8th Laboratory exercise

Buoyancy-Archimedes' Law

Theoretical part

Have you ever wondered what forces keeps your body on the surface of the sea when you swim? Which force keeps ships on the surface of the sea, lake or rivers when they travel?
It's the same force that prevents you from sinking a balloon into the water. Each liquid exerts strength on the bodies that sink into it. This power is called **Buoyancy**.

It is easier to lift a stone when it is immersed in the water than when it is outside. You form the impression that the weight of the stone decreases when you immerse it in the water. If you hang it from a dynamometer, the indication of the dynamometer when the stone is in the water is less than the indication when the stone is in the air (Fig. 1). The weight of the stone, i.e. the gravitational force that the earth exerts on the stone, is the same either the stone is in the water or it is in the air.

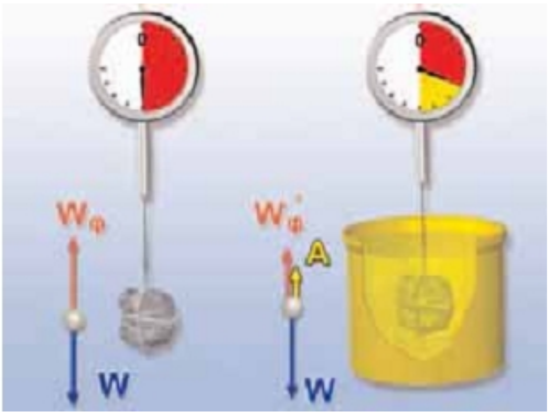

Fig. 1: The buoyancy has a vertical direction and is once upward.

Why does the dynamometer show a smaller indication when the stone is hung in the water? The water exerts on the stone a force that we called buoyancy: A. The indication of dynamometer, W_φ, is equal to the measure of force the dynamometer exerts on the stone. The stone is balanced. So, when it is in the air, it applies: $W_\varphi=W$,
While immersed in water: $W'_\varphi+A=W$, *i.e* $W'_\varphi=W-A$, *so* $\boldsymbol{A=W-W_\varphi{}'}$

1. Buoyancy does not depend on the shape and weight of the body being immersed.
2. If a body is <u>Entire</u> Immersed in the liquid, buoyancy is independent of the depth at which it is located.
3. The liquid with the highest density exerts greater buoyancy.
   - Buoyancy increases when the volume of fluid that is displaced by the body is increased, which we plunge into it.

Archimedes gathered all the above observations and formulated a proposal known as **Archimedes ' principle**:

Fluids exert Force in every body that sinks into them. This force is called buoyancy, it is perpendicular, and its value equals the weight of the fluid being displaced by the body.

$$A = W_{displaced\ liquid}$$

$$A = \rho_{liquid} \cdot g \cdot V_{displaced\ liquid} \quad \textbf{(Archimedes Law)}$$

Where A *is the* Buoyancy exerted on a body immersed in liquid with density ρ and $V_{displaced}$ *the* volume of liquid being displaced.

Experimental part

instruments, apparatus and materials:

1. Dynamometer
2. Calibrated Beaker
3. Teflon Roller
4. Water

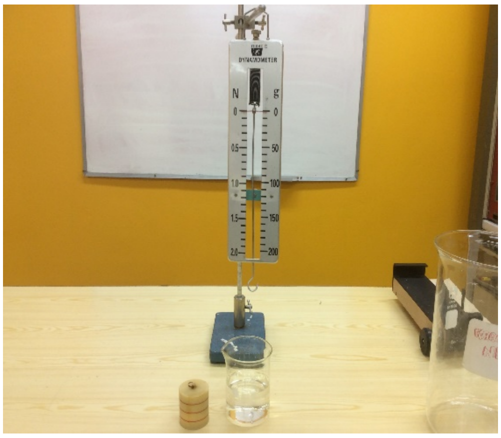

Fig. 4: Experimental apparatus

Experimental procedure:

1. We hang from the 2 N dynamometer The cylinder, let it balance and denote the indication of the dynamometer which equals the weight of the roller. So:

$$F_{dyn(air)} = W_{cylinder} = \ldots\ldots\ldots N$$

2. Fill the beaker up to the Mark 200 ml with water. We sink the cylinder **Until the second mark** (Lowering the dynamometer) and note the indication.

$$F'_{dyn(liquid)} = \ldots\ldots\ldots N$$

3. Compare the two dynamometer indications. Can you explain the difference you observe? To what force can we attribute the difference between the indications of the dynamometer?

4. In step 2, we fill the beaker until the 200 ml and we sunk the cylinder until the second mark. The water level on the beaker went up. Note the volume of water when we sank the cylinder until the second mark. This volume is the $V_{displaced\ liquid}$.

$$V_{displaced\ liquid} = \ldots\ldots\ldots ml$$

5. Considering that the water density is $\rho_{Liquid} = 1\ gr/cm^3$ and the $g = 10\ m/s^2$ Calculate from the relationship (2) buoyancy A Applied to the cylinder. Compare this value to the one that you calculated in step 2. What do you notice?

6. Why do we float more easily to the sea than to a lake or pool (with "sweet" water)? You can answer the above question if you know that saltwater (seawater) has a higher density than pure water (lake water).

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