Physical Quantities and Measurement

Physical Quantities:

- A physical quantity is a quantity that can be measured.
- Length, time, mass and temperature are the fundamental physical quantities.
- A physical quantity can be expressed as the combination of a numerical value and a unit. For example, the physical quantity mass can be quantified as n kg, where n is the numerical value and kg is the unit.

Measurement

Comparing an unknown quantity with some known quantity is called measurement.
Result of Measurement: The result of measurement has two parts; one part is the number and another part is the unit.
The known quantity which is used in measurement is called a unit.
For example; when you say that your height is 150 cm then the measurement of your height is being expressed in a number, i.e. 150 and a unit, i.e. centimetre.

Length

- It is the distance between two points
- Its SI unit is metre (symbol m)
- It is measured with the help of a metre ruler or a measuring tape.

Mass

- It is the quantity of matter contained in the body.
- Its SI unit is kilogram (symbol kg)
- It is measured using a beam balance or an electronic balance

Time

- It is the interval of occurrence of an event.
- Its SI unit is second (symbol s)
- It is measured with the help of a pendulum clock or a watch

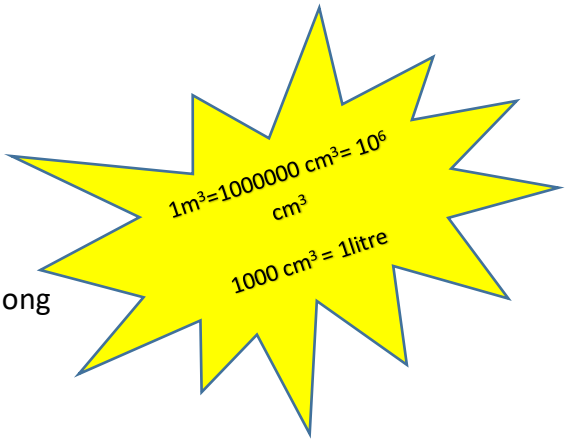
Temperature

- It is a quantity which measures the hotness and coldness of a body
- Its SI unit is Kelvin (symbol K)
- It is measured using a thermometer.

Measurement of Volume

Volume

The space occupied by an object is called its volume.
SI Unit of Volume
The SI unit of volume is cubic meter(m^3)
One cubic meter is the volume of a cube with each side 1m long
$1m^3$=1m*1m*1m
Relation between m^3 & cm^3
$1m^3$ = 1m × 1m × 1m
=100cm ×100cm ×100cm
=1000000 cm^3



The volume of liquids is generally expressed in liter (symbol L)
1000 cm^3 make one litre
i.e.,
1000 cm^3 = 1litre

Vessels for measuring the volume of liquids

To measure the volume of liquid such as water, milk, oil etc.,
We generally use the following two kinds of vessels:

- Measuring cylinders
- Measuring beakers

Measuring cylinders

- ✓ Measuring cylinder is a common piece of laboratory equipment used to measure the volume of a liquid.
- ✓ It has a narrow cylindrical shape.
- ✓ Each marked line on the graduated cylinder represents the amount of liquid that has been measured.

Measuring beakers

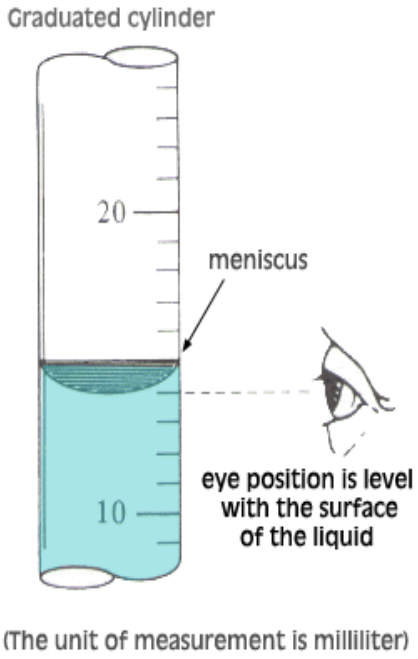
- ✓ A measuring beaker is used generally to measure fixed volume of a liquid such as milk, oil etc.
- ✓ They are available in different capacities such as 50 mL, 100 mL,500 mL,1000mL.

Measurement of volume of a liquid

By using a measuring cylinder

A measuring cylinder is used in a laboratory to measure the volume of a given liquid.

For this, proceed as follows



(The unit of measurement is milliliter)

Select a cylinder that is large enough to hold the volume of liquid being measured.

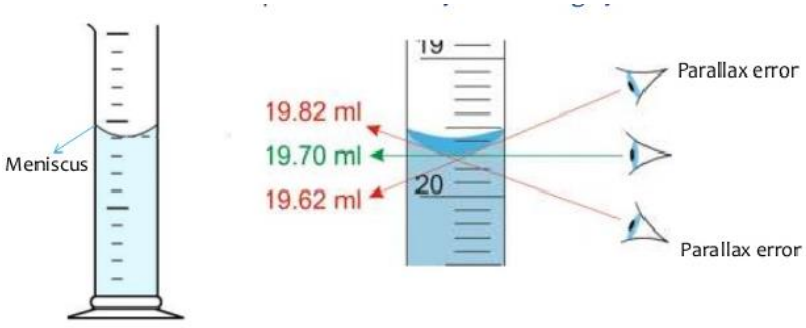
Confirm that the tube is clean and dry. Unwanted particles or drops of liquid in the cylinder could throw off the measurement.

Steady the tube with one hand while pouring the liquid you are measuring into it from another container. Graduated cylinders are thin and can be tipped over easily, so take special care when working with noxious or volatile liquids.

Hold the cylinder at eye level to take a reading. Ensure that it is hanging straight down. Avoid crouching to read the cylinder while it is resting on the table; if jostled, the container could tip over and pour liquid onto your face or torso.

Take the liquid measurement at the very bottom of the dip in the surface of the liquid. This dip is called the meniscus; it forms because liquid molecules are more attracted to the glass than they are to each other.

Look at the horizontal lines on the side of the cylinder. Ascertain to which line the meniscus is closest.



Determine the increments of measurement on the tube. For example, if the area between the 40ml mark and the 50ml mark is divided into ten segments, each segment represents 1ml.

Locate the closest whole measurement below the surface of the liquid.

Count the number of segments up to the line nearest the meniscus. Calculate the volume of the liquid by adding the whole measurement to the sum of the segments.

By using a measuring beaker

- ✓ A measuring beaker is used to measure a fixed volume of liquid from a large volume.
- ✓ A measuring beaker is used to measure a fixed volume
- ✓ Suppose it is required to measure 500 Ml of milk from the milk contained in a bucket.
- ✓ For this, take the measuring beaker of capacity 500 Ml. Wash it and dry it.
- ✓ Then immersed the measuring beaker from the bucket gently so that no milk splashes out and then pour the milk from the measuring beaker in to another empty vessel.

Note: There are various types of liquids. While measuring the **volume** of liquids, some liquids form a concave surface on the cylinder and some form convex surface in the cylinder. Liquids like oil, water, alcohol, etc. form a concave surface and liquids like mercury, etc. form a convex surface in the cylinder. For the liquid forming convex surface, the reading should be taken from the upper meniscus and for the liquid forming concave mirror, the reading should be taken from the lower meniscus.

Measurement of volume of regular object

For the calculation of the volume of regular solids, various formula is used which are given below,

- Volume of a cuboid (V)= length(l) × breadth (b) × height(h)
  ∴ V= l × b × h
- Volume of a cube (V)= $(\text{length})^3$
  ∴ V= l^3
- Volume of sphere (V)= $4/3\pi(\text{radius})^3$
  ∴ V=$4/3\pi r^3$
- Volume of cylinder (V)=π × $(\text{radius})^2$ × height (h)
  ∴ V=$\pi r^2 h$

Measurement of volume of irregular object

We can measure the area of irregular bodies by using graph paper. But it is impossible to measure the volume of irregular bodies by using graph paper. We can measure the volume of irregular bodies by using measuring cylinder.

This method is based on the fact that the volume of an irregular solid is equal to the volume of water displaced by it when it is immersed in water. When we immerse an irregular body in water, it displaces some amount of water. The volume of displaced water is equal to the volume of an irregular body that displace water. This method can be used to calculate the volume of those irregular bodies which sink in water and do not dissolve in water.

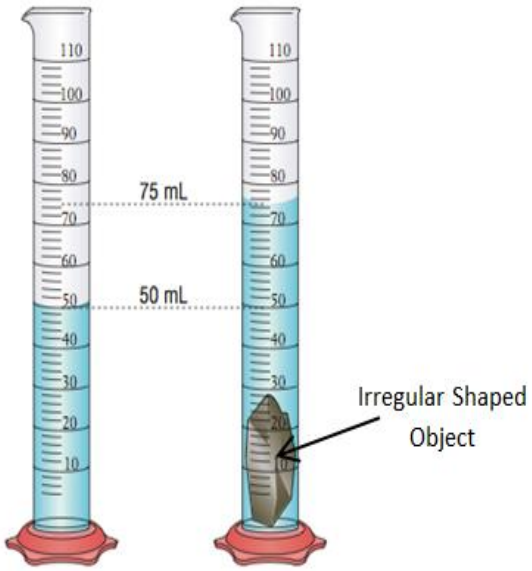
Experiment

Objective: To measure the volume of a piece of stone.

Materials Required: Measuring cylinder, water, thread, a piece of brick

Procedure

At first, fill the measuring cylinder partially with water. Note down the level of the water. Let it be the initial level of water, V_1. While recording the level of water, keep the eye in the level with the bottom of the meniscus to avoid parallax error. After this, tie the piece of stone with the help of thread and immerse it into the water of measuring cylinder. We can see that, the level of water rises. Then, note down the new level of water carefully. Let it be the final reading, V_2.



Observation

Suppose V_1 is 50 ml and V_2 is 75 ml.

Now,

Initial volume of water in the cylinder (V_1)= 50 ml

Final volume of water in the cylinder (V_2)= 75 ml

∴ Volume of the water displaced (V)=V_2 -V_1

= 75ml - 50ml

= 25ml

∴ Volume of the Stone= Volume of water displaced

= 25ml

Precautions

- While taking the readings, the water should be at rest and the measuring cylinder should be placed on a horizontal surface.
- For the liquid forming convex surface, the reading should be taken from the upper meniscus and for the liquid forming concave mirror, the reading should be taken from the lower meniscus.

Area

The total space occupied by the plane surface of the object is known as the area of that object. The SI unit of area is the square metre (m^2). Other similar units of area are mm^2, cm^2, km^2, etc.

Measurement of area of regular object

There are various formulae used for the measurement of the area of the regular plane surface. Some of them are given below,

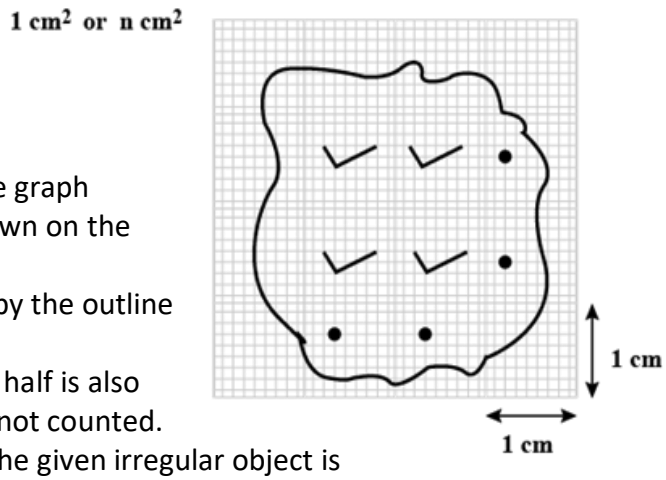
- Area of a rectangular object (A) = length(l) × breadth(b)
  ∴ A= l × b
- Area of a circle (A)=π × (radius)^2[π = 22/7]
  ∴ A=πr^2
- Area of a square (A)= (length)^2
  ∴ A= l^2

Example 1
The radius of the circle is 7cm, if the value of π is 22/7, then what is the area of circle.

Solution:
Given,
Radius (r)= 7 cm
π = 22/7
Area (A)= ?
By using formula,
A =πr^2
=22/7 × 7^2
= 22 × 7
= 154cm^2

Measurement of Area of Irregular Surfaces

There are no exact formulae for the measurement of the area of irregular surfaces. But we can measure the area of irregular surfaces by using graph paper.



- ✓ A graph paper is divided into equal- sized squares of side 1 cm and 1 mm.
- ✓ At first, the irregular object is placed on the graph paper. Then the outline of the object is drawn on the graph paper.
- ✓ After this, the number of squares covered by the outline is counted.
- ✓ The number of squares that are more than half is also counted but the squares less than half are not counted.
- ✓ Then by adding two numbers, the area of the given irregular object is calculated.

Density
The density of material shows the denseness of that material in a specific given area. A material's density is defined as its **mass per unit volume**.
Density is essentially a measurement of how tightly matter is packed together. It is a unique physical property for a particular object.

Examples

Iron, platinum, and lead are examples of dense materials. Many types of rock and minerals are examples of dense material. Materials that are dense are most likely to 'feel' heavy or hard.

In general, liquids are less dense than solids and gases are less dense than liquids. This is due to the fact that solids have densely packed particles, liquids are materials where particles can slide around one another, and gases have particles that are free to move all over the place.

Mathematically, the density of an object is expressed as follows:

Where,

Density=Mass/Volume $\rho=m/v$

- ρ is the density
- m is the mass
- V is the volume

Unit of Density

SI unit of density is kg/m^3, for convenience we use g/cm^3 for solids, g/ml^3 for liquids, and g/L for gases.

Determination of density of regular solid

To find the density of a regular solid by using formula, density = mass / volume

We proceed as follows

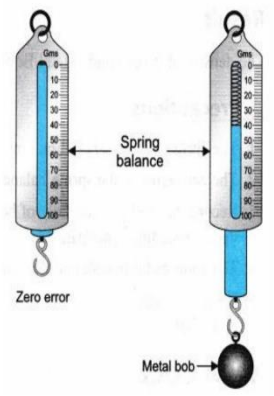
- ✓ Using a beam balance, measure the mass (m) of the solid
- ✓ Using the meter ruler, measure the length, breath and height of regular solid and find the volume V using the relation $V = l \times b \times h$
- ✓ Once we know the mass and volume, density is calculated using the relation $d=M/V$

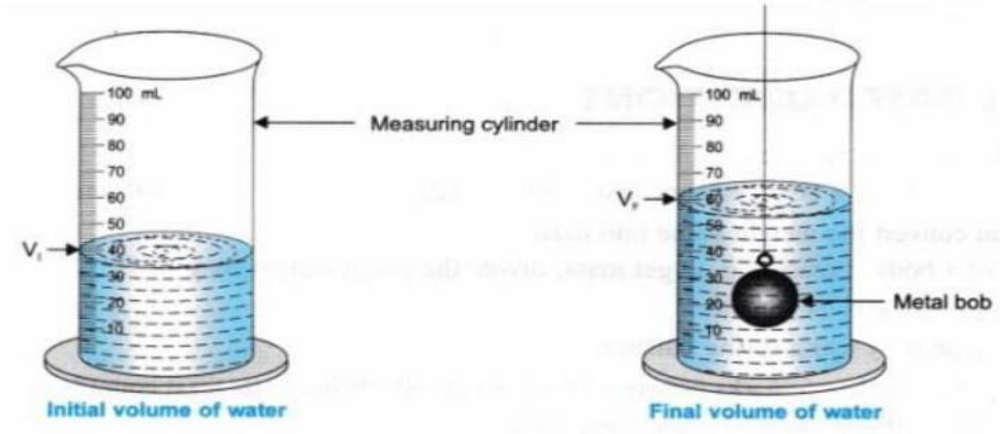
Determination of density of irregular solid

Materials Required A spring balance, a measuring cylinder, a beaker with water, a metal bob (or anybody that is heavier than water and does not dissolve in water), a cotton string, a stand (optional).

Procedure

1. Tie a metal bob (or any solid) with the string of cotton to the hook of the spring balance. The spring balance should be checked for any error. Let the zero error be 'x'.
2. Hold the spring balance (or tie it to the stand), suspended with the metal bob in air. Measure the weight of the bob. Let its weight be 'WF'
3. Pour the water in the measuring cylinder and record the initial volume of water, let it be ' V_1'
4. Suspend the metal bob into the measuring cylinder with water. The bob should not touch the base, nor the sides of the cylinder. The water level rises, measure the increased water level, let this volume be ' V_F'
5. Record all your observations in the observation table and do the calculation to find the density of a given solid metal bob





Determination of density of a liquid

To determine the density of a liquid, follow the procedure given below
Take a beaker, measure the mass of given beaker using a common beam balance. let the mass be M_1 gram.
Now take a measuring cylinder and pour given liquid in to a certain level say 50 Ml
Thus, volume of milk, V = 50 cm^3 .
Transfer the liquid in to the empty beaker.
Measure its mass again. Let's its mass be M_2 gram
The difference between M1 and m2 will give the mass M of the liquid.
Thus mass of liquid M=(M_2-M_1) gram
Calculate the density of liquid using following relation
Density =Mass/Volume
Different substances have different densities.

Speed

Speed is defined as

The rate of change of position of an object in any direction.

Speed is measured as the ratio of distance to the time in which the distance was covered.

Speed is a scalar quantity as it has only direction and no magnitude.

Units of speed

Speed is measured as v=Distance/Time

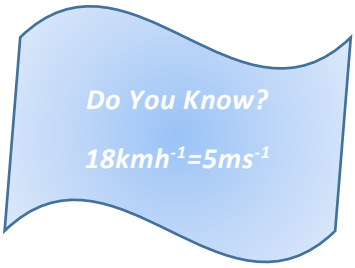
where SI unit of distance is m and that of time is s.

Thus SI unit of speed is m/s.

Sometimes we measure distance in kilometre and time in hour then the unit of speed is kilometre per hour $km.h^{-1}$

How do you convert km/h to m/s?

SI unit of distance is a meter according to the International System of Units.



Conversion

We know that

1 km = 1000m

1 h = 3600 s

So 1km /h = 1000/3600 = 5/18 = 0.28 m/sec

So to convert km/h to m/s we multiply the given number by 5/18 or 0.28m/sec

Example

Speed of bicycle = 90 km/hr

To convert the speed into m/sec, we multiply by 5/18

Therefore, speed of bicycle = 90 × 5/18 m/sec = 25 m/sec