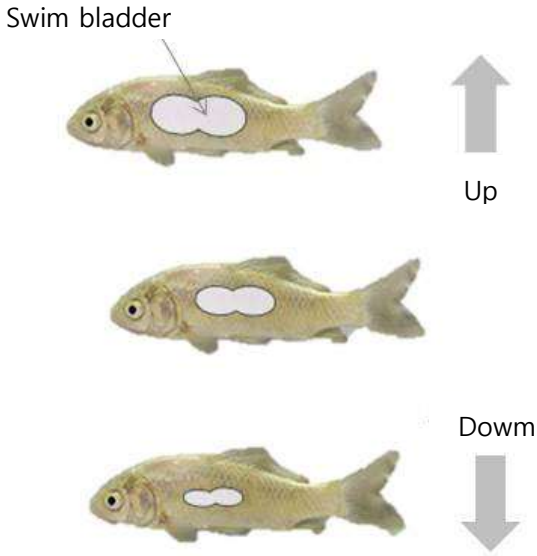
Extended Activities

1. Calculate the weight of the overflowed water when a 750g weight is placed in a beaker full of water and the measured weight is 710g.

2. Identify the phenomena caused by buoyancy.

    ① The spring scale stretching
    ② An apple falling to the ground
    ③ A submarine floating and sinking
    ④ The uneven soles of hiking boots
    ⑤ The attraction between two poles of a magnet

3. The following explains the principle by which fish can move up and down in the water. Fill in the blanks in the diagram



To float or sink in water, a fish needs to change its (A _____). The force acting upwards, equal to the weight of the displaced water, is called (B _____). To adjust this, the fish has an air sac called a (C _____) near its back. Normally, it keeps a certain amount of air in it, but when moving up or down, it adjusts by adding or removing air. Usually, when the air sac expands, the fish's (D _____) increases, resulting in greater buoyancy, causing it to rise.