2 Physical Quantities and Measurement

Learning Outcomes

Students will be able to

- define length, mass and time.
- express length, mass, time, temperature and area in proper units with proper symbols.
- measure length of objects using a ruler and a measuring tape.
- measure mass of an object using a beam balance and an electronic balance.
- measure time using a clock, a watch and a stopwatch.
- relate temperature of an object with its hotness or coldness.
- measure temperature of a person using a clinical thermometer.
- measure temperature of an object using a laboratory thermometer.
- measure area of a regular object using a graph paper.
- convert a physical quantity from one unit into other related units.

Key Concepts

- Physical Quantities
- Units
- Measuring Length
- Measuring Area
- Measuring Mass
- Measuring Time
- Measuring Temperature

Warm Up Activity

List the things that you use to measure the following.

Time: ____________________

Length of a notebook: ____________________

Fever: ____________________

Weight of a pencil box: ____________________

Name any three things that you carry in your school bag which are not heavy.

____________ ____________ ____________

Name any three things that you carry in your school bag which are heavy.

____________ ____________ ____________

In our day-to-day lives, we come across many things which we need to measure. For example, to buy fruits from the market we weigh them on a balance scale, a tailor takes our measurement to stitch the clothes that we wear, a doctor measures our height, weight and our body temperature when we are sick and so on. This shows that measurement plays a very important role in our daily life. It helps us to make a correct judgement and avoid wrong decision. For example, see the two bowls filled with

Fig. 2.1: Measurements in da

milk in Fig. 2.2. Can you say which of them has more milk? Without measuring the volume of milk in both the bowls, it is very difficult to tell which one has more milk.

Fig. 2.2: Which of these has more milk?

Therefore, human beings not only realised the need but also devised methods for various measurements. Measurement can be defined as the process of the finding exact value of an unknown quantity by comparing it with a known fixed quantity.

PHYSICAL QUANTITIES

All the quantities that can be measured are known as physical quantities. Some examples of physical quantities are length, mass, area, time, temperature and volume.

Physical quantities can be categorised into two types—fundamental quantities and derived quantities.

Fundamental Quantities

Fundamental quantities are those physical quantities that are unique and do not depend on any other quantity. Length, mass, time, temperature, electric current, luminous intensity and amount of substances are taken as seven fundamental quantities.

Derived Quantities

Derived quantities are those quantities that are derived from fundamental quantities. For example, area depends on length and breadth. Similarly, volume, speed, force, density, etc. are all derived quantities.

Measurement of Physical Quantities

Whenever we measure an unknown physical quantity, we do so by comparing it with some known quantity. This known quantity is called the unit of measurement. In order to measure any physical quantity, we should know the following things.

- The unit of measurement
- The magnitude of measurement, i.e., a value that represents the number of units contained in that quantity.

For example, if a bucket weighs 2 kg, then kg is the unit of measurement and 2 represents that the unit kilogram is included 2 times in the mass of this bucket.

So we may represent the measurement of a physical quantity as the product of its magnitude and unit.

$$P = N \times U$$

where, P = physical quantity

N = magnitude

U = unit of measurement

Curious Mind

Look at the ruler in your geometry box. What is its length? Also mention its P, N and U.

In the above example, N is 2, U is kg and P is mass (a physical quantity) of the bucket.

Let's study more about units of measurements.

UNITS

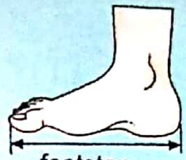
A unit may be defined as a fixed quantity that is used as a standard for measuring physical quantities. For example, length is measured in metres and centimetres, mass is measured in kilograms and grams, and volume is measured in litres. Units are further classified into two types—non-standard and standard units.

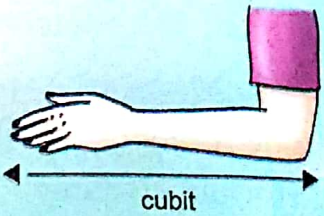
Non-standard units refer to the methods of measurement that were adopted by people in earlier times. For example, cubit, handspan, footstep, etc. were used to measure length. Time was measured with the help of natural events like sunrise and sunset. Seeds, stones and pebbles were used as standard weights to measure mass. These units were approximate and could not be taken as reliable.

In order to avoid confusion in measurement and to maintain uniformity, a set of units were accepted by scientists all over the world as **standard units** of measurement.

The three systems that were developed include the following.

1. CGS (centimetre-gram-second) system
2. FPS (foot-pound-second) system
3. MKS (metre-kilogram-second) system





SI Units

In earlier times, physical quantities measured in different units had different magnitudes. Thus, it bec inconvenient and difficult to compare results. Different units gave complicated relation with some physical quantities. Therefore, the resulting units were also not practical. So there was a need for h only one universal system of units.

In 1960, the General Conference of Weights and Measures met at Paris and accepted the Interna System of Units (SI) world wide. The SI units of seven fundamental physical quantities are given bel

Table 2.1: SI Units

Fundamental physical quantity	Unit and its symbol
Length	metre (m)
Mass	kilogram (kg)
Time	second (s)
Temperature	kelvin (k)
Electric current	ampere (a)
Luminous intensity	candela (cd)
Amount of substance	mole (mol)

Rules for SI Units

Certain rules are to be kept in mind while using the SI units. They are as follows:

- The name of a unit is always written in small letters including the case when it is named after a scientist. Some examples are metre, watt and joule.
- Symbols for units are written in small letters, for example, m for metre, kg for kilogram and s for second. However, symbols for units named after scientists are always written in capital letters, for example, N for newton and W for watt.
- Symbols for derived units which are formed by multiplication are joined with a space or centre dot. For example, the unit newton second is written as N s or N.s. In case of derived units formed by division, the symbols are joined with a solidus (/) or as a negative exponent. For example, the unit metre per second is written as m s^{-1} or m.s^{-1}.
- Names of the units can be written in plural form, for example, 5 metres. But the symbols of units are always written in singular form, for example, 5 m and not 5 ms.
- Since symbols of units are not abbreviations, they do not end in full stops unless they are at the end of a sentence.

Multiples and Submultiples of Units of Measurement

...deal with different magnitudes of physical quantities, we express the units in multiples and submultiples. ...create larger forms of units, factors that are used are called **multiples of units**. The factors which help ...getting smaller forms of units are called **submultiples of units**. To express distance or size of the sun, we ...multiple of metre whereas size of nucleus is expressed using submultiples.

...efix is added to a unit to produce a multiple or submultiple of the original unit, both being integer ...ers of ten. For example, the prefix kilo represents a multiple of thousand and the prefix milli represents ...ultiple of one-thousandth. So, we may express 10000 m as 10 km and 0.004 m as 4 mm.

Table 2.2: Multiples and Submultiples of Units of Measurement

	Prefix	Prefix symbol	Value
Multiple (To produce larger quantities)	peta	P	10^{15} = 1000000000000000
	tera	T	10^{12} = 1000000000000
	giga	G	10^{9} = 1000000000
	mega	M	10^{6} = 1000000
	kilo	k	10^{3} = 1000
	hecto	h	10^{2} = 100
	deca	da	10^{1} = 10

Submultiple (To produce smaller quantities)	deci	d	$10^{-1} = 1/10$
	centi	c	$10^{-2} = 1/100$
	milli	m	$10^{-3} = 1/1000$
	micro	μ	$10^{-6} = 1/1000000$
	nano	n	$10^{-9} = 1/1000000000$
	pico	p	$10^{-12} = 1/1000000000000$
	femto	f	$10^{-15} = 1/1000000000000000$

Stop and Reflect

A. Fill in the blanks.

1. A unit is a __________ quantity used as a standard for measuring physical quantities.
2. Volume is an example of a __________ quantity.
3. Time is a __________ physical quantity.

B. Check whether the following are correct as per the rules of SI units.

1. 8 m
2. 15 kgs
3. 6 metres
4. 10 Joule
5. 40 Kg
6. 20 cm
7. 25 N

MEASURING LENGTH

Length is one of the fundamental physical quantities. **Length** of an object is defined as the distance between its two extreme ends. The SI unit of length is metre (m).

Suppose your teacher asks you to find the length of a table. What will you do? You will immediately find the distance between the two ends of the table with the help of a scale. This distance gives the length of the table.

As different objects have different lengths, we have different units for measuring length. Sometimes we need to measure very long lengths and sometimes very short ones. Therefore, depending upon the need, different units of lengths are used. Some of them are tabulated below.

Table 2.3: Different Units of Length and their Relation to Other Units

Name of unit	Symbol	Relation with other units
Millimetre	mm	1 mm = 0.001 m = 0.1 cm
Centimetre	cm	1 cm = 10 mm = 0.1 dm = 0.01 m
Decimetre	dm	1 dm = 10 cm = 0.1 m
Metre	m	1 m = 100 cm = 10 dm = 0.001 km

Kilometre	km	1 km = 1000 m = 1,00,000 cm
Inch	inch	1 inch = 2.54 cm = 0.0254 m
Foot	ft	1 ft = 12 inches = 0.305 m
Yard	yd	1 yd = 3 ft
Astronomical Unit (Used to measure distance in space)	A.U.	1 A.U. = 1.5×10^{11} m

If we need to measure the length of a book, we measure it in centimetres. The thickness of a wire is measured in smaller units like millimetre. The length and breadth of a room is measured in metres. The distance between two cities is measured in kilometres, and between two planets in much bigger units like astronomical unit. Height of a person is measured in feet (plural of foot) and inches.

Instruments for Measuring Length

The measurement of length can be made using various measuring tools such as ruler, metre rod, measuring tape, vernier callipers and screw gauge. For very small length measurements, instruments like vernier callipers and screw gauge are used. These are used to measure the thickness, diameter, length, breadth, etc.

(a) Ruler (b) Measuring tape (c) Vernier callipers (d) Screw gauge

Fig. 2.3: Some devices used for measuring length

Let's understand the following two devices for measuring length: a metre ruler/rod and a measuring tape.

Using a Metre Ruler/Rod to Measure Length

To measure straight objects we use a ruler. It is available in different lengths (30 cm, 15 cm) and material (plastic, wood and metal). The smallest marking on a ruler is one millimetre (mm).

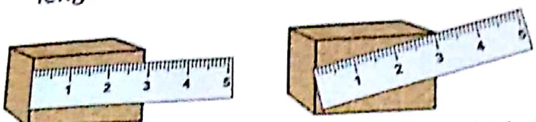
A metre rod is one metre long and is divided into 100 divisions of one centimetre each. Each centimetre is further divided into 10 millimetres. So it is graduated to read up to one millimetre.

To measure the length of any material using the ruler, the steps given below should be followed.

1. Place the ruler along the length to be measured, parallel to its graduation (the markings on ruler).
2. Make sure that the zero mark of the ruler coincides with one of the ends of the length to b measured.
3. In some rulers, the ends may be broken and the zero mark may not be clearly visible. In such case some other digit say mark 1 can be taken as the initial reading. You must remember the digit take

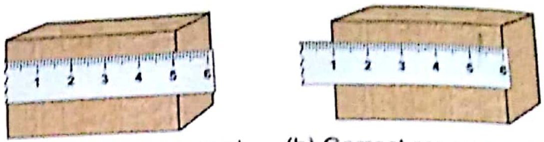
and subtract it from the final reading at the other end to get an accurate measurement of the length.

For example, in Fig. 2.5(b) the initial reading is 1 cm and the final reading is 6 cm. Therefore, the length of the box is 6 cm – 1 cm = 5 cm.



(a) Correct method (b) Incorrect method

Fig. 2.4: Methods of placing the ruler



(a) Incorrect measurement (b) Correct measurement

Fig. 2.5: Measurement when one end of the ruler is broken

4. For taking measurements, correct position of the eye is also very important. The eye must be exactly vertically above the mark to be read. In other positions of the eye, the reading is either more or less than the actual reading. Such an error in measurement that arises due to wrong positioning of the eye is called parallax error.

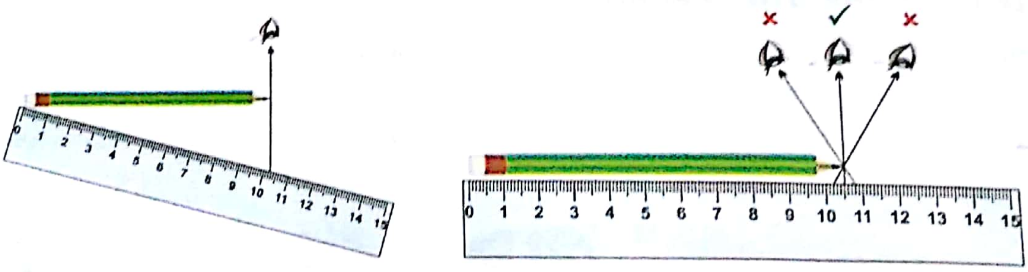


Fig. 2.6: Correct position of eye for measuring the length of an object

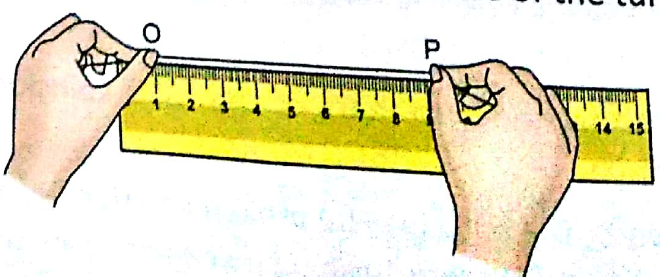
Now let's now learn how to measure length of objects of different shapes with the help of activities.

Activity 2.1

Aim: To measure the length (circumference) of a curved object (tumbler)

- Take a thread and mark a point on it with the help of a marker. This point will serve as the starting point on the thread. Mark it as point O.
- Now, wrap the thread around the curved surface of the tumbler.
- Mark the end of the thread that meets point O as point P.
- Now, hold the thread tightly and keep point O at zero or any other marking of the ruler. Note down the marking where point P falls.

The difference between the readings at points P and O gives the circumference of the tumbler.



Stop and Reflect

Make the following conversions.

1. 2 cm = ______ m
2. 4.5 km = ______ m
3. 5 ft = ______ inches
4. 7 m = ______ dm
5. ______ cm = 450 mm
6. 1 A.U. = ______________ km

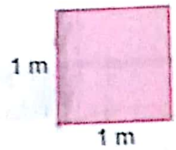
MEASURING AREA

The space occupied by a two-dimensional figure on a plane is called the area of that object. In other words, area is the surface enclosed within the boundary of a two-dimensional figure.

For measuring area of an object, we need measurement of its dimensions like length, breadth, etc. therefore, it is a derived quantity.

The area of a given figure is calculated by finding the product of its length and breadth. The SI unit of area is metre^2 or m^2 (read as square metre), as the SI unit of length and breadth is metre.

For example, a square cardboard piece has side equal to 1 metre. Its area is calculated as follows.



$A = 1\text{ m} \times 1\text{ m} = 1\text{ m}^2$

Larger units of area which are used to measure bigger areas like area of a farm, a house, a country, etc. are hectare and km^2. Similarly, for expressing area of smaller objects like a book, a matchbox, a round plate, etc. the units of area used are cm^2 and mm^2.

Table 2.4: Relationship between Various Units of Area

$1\text{ km}^2 = 1\text{ km} \times 1\text{ km}$	1 hectare = 100 m × 100 m	$1\text{ cm}^2 = 1\text{ cm} \times 1\text{ cm}$	$1\text{ m}^2 = 1\text{ m} \times 1\text{ m}$
= 1000 m × 1000 m	$= 10^4\text{ m}^2$	= 10 mm × 10 mm	= 100 cm × 100 cm
$= 1000000\text{ m}^2$		$= 10^2\text{ mm}^2$	$= 10^4\text{ cm}^2$
$= 10^6\text{ m}^2$			

Measuring Area of Regular Surfaces

Using Standard Formulae

The area of regular surfaces such as square, rectangle and triangle is easy to calculate because there are specific formulae for each of them.

For example, we calculate the area of a rectangular tray of length 8 cm and breadth 12 cm in the following manner.

Length = 8 cm

Breadth = 12 cm

Area of tray = Length × Breadth

$= 8\text{ cm} \times 12\text{ cm} = 96\text{ cm}^2$

Remember

- If the shape of an object covers ½ a square on graph paper, the area is taken as ½ square unit.
- If the shape of an object covers more than ½ a square on graph paper, the area is taken as 1 square unit.
- If the shape of an object covers less than ½ a square on graph paper, then that square is left out.

MEASURING MASS

The mass of an object is the amount of matter contained in it. More the matter in a substance, heavier it is.

There are various units in which mass is measured such as kilogram (kg), milligram (mg), gram (g), quintal and tonne. Kilogram is the SI unit of mass.

Table 2.6: Relationship between Various Units of Mass

1 g = 1000 mg	1 kg = 1000 g	1 pound = 453.59 g	1 quintal = 100 kg	1 tonne = 10 quintals
1 mg = 1/1,000 g	= 1000 × 1000 mg	or		= 1000 kg
= 10^{-3} g	= 1000000 mg	1 lb = 453.59 g		= 10^{3} kg
	= 10^{6} mg			

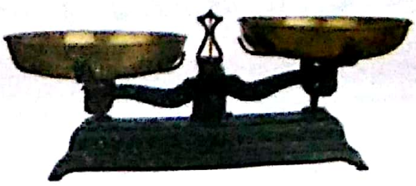
Activity 2.8

Aim: To identify objects of different mass and their units

- Make a list of objects (examples: cartons of food items, detergents, etc.) for which you can observe different units of mass.
- Take help from your teacher to identify the objects which can be measured using units like mg, g, kg, tonne, etc.
- Prepare a list of the objects identified by you and arrange these objects in ascending order of their mass.

Instruments for Measuring Mass

There are various instruments available for measuring mass such as beam balance, physical balance and electronic balance.



(a) Grocer's beam balance

(b) Electronic/digital weighing balance

Fig. 2.7: Different types of weighing balances

Measuring Mass with a Beam Balance

One of the simplest instruments is a beam balance that you might have seen at a grocer's shop. A beam balance consists of a horizontal metallic beam with a support and a pointer at its centre. The beam can move freely about the support. From the ends of the beam, two similar pans are suspended such that they are equidistant from the centre of the beam.

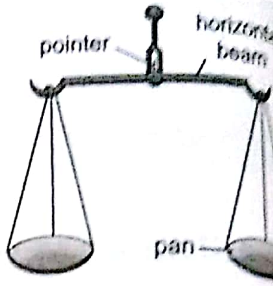


Fig. 2.8: Beam balanc

Principle: When both the pans are empty or loaded with equal masses, a state of equilibrium (balance) is achieved. In such a state, the beam is horizontal and the pointer points vertically up.

Working: To find the mass of an object, it is placed on one pan and standard weights are kept on the other pan of the beam balance. The standard weights are available in different sizes and masses like 5 g, 10 g, 20 g, 50 g, 100 g and 500 g to measure smaller masses and 1 kg, 2 kg, 5 kg, 10 kg and 20 kg to measure bigger masses. The weights are adjusted till the beam is horizontal and the pointer points vertically up. The sum of the masses of the standard weights gives the mass of the obje

The most accurate and highly sensitive version of the beam balance is called physical balance. It is used in science laboratories and also, used by goldsmiths for its utmost accuracy.

Ensure the following points to get the accurate reading of mass.

- Both the arms of the beam balance must be of equal length and both the pans must be of eq mass.
- When both the pans are empty, the beam should be horizontal and the pointer should be verti

Measuring Mass with Electronic Balance

For scientific purposes, where measurements should be accurate, we need highly sensitive instrumen Nowadays, electronic weighing machines with digital display are also being used in laboratories and sh due to their high degree of accuracy in measuring mass of different objects, especially small obje These machines give the mass of an object to the accuracy of grams and milligrams instantly, and he are accurate and reliable.

For example, an object whose mass is shown as 3.550 kg on electronic machine tells us that the mas the object is 3 kg 550 g.

Before measuring mass with an electronic balance, it is important to make sure that the instruments working properly. This can be done by making sure that the devices show zero reading when no obj is being placed on the balance. For example, in a beam balance, the two pans should be balanced wh nothing is being measured. Similarly, an electronic balance should give the zero reading, when nothin placed on it.

Activity 2.9

Aim: To demonstrate a beam balance and an electronic balance to students

- Take students to the physics lab.

- Demonstrate measuring instruments such as beam balance and electronic balance.
- Explain the markings or divisions on the instruments with which readings are taken. You can also display the weights of a beam balance to the students.

Activity 2.10

Aim: To measure the mass of various objects using a beam balance and an electronic balance

- Divide the students into groups, each group having four students.
- Since the students have learnt the working of the instruments, ask them to measure the mass of various objects in their surroundings using a beam balance and an electronic balance.
- Record the readings in the following table.

Object	Reading with beam balance	Reading with electronic balance
Pencil box		
Stone		
Wooden block		
Duster		

- Compare the two sets of readings. Which of the two indicate a better reading of mass?
- Discuss the readings and results obtained with other students.

Stop and Reflect

A. Make the following conversions.

1. 50 g = ______ kg
2. 4.5 g = ______ mg
3. 5000 mg = ______ g
4. 7.5 quintal = ______ kg
5. 0.6 kg = ______ g
6. 450 cm^2 = ______ m^2
7. 5 hectare = ______ m^2
8. 1 m^2 = ______ mm^2

B. Fill in the blanks.

1. Mass is the quantity of ______ contained in an object.
2. The area of a/an ______ surface can be determined by a standard ______ and ______ method.
3. An electronic balance is used to measure ______ of an object accurately.

MEASURING TIME

Time is an essential part of our lives. All our daily activities like getting up in the morning, coming to school, attending classes, watching television, etc. are time-bound. Therefore, accurate measurement of time is necessary for us.

Time may be defined as the interval between two events. The various units used for measuring time are second (s), hour (h), minute (min), mean solar day and year.

Table 2.7: Relationship between Different Units of Time

1 solar day = 24 h
1 hour = 60 minutes, i.e., 1 h = 60 min
1 minute = 60 seconds, i.e., 1 min = 60 s
∴ 1 solar day = 24 × 60 × 60 = 86400 s
7 days = 1 week
1 year = 365 days
1 decade = 10 years
1 century = 10 decades
1 millennium = 10 centuries

Mean Solar Day

Time taken by the earth to complete one rotation

Smaller Units of Time

1 microsecond = 10^{-6} second

1 nanosecond = 10^{-9} second

In earlier times, people used to measure time with the help of natural events since they occur at regular inter... People had also developed various devices based on natural periodic events to measure time. Some such devices... sundial, candle clock and sand clock.

Instruments for Measuring Time

There are various instruments for measuring time. Let's discuss a few of them.

Pendulum Clock

Fig. 2.9: Pendulum

A pendulum clock works on the principle of a simple pendulum and uses a swinging pendulum as its timekeeping element. The time taken by the pendulum to go from one extreme to the other is equal to 1 second, so it completes one to and fro motion in two seconds. The dial of the clock consists of 12 big markings (either numbers or bold marks) which represent the hours. These markings are further divided into 5 smaller divisions, giving a total of 60 small divisions. These smaller divisions indicate the minutes. There are three needles namely hour arm, minute arm and second arm, attached from the centre of the dial with the help of gear w... As the pendulum of the clock moves from one end to the other, the second's arm moves ahead b... small division. Once the second's arm completes 60 small divisions, i.e., it moves one full round of the circular dial, the minute's arm moves to the next small division. Once the minute hand also goes once round the dial covering 60 small divisions, the hour hand reaches the next big marking indicating that 1 hour has gone past.

(a) Analogue watch (b) Digit...

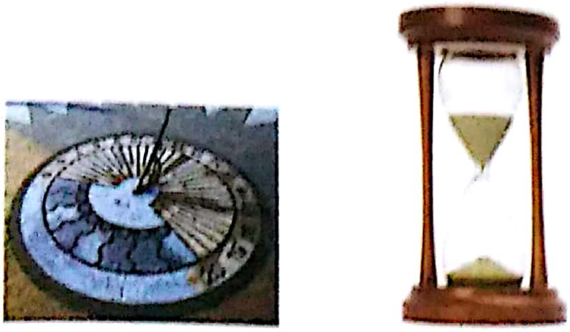
Fig. 2.10: Wrist watche...

Watch

A watch also has the same markings on its dial as in a clock and the time is also read the same way. The difference between the two is that in case of a watch the hour, minute and second's arms are set in motion by a wound up spring which controls their speed. These types of watches are also known as analogue watches. These watches are now made by using electric button cell instead of wound up spring. Some watches that display time directly in numerals are known as digital watches. The time displayed by them is in hh:mm or hh:mm:ss format.

Stopwatch and Stop Clock

Stop clocks and stopwatches are used in laboratories and sports events to measure short intervals of time accurately. For making time measurements as small as 0.01 s, there are electronic stopwatches and stop clocks. They are mostly having a display panel that gives time in a digital format of mm:ss. Stopwatches are used in time-bound activities like sporting events, debate competitions, extempore and many others.



(a) Sundial (b) Sand clock

Fig. 2.11: Ancient timekeeping devices

(a) Digital watch (b) Digital stopwatch

Fig. 2.12: Modern timekeeping devices

Clock System

There are two clock systems for measuring time: 12-hour clock system and 24-hour clock system.

12-hour Clock System

In the 12-hour clock system, 24 hours of a day are divided into two periods of 12 hours numbered 1 to 12. Time period (of 12 hours) from midnight to noon is a.m. (ante meridiem) and from noon to midnight is p.m. (post meridiem). For example, 6:15 a.m. represents 6:15 in the morning and 6:15 p.m. to represents 6:15 in the evening.

24-hour Clock System

In the 24-hour clock system, a day is divided into 24 hours, numbered 0 to 23. Time, in this system, indicates the hours and minutes that have passed since midnight. A day begins from 00:00 hours, i.e., midnight and ends at 24:00 hours, which is equal to 00:00 hours of midnight. Time from 00:00 hours to 12:00 hours represents the period of morning to noon (a.m.). Time from 12:00 to 24:00 hours represents the period of noon to midnight (p.m.). For example, 04:15 hours represents 4:15 a.m. and 16:15 hours represents 4:15 p.m. (16:15 – 12:00 = 4:15). This system is more commonly used in transportation services as they operate throughout the day and such a system helps to avoid any confusion in timings for the passengers.

MEASURING TEMPERATURE

When we touch an object, we feel its hotness or coldness with respect to the warmth of our body. An object appears hot because its temperature is more than our body temperature.

But what is this temperature?

Temperature is the measure of degree of hotness or coldness of a body. The SI unit of temperature is kelvin (K). The other commonly used units to measure temperature are degree Celsius (°C), degree Fahrenheit (°F) and degree Rankine (°R).

Let's study the device used to measure temperature.

Know Your Scientist

Daniel Gabriel Fahrenheit (1686–1736) was a Polish-born Dutch-German physicist and maker of scientific instruments. He is best known for inventing the first modern thermometer, the mercury thermometer, and for developing the Fahrenheit temperature scale in 1714. This temperature scale is used as a standard scale for scientific purposes worldwide.

Thermometer

To measure the temperature, we use a device called thermometer. It is made up of a thin, long and uniform glass tube called capillary tube. It has a bulb at one end containing a liquid (either mercury or alcohol) which is used for measuring temperature. Mercury is generally used as a thermometric fluid.

Thermometer works on the principle that heat energy causes expansion in solids, liquids and gases. On coming in contact with a hot body, mercury in the thermometer expands (according to the temperature) and moves up in the capillary tube. By reading the markings on the scale corresponding to the mercury level of the thermometer, we can know the temperature of the body. The markings on a thermometer are calibrated in degree Celsius/Fahrenheit usually.

Advantages of Using Mercury as a Thermometric Fluid

- Mercury is easily visible through the glass as it is opaque and shiny.
- Mercury does not stick to the glass or wet it.
- Mercury can be used over a wide range of temperatures owing to its low freezing point (–39 °C) and high boiling point (357 °C).
- Mercury being a good conductor of heat, quickly absorbs heat to attain the temperature of the object.

Scales on a Thermometer

Usually markings are done on a thermometer taking into consideration two fixed reference temperatures. These points are known as the lower fixed point and the upper fixed point.

Generally, Celsius, Fahrenheit and Kelvin scales are used in thermometers.

In Celsius scale, the lower fixed point is 0 °C which is the melting point of ice and the upper fixed point is 100 °C which is the boiling point of pure water. The scale between these fixed points is then equally divided into 100 equal parts of 1 °C each (Fig. 2.13).

In Fahrenheit scale, the lower and upper fixed points are 32 °F and 212 °F, respectively, and the scale between these fixed points is divided into 180 equal parts, each equal to 1 °F.

The Kelvin scale has been adopted as an international standard for scientific temperature measurement. It is related to the Celsius scale as the difference between the freezing point and boiling point of water is 100 degrees in each scale (Fig. 2.14). The ice melts at 273 K or 0 °C and water boils at 373 K or 100 °C.

Curious Mind

Who developed the Celsius scale and the Kelvin scale?

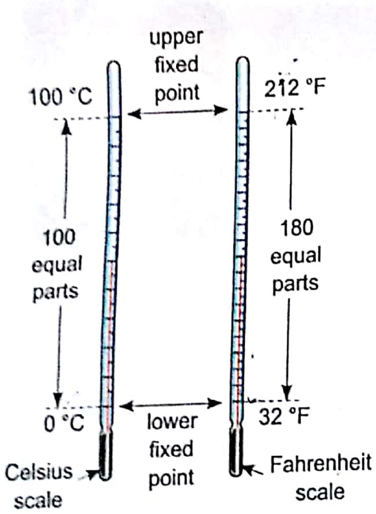


Fig. 2.13: Comparison of Celsius and Fahrenheit scales

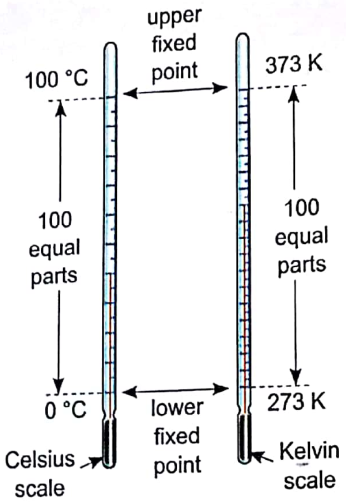


Fig. 2.14: Comparison of Celsius and Kelvin scales

Enlighten Your Mind

- The temperature in degree Celsius can be converted into degree Fahrenheit and vice-versa using the given formulae.

  $°C = \frac{5}{9}(°F - 32)$

  or

  $°F = \left(\frac{9}{5} \times °C\right) + 32$

- Also, temperature in degree Celsius and Kelvin are related as

  $K = °C + 273$

  If the value on one temperature scale is known, temperature on other scale can be calculated.

Types of Thermometers

Based on their uses, thermometers can be classified into the following types.

1. Clinical thermometer: A clinical thermometer is used to motion the body temperature of humans. It is also called a doctor's thermometer. If you look carefully at a clinical thermometer (Fig. 2.15), you will see that the scale on its stem shows temperature from 35 °C to 42 °C only. The normal temperature of a healthy human body is 37 °C and it never drops below 35 °C or rises above 42 °C unless certain drastic conditions are reached.

   A clinical thermometer has a slight bent or kink in the capillary tube just above the bulb. To check the body temperature, the thermometer is normally placed in the mouth, below the tongue. The mercury in the bulb expands according to the temperature in the mouth and its level increases in the capillary tube. We take out the thermometer from the mouth (after a minute or two) and read the marking on the scale corresponding to the mercury level to know the body temperature.

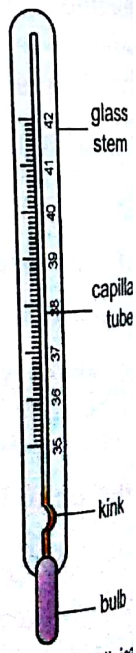


Fig. 2.15: Clinica thermometer

Why does the temperature in a clinical thermometer not drop when it is taken out of the mouth? Actually when the thermometer is taken out of the mouth, the mercury in the bulb contracts as the temperature outside our body is normally less and the mercury column breaks at the kink. Thus, the level of mercury remains constant even after taking the thermometer out of the mouth.

The mercury in the stem is brought back to the bulb by giving it a few soft jerks before the thermometer is used again.

Activity 2.13

Aim: To observe the body temperature of different persons

- Make a chart of body temperatures of yourself and any two members of your family (mother, father or your grandparents).
- Measure the temperature at the same time everyday and for at least a week.
- Record your temperature readings in the table given below.

S. No.	Name	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1.								
2.								
3.								

Do you find any difference in the body temperature of different persons?

Conclusion: The body temperature of every person is not exactly 37 °C but may be slightly lower or higher. Actually, the normal temperature (37 °C or 98.6 °F) is the average body temperature of a large number of healthy persons.

Note: To be performed under supervision of your elders.

2. Laboratory thermometer: A laboratory thermometer measures the temperature in the range of –10 °C to 110 °C. It is used to measure temperature in laboratories for various experiments with a high degree of precision. The construction of the laboratory thermometer is same as that of a clinical thermometer except for the kink.

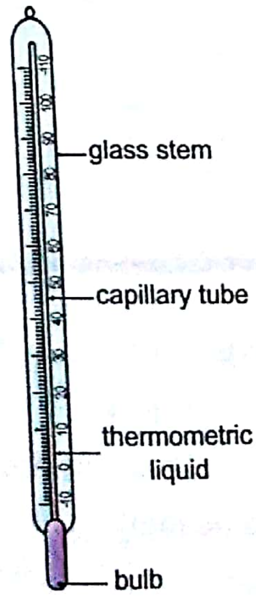


Fig. 2.16: Laboratory thermometer

There are some precautions to be observed while measuring temperature with a laboratory thermometer.

- A laboratory thermometer should always be kept upright and not tilted.
- The bulb of the thermometer should be properly dipped in the substance whose temperature is to be measured.
- The bulb should not touch the base or the side of the container.

I Objective Type Questions

A. Column A lists out the branches of Physics and column B gives the description. Match the branch with the appropriate description. Draw lines to match column A with column B.

Column A	Column B
1. Mechanics	6 (a) Deals with the underlying structures of the smallest particles in nature
2. Thermodynamics	5 (b) Study of the interaction between electric and magnetic fields
3. Electronics	4 (c) Investigates the interaction between electric charges
4. Electricity	3 (d) Deals with the development, behaviour and applications of electronic devices and circuits
5. Electromagnetism	2 (e) Study of the relationship between heat and other forms of energy
6. Modern physics	1 (f) Concerned with the behaviour of physical bodies under the action of external forces

B. Name the following:

1. Study of the composition and properties of substances and the interaction among them to form new substances Chemistry
2. A person who works for acquisition of knowledge of the natural world through systematic observation and experimentation Scientists
3. Systematic study of the structure and behaviour of the physical world through observation and experimentation Science
4. Latin word from which the word 'science' is derived Scire (to know)
5. Study of the nature and properties of matter and energy, and the interaction between them Physics

II Subjective Type Questions

A. Short answer type questions.

1. What is Scientific Method? List out the steps which define Scientific Method.

Systematic way to ask questions and find their answers through observation and experiments is called scientific method. The steps which define scientific method are: 1) Identifying the problem 2) collection of basic information 3) Working out a hypothesis 4) Experimental verification 5) Conclusion and generalisation 6) Application.

2. State the difference between invention and discovery.

Something made for the first time is called invention. Eg Invention of electric bulb. Something that already exists and found out for the first time is called discovery. Eg. Discovery of Newton's Law of gravity.

B. Long answer type question.

Physics has become an integral part of our lives. The different rooms of our house have different gadgets that are useful to us. From each room, pick out a gadget whose working is based on principles of Physics and find out how they work.

QUIZ

1 **Fill in the blanks.**

a The first step in the scientific method is Identification of the problem.

b Scientists who study physics are called physicist.

c The word 'physics' means (the knowledge of nature) nature

2 **Answer the following:**

a Describe the different steps involved in the scientific method.

b Explain the different branches of science.

BRANCHES OF PHYSICS

Physics has been divided into many branches such as astrophysics, geophysics, mechanics, statistical mechanics, heat, biophysics, theoretical physics, thermodynamics, light, electricity, electromagnetism, modern physics, and electronics. Some of these are briefly discussed below:

Mechanics: The branch of physics concerned with the behaviour of physical bodies as well as how force acts on objects in their environment.

Heat: The branch of physics which deals with the nature of heat and the physical changes brought about by increasing or lowering the temperature of a body.

Thermodynamics: The study of the relationship between heat and other forms of energy.

Light: The branch of physics which deals with properties of light, including its interactions with matter, and the construction of instruments that use or detect it.

Electricity: The branch of physics which investigates the interaction between electric charges.

Electromagnetism: The study of the relationship between electric current and magnetism.

Modern physics: It deals with the underlying structure of the smallest particles in nature.

Electronics: It deals with the development, behaviour, and applications of electronic devices and circuits.

PHYSICS IN DAILY LIFE

Physics has made tremendous contribution towards the betterment of our lifestyle. The principles of physics have been able to explain various day-to-day phenomena. For example, the fact that we do not float and gravity holds us to the ground, is explained by the laws of physics. Every gadget that you use at home such as refrigerators, televisions, music systems, computers, and cars have been designed based on the principles of physics (Fig. 1.5). Thus, physics has become an integral part of our lives. Some of the main areas in which physics has been particularly beneficial to us are discussed here.

Optical instruments

Many optical instruments such as magnifying lenses, microscopes, and telescopes are based on the principles of physics.

Transport

Efficient and better means of transport such as trains, buses, cars, and airplanes have made the world seem a smaller place by reducing travel time.

Communication

Telephones, computers, internet, and mobile phones have made communication and access to information faster. Satellites are used for long distance communications and weather forecasting.

Health

Advanced healthcare machines such as the X-ray, ultrasound, and CT scan are used to diagnose diseases. New methods such as radiation therapy to cure cancer and the use of laser beam for bloodless surgery are all applications of physics.

Appliances and gadgets

Various household appliances such as fans, heaters, ovens, irons, and washing machines are based on the principles of physics. These have made our lives much more comfortable.

Energy

Physics continues to play a vital role in identifying and developing new sources of energy such as nuclear energy, solar energy, wind energy, and the most important electrical energy.

Entertainment

With the help of physics, today we have a wide range of entertainment facilities such as cinematography, televisions, music systems, and video games.

Machinery

Various machines and equipment such as bulldozers, dumpers, cranes, road pavers, rollers, trucks, and concrete mixers are required for construction of roads and buildings. All these machines are based on the principles of physics.

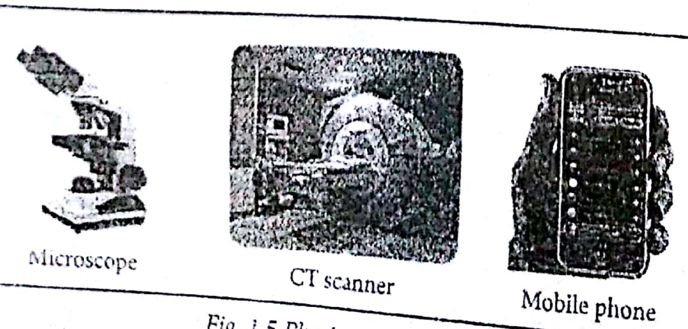


Fig. 1.5 Physics in daily life

> **Get it right!**
>
> Invention is the result of experimentation while discovery means finding out something that already exists. For example, the discovery of fire and the invention of the wheel.