1 Measurement

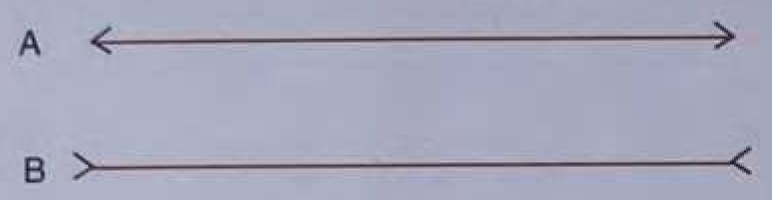
SYLLABUS

1. Measurement – Its importance – units of measurement – the need for standard units of measurement – S.I. Units – length, mass, area, volume, time, temperature – correct abbreviations – rules to follow to write units correctly. Simple multiples and sub-multiples of these units, understanding the prefixes – centi, milli and kilo.
2. Measurement of length
   * Using a ruler correctly, without parallax error (E). * Estimating lengths keeping in mind the size of 1 cm and 1 mm (E). * Measuring small lengths – *e.g.*, thickness of a coin, diameter of a wire (E). * Measuring the length of line that is not straight, using a string (E).
3. Measuring mass, area, volume / capacity – units, multiples and sub-multiples and correct abbreviations.
   * Survey to find out which items are sold by mass and which by volume (E). * Finding approximate areas of irregular shapes using a square centimetre grid (E).
4. Measuring time – common units.
   * Reading a twenty-four hour clock – air/train schedules (E). * Estimating time for common, daily activities (E). * Learning to count seconds - approximately (E).
5. Measuring temperature – Celsius scale – the two fixed points. Commonly measured temperatures – maximum-minimum thermometer - temperature of the human body.
   * Reading a laboratory thermometer (E). * Reading a clinical thermometer (E).
6. Approximations – when do we need very accurate measurements ?
   Taking many measurements and finding an average.
   * Finding the average pulse of the class and the range of the pulse rate of the students (E).
   Standard Weights and Measures – to avoid being cheated in commercial transactions.

MEASUREMENT – ITS IMPORTANCE

Measurement is necessary in our life. Daily, we come across many things which we have to measure. When we visit a grocery shop to buy rice, sugar, etc., we ask the shopkeeper to weigh them because we have to calculate the amount to be paid with respect to their weight. Similarly, we need to measure the height and weight of students in our school to check up their body growth. Thus, measurement is an essential need to keep accuracy in our various day-to-day activities. Without actual measurement, we cannot make a correct judgement about the length, height, area, volume, mass and temperature of a given object. *Our rough estimate may give a wrong answer.* Let us consider some more examples to know the importance of measurement.

Example 1 : Two lines are given below. Can you guess which line is longer ?



At a glance, line B seems to be longer than line A. Now measure both the lines with the help of a scale. You will find that both of them are equal.

Example 2 : Some orange juice is kept in two glasses, as shown below. Can you guess which glass has more juice ? It is difficult to answer without measuring their actual volumes.

ORANGE JUICE

Example 3 : A tailor has to stitch a new dress for you. Think! What will happen if he stitches it without taking your measurement ?

Example 4 : When you feel sick, your mother measures your body temperature with the help of a thermometer. The thermometer shows 101°F temperature. Do you have fever (temperature) ? Yes, since the normal body temperature is 98.6°F. It means that on measuring your body temperature, she would know exactly whether you have fever or not.

It is clear from the above examples that measurement has great importance in our daily life.

We frequently come across questions like, how big or small, how long or short, how many in number, etc. *Measurement is the only solution to all these questions.*

> **Measurement** is a comparison of an unknown quantity with a known fixed quantity of the same kind.

PHYSICAL QUANTITY

A quantity that can be measured is called a physical quantity. Length, time, volume, and temperature are some examples of physical quantity.

Physical quantities are of *two* types

1. **Fundamental physical quantities or fundamental quantities**

The quantities which are completely independent of each other and do not depend upon any other quantity are known as *fundamental quantities e.g., mass, length, time, temperature, etc.*

2. **Derived physical quantities or derived quantities**

The quantities which are obtained by combining two or more fundamental quantities are known as *derived quantities*. *For example*, area (depends on length and breadth), density (depends on mass and volume), speed (depends on distance and time), etc. are derived quantities.

UNITS OF MEASUREMENT

When we measure any physical quantity, what we actually do is that we compare it with a known standard. *The standard of comparison is called a unit*. The need of a standard unit was felt because units kept changing from place to place. *A **unit** is a fixed quantity which is accepted as a standard by people all over the world.*

Nowadays, to measure length, we use the unit "metre" (m). People in ancient times used their footstep, arm length (cubit), hand span, ropes, sticks, etc. to measure length. One **cubit** was the length from the elbow to the tip of the middle finger of a person's hand.

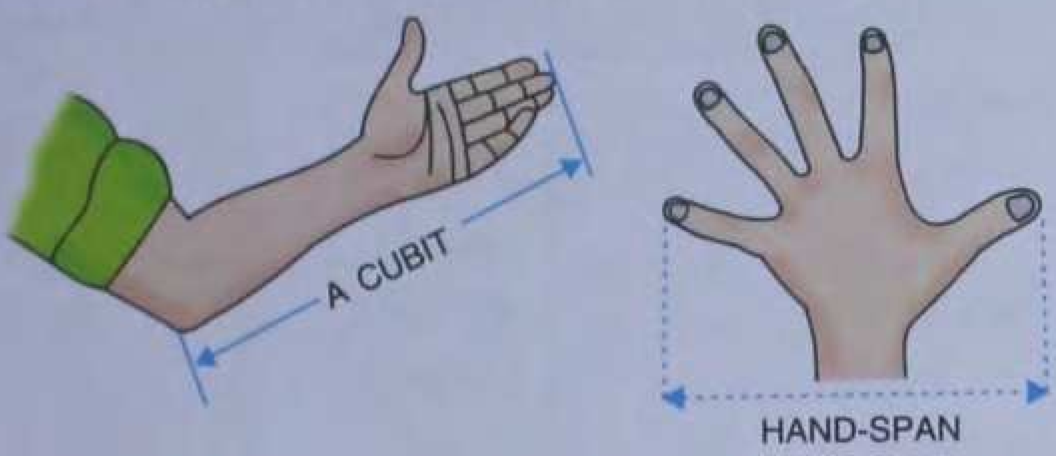


Fig. 1.1 Some ancient methods of measurement

Similarly, a hand-span was the length from the tip of the thumb to the tip of the little finger when they are stretched completely.

In the past, when an object was measured with a hand-span, its length varied from person to person. The simple reason for the variation was the difference in the size of the hand-span of each person. Thus, this system of measurement was felt inconvenient as well as inaccurate.

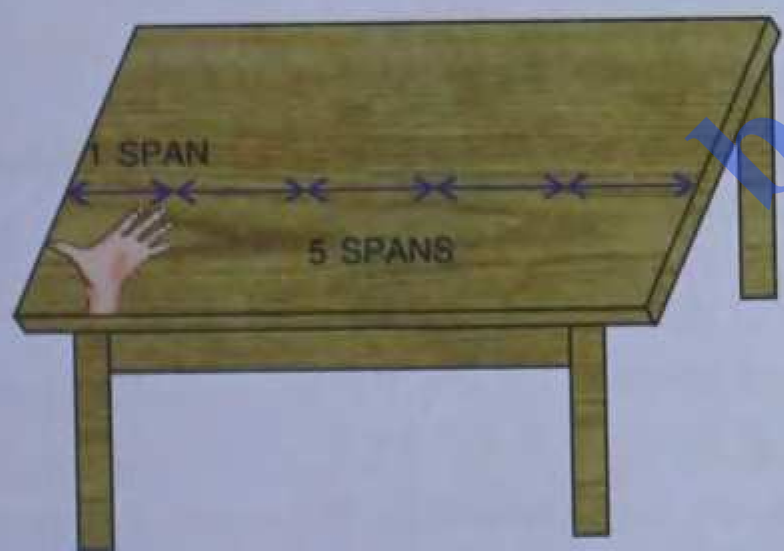


Fig. 1.2 Measuring the length of a table

ACTIVITY 1

Measure the length of sofa in your drawing room with your outstretched palm. How many hand spans is the length of sofa ? Now ask your father or mother to measure in the same way. How many hand spans is it with your parents hand ? Are they same ? No, because your hand span is smaller than your parents. What conclusion do you arrive at ?

To avoid confusion, scientists evolved rulers. Now, if we take two rulers and measure the same object, say, a table, both the rulers will give us the same measurement. Why ? It is simple, because the rulers are calibrated (marked) with the standard units of measurement but hand-spans are not.

Similarly, you cannot use a bowl to measure the exact volume of a liquid like milk or oil.

Do You Know ?

When we had no means of weighing, seeds and stones were the only standards to measure mass.

Hence, to express the result of a measurement of a physical quantity, we must know :

(a) the **unit** in which the quantity is to be measured.

(b) the **numerical value** which expresses how many times the above mentioned unit is contained in the given quantity.

Example : If the length of a piece of cloth is 10 metres, it means that the length is measured in the unit metre and this unit is contained 10 times in the length of that piece of cloth.

Thus, a measurement consists of two parts — the magnitude (or number) and a unit. The physical quantities are the product of magnitude and the unit, *i.e.*

$$Q = n \times u$$

Where, Q ⇒ Physical quantity

n ⇒ Magnitude

u ⇒ Unit

For example – When we measure the mass of sugar as 15 kg, then,

15 — is the *magnitude*,

kg — is the *unit* and

mass — is the *physical quantity*.

Need for Standard Units of Measurement

In the past, different units were used for measurement in different countries. To maintain uniformity in measurement, scientists from all over the world accepted some of the units as **standard units.** Considering the fundamental quantities as length, mass and time, the three systems — MKS *(Metre, Kilogram and Second)*, CGS *(Centimetre, Gram and Second)* and FPS *(Foot, Pound and Second)* were developed.

Fundamental Quantities	System		
	MKS	CGS	FPS
Length	Metre	Centimetre	Foot
Mass	Kilogram	Gram	Pound
Time	Second	Second	Second

Out of the three systems, the MKS system was widely accepted. Since the comparison of data was difficult with a large number of units, the *General Conference of Weights and Measures*, in 1960, adopted a system of units commonly known as S.I. units. S.I. stands for *Syste'me Internationale d'Unites* (in French) or *International System of Units* (in English). The S.I. units of measurement are standard units and are adopted for the purpose of uniformity.

The unit that could be used everywhere as a basic unit of measurement is called a **standard unit**.

Fundamental Units of S.I. System

The units that we use to measure fundamental quantities are called *fundamental units.*

The S.I. system has nine basic or fundamental units. Commonly used fundamental units and their standard symbols are given in Table 1.1.

Table 1.1 Fundamental units of S.I. system

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Temperature	kelvin	K
Current	Ampere	A
Luminous intensity	Candela	Cd
Amount of substance	Mole	mol
Angle	radian	rd
Solid angle	Steradian	st-rd

Some standard conventions followed in the usage of S.I. units.

Whenever we write S.I. units and their symbols, we follow certain **conventions**. These conventions are as follows :

- Symbols used for units are always written in small letters (other than the names of scientists). *For example:*
  Symbol of kilogram – kg and not Kg
  Symbol of metre – m and not M
  Symbol of second – s and not S
- Symbol for a unit named after a scientist is always written with a capital letter. *For example :*
  Symbol of Fahrenheit – °F, and not °f
  Symbol of Ampere – A and not a
  Symbol of Newton – N and not n
  Symbol of Kelvin – K and not k
- Symbols are not followed by full stops. *For example :*
  Symbol of Fahrenheit – °F and not °F.
  Symbol of metre – m and not m.
  Symbol of kilogram – kg and not kg.

However, we may use a full stop if the unit is written at the end of a sentence.

- Symbols for units remain unaltered in the plural, that is, the symbols for units are never written in plural, but when written in words, plurals are used. *For example :*
  Symbol for 10 kilograms is 10 kg (and not 10 kgs)
  Symbol for 20 metres is 20 m (and not 20 ms)

- If we are writing the full form of a unit, we start with a small letter. *For example :*
  kelvin and not Kelvin, metre and not Metre,
  newton and not Newton, celsius and not Celsius.
- Negative powers are used for compound units formed by dividing one unit by the other. *For example,* the unit of speed is metre/second. It is expressed as m s^{-1}.

Do You Know ?

The National Physical Laboratory (NPL), New Delhi, is responsible for maintaining the national standards for all the basic (base) units in India.

Multiple Units

To measure the distance between two far-off cities, say, Delhi to Mumbai, measuring in metres is not only difficult but very inconvenient too. Hence, we use some bigger unit, say, kilometre, which is a multiple of metre.

1 kilometre = 1000 metres or 10^3 m

In short, 1 km = 1000 m

Units which are used to measure large quantities are called **multiple units.**

Example : If the distance between Delhi and Agra is 200,000 metres, for convenience, it is expressed as 200 kilometres or 200 km.

Sub-multiple Units

Similarly, if we are trying to measure the length of an eraser or a pen, or, say, our nails, we again cannot depend on the unit metre but we need some smaller or sub-multiple units like centimetre (cm), millimetre (mm), decimetre (dm), etc.

Units which are used to measure smaller quantities are called **sub-multiple units.**

1 m = 100 cm or 1000 mm

1 cm = 10 mm

For example, if the diameter of a coin is 2×10^{-2} metres, it is expressed as 2 centimetres or 2 cm.

Some very old units are still accepted in terms of S.I. standards for our convenience. *For example* :

1 yard = 0·9144 m* 1 inch = 2·54 cm*

1 pound = 0·454 kg* 1 foot = 30·48 cm*

Example : Tanu's house is 3250 metres from her school. Express this distance in kilometres.

Solution : Distance = 3250 m.

we know, 1 km = 1000 m

So, Distance $= \frac{3250}{1000}$ km = **3·25 km**

Table 1.2 : Multiple and sub-multiple units of some fundamental units are listed below

Length

Sub-multiple units	
10 mm	= 1 cm
10 cm	= 1 dm
10 dm	= 100 cm
100 cm	= 1 m
Multiple units	
1000 m	= 1 km
10 mm	= 1 dm

Mass

Sub-multiple units	
1000 mg	= 1 g
1000 g	= 1 kg
Multiple units	
100 kg	= 1 quintal
10 quintal	= 1 metric tonne
1000 kg	= 1 metric tonne

* All values are approximate values

Do You Know?

1. For measuring the distance between stars and the earth, kilometre is considered to be a very small unit. For measurement of such large distances, the commonly used unit is light year (1 light year = $9{\cdot}46 \times 10^{12}$ km) (distance travelled by light in an year).

2. For measuring very small lengths like the size of molecules, atoms, protons, etc., most commonly used units are micron, angstrom and nanometre (nm)

1 micron (μ) = 10^{-6} m

1 angstrom (Å) = 10^{-10} m

1 nanometre (nm) = 10^{-9} m

Derived Units

The fundamental units mentioned above are not sufficient to measure all the quantities in science and technology. Units obtained by combining two or more fundamental units of measurement, are known as **derived units.** *For example : unit of area* – square metres and square centimetres, *unit of speed* – metre per second (m s^{-1}) and centimetre per second (cm s^{-1}).

If we choose a surface of some definite length and breadth, the product of the units of its length and breadth is taken as the unit of its area. Thus, in the measurement of area, we need a unit which is length (unit – m) × breadth (unit – m) *i.e.*, m^2. Similarly, for measurement of volume, the unit will be calculated as length (m) × breadth (m) × height (m) *i.e.*, m^3. In the same way, unit of speed of a moving body is obtained by dividing the unit of distance or length (metre) by the unit of time (second) *i.e.*, ms^{-1}.

Table 1.3 : Some of the derived units

S. NO.	PHYSICAL QUANTITY	FORMULA	DERIVED UNIT	SYMBOL
1.	Area	Length × Breadth	metre × metre	m^2
2.	Volume	Length × Breadth × Height	metre × metre × metre	m^3
3.	Density	$\frac{\text{Mass}}{\text{Volume}}$	$\frac{\text{kilogramme}}{\text{metre}^3}$	kg/m^3 or $kg\ m^{-3}$
4.	Speed	$\frac{\text{Distance}}{\text{Time}}$	$\frac{\text{metre}}{\text{s}}$	m/s or $m\ s^{-1}$
5.	Acceleration	$\frac{\text{Change in velocity}}{\text{Change in time}}$	$\frac{ms^{-1}}{s}$	ms^{-2}
6.	Force	Mass × Acceleration	$kg \times m/s^2$	newton
7.	Velocity	$\frac{\text{Displacement}}{\text{Time}}$	$\frac{\text{metre}}{\text{sec}}$	m/s or ms^{-1}
8.	Work	Force × displacement	N × m	joule
9.	Power	$\frac{\text{Work}}{\text{Time}}$	$\frac{\text{Joule}}{\text{s}}$	watt
10.	Potential energy	mgh	$kg \times \frac{m}{s^2} \times m$	joule

TEST YOURSELF

A. Short Answer Questions :

1. What is measurement ?
2. What is a standard unit ?
3. What are derived units ?
4. What are S.I. units of mass, length and time?
5. How many quintals are there in one metric tonne ?
6. Which institution in India maintains standards of S.I. units ?
7. Change the following lengths as indicated.
   (a) 1.0 km = ... m (b) 3.6 km = ... m
   (c) 3 m = ... cm (d) 4.2 m = ... cm
   (e) 20.0 cm = ... mm (f) 152 mm = ... m

B. Long Answer Questions :

1. Why are standard units used in measurements?
2. Why is a ruler more useful than a hand-span for measuring lengths ?
3. What are fundamental quantities ? Name any *three* fundamental quantities.
4. Why do we need multiples and sub-multiples of standard S.I. units.
5. Which unit you would prefer to measure the following :
   (a) weight of a man
   (b) weight of truck
   (c) length of a pencil box
   (d) length of your class room
   (e) area of a football field
   (f) area of your door mat.
6. Give *one* example of each where the following units are used :
   (a) gram (b) kilometre
   (c) degree celsius (d) second
   (e) hour
7. What do you understand by the S.I. system of measurement ?

1A Measurement of Length, Area, Volume and Mass

MEASUREMENT OF LENGTH

When we measure the width, thickness, depth, distance and height, we actually measure the length. Various instruments like ruler, metre scale, measuring tape, vernier callipers and spherometer are commonly used for measuring the length of an object.

In the S.I. system of measurement, the unit of length is metre. Its *multiple and sub-multiple units are related to each other by the power of ten.*

1 centimetre = 10 millimetres (10 mm)

1 metre = 100 centimetres (10^2 cm)

1 kilometre = 1000 metres (10^3 m)

Metre is used as a unit of length in most of the countries. To ensure that it is the same metre used everywhere, we need one special metre for reference. This is called the **standard metre**. The original standard metre which is kept *in the International Bureau of Weights and Measures at Sevres near Paris, France.* It is made of an alloy of 90% platinum and 10% iridium metal bar. It is kept at a fixed temperature (0°C) and was first used in 1889.

One metre is the distance between two marks on this bar. Other countries have a copy of this metre. The accuracy of any other metre rule can be checked against the standard metre.

The unit metre is too small for measuring some lengths and too large for others. So, it was decided to increase it in multiples of 10 for large measures and decrease it by sub-multiples of 10 for small measures. These measures are given special names as shown in Table 1.4.

Table 1.4 : Special names of measures

Multiple units		
1 kilometre (km)	= 1000 metres	= 10^3 m
1 hectometre (hm)	= 100 metres	= 10^2 m
1 decametre (dam)	= 10 metres	= 10 m
Sub-multiple units		
1 decimetre (dm)	= $1/10^{th}$ metre	= 10^{-1} m
1 centimetre (cm)	= $1/100^{th}$ metre	= 10^{-2} m
1 millimetre (mm)	= $1/1000^{th}$ metre	= 10^{-3} m

Intext Questions

Which of the above units would be the best to measure the following distances ?

1. The distance from Mumbai to Pune ....
2. The length of a classroom ....
3. The length of your text book.......................
4. The thickness of an exercise-book ....
5. What is the S.I. unit for measurement of length?
6. How are multiple and sub-multiple units releated to each other ?

Devices for Measuring Length

1. Measuring Length by Ruler Correctly Without Parallax Error

Generally, the length of straight objects is measured with the help of a metre scale or ruler. It is graduated to read upto one mm. While measuring the length using a ruler, the eye must be kept vertically above the end of the object and the corresponding graduation in the line of the sight should be read. This avoids the error due to the thickness of the scale also called the **error due to parallax.**

ACTIVITY 2

Suppose you want to measure the length of a rod. While doing this :

- The ruler should be placed very close to the rod or object to be measured.
- The eye must be kept vertically above the end of the rod.
- In Fig. 1.3, the eye, when at point A (at 4.2 cm) takes the correct measurement while from positions B (at 4.1 cm) and C (at 4.3 cm), it takes a wrong measurement. This is because of the thickness of the scale and this error is called the error due to parallax.
- The ends of the ruler must not be worn out. If you want to use the same ruler, leave the 0-mark and use the other full mark on the ruler. Subtract the reading of this full mark from the reading of the other measured end.

Figure 1.3 illustrates that the correct length of the rod is 4·2 cm – 1·0 cm. = 3·2 cm.

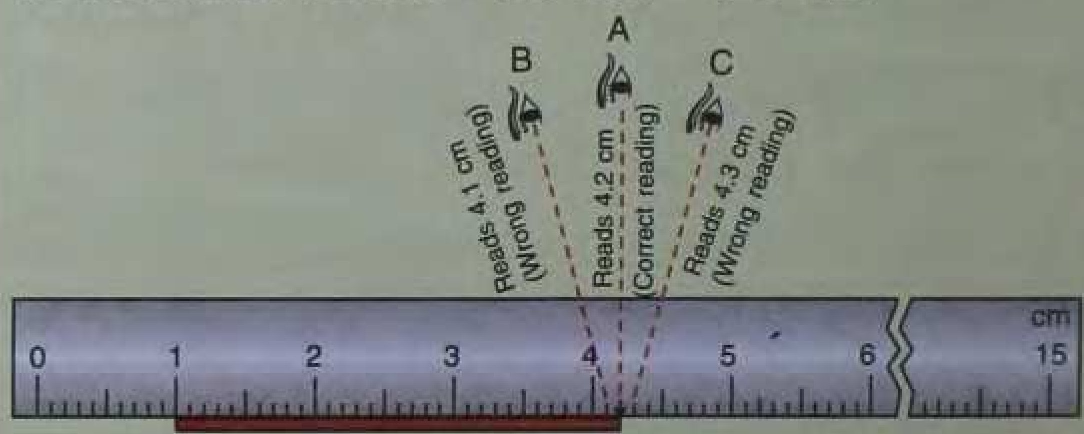


Fig. 1.3 Measuring the length of a line with a ruler

2. Measuring Large Lengths by the device called Measuring Tape

To measure longer lengths, we use a measuring tape. The metre rule and the measuring tape have marks dividing them into centimetres and millimetres. The smallest measurement possible is 1 mm.

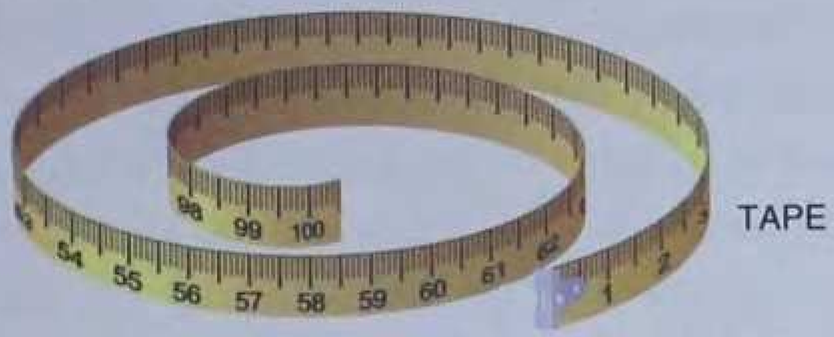


Fig. 1.4 Big lengths are measured with the help of a measuring tape

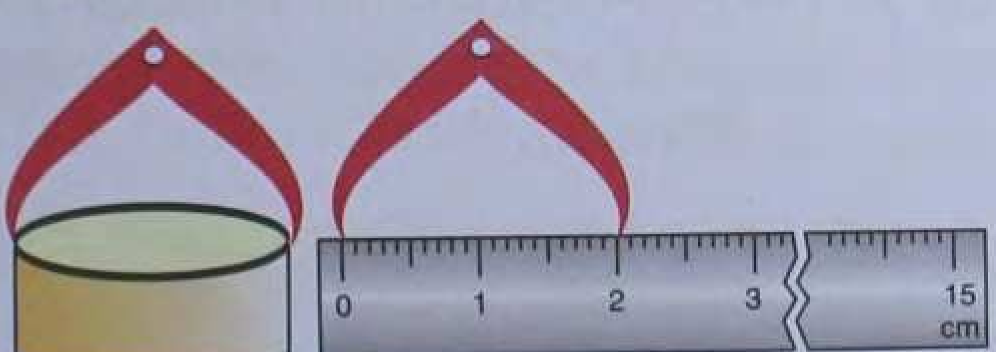
Measuring tape is used for measuring curved as well as straight objects.

Example : The girth of a tree or the chest of a person.

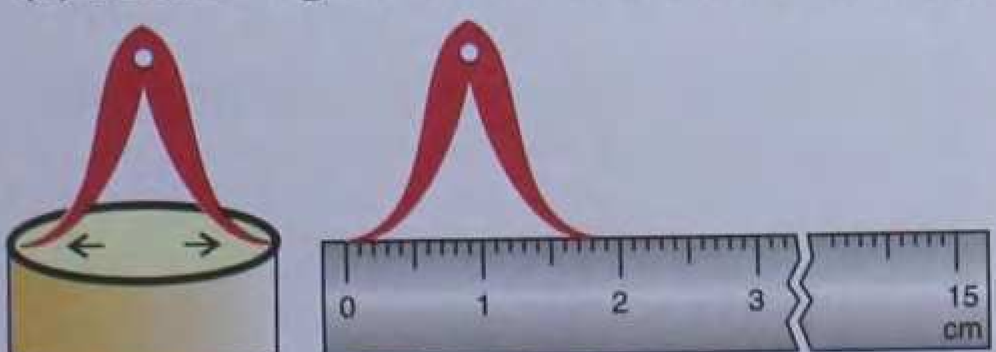
> **Knowledge bank**
> - Metre rod is generally used by cloth merchants.
> - A correct metre scale used by shopkeepers in the market has the sign ← at the beginning and the sign → at the end of the scale. Such a scale is also stamped by the Department of Weights and Measures.

3. Measuring the Diameter of a Cylinder

Callipers, together with a metre rule, are useful for measuring round objects.



(a) Measuring the external diameter of a pipe



(b) Measuring the internal diameter of a pipe

Fig. 1.5 Measuring the diameter of a cylinder

External callipers are used to measure external diameters of the objects. While internal callipers are used to measure internal diameters of the objects. Figure 1.5 shows how they are used.

4. Measuring the Length of a Curved Object

The length of a curved surface can be measured by using a thread. Figure 1.6 shows two points A and B on the curved surface of an object. Spread a thread along the surface of the object and make it tight between the points A and B.

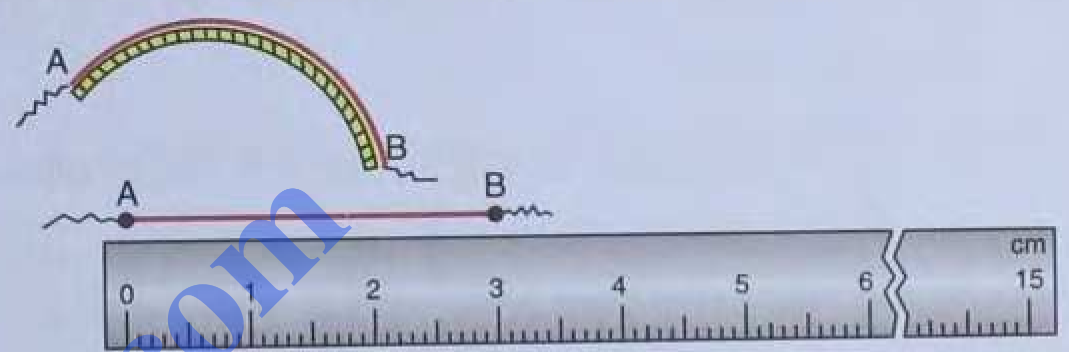


Fig. 1.6 Measuring a curved line with a thread

Now spread the length of the thread AB on a scale starting from its zero and take the required measurement.

5. Measuring the Diameter of a Sphere

A sphere such as a tennis ball, whose diameter is to be measured is placed on the surface of a table. Two rectangular blocks of wood are placed on either side such that they

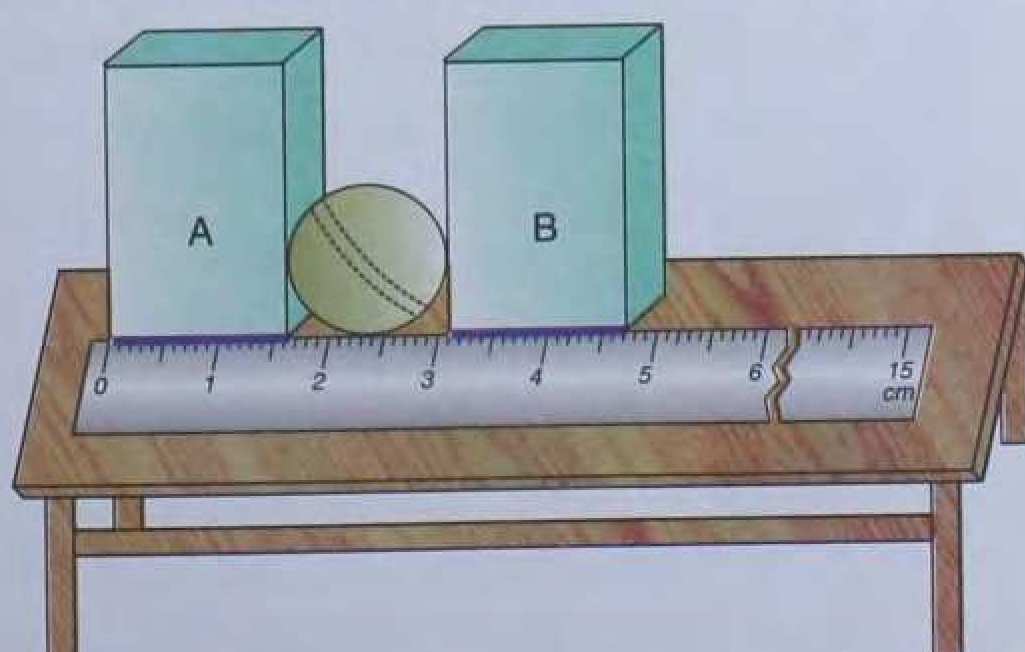


Fig. 1.7 Measuring the diameter of a ball

touch the opposite sides of the spherical object. Then we adjust the lower edges of the blocks along a ruler (see Fig. 1.7). The reading is taken for each face of the block touching the spherical object. The difference between these two readings gives the measurement of the diameter of the sphere.

In Fig. 1.7

Box A is kept at 1·6 cm

Box B is kept at 3·1 cm.

∴ **Diameter of the ball** = (3·1 – 1·6) cm = **1·5 cm**

6. Measuring the Thickness of Thin Objects

It is not possible to measure the thickness of very thin objects like coins or paper. So, to measure the thickness of such dimensions, we have to stack them together (Fig. 1.8).

ACTIVITY 3

Take 20 coins together and stack them close to a ruler. Take the total thickness and then divide this thickness by 20 to get the thickness of one coin.

Thickness of the stack = 2·2 cm

Thickness of one coin = $\frac{2 \cdot 2}{20}$ cm

= 0·11 cm

= 1·1 mm

Fig. 1.8 Measuring the thickness of a stack of coins

ACTIVITY 4

Take a thick long thread and a pencil. Wound the thread around the pencil, as shown in the figure below. Make sure there is no space between two consecutive turns of the thread. Now count the number of turns of the thread around the pencil and then measure the total width of all the turns you have given. Divide the width by the number of turns of the thread. This wil give you the width of the thread.

This is how small diamensions are measured.

Measuring Very Small Lengths

Sometimes, we need to measure very small lengths. *For example*, the diameter of a fine wire, machine parts, *etc*. In such cases, metre scales or measuring tapes cannot be used. For measuring such small lengths, the vernier callipers (Fig. 1.9) and screw gauge (Fig. 1.10) are used.

The vernier callipers is used to measure the length, the breadth, *etc*., of small objects, upto the accuracy of 0·1 mm. The screw gauge is used to measure the diameter of a wire or thickness of a paper, *etc*., upto the accuracy of 0·01 mm.

Intext Questions

1. What unit will you use to measure the length of :
   (a) this book : ....
   (b) hockey field : ....
2. Name the instrument to measure :
   (a) length of a book ....
   (b) diameter of a round pencil ....
   (c) length of a football field ....

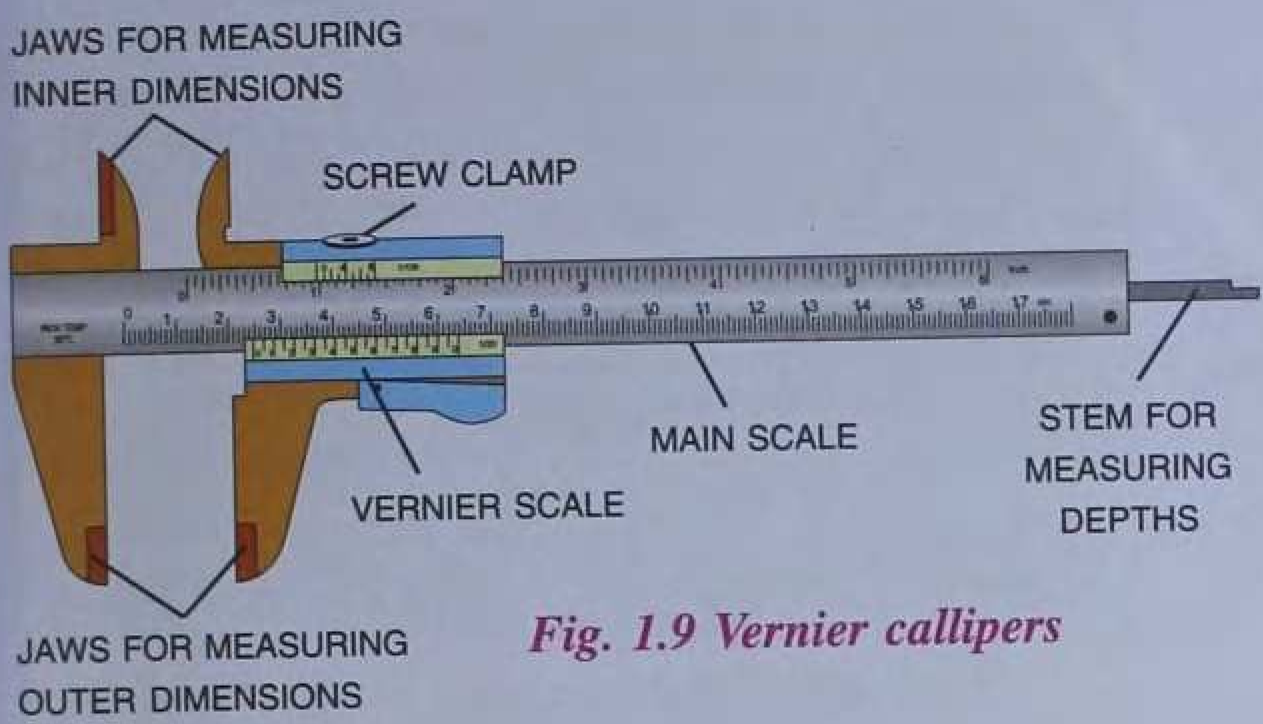


Fig. 1.9 Vernier callipers

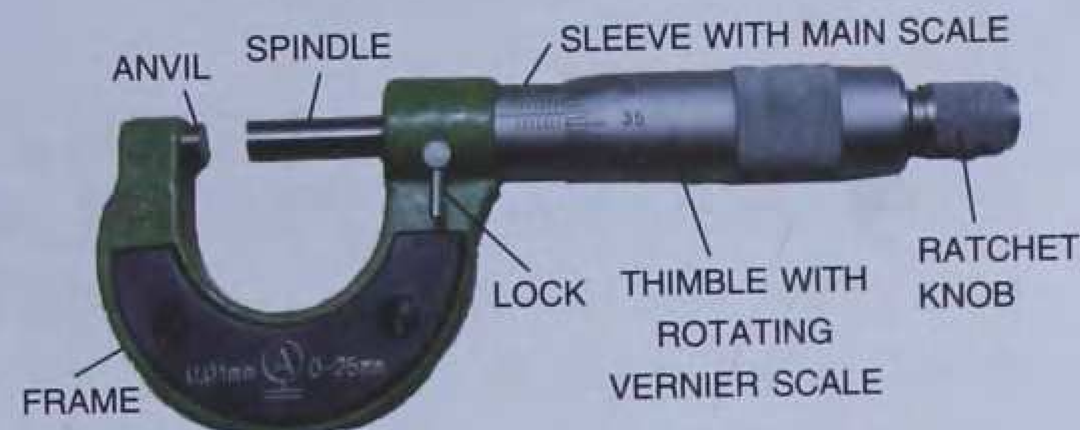


Fig. 1.10 Screw gauge

MEASURING AREA

We deal with various objects everyday. *For example*, a book, a pencil, an eraser, a sheet of paper and many such things. If we keep these objects on a table, each object will occupy some surface on the table, which may be different for each object depending upon its size.

The surface occupied by an object on the top (surface) of a table is called the area. This is also called **surface area**.

The area (A) of regular plane surfaces such as squares and rectangles can be calculated by using a formula. *For example* :

The area of a square = side × side

The area of a rectangle = $l \times b$,

where l = length and b = breadth

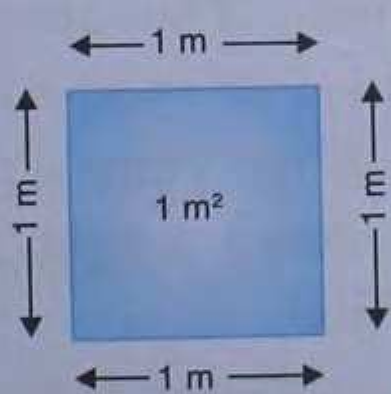
The area of a triangle = $\frac{1}{2} b \times h$

where b = base and h = height

Unit of Area

The S.I. unit of area is square metre (m^2).

One square metre is the area of a square whose each side is 1 metre long.



Area : One metre²

For example :

Length of a geometry box = 20 cm

and its breadth = 7 cm

∴ Area of geometry box = length × breadth

= 20 cm × 7 cm

= 140 cm^2

Formula for calculating the area of regular shapes

S. No.	Shape	Area	Formula
1.	Square	Side × Side	l^2
2.	Rectangle	length × breadth	$l \times b$
3.	Circle	π × (radius)²	$\pi r^2 (\pi = \frac{22}{7})$
4.	Triangle	$\frac{1}{2}$ base × height	$\frac{1}{2} \times b \times h$
5.	Parallelogram	Base × height	$b \times h$

Multiple and Sub-multiple Units of Area

The standard unit of area is square metre (m^2). But sometimes, we need to measure a bigger area, say, a piece of land used for farming, etc. In such cases, bigger unit or multiple unit of area, called **acre** and **hectare** are used.

1 acre = 4046.85 m^2

1 hectare = 2.471 acres

1 hectare = 100 m × 100 m = 10000 m^2

To measure the area of a much bigger size, like the area of a country, a continent or the earth, another bigger unit called square **kilometre (km^2)** is used.

$1 \text{ sq. km } (km^2) = 1 \text{ km} \times 1 \text{ km}$
$= 1000 \text{ m} \times 1000 \text{ m}$
$= 1000000 \text{ m}^2$
$= 10^6 \text{ m}^2$

Sometimes, we need to measure the area of very small objects like a matchbox, book, pencil box, *etc*. In such cases, a smaller unit or sub-multiple unit is used. Some of the sub-multiple units are **square centimetre (cm^2)**, **square millimetre (mm^2)**, *etc*.

$1 \text{ sq. cm } (cm^2) = 1 \text{ cm} \times 1 \text{ cm}$
$= 10 \text{ mm} \times 10 \text{ mm}$
$= 100 \text{ mm}^2 \text{ or } 10^2 \text{ mm}^2$

Measuring Irregular Surface

Although an approximate method, we can find the area of an irregular object with the help of a graph paper. Graph papers have equal sized squares with the sides 1 cm or 1 mm. Activity 5 shows how the area of an irregular surface can be measured

MEASUREMENT OF MASS

When you visit a shopkeeper and ask for 1 kg of sugar, he measures the **mass** of sugar by a beam balance.

ACTIVITY 5

Place an irregular object on a graph sheet. Draw an outline of the object and remove it. First, count the number of complete squares. Then count the number of incomplete squares which are more than half (within the outline). Ignore the squares which are less than half (within the outline). The sum of the number of complete squares and the number of incomplete squares more than half gives the approximate area of the irregular object.

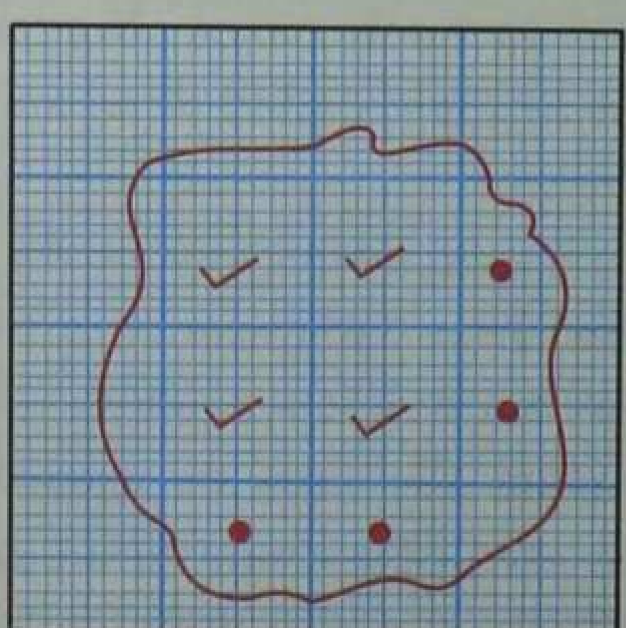


Fig. 1.11 Measuring an irregular surface

No. of complete squares = 4
No. of incomplete squares (More than half) = 4
∴ Area (approx.) of the object = $4 + 4 = 8 \text{ cm}^2$

The amount of matter contained in an object is the measure of its mass.

We generally use a beam balance (Fig. 1.12) to measure the mass. In this balance, there is a beam which has a support at its centre and two identical pans suspended at equal distances from the centre of the beam.

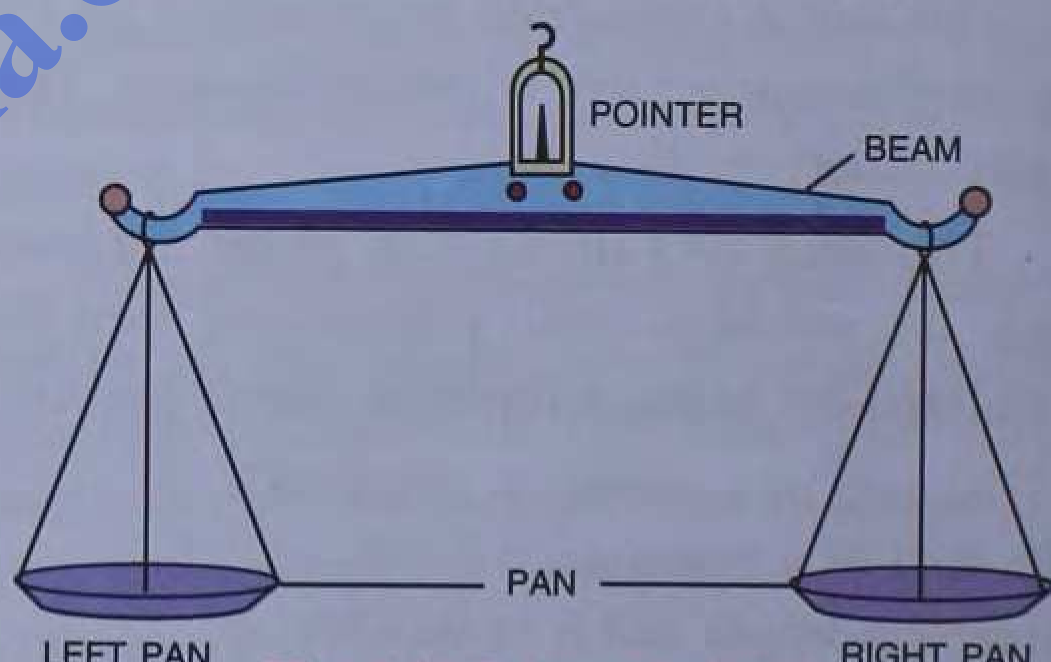
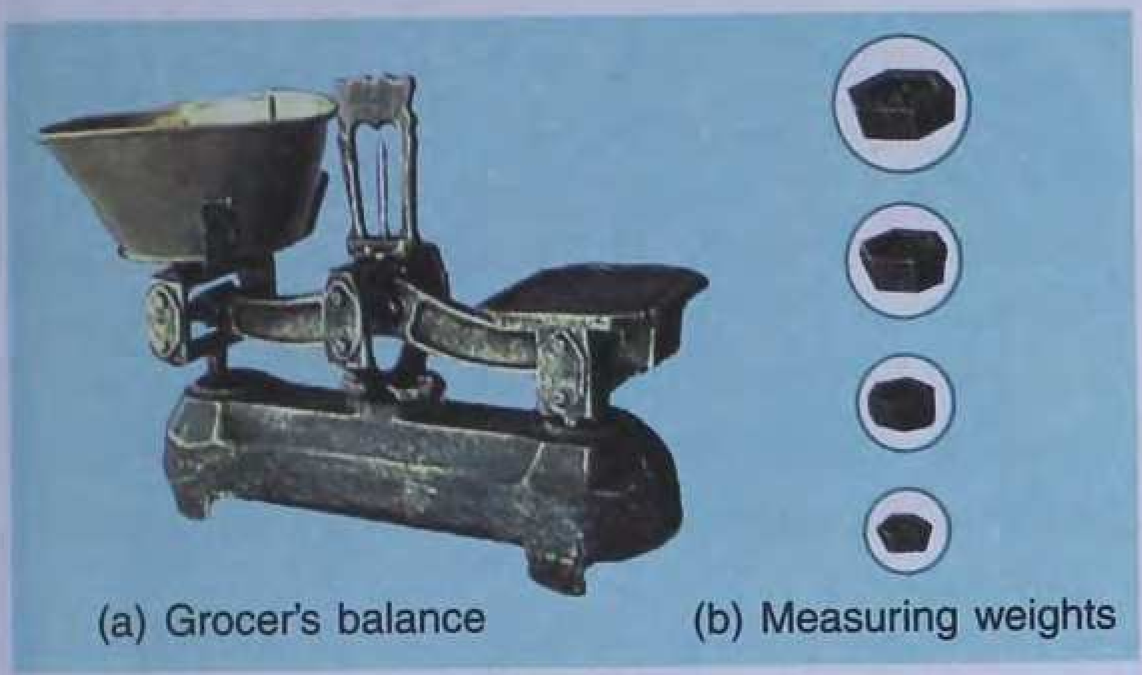


Fig. 1.12 A beam balance

The object to be weighed is placed on one pan and standard weights are placed on the other. The quantity of the object or the value of standard weights used is so adjusted that the pans are balanced. The total of the standard weights used gives the mass of the object.

Some shopkeepers use the grocer's balance (Fig. 1.13) for weighing articles like sugar, rice, pulses, vegetables, *etc*.



(a) Grocer's balance (b) Measuring weights

Fig. 1.13

In the laboratory, we use a more accurate balance known as **physical balance** (Fig. 1.14). It is also used by goldsmiths. Its accuracy and sensitivity both are very high.

Fig. 1.14 A physical balance

Sometimes, an electronic balance is also used in the laboratory for precise and accurate results. Your teacher will show you different kinds of balances used for the measurement of various masses.

Unit of Mass

Its S.I. unit is kilogram (kg) and its CGS unit is gram (g).

Multiples and Sub-multiples of Mass

Following are the multiple and sub-multiple units of mass :

1000 milligrams (mg) = 1 gram (g)
1000 grams (g) = 1 kilogram (kg)
100 kilograms = 1 quintal
10 quintals = 1 metric ton

Intext Questions

1. Name the instruments used to measure the mass of :
   (a) 5 kg of sugar ....
   (b) 3 gms of gold ....
   (c) A sack full of rice ....
2. Mass is the .... of .... contained in a ....
3. Physical balance have now been replaced by ....

MEASUREMENT OF VOLUME OR CAPACITY

If you measure a liquid like petrol, milk, etc., it is measured by volume.

Example : Take a glass tumbler. Paste a paper strip on it as shown in Fig. 1.15. Pour some water in the glass. Mark the water level on the strip as A. Take a stone and tie a string to it.

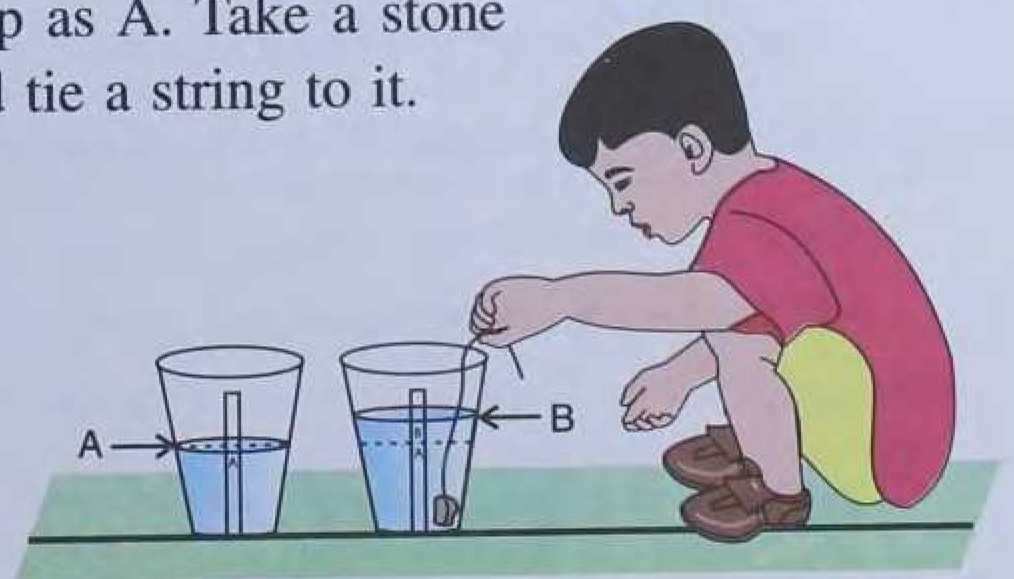


Fig. 1.15 Level of water rises on immersing a stone

Suspend the stone in water in the glass. What do you observe ? The level of water has risen. Mark the new water level as B. What does it suggest ? The stone has displaced water because it occupies space.

The space occupied by an object is known as its **volume** **or** **capacity**.

You know that a brick occupies more space than a match box. It simply conveys that a brick has greater volume in comparison to a match box.

Measuring Volume of Regular Solids

The solids which have regular shapes are called **regular solids**. There are different formulae for finding the volume of regular solids. *For example* :

Volume of a cube = l^3 (where l is the side of the cube)

Volume of cuboid = $l \times b \times h$ (where l, b and h are respectively the length, breadth and height of the cuboid)

Volume of a sphere = $\frac{4}{3}\pi r^3$ (where r is the radius and $\pi = \frac{22}{7}$)

Volume of a cylinder = $\pi r^2 h$ (where r is the radius of the cylinder, h is its height and $\pi = \frac{22}{7}$)

Measuring volumes of regular shapes

S. No.	Shape	Volume	Formula
1.	Cube	Side × Side × Side	l^3
2.	Cuboid	Length × Breadth × Height	$l \times b \times h$
3.	Sphere	$\frac{4}{3}\pi(\text{radius})^3$	$\frac{4}{3}\pi r^3 (\pi = \frac{22}{7})$
4.	Cylinder	$\pi \times (\text{radius})^2 \times$ height	$\pi r^2 h$
5.	Cone	$\frac{1}{3} \times \pi\ (\text{radius})^2 \times$ height	$\frac{1}{3}\pi r^2 h$

Sub-multiple Unit of Volume

The S.I. unit of volume is cubic metre (m^3). A smaller unit of volume is cubic centimetre (cm^3).

$$1\ m^3 = 1\ m \times 1\ m \times 1\ m$$
$$= 100\ cm \times 100\ cm \times 100\ cm$$
$$= 1000000\ cm^3 \text{ or } 10^6\ cm^3$$

$$1\ m^3 = 1000\ dm^3$$
$$1\ dm^3 = 1000\ cm^3$$
$$1\ cm^3 = 1000\ mm^3$$

When the volume of an object is small, it is convenient to express its volume in sub-multiples of m^3, such as, cubic decimetre (dm^3) and cubic centimetre (cm^3), etc.

VESSELS TO MEASURE VOLUME

The volume of a liquid, which can fill a container completely, expresses the capacity of the container. Thus, the inner volume of a container is expressed as its **capacity**.

Look at Fig. 1.16. You must have seen some of these vessels for measuring volume

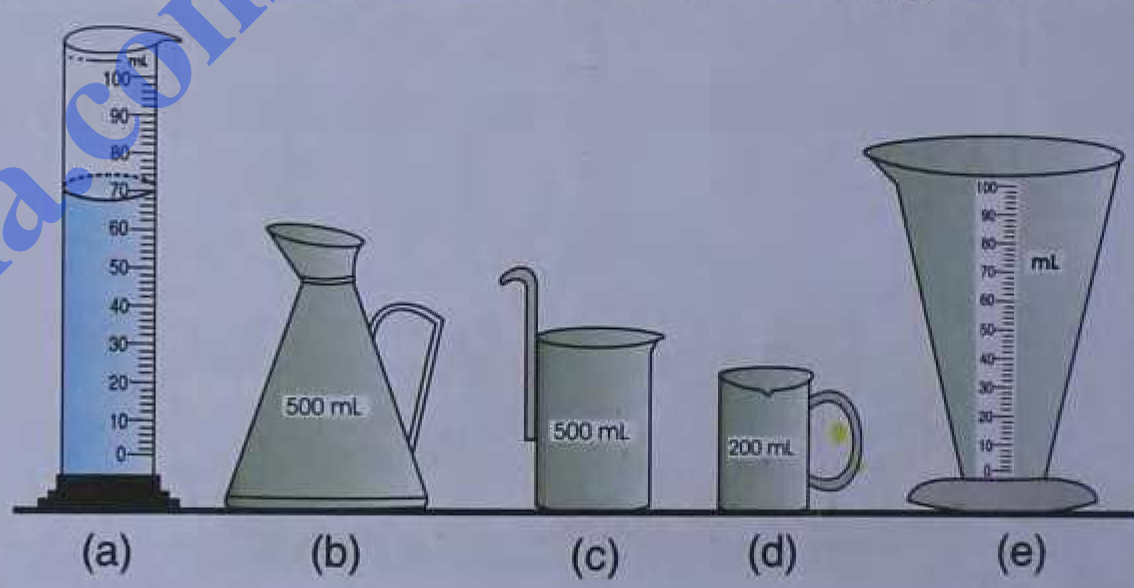


Fig. 1.16 Various containers are used to measure the volume of liquids

of a liquid. Vessel (a) is known as a measuring cylinder. Measuring cylinders are used in laboratories to measure the volume of liquids. Vessel (b) is used for measuring kerosene and lubricating oils. Vessels (c) and (d) are generally used for measuring milk or edible oils. Pharmacists use vessel (e) to measure liquid medicines.

The volume of a liquid is measured with the help of a measuring cylinder. In a measuring cylinder, the liquid surface is curved slightly. This curved shape is called the *meniscus*. When you take a reading from a measuring cylinder, your eye must be at the same level as the ***bottom of the meniscus***, as shown in Fig. 1.17.

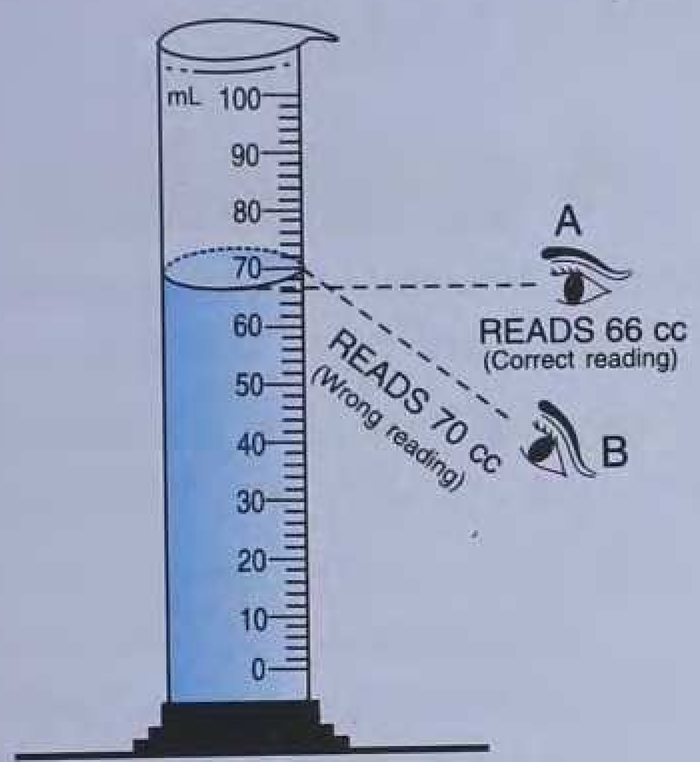


Fig. 1.17 Position of eye at point A is correct while reading the measurement of volume of a liquid

Measuring Volume of Irregular Solids

We can find the volume of irregularly shaped solids with the help of a measuring cylinder. We have just studied that everything occupies space. The space occupied by the object is nothing but its volume. Therefore, when a solid object is dipped in a liquid, the level of the liquid rises. The difference between the original volume of the liquid and the final volume of the liquid (obtained after dipping the solid) is the volume of the irregularly shaped solid.

The volume of the liquid displaced is equal to the volume of the submerged object.

ACTIVITY 6

To measure the volume of a stone, take a stone, a measuring cylinder, sufficient thread and some water.

Take the measuring cylinder and fill it partially with water. Note the reading of the water level very carefully. Now tie a stone with a thread and dip it completely into water. We see that the level of water rises. Note the new reading of the water lever. The difference in the two levels of water gives the volume of the stone.

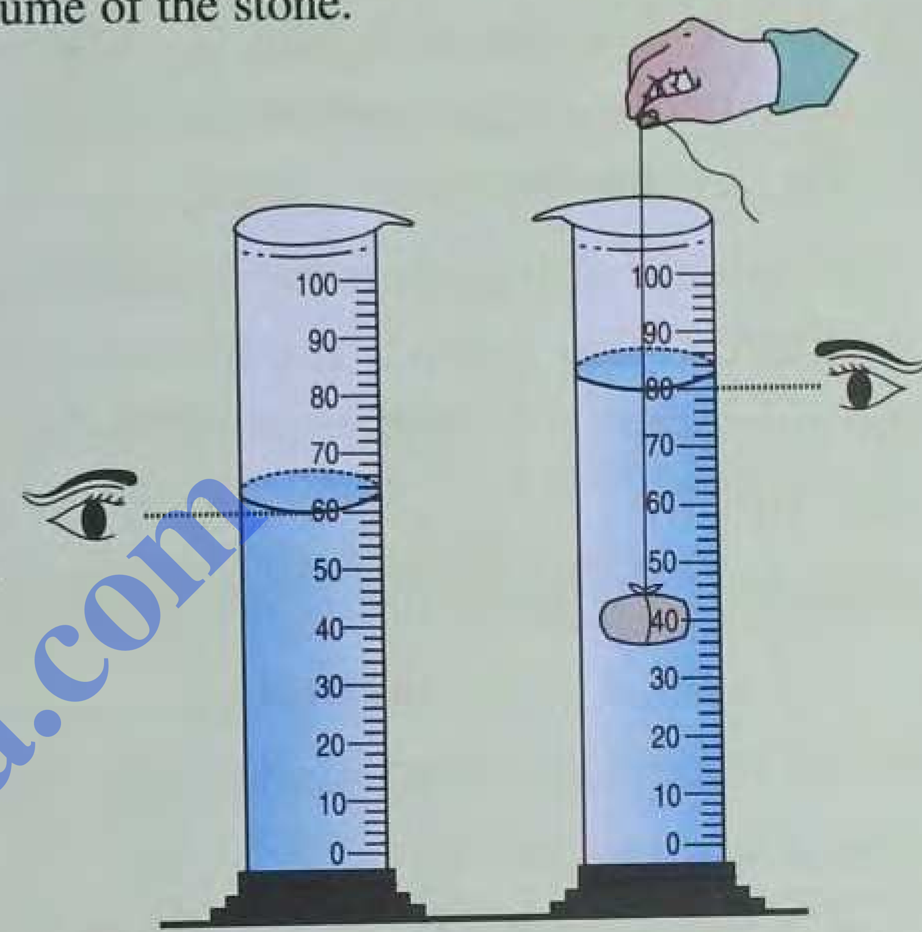


Fig. 1.18 Measuring volume of a stone (an irregular object)

We may write

Initial volume of water = 60 mL

Volume of water when stone is immersed = 80 mL

∴ Volume of water displaced = 80 mL – 60 mL = 20 mL

∴ **Volume of the stone = 20 mL**

VOLUME OF LIQUID

Liquids such as water, milk, edible oil, petrol, kerosene, *etc*., are measured by their volume. Many other things such as liquid medicines, ghee and ice-cream *etc*., are also sold by volume. **The volume of liquids is expressed in litre (L).** Note that litre is denoted both by 'L' and '*l*' though 'L' is perferred. How much is one litre ? Let us find out.

If we fill oil in two bottles of difference size, we shall say that the capacity (volume) of the big-sized bottle is more than that of the small-sized bottle.

We can also express the capacity of the bottle as its volume. *For example*, if we say the capacity of the bigger bottle is 2 litres and that of the smaller one is 1 litre, it means that the volume of the bigger bottle is 2 litres and that of the smaller bottle is 1 litre.

The volume of liquids is measured in litres and millilitres. The symbol for litre is L. The commonly used sub-multiple of a litre is millilitre (mL).

1 litre (L) = 1000 millilitres (mL)

1 mL is same as 1 cm^3.

Also remember that, one cubic metre contains one thousand litres.

or, $1\ m^3 = 1000$ L

Relation between litre and other units of volume

Other units of volume, in use, are cm^3, and dm^3, where

$$1\ l = 1000\ cm^3$$

Also, $1\ l = 1\ dm^3$

Intext Questions

1. Change the following masses from kilogram to gram : (a) 5 kg (b) 3.8 kg.
2. Change the following masses from gram to kilogram : (a) 2600 g (b) 800 g.
3. A measuring cylinder contains 20 cm^3 of water. Four marbles of equal size are added to the measuring cylinder. The total volume of contents (water + marbles) in the cylinder becomes 28 cm^3. What is the volume of (a) 4 marbles (b) each marble ?
4. Unit of volume in MKS system is ....
5. Unit of volume in CGS system is ....
6. 1 litre = ... mL
7. 1 litre = ... cm^3.

TEST YOURSELF

A. Short Answer Questions :

1. Write ***true*** or ***false*** against each of the following statements :
   (a) Area is the measure of surface of an object.
   (b) Cubit is the standard unit of measurement.
   (c) The S.I. unit of area is square metre.
   (d) The word capacity means the same as volume.
   (e) Mass is a measure of the quantity of matter.

2. Fill in the blanks :
   (a) The volume of an object is the .... occupied by it.
   (b) The S.I. unit of length is ....
   (c) 1 cm^3 is equal to .... mL.
   (d) The area of a rectangle is the product of its length and ....
   (e) The volume of a liquid can be measured by using a ....

3. (a) Answer the following in *one* word.

(i) What is the standard unit of length ?

(ii) What is the S.I. unit of mass ?

(b) The S.I. unit of area is

(i) m^3 (ii) m^5

(iii) m^2 (iv) m^4

(c) The S.I. unit of volume is

(i) m^2 (ii) m^3

(iii) m^4 (iv) m^5

(d) The common unit of capacity is

(i) cubic litre (ii) centilitre

(iii) millilitre (iv) litre

(e) The quantity of matter present in a body is called its

(i) mass (ii) weight

(iii) pressure (iv) force

4. Match the following :

(a) Volume of a liquid	(i) measuring jar
(b) Mass	(ii) measuring tape
(c) Length	(iii) litre
(d) Cubic decimetre	(iv) kilogram

B. Long Answer Questions :

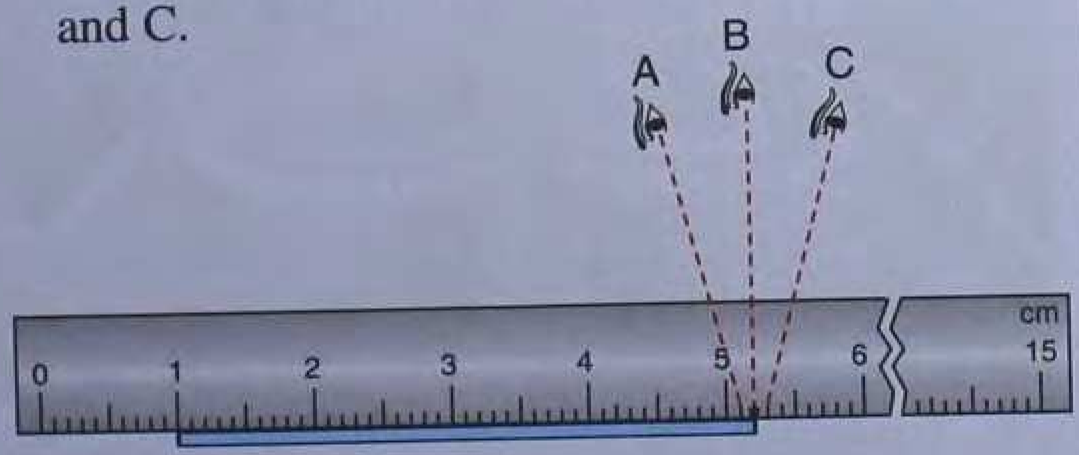
1. Define mass. State its S.I. and C.G.S. units.

2. How will you measure the area of an irregular surface ?

3. How will you measure the diameter of a ball ?

4. What are the multiples and sub-multiples of kilogram ? How are they related ?

5. The diagram given below shows a stick placed along a metre scale. The length of the stick is measured keeping the eye at positions A, B and C.



(a) Write the length of the stick as observed for each position of the eye. Are they all same ?

(b) Which is the correct position of the eye ?

(c) Write the correct length of the stick.

6. The adjacent diagram shows eighteen 1-rupee coins placed one above the other, near a metre scale. What is the reading on the scale ? Calculate the thickness of one coin.

7. Name the instrument which is used to measure the mass of a body.

8. What do you mean by volume ? What is its unit ?

C. Numericals

9. (a) Measure the length of the pencil given in the figure to the nearest millimetre.

(b) Write this length in centimetre ?

(c) How is a centimetre related to a millimetre and a metre ?

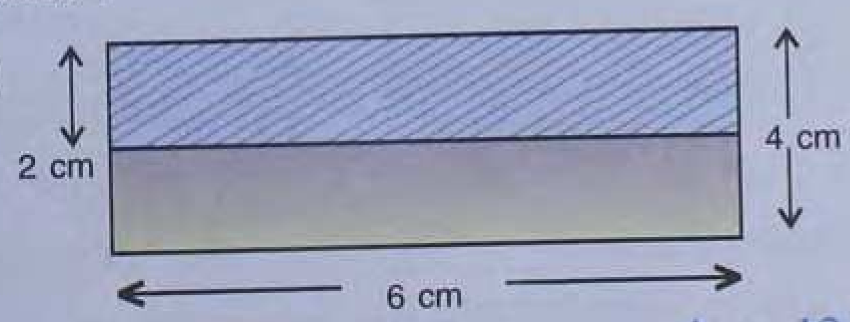
10. Ritu bought 5 packets of biscuits each containing 50 biscuits. The weight of all packets was 2 kg and 500 gm. What is the weight of *one* biscuit ? **Ans.** 10 g

11. One dozen of carom board coins were arranged one above the other. Their total height was 6 cm and 6 mm. What is the thickness of each coin ? **Ans.** 5·5 mm

12. Calculate the mass of water in a tank of length 50 cm, breadth 40 cm and height 10 cm, if the mass of 1 cm^3 of water is 1 g. **Ans.** 20 kg

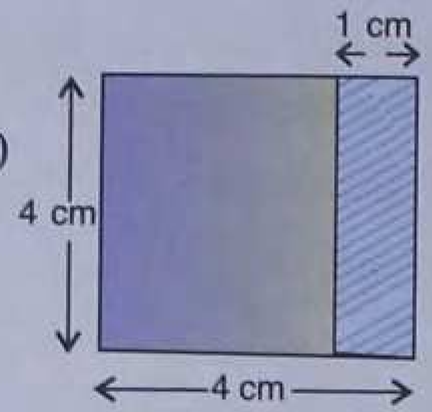
13. Find the area of shaded portions in the following figures :

(a)



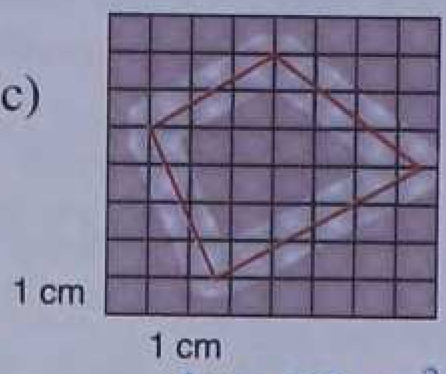
Ans. 12 cm^2

(b)



Ans. 4 cm^2

(c)



Ans. 20 cm^2

14. The length of a rectangular field is 60 m and its width is 35 m. Calculate its area.

Ans. 2100 m^2

15. How much water will fill a dish of size 10 cm × 10 cm × 5 cm ?

Ans. 500 cm^3 or 500 mL

1B Measurement of Time, Temperature and Approximation

MEASUREMENT OF TIME

The interval between two instances or events is called time. We measure time with the help of **mean solar day**. *Mean solar day is the time taken by the earth to complete one rotation about its own axis.*

Unit of Time

Second is the standard unit of time. It is followed all over the world. In short form, we write it as 's'.

Other Units of Time

The other units of time are as follows :

60 seconds = 1 minute

60 minutes = 1 hour

24 hours = 1 day

7 days = 1 week

365 days (approx) = 1 year

10 years = 1 decade

10 decades = 1 century

10 centuries = 1 millennium

Ancient Methods of Time Measurement

It seems time has always been important to mankind. In ancient times, people used to estimate time by observing the regularity of day and night. With the passage of time, for accuracy, a water clock, a candle clock, a sundial, a sandclock, *etc.*, were invented.

The sundial was used to record time in the days of Alexander the Great (300 B.C.). It was based on the fact that the shadow of an object changes its position and length with the position of the sun in the sky.

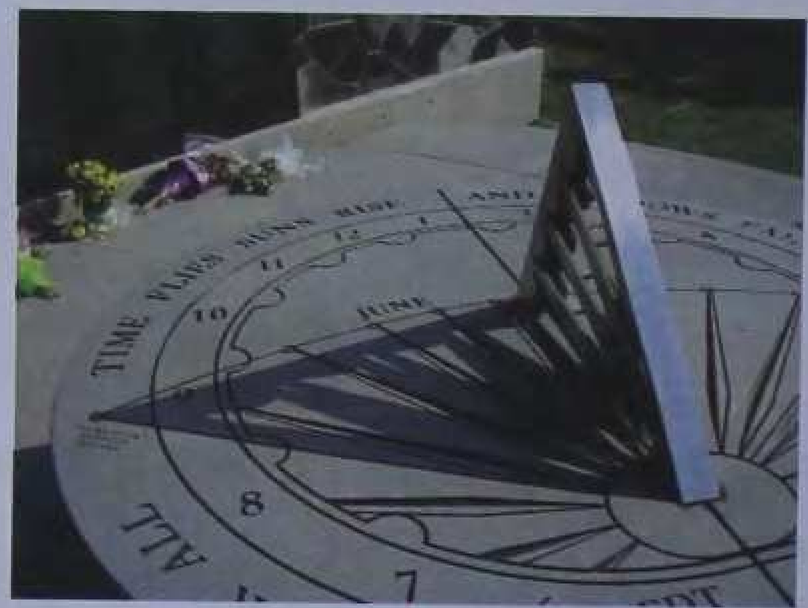


Fig. 1.19 A sundial

Maharaja Jai Singh made huge sundials, which can be seen even today at Jantar Mantar, New Delhi, and at Jaipur in Rajasthan.

Fig. 1.20 Misra Yantra at Jantar Mantar, New Delhi

Modern clock and watches also measure time with the help of events that repeat after a fixed time-interval. The common example is a simple pendulum clock (Fig. 1.21).

Fig. 1.21 Pendulum Clock

In a pendulum clock, time is measured by making use of the time taken by the pendulum for each oscillation.

A simple pendulum is a heavy point mass (called the bob) suspended from a rigid support by a massless and inextensible string. Figure 1.22 shows a simple pendulum.

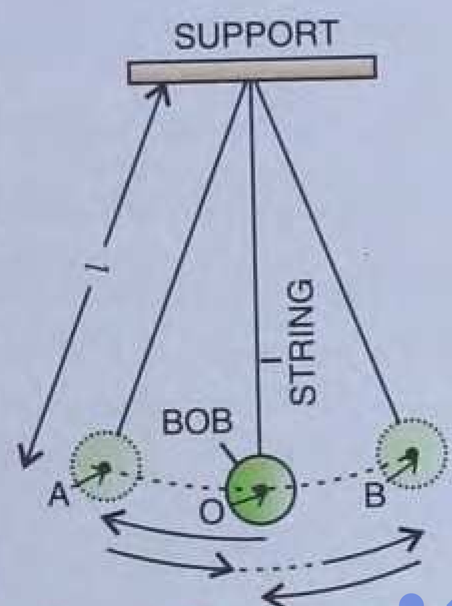


Fig. 1.22 A simple pendulum

When the bob from its rest position O is moved to one side and then released, the pendulum is set in motion and the bob moves alternately on either side of its rest position.

One complete to and fro motion of the pendulum is called one *oscillation*.

For example, in a simple pendulum shown in Fig. 1.22, the rest (or mean) position of bob is O, while its extreme positions on either side are A and B. One oscillation is the motion of the bob from O to A, A to B and then back from B to O, (or it is from A to B and back from B to A).

Devices for Measuring Time Interval

The time interval of an event is measured with the help of a stop clock or a stop watch. Figure 1.23 shows a stop clock and a stop watch.

(a) STOP CLOCK (b) STOP WATCH

Fig. 1.23 Devices for measuring time interval

ACTIVITY 7

To estimate the time taken for common day-to-day activities, we always do not act according to the clock. We make approximations and estimations. *For example*, we may utilise 15 minutes to take a bath. It can take 13 or 16 minutes but may not take exactly 15 minutes. This is an estimated time which is mostly different from actual time. A list of various activities are given below. Find the estimated and actual time for all these activities. Write your observations too.

Activities	Time (Estimated)	Time (Actual)
1. Bathing		
2. Eating breakfast		
3. Reaching school		
4. Playing in park		
5. Watching television		
6. Doing home work		

An electronic stop watch (Fig. 1.24) is more accurate than a mechanical stop watch. It can measure time intervals accurately upto 0.01 s. It does not have a minute or second hand. Instead, it has a digital (number) display. Such watches are used for measuring the timings of athletic activities.

Fig. 1.24 An electronic stop watch

Do You Know ?

1. One of the most famous clocks in the world is located at the Parliament in London. It is called the Big Ben, which is the name of its biggest bell.

2. The most accurate clock is fixed at the United States Naval Research Laboratory in Washington D.C. It is an atomic hydrogen master clock and is accurate to one second in 17,00,000 years.

Our conventional watches can measure a minimum time of one second, but at times, this is not sufficient. In present day world, many a time, we need to measure even one hundreth of a second. For this, electronic watches are used. But there are watches which can even record the 10 millionth of a second. Such watches are used for scientific works and are called **atomic watches**.

Reading a Twenty-four Hour Clock

In a clock, the shorter arm is the **hour** arm while the bigger arm is the **minute** arm and in some clocks, there is one more arm which is called the **second's** arm. The hour arm completes one round in 12 hours and the minute arm does it in 1 hour. The second's arm completes one round in 1 minute or 60 seconds.

A day starts from the midnight of a day and ends at the next midnight. Thus in one day, the hour arm completes two rounds. The time of arrival or departure of a train or an aeroplane is expressed by a 24 hours clock, as a day consists of 24 hours. In such a clock, the time from 12 o'clock at midnight to 12 o'clock at noon is expressed as a.m. The time from 12 o'clock at noon to 12 o'clock at midnight is expressed as p.m.

We can convert 24 hours time to 12 hours time by following these rules.

1. In a 24 hours clock – 00 hours means 12 o'clock at midnight.
2. 12 hours means – 12 o'clock at noon.
3. The time between 00 hours and 12 o'clock at noon is called a.m. (*ante meridiem*) (before midday). Similarly, the time between 12 o'clock at noon and 00 hours at midnight is called p.m. (*post meridiem*) (after midday).

Lucknow Jabalpur Chitrakoot Express	↓ TRAIN NAME ↑				Lucknow Jabalpur Chitrakoot Express
5009	Train Number				5010
3A, SL,II	Class of accommodation				3A,SL,II
Daily	Dep. Days of Operation Arr.				Daily
17.30	km	d	Lucknow	a	09.35
19.00	72	a	Kanpur	d	08.10
19.25		d		a	07.50
22.55	216	a	Banda	d	03.03
23.05		d		a	02.55
00.44	285	a	Chitrakoot	d	01.17
00.49		d	Dham Karvi	a	01.12
02.20	316	a	Manikpur	d	00.45
02.45		d		a	00.20
04.15	401	a	Satna	d	22.35
04.25		d		a	22.25
06.05	492	a	Katni	d	20.50
06.10		d		a	20.45
07.55	583	a	Jabalpur	d	19.30
Daily	Arr. Days of Operation Dep.				Daily

Table showing the use of twenty-four hour clock in train schedule

ACTIVITY 8

You want to travel by train which is scheduled at 14 hours 30 minutes and you want to know this time in 12 hour clock time.

14 hours 30 minutes – 12 hours 00 minutes

= 2 hours 30 minutes

Thus, your train is scheduled to run on 2 hours 30 minutes in the afternoon or at 2 : 30 p.m. in 12 hour clock time.

Intext Questions

1. What is the S.I. unit of time ?
2. What unit of time is suitable for measuring the following ?
   (a) The time for a 100 - metre race.
   (b) The time for a 1600 - metre race.
   (c) The time to fly from Mumbai to Kolkata.
   (d) Time for which you sleep in night.
   (e) Time for which you study at home.
   (f) Time you take to reach school.

MEASUREMENT OF TEMPERATURE

When we put our hand in hot water, we feel hot. It is because the temperature of hot water is more than our body temperature. Actually, it is the difference in temperature that makes the feeling of hotness or coldness.

The temperature is the measure of degree of hotness or coldness of a body or environment.

The S.I. unit of temperature is **Kelvin**. But the commonly used unit to measure temperature is degree celsius (°C).

Thermometer

We use a thermometer to measure the temperature. A thermometer consists of a small cylindrical bulb containing a liquid, either mercury or alcohol. Generally, mercury is used in a thermometer. The bulb is attached to a narrow glass tube called the capillary tube. The outer body is triangular in shape so that markings on the body get magnified when we try to see them. These markings are calibrated in **degrees**.

Fig. 1.25 A thermometer

Scales on Thermometers

Whenever markings are done on a thermometer, usually two points are taken into consideration, one is the melting point of pure ice and the other is the boiling point of pure water. These two points are called reference temperatures and are termed as **lower fixed point** and **upper fixed point** respectively.

In general, Fahrenheit, Celsius and Kelvin are the three scales used in thermometers.

The Celsius scale, also known as centigrade scale, is named after Swedish scientist Anders Celsius. The name 'centigrade' was given because there are 100 degrees between the two reference temperatures. The lower fixed point is 0° C and the upper fixed point is 100°C.

The Fahrenheit scale is named after the German scienteit G.D. Fahrenheit.

The Fahrenheit scale distributes the two reference temperatures into 180 degrees making the lower fixed point at 32° F (0° C) and the boiling point of water at 212° F (100° C).

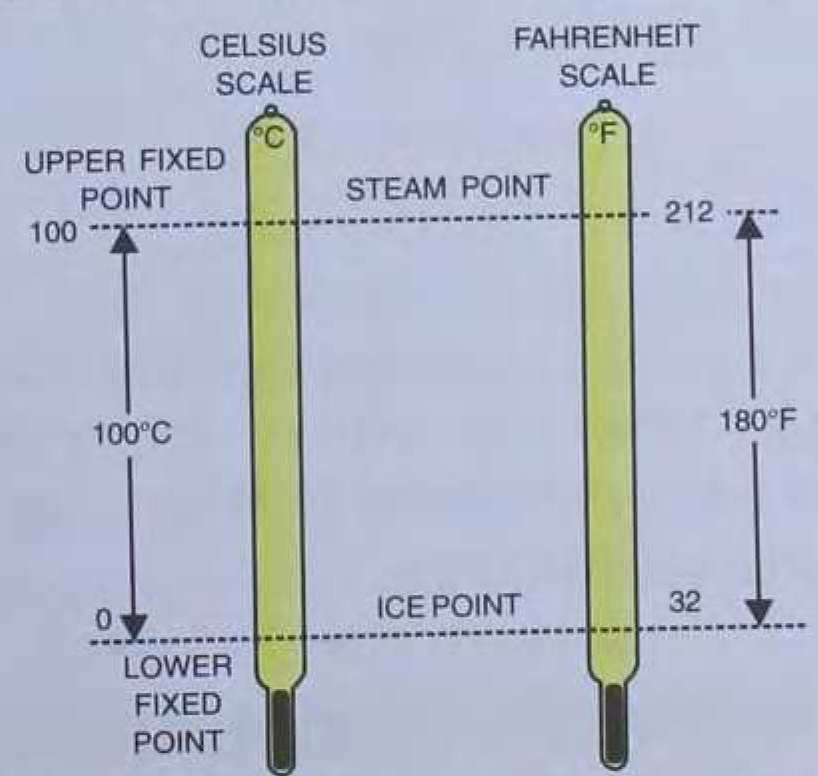


Fig. 1.26 Celsius and Fahrenheit scales

The Kelvin scale is based on the fact that the lowest possible temperature is 273 degrees below the zero degree Celsius.

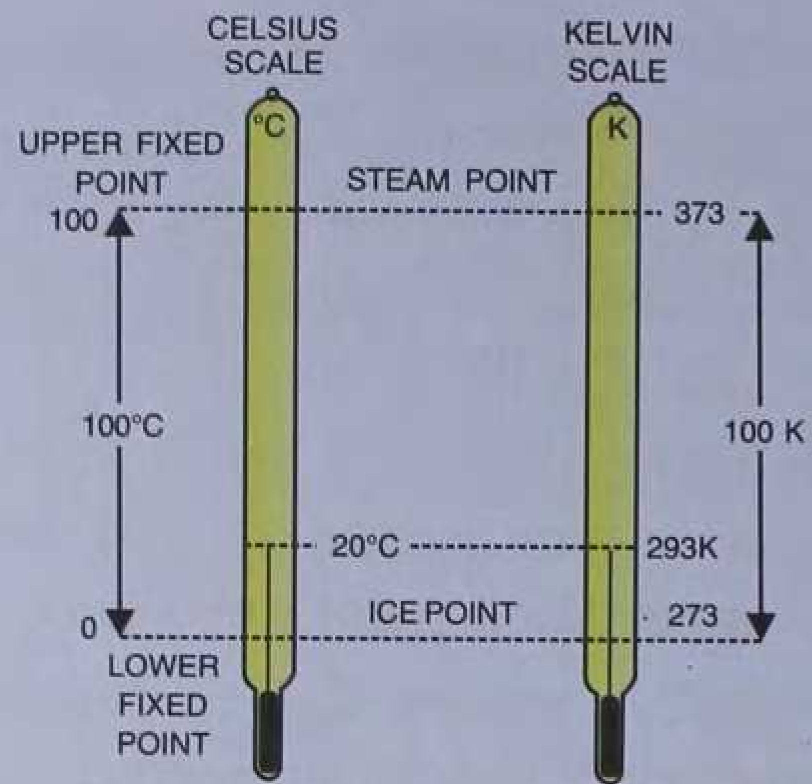


Fig. 1.27 Celsius and Kelvin Scales

A unit on the Kelvin scale is of the same size as a celsius degree and is called Kelvin abbreviated as K. Therefore, to obtain Kelvin as a unit of temperature, we have to simply add 273 to the given value of temperature in degree Celsius.

To convert Celsius into Fahrenheit, the following equation is used :

$$\frac{C}{5} = \frac{F-32}{9}$$

Using equation $\frac{C}{5} = \frac{F-32}{9}$ you can show that 100°C = 212°F. Similarly 0°C = 32°F and –40°C = –40°F.

TYPES OF THERMOMETERS

1. Laboratory Thermometer

In a laboratory thermometer (Fig. 1.28), the markings on its stem (or capillary tube) are between **–10°C** and **110°C**. The distance between two consecutive markings represent one degree celsius (1°C).

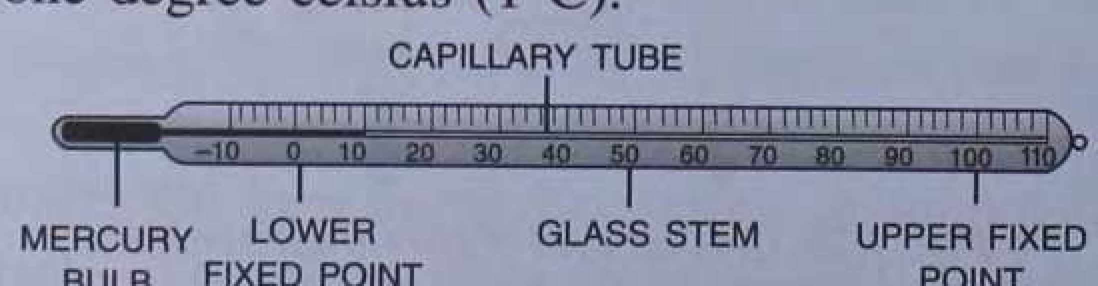


Fig. 1.28 A laboratory thermometer

Laboratory thermometer is used to measure temperature other than human body.

2. Clinical Thermometer

The thermometer which is used to measure human body temperature is called a **clinical thermometer** (Fig. 1.29). It has measurements between a short range of 35°C to 42°C. This is because human body temperature does not vary beyond these limits. Our normal body temperature is 37°C (or 98·6°F).

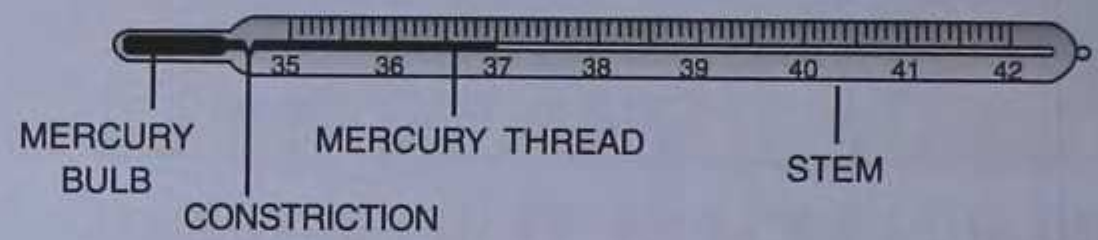


Fig. 1.29 A clinical thermometer

ACTIVITY 9

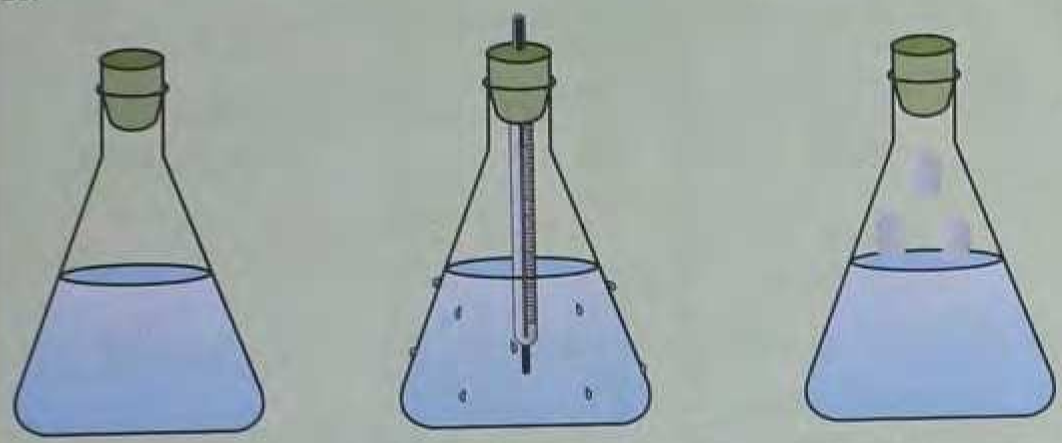
To observe the effect of temperature using a laboratory thermometer.

1. Take three conical flesks.
2. In the first flask, add 100 ml tap water.
3. In the second flask, add 100 ml ice-cold water.
4. In the third flask, add 100 ml hot water.
5. Put a rubber stopper with a hole on each.
6. One by one, dip the laboratory thermometer in the three flasks.
7. Make sure that the bulb of the thermometer is completely immersed in the water and does not touch the bottom or the sides of the flasks.
8. Observe the movement of mercury in the thermometer in each flask. Wait till the mercury thread becomes steady.
9. Note the temperature in each case and record it in the table given below.

Measurement of temperature using a laboratory thermometer.

S.No.	*Sample water*	*Temperature in °C*
1.	Tap water	
2.	Ice-cold water	
3.	Hot water	

Heating expands mercury whereas cooling contracts it.



(a) Tap water (b) Ice-cold water (c) Hot water

Fig. 1.30 Recording the temperature of water

Apart from a prismatic body (triangular body, so that we can read conveniently), a clinical thermometer has a **constriction** in the capillary tube near the bulb. It checks the back flow of mercury when it is taken out of the patient's mouth *i.e.*, the mercury level remains stationary.

Knowledge bank

Digital thermometer : Mercury is toxic in nature. If a thermometer breaks it is difficult to dispose of the mercury. So nowadays, mercury thermometers are being replaced by digital thermometers that do not use mercury.

These days, many doctors use digital thermometers.

Fig. 1.31 A digital thermometer

ACTIVITY 10

To observe the body temperature of different persons.

1. Make a chart of body temperatures of yourself and any two members of your family.
2. Measure the temperature at the same time everyday and for at least a week.
3. Record the temperature in the table given below.

Table : Measurement of body temeprature

Name	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun

Do you find any difference in the body temperature of different persons. The body temperature of every person is not exactly 37°C but may be slightly lower or higher. Actually, the normal temperature (37°C) is the average body temperature of a large number of healthy persons.

Following precautions should be taken while checking the temperature of a body with a clinical thermometer.

1. The thermometer should be washed before and after every use, preferably with an antiseptic solution.
2. Before measuring the temperature, make sure that the mercury level is below 35°C. You can do it by holding it firmly and giving it a few jerks.
3. Keep the thermometer bulb properly under your tongue or in your arm pit at least for one minute.
4. To read the temperature, keep the thermometer at eye level.
5. Never hold the thermometer by the bulb.

ACTIVITY 11

To measure the temperature of a human body with a clinical thermometer.

Take a clinical thermometer in your hand and give few jerks to bring the mercury level below

35°C. Now put the bulb of the thermometer under the tongue and after a minute, take it out and hold it horizontally. Rotate it to see the magnified image of mercury thread. The temperature of the body can now be read. The normal temperature is 98·6°F or 37°C. The temperature below or above these values denotes sickness.

3. Maximum and minimum temperatures on a thermometer

It is a thermometer which measures the minimum and maximum temperatures attained during the day.

It is also known as **Six's thermometer** by the name of its inventor James Six in 1782. It is commonly used in meteorology and horticulture (Fig. 1.33).

It has a U-shaped tube with two separate temperature readings, one for the maximum temperature and the other for the minimum. The bulbs are fixed at the top of each arm. The bulb at the top of the minimum reading scale contains alcohol. The other bulb contains vacuum or low pressure alcohol vapour.

It is the alcohol which measures the temperature and the mercury indicates temperature reading on both the scales. When temperature rises, the alcohol in bulb A expands and pushes the mercury down, with the result that mercury rises into the other arm and we can read the corresponding high temperature on the scale below bulb B.

Similarly, when temperature falls, the alcohol in bulb A contracts and to fill the gap, the mercury below it moves towards bulb A and we can thus read the corresponding low temperature on the scale below bulb A.

As the mercury moves towards bulb B or towards bulb A, it pushes two small steel markers inside the tube. These markers record

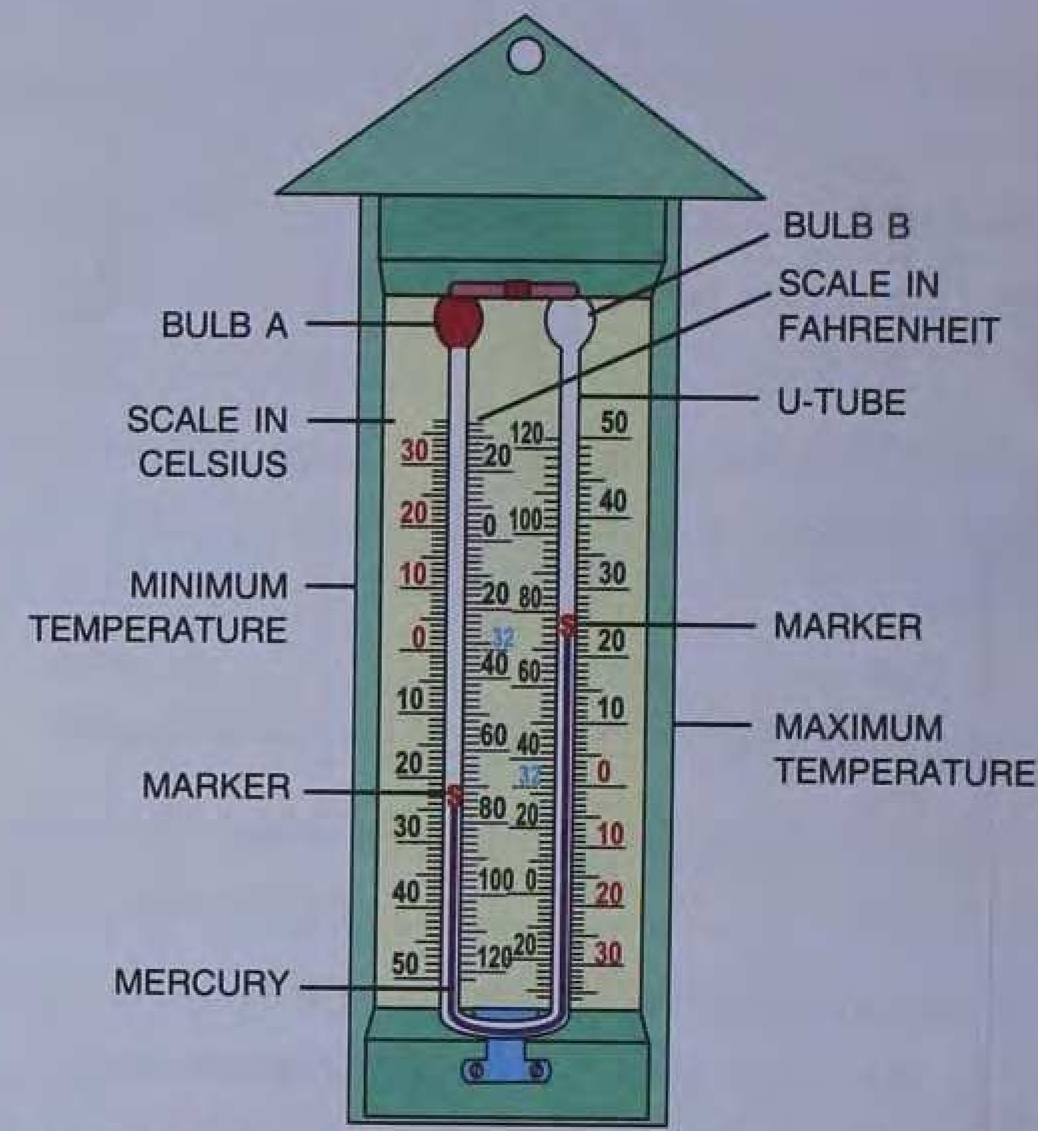


Fig. 1.32 A maximum-minimum thermometer

the farthest point reached by the mercury in each arm of the tube. The markers can be reset by using a small magnet which can drag the markers along the tube so that they can again rest on the surface of the mercury.

Intext Questions

1. What is temperature ?
2. What is the normal body temperature in Celsius and Fahrenheit scales ?
3. Distinguish between clinical and laboratory thermometer.
4. List the precautions that should be taken while taking temperature.
5. Do you know at what value °C is equal to °F?
6. Why is water not suitable for thermometer liquid ?

Advantage of using mercury in a thermometer

- It is opaque and shining. Hence, it is easily visible through the glass.
- It does not wet the glass.
- It has a low freezing point (–39°C) and a

high boiling point (357°C). Hence, it can be used over a wide range of temperatures.

- It is a good conductor of heat, so it quickly absorbs heat to attain the temperature of the object.

APPROXIMATION

Many times, in our daily life, we do not need actual measurement. In other words, we need to make estimations or approximations. In such cases, we estimate things by using our senses of sight and touch. Proper estimations depend on our experience and practice. Thus, *approximation or estimation is a quick judgement about any measurement.* Let us consider some examples, where we use estimations in our daily life.

1. Your mother adds salt or sugar while cooking food, just by estimation. By regular practice, she is able to make correct estimations.
2. You estimate the time of reaching your school from your home.
3. You add sugar to your glass of milk, just by estimation.
4. A painter paints wall by mixing colour paint and oil by estimation only.

From the above examples, we can say that approximations are not accurate measurements but are quite close to actual measurements. This method is useful only when rough measurements are required.

Accuracy in Measurement

We cannot depend on estimations in all situations. Generally, we need to make correct and precise measurements. Let us consider some examples where we need accurate measurements.

1. You take a piece of cloth to a tailor to stitch a shirt for you. The tailor stitches the shirt on the basis of approximate measurements. Does the shirt fits in size ? It may be loose or tight. Now you can say that the tailor should take your accurate measurement so that the shirt fits you well.
2. A chemist should weigh the medicine accurately, otherwise serious problems may occur to the patient.

We can also say that accuracy in measurement also depends upon the need and value of situations.

Taking Average

We can minimise errors in measurements by taking their average. In scientific laboratories, accurate measurements are essential. In such cases, the measurement of a particular object is taken several times and then the average of all the measurements is taken.

$$\text{Average} = \frac{\text{Sum of observations}}{\text{Number of observations}}$$

ACTIVITY 12

(a) To calculate the average pulse rate of your five classmates.

Check the radial artery on your right wrist towards the thumb side. You will find the pulse. Each pulse represents one heart beat. You can count how many times your heart beats in one minute. In a similar way, note down the pulse rates of other students.

Fig. 1.33 Measuring pulse rate

To find the average pulse rate of all the five students, first add their pulse rates and divide them by five. By doing this, you will get the average pulse rate.

$$\text{Average} = \frac{70+71+72+72+72}{5}$$

Average pulse rate = 71·4

(b) As a project work, do the same for the whole class.

ACTIVITY 13

Take the heights of all the students in your class.

1. Find the average height of the students.
2. Find the range of the heights of the students in your class.

MAINTENANCE OF STANDARDS

In order to maintain the national standard, laboratories have been set up in different regions or States of India. The weights and other measures used in any part of the country are to be tested and certified. In India the National Physical Laboratory is responsible to calibrate the measurement standards of all the regional laboratories. Thus, the measurements made in different parts of India are standardised by linking them to the national and international standards.

After establishing National Standards of different physical quantities, they are periodically compared with the standards maintained at the *International Bureau of Weights and Measures* in Paris.

Intext Questions

1. Write names of four ancient devices of measurement of time.
2. How can you measure a time interval ?
3. What are the different scales of thermometer ?
4. Where is maximum and minimum thermometer used ?
5. What are the uses of estimation and approximation ?
6. Why in case of infants, the thermometer is not put into their mouth while checking their fever ?

1. While meauring a line, Akash puts 3·1 cm mark of the ruler at one end of the line and 8·9 cm mark of the ruler to the other end. What is the length of the line ?

Solution :

Length of line = Difference in readings

= 8·9 cm – 3·1 cm

= **5·8 cm**

2. A circular park has a diameter of 30 metres. Calculate the area of the park.

Solution :

Given diameter = 30 m

$\therefore$ radius $= \frac{30}{2}$ m = 15 m

Area, (A) $= \pi r^2 = \frac{22}{7} \times 15 \times 15 \text{ m}^2$

$= \frac{22}{7} \times 225 =$ **707·14 m²**

3. Calculate the volume of your book which is 24 cm in length, 15 cm in width and 1 cm in height.

Solution :

Given l = 24 cm, b = 15 cm, h = 1 cm

Volume $= l \times b \times h$ = 24 cm × 15 cm × 1 cm

= **360 cm³**

4. Express your answer for question no 3 in m^3.

Solution :

$1000000 \text{ cm}^3 = 1 \text{ m}^3$

$\Rightarrow \quad 1 \text{ cm}^3 = \frac{1}{1000000} \text{ m}^3$

$\therefore \quad 360 \text{ cm}^3 = \frac{1}{1000000} \times 360 \text{ m}^3$

= **0·00036 m³**

TEST YOURSELF

A. Short Answer Questions :

1. Write ***true*** or ***false*** for each statement :
   (a) Common unit of temperature is Fahrenheit.
   (b) Every measurement involves two things – a number and a unit.
   (c) Mass is the measure of quantity of matter.
   (d) The standard unit of time is hour.
   (e) The human body temperature is measured in degree celsius.

2. Fill in the blanks :
   (a) One quintal = ... kg.
   (b) The quantity of wheat produced by a state is expressed in ....
   (c) Temperature is measured in ....
   (d) The lower fixed temperature in celsius thermometer is the melting point of ....
   (e) The thermometer used to measure human body temperature is called the .... thermometer.
   (f) The normal temperature of human body is .... °C.
   (g) The .... of an object is measured with the help of a beam balance.
   (h) The standard unit of time is ....
   (i) The standard unit of length is ....
   (j) The volume of an object is the .... occupied by it.
   (k) The volume of liquids is expressed in ....
   (l) To read the volume of a liquid in a measuring cylinder, it should be kept on a .... surface.
   (m) The capacity of a tank is expressed in ....
   (n) Measuring cylinder is a device used to measure .... of liquids.
   (o) 1 m^2 = ... cm^2.
   (p) One complete to and fro motion of the pendulum is called one ....

3. Match the following columns :

Column A	*Column B*
(a) Length of housing plot	(i) Clock
(b) Thickness of a ball	(ii) Common balance
(c) Mass of an apple	(iii) Thermometer
(d) Period of time for study	(iv) Measuring tape
(e) Temperature of body	(v) Measuring scale
(f) Surface area of a leaf	(vi) Measuring jar
(g) Volume of a liquid	(vii) Graph paper

4. Answer the following questions :
   (a) The symbol of degree celsius is :
   (i) °C (ii) °F (iii) K
   (b) 10 mm is equal to :
   (i) 1 cm (ii) 1 m (iii) 10 dm
   (c) The amount of surface occupied by an object is called its :
   (i) volume (ii) area (iii) mass
   (d) The space occupied by an object is called :
   (i) area (ii) volume (iii) mass

B. Long Answer Questions :

1. Name the S.I. unit of time. Write its short form.
2. What are the multiples of a second ? How are they related ?
3. What are the *two* conventional units of temperature ?
4. The SI unit of temperature is.
   (a) Kelvin (b) Celsius
   (c) Fahrenheit (d) Centigrade
5. Name the instrument used for measuring temperature.
6. Which liquids are used in thermometers ?
7. What do you mean by lower and upper fixed points ? Write the values of both the points ?
8. A clinical thermometer cannot be used for measuring the temperature of ice or boiling water. Why ?
9. Name *three* types of thermometers.
10. Give *two* advantages of using mercury as thermometric liquid.
11. What does the temperature measure ?

RECAPITULATION

- Science and technology cannot progress without precise measurements.
- Measurement is an essential part of our daily life.
- Measurement has two parts : a number (magnitude) and a unit.
- A physical quantity is a quantity that can be measured.
- Standard units are essential for the purpose of uniformity.
- S.I. units are used for measurements in Science. S.I. stands for *International System of Units.*
- Mass is the quantity of matter contained in a body.
- A physical balance is used to measure the mass.
- Mass is expressed in the units of kilogram (kg), gram (g) and milligram (mg).
- Standard units of length and mass are metre and kilogram respectively.
- The area of irregular surfaces can be calculated with the help of graph paper.
- The space occupied by an object is called its volume.
- Volume is expressed in the units of m^3, cm^3 or mm^3.
- The volume of irregular solids can be found by the "method of displacement".
- Time is an interval between two instances or events.
- Time is expressed in second.
- Temperature is the degree of hotness or coldness of an object.
- Temperature is measured by thermometer.
- Temperature is expressed in degree celsius (°C).
- Clinical thermometer measures human body temperature.
- The normal body temperature of a human is 37°C or 98·6°F.

Project Work

1. Measure length of a curved line :
   You can use a divider from your geometry box to measure the length of a curved line. Your teacher may help you in it. You may use a thread to measure the length again. Then compare the two lengths as formed by divider and by thread.
2. Find the circumference of a cylinder by using the thread method.
3. Find out the different materials sold in market in terms of mass and in terms of volume for example rice is sold in kg *i.e.* mass while milk is sold in litres *i.e.* volume. List atleast 10 items each that are sold in kgs and in litres.
4. Collect pictures of different types of watches and clocks used in the present day world and paste them on a chart paper. Find out a suitable place in your class room for its display.