ATOMIC ENERGY CENTRAL SCHOOL-KAKRAPAR

CLASS- IX

SUBJECT- PHYSICS

NAME OF THE CHAPTER- GRAVITATION

MODULE-5

Subtopics-

Archimedes Principle

Application of Archimedes Principle

Relative density

Determination of Density of Solid

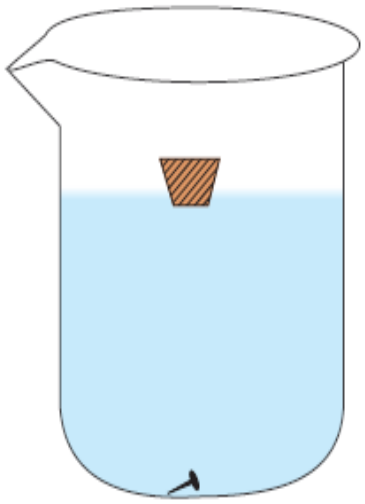
Introduction

- What is the magnitude of the buoyant force experienced by a body?
- Is it the same in all fluids for a given body?
- Do all bodies in a given fluid experience the same buoyant force?
- The answer to these questions is contained in Archimedes's principle, Let us do the following activities to arrive at an answer for the above question.

Activity

- Take a beaker filled with water.
  • Take a piece of cork and an iron nail of equal mass.
  • Place them on the surface of water.
  • Observe what happens.

  The cork floats while the nail sinks. This happens because of the difference in their densities. The density of a substance is defined as the mass per unit volume. The density of cork is less than the density of water. This means that, the upthrust of water on the cork is greater than the weight of the cork. So it floats (Fig. 10.5).
  The density of an iron nail is more than the density of water. This means that, the upthrust of water on the iron nail is less than the weight of the nail. So it sinks.
  Therefore if density of objects is less than liquid it will float on the liquid. If the density of objects is greater then liquid, it will sink in the liquid.



10.5: *An iron nail sinks and a cork floats when placed on the surface of water.*

Archimedes Principle

When a body is immersed fully or partially in a fluid, it experiences an upward force (buoyant force) that is equal to the weight of the fluid displaced by it.

or

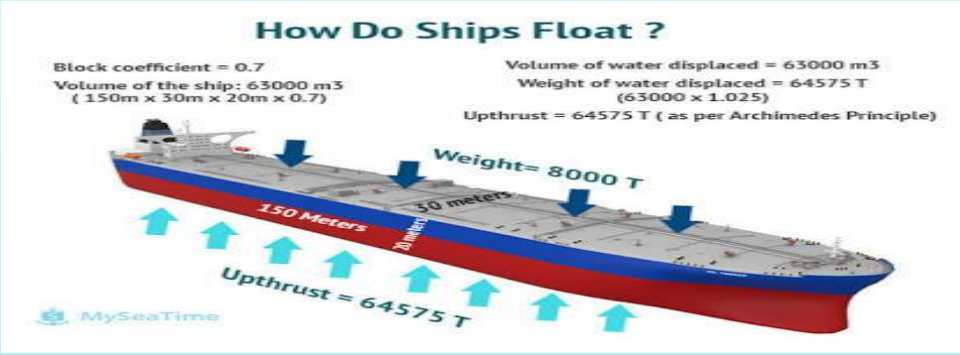
That is weight of liquid displaced by a immersed part of the body = Buoyant force

Applications of Archimedes Principle

Q1. An iron nail sinks in water but a ship made of iron floats?

The floating of a big ship is based on the Archimedes' principle. An iron nail sinks because it has more weight than the weight of the water it displaces.

In other words, the density of the iron nail is greater than the density of water.



In case of a ship, a large portion of it is hollow inside. This reduces the apparent density of the ship to a value less than the density of water. The weight of the water displaced by the ship is much more than its own weight. This makes the ship float on water.

Applications of Archimedes Principle

Q2.How do submarines go up and down in the sea-water?

A submarine can dive into the water or rise to the surface as needed. The most important compartments of a submarine that help in its floatation are the ballast tank, and the compressed air tank.

To dive, the ballast tanks are filled with water so that the average density of the submarine becomes greater than the density of sea water, therefore submarine dives.

To rise,

the water from the ballast tanks is forced out into the sea by pushing air from the compressed air tank to ballast tank. As a result, the average density of the submarine decreases, therefore submarine rises.

Applications of Archimedes Principle

- **Fish float based on Archimedes' principle. Most fish have an organ known as the swim bladder. When they want to rise, fish release gas into the swim bladder and increase their volume. As a result, they displace more water. The force of buoyancy acting on them increases. To come down, a fish empties the bladder to the required extent, reducing the volume and the force of buoyancy acting on it.**

- A hot air balloon rises and floats due to the buoyant force (when the surrounding air is greater than its weight). It descends when the balloon's weight is higher than the buoyant force. It becomes stationary when the weight equals the buoyant force.

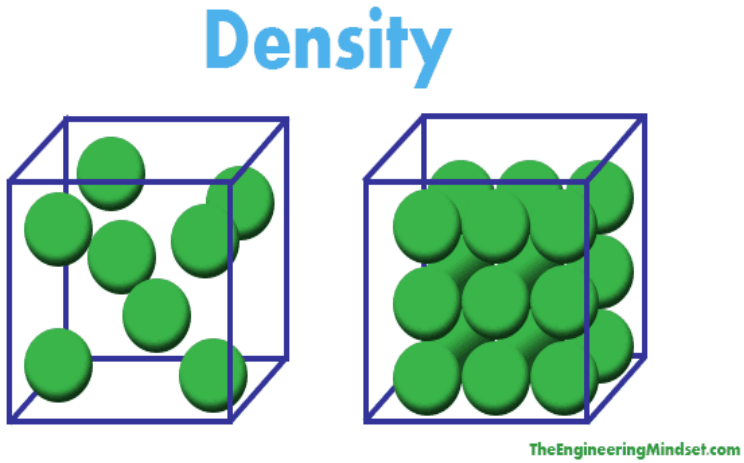
- Lactometers, which are used to determine the purity of a sample of milk and hydrometers used for determining density of liquids, are also based on this **Archimedes** principle.

Density of a substance

Definition and Equation

$$\text{density} = \frac{\text{mass}}{\text{volume}} \rightarrow D = \frac{M}{V}$$

- Density is the mass per unit volume of an substance or material.
- Units
  - $kg\ m^{-3}$
  - $g\ cm^{-3}$
  - Density in $g\ cm^{-3} \times 1000 \rightarrow kg\ m^{-3}$



Relative density

As you know, the density of a substance is defined as mass of a unit volume. The unit of density is kilogram per meter cube (kg m^{-3}). The density of a given substance, under specified conditions, remains the same. Therefore the density of a substance is one of its characteristic properties. It is different for different substances. For example, the density of gold is 19300 kg m^{-3} while that of water is 1000 kg m^{-3}. The density of a given sample of a substance can help us to determine its purity. It is often convenient to express density of a substance in comparison with that of water. The relative density of a substance is the ratio of its density to that of water:

$$\text{Relative density} = \frac{\text{Density of a substance}}{\text{Density of water}}$$

Since the relative density is a ratio of similar quantities, it has no unit.

Law of floatation in terms of Relative density

- If Relative density > 1, ==> Sink in water
  (density of object > density of water)
- If Relative density < 1, ==> Float on water
  (density of object < density of water)

- If Relative density = 1, ==> Float inside the water
  (density of object = density of water)

Example-1: Relative density of silver is 10.8. The density of water is 10^3 kg m^{-3}. What is the density of silver in SI unit?

Solution:

Relative density of silver = 10.8

$$\text{Relative density} = \frac{\text{Density of a substance}}{\text{Density of water}}$$

Density of silver = Relative density of silver x Density of water

$= 10.8 \times 10^3$ kg m^{-3}.

Example-2: The volume of a 500 g sealed packet is 350 cm^3. Will the packet float or sink in water if the density of water is 1 g cm^{-3}? What will be the mass of the water displaced by this packet?

Given that : Volume of sealed packet(object) = 350 cm^3

Mass of sealed packet(object) = 500g

density of water = 1 g cm^{-3}

$$\text{Relative density} = \frac{\text{Density of a substance}}{\text{Density of water}}$$

Density of sealed packet (object) = 500/350

= 1.428 g cm^{-3}

Here, density of sealed packet > density of water, hence it will sink in water.

Since mass of water displaced by packet = volume x density of water

= 350 x 1

= 350 g

Determination of Density of Solid

ACTIVITY :How can you determine the density of a solid (denser than water)?

Material required:


Iron stand


Measuring jar


Steel bob


Iron block


Spring balance


Copper lock


Wooden block


Stone

A metal bob with a hook, thread, measuring cylinder and spring balance.

Determination of Density of Solid

How will you proceed?

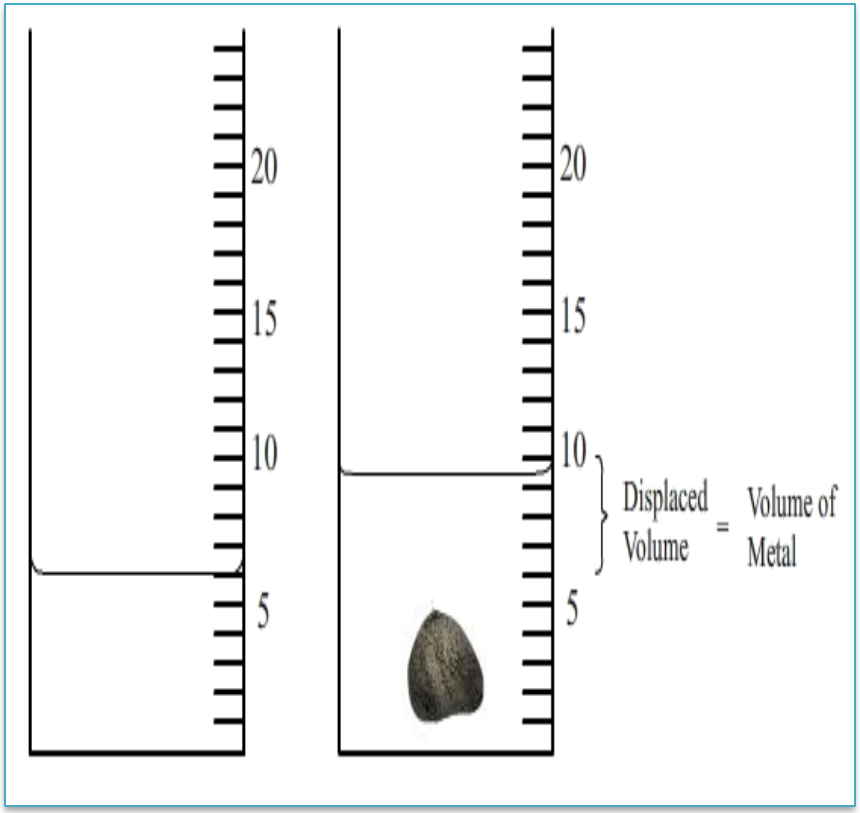
1. Take a metal bob , Suspend it from the hook of a spring balance using a thread. Note down its mass.

Determination of Density of Solid

2.Take a measuring cylinder and fill about half of it with water. Note the reading of water level in the measuring cylinder. Now suspend the bob in the measuring cylinder so that it is completely immersed in water.

3. Note down the level of water in the measuring cylinder.

4. The difference in the two readings of the measuring cylinder is the volume of the metal bob.



Determination of Density of Solid

$$D = \frac{mass}{volume}$$

Find out the ratio of mass of the bob in air to the volume of the metal bob. This gives you the density of material of the bob in kg m^{-3} or g cm^{-3}.

THANK YOU