Class: 2^{nd} stage

Subject: Fluid flow

Ministry of Higher Education and Scientific Research

Al-Mustaqbal University College

Chemical engineering and petroleum industries

(Fluid Flow Lab)

Experiment No. 5

Buoyant Forces and Archimedes Principle

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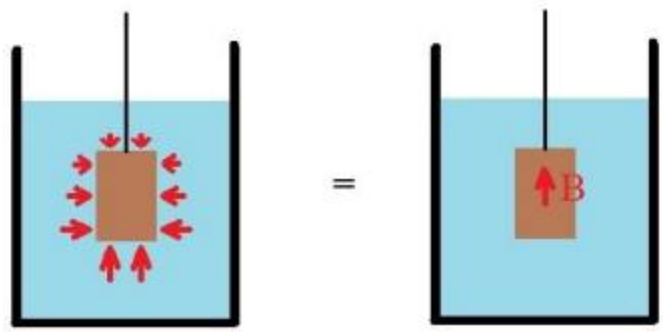
The aim of the experiment:

- To study buoyant force and equilibrium in fluids.
- To explain Archimedes' Principle.
- To use Archimedes' Principle to determine the density of a solid sample.

Introduction:

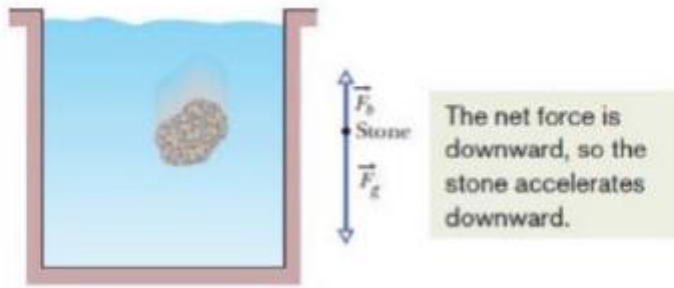
Archimedes' principle states that a body fully or partially submerged in a fluid is buoyed up by a force equal in magnitude to the weight of the fluid displaced by the body. This force is given by:

$$F_B = \rho V g$$

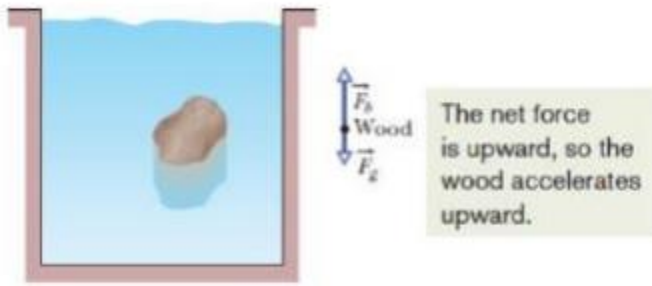


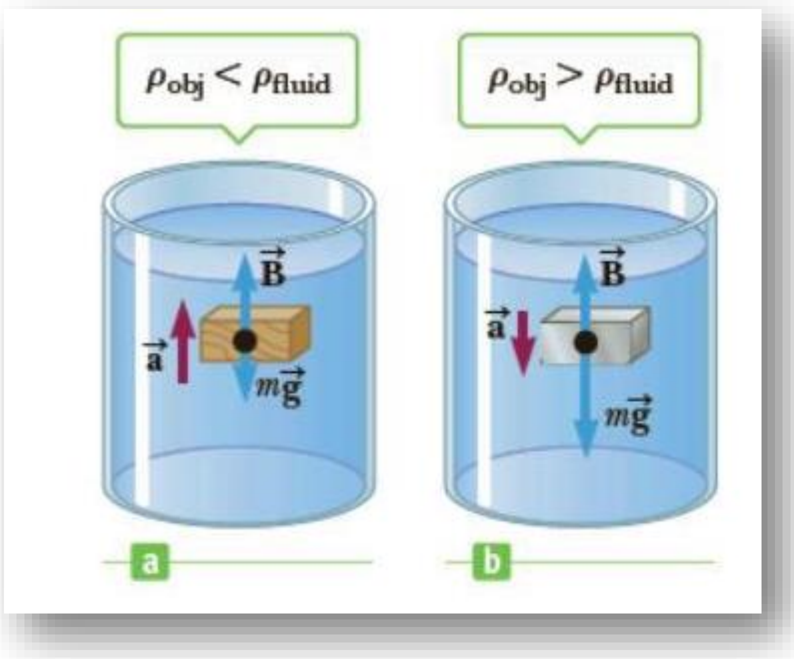
Where (ρ) is the density of the fluid, V is the volume of fluid displaced and g is acceleration due to gravity. It is the buoyant force that keeps ships afloat in water.

- If a stone is immerged in water, It will sink. The direction of the resultant force will be downside due to the difference in densities between the stone and the water ($\rho_{obj.} > \rho_f$).



- If a piece of wood is immerged in water, It will float. The direction of the resultant force will be upside due to the difference in densities between the wood and the water ($\rho_{obj.} < \rho_f$).

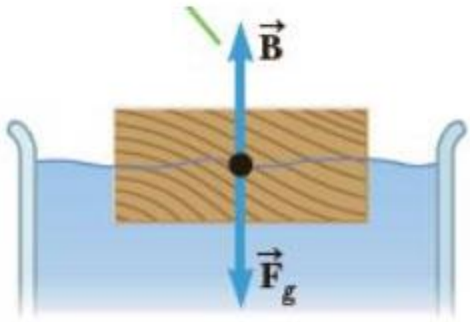




Therefore, there will be two cases of immersion:

- Partially immersioed

In this case, the body will float. Moreover, in the case of equilibrium, the buoyant force will be equal to the weight of the immersioed part of the body.



$$Fb=W=mg \text{ or}$$

$$luid V_{fluid} g = \rho_{obj} V_{obj} g \Rightarrow\Rightarrow \quad \frac{\rho_{obj}}{\rho_{fluid}} = \frac{V_{fluid}}{V_{obj}}$$

- Fully immersioed

If a body is fully immersioed, it will sink.

The buoyant force will be given in the following equation:

$$F_b = \rho_{fluid} V_{obj}\, g$$

Moreover, the weight will be given in the following equation:

$$W = \rho_{obj}\, V_{obj}\, g$$

True and apparent weight:

There is a difference between the real weight of the body and its weight when it will be immersioed in water. The difference between true and apparent weight belongs to the buoyant force. The buoyant force can be determined in the following equation:

Buoyant force F_B = weight in air (W_a) – apparent weight (W_L)

Conclusion:

1. When a body immersioed in water, the loss in its weight will be equal to the buoyant force.
2. The volume of the displaced water equals the volume of the immersioed part of the body.

Apparatus:

Spring balance, a ball of iron, Graduated cylinder and a bowl full of water.

Procedures:

- Determine the weight of the ball in air.
- Immerse the ball in the bowl and determine its weight in water.
- Find the buoyant force from the following equation:
  Buoyant force FB = weight in air (Wa) – apparent weight (WL)
- Collect the displaced water in the graduated cylinder and determine its volume.
- Determine the mass of the displaced water by multiplying the volume and the density of the fluid, then determine the weight.
- Compare the buoyant force with the weight of the displaced water. if they were equal, then the rule is fulfilled.

Results and conclusions:

According to the previous experiment, if the weight of the ball was 5 Newton, and after placing it in water, its weight became 4.5 Newton, then its density is calculated through

$F=W_a-W_L$

$5-4.5=0.5\ N$

$F= mg = \rho vg$

$0.5= v\ x1000x10$

$=5x10^{-5}\ m^3$

$W= mg$

$= \rho vg$

$5= \rho\ x5x10^{-5}\ x10$

$\rho = 10^4\ kg/m^3$

Discussion:

1. **What are the applications of Archimedes principle?**
2. **What types of fluids does Archimedes' principle apply to?**
3. **Determine the buoyant force that affect on an iron ball fully immersioed in water its radius equals 30 mm, known that the density of the ball equals 7900 Kg/m3.**