

CHAPTER-10

GRAVITATION

Module-5

Class-IX (PHYSICS)

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?

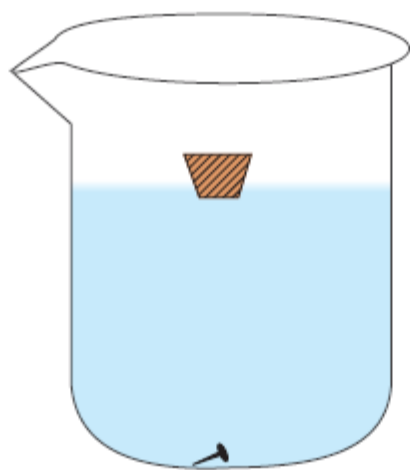
The answer to these questions is contained in Archimedes' principle, stated as follows:

Let us do the following activities to arrive at an answer for the above question.

Activity

- Take a beaker filled with water.
- Take an iron nail and place it on the surface of the water.
- Observe what happens.

The nail sinks. The force due to the gravitational attraction of the earth on the iron nail pulls it downwards. There is an upthrust of water on the nail, which pushes it upwards. But the downward force acting on the nail is greater than the upthrust of water on the nail. So it sinks (Fig. 10.5).



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

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:

$$\text{Relative density} = \frac{\text{Density of a substance}}{\text{Density of water at } 4^{\circ} \text{ C}}$$

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

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

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

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

$$\begin{aligned} \text{Density of silver} &= \text{Relative density of silver} \times \text{Density of water} \\ &= 10.8 \times 10^3 \text{ kg m}^{-3}. \end{aligned}$$

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}

$$\begin{aligned} \text{Density of sealed packet (object)} &= \frac{\text{Mass of object}}{\text{volume of object}} \\ &= \frac{500}{350} = 1.428 \text{ g cm}^{-3} \end{aligned}$$

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

$$= 350 \times 1$$

$$= 350 \text{ g}$$