Chapter Seven

Density:

- The density of a substance is defined as its mass per unit volume.
- In short, density = $\frac{Mass}{Volume}$

Determination of the density of a regularly shaped body:

- Objects such as the cube, cuboid, cylinder and the sphere are examples of objects having regular shapes. In order to determine the density of any of such objects, one must go through the following steps:

1. The mass or the weight of the object is determined, by using a weighing machine or a spring balance.

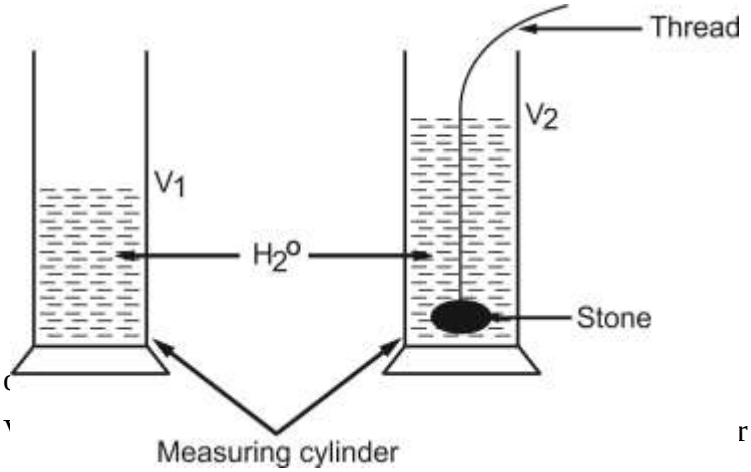
2. Since the body has a regular shape, its dimensions (i.e. the length, the breadth and the height) can be measured by using a ruler or a tape.

3. Using these dimensions, the volume of the object can be calculated.

4. The mass is then divided by the volume to get the density.

5. The unit of density is g/cm^3 (gcm^{-3}) or kg/m^3 (kgm^{-3}).

Determination of the density of an irregularly shaped object:



V_2 = the final volume of water after the immersion (or putting) of the stone into the water.

The volume of stone = $V_2 - V_1$.

- Objects such as a stone or a piece of rock, are examples of irregularly shaped objects.
- To determine the density of any of such objects, one must go through the following steps:

(1) The mass or the weight of the object must first be determined, using a weighing machine or a spring balance.

(2) To determine the volume of the object, we first put water into a measuring cylinder, and the volume of water within the measuring cylinder is noted

(3) The object is attached to a thread, and then immersed into the water within the measuring cylinder, and the new volume of the water is also noted.

(4) The difference between the first and the second volumes of water within the measuring cylinder, gives us the volume of the object (stone).

(5) The mass is then divided by the volume to get the density.

Apparent loss in weight:

- When a body is placed in water, a force acts on it in the upward direction, which causes a decrease in its weight.
- The presence of this force which is called upthrust, can be demonstrated by tying a length of cotton thread to the brick.
- Any attempt made to lift the brick by the cotton fails, through the breakage of the cotton.
- When the brick is immersed in water, it will be noted that it can easily be lifted, without any breakage in the cotton, so long as it remains in the water.

Reason why a body may sink or float in water:

- If a body is placed in water and its density is less than that of water, then that body or object will float in water.
- On the other hand, if the density of the body is greater than that of water, then it will sink in water.
- For this reason, a piece of solid steel will sink in water, since its density is greater than that of water.
- But a ship made of steel will not sink, since its density is less than that of water.
- Since the ship has a hollow portion which contains air, which causes a decrease in its mass and as such its density, the density of such a ship will be less than that of water, causing it to float in water.

The submarine:

- This is a specially designed or made ship, which is capable of moving above and below the surface of the sea.
- The submarine has ballast tanks, which can be filled or emptied when the need arises.
- By filling these tanks, the mass of the submarine is increased, causing an increase in its density.
- Its density therefore becomes greater than that of water causing it to sink.
- In order for it to float or rise to the surface of the water, the water is ejected or removed from the ballast tanks using compressed air.
- A decrease in the mass of the submarine occurs, causing its density to fall and become less than that of water.
- The submarine therefore rises to the surface and floats.

Density and gases:

- Gases also have densities just like solids or liquids.
- If the density of a particular gas is less than that of air, then that gas will rise in air.
- For this reason, a gas such as smoke or hydrogen rises in air.
- Apart from that if a gas is put into a balloon, and its density is less than that of air, the balloon will rise in air.
- For this reason, a balloon filled with smoke or hydrogen rises in air.
- But if the density of the gas within the balloon is greater than that of air, then the balloon will not rise in the air.

Uses of density:

(I) Used by chemist to determine how pure a substance is.

(II) Used by engineers to design structures such as bridges and buildings.

(Q1) A lump of metal has a weight of 72g and a volume of $20cm^3$. Find its density.

Soln:

Density = $\frac{Mass}{Volume}$

= $\frac{72}{20}$ = $3.6gcm^{-3}$.

(Q2) A piece of gold has a density of $5g/cm^3$ and a volume of $15cm^3$. Calculate its mass.

Soln:

Since density = $\frac{Mass}{Volume}$, =>

mass = density x volume,

=>mass = 5 x 15 = 75g.

(Q3) A piece of stone weighs 60g. When it was put into a measuring cylinder containing water, the water level rose from the $55cm^3$ mark to the $75cm^3$ mark. Find the density of the stone.

Soln:

Initial volume of water = $55cm^3$.
Volume of water after the immersion of the stone = $75cm^3$.
Volume of stone = 75 – 55 = $20cm^3$.
Mass of stone = 60g.
Density o stone = $\frac{Mass}{Volume}$, = $\frac{60}{20}$ = $3gcm^{-3}$.

(Q4) A cuboid made of silver has a weight of 200g. It has a length of 8cm, breadth of 4cm and a height of 2cm. Determine its density.

Soln:

Volume of cuboid = L x B x H
= 8 x 4 x 2 = $64cm^2$.
Mass of cuboid = 200g.
Density = $\frac{Mass}{Vollume} = \frac{200}{64}$
= $3.1g/cm^3$.

(Q5) An aluminum cube of side 5cm has a mass of 0.05kg. Find its density.
N/B: Since the length or the side of the cube is given in centimetres, then the mass in kilogram must be converted into grams.

Soln:

Mass = 0.05kg
= 0.05 x 1000 = 50g.
Volume of cube = side cubed
= $5^3 = 125cm^3$.

Density = $\frac{Mass}{Volume=} = \frac{50}{125}$

= $0.4gcm^{-3}$.