CONTENTS

1

Physical Quantities and Measurement

Theme : In the earlier classes, teaching-learning emphasised on the measurement of length, mass, time and temperature using devices made for such measurements and how a particular unit and symbol is used to express the result of measurement of each physical quantity. In continuity, this theme aims at enabling children to develop the ability to measure volume and determine the density of a regular solid. They will be introduced to the concept of speed, that contains simple problems to get an idea of the speed of objects around them and also to know how fast or slow an object is moving.

In this chapter you will learn to

- define volume;
- express volume of an object in a proper unit with proper symbols;
- measure volume of a liquid using a graduated cylinder and a graduated beaker;
- estimate the area of an object of irregular shape using a graph paper;
- measure the volume of an irregular solid using a graduated cylinder/a graduated beaker;
- define density and write its formula;
- express density in a proper unit and symbol;
- measure density of a regular/irregular solid;
- express result of measurement in a proper unit with proper symbol;
- define speed and write its formula;
- express speed in proper units with proper symbol;
- solve simple numerical problems based on formula of density and speed.

LEARNING OBJECTIVES

- Demonstration of graduated cylinder and graduated beaker
- Explanation of the process of measurement of volume
- Explaining the use of graph paper to measure area of irregular shape objects
- Explanation of the process of measuring density of a regular solid
- Explanation of the concept of speed with examples from daily life
- Explaining calculation of speed
- Engaging children in activities involving measurement of volume, area and density.
- Engaging children in solving simple problems involving the concept of density and speed.

KNOWING CONCEPTS

- Measurement of volume (3D concept) :
  - Concept of unit volume
- Measurement of area :
  - Estimate the area of irregular shape objetcs using a graph paper
- Measurement of density of regular solids :
  - Basic concept
  - Formula
  - Simple Numericals (SI units not required)
- Calculation of speed :
  - Basic concept
  - Formula
  - Simple Numericals (SI units not required).

INTRODUCTION

In class VI, we learnt the measurement of four basic quantities in our daily life, namely length, mass, time and temperature. Measurement is a process of comparison of the given unknown quantity with a fixed known quantity of the same kind called the **unit**. The magnitude of the quantity is expressed as

Magnitude = number of times the unit is contained in the quantity × unit.

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

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

Time is the interval of occurrence of an event. Its S.I. unit is second (symbol s). It is measured with the help of a pendulum clock or a watch and for short time intervals we use a stop-clock or stop watch.

Temperature is a quantity which measures the hotness or coldness of a body. Its S.I. unit is kelvin (symbol K). Other common units are °C and °F. It is measured using a thermometer.

In this chapter, we shall study the measurement of volume, density and speed.

Note : S.I. is the short form of Standard Internationale, *i.e.* S.I. unit is the unit accepted internationally.

MEASUREMENT OF VOLUME

We have read that matter occupies space. All solids, liquids and gases occupy space.

The space occupied by an object is called its **volume**.

This can be demonstrated by the following activity.

ACTIVITY 1

Take a glass tumbler. Paste a paper strip on it as shown in Fig. 1.1. Pour some water in the tumbler. Mark the water level on the strip as A. Take a piece of stone and tie it with a string.

Fig. 1.1 A piece of stone occupies space in water

Suspend the stone piece inside the water in the tumbler. You will observe that the level of water has risen. Mark the new water level as B. It suggests that the piece of stone has displaced water equal to its volume because it has occupied space in water.

If we say that a brick is bigger than a match box, we mean that the volume occupied by the brick is more than that occupied by the match box. Similarly if we say that a school hall is bigger than a class-room, we mean that the volume of air in the empty hall is more than that in the empty class room.

S.I. unit of volume

The S.I. unit of volume is **cubic metre**. In short form, it is written as m^3.

One cubic metre is the volume of a cube with each side 1 metre long as shown in Fig. 1.2. *i.e.*,

$$1 \text{ m}^3 = 1 \text{ m} \times 1 \text{ m} \times 1 \text{ m}.$$

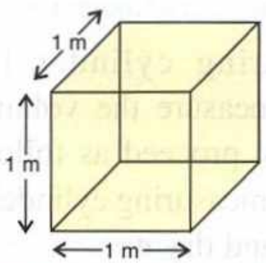


Fig. 1.2 Volume one metre³ (or 1 m³)

Other units of volume

Cubic metre is a bigger unit. A smaller unit of volume is **cubic centimetre** (symbol cm^3). One cubic centimetre is the volume of a cube with each side 1 centimetre long, *i.e.*,

$$1 \text{ cm}^3 = 1 \text{ cm} \times 1 \text{ cm} \times 1 \text{ cm}.$$

Relationship between m^3 and cm^3

$$\begin{aligned} 1 \text{ m}^3 &= 1 \text{ m} \times 1 \text{ m} \times 1 \text{ m} \\ &= 100 \text{ cm} \times 100 \text{ cm} \times 100 \text{ cm} \\ &= 10{,}00{,}000 \text{ cm}^3 \\ &= 10^6 \text{ cm}^3. \end{aligned}$$

Note : 1 m = 100 cm

The volume of liquids is generally expressed in **litre** (symbol L).

1,000 cm^3 make one litre. *i.e.*,

1 litre = 1,000 cm^3

Hence, 1 cm^3 = 10^{-3} litre = 1 millilitre

The symbol of millilitre is mL.

Thus, 1 m^3 = 10,00,000 cm^3 = 10^6 cm^3

1 L = 1,000 cm^3 = 1,000 mL

1 mL = 1 cm^3 (or 10^{-6} m^3)

Do You Know ?

1. Sometimes the word capacity is used to express the volume of a vessel or container. We often say that the capacity of a water tank is 250 litre. This statement means that the water tank can store a maximum volume of water equal to 250 litre.

2. Sometimes cubic decimetre is also used as the unit of volume. Its symbol is dm^3.

$$\begin{aligned} 1 \text{ dm}^3 &= 1 \text{ dm} \times 1 \text{ dm} \times 1 \text{ dm} \\ &= 10 \text{ cm} \times 10 \text{ cm} \times 10 \text{ cm} = 1{,}000 \text{ cm}^3 \\ &= 1 \text{ litre} \end{aligned}$$

3. Cubic centimetre is also written in short form as c.c.

VESSELS FOR MEASURING THE VOLUME OF LIQUIDS

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

(1) Measuring cylinder, and

(2) Measuring beaker.

(1) **Measuring cylinder :** It is a cylinder generally of area of cross section 10 cm^2, made up of either glass or plastic. It is of length nearly 10 cm graduated in cm^3 (or mL) with its zero mark at the bottom and 100 mark at the top. Thus, it is of capacity 100 cm^3 (or 100 mL) as shown in Fig. 1.3.

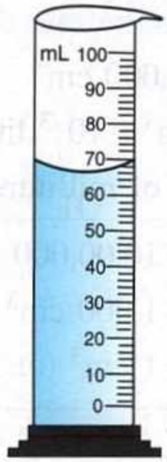


Fig. 1.3 Measuring cylinder

It is generally used in laboratories to measure the volume of liquids and also to find the volume of an irregular object by measuring the displacement of water or liquid by the object. Big measuring cylinders of volume 200 mL and 500 mL are also available.

Fig. 1.4 shows the other form of a measuring cylinder which is used by pharmacists to measure liquid medicines.

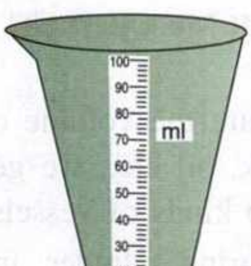


Fig. 1.4 Measuring cylinder used by a pharmacist

(2) Measuring beaker : A measuring beaker is used generally to measure a fixed volume of a liquid such as milk, oil, lubricating oil etc. Thus, they are available in different capacities such as 50 mL, 100 mL, 200 mL, 500 mL, 1000 mL. The capacity of a beaker is marked on it. It is provided with a handle to hold it. Some such beakers are shown in Fig. 1.5.

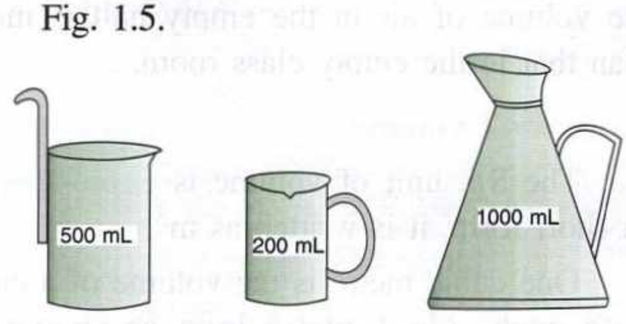


Fig. 1.5 Measuring beakers

MEASURMENT OF VOLUME OF A LIQUID

(1) By using a measuring cylinder

A measuring cylinder is used in a laboratory to measure the volume of a given liquid. For this, proceed as follows :

(i) Take a measuring cylinder. Wash it with water and dry it.

(ii) Place the measuring cylinder on a flat surface and then pour the given liquid completely into the measuring cylinder gently so that no liquid splashes out of the cylinder.

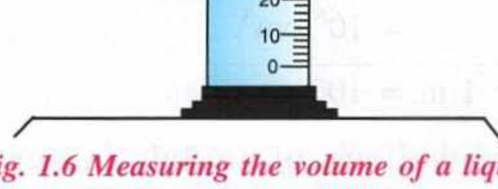


Fig. 1.6 Measuring the volume of a liquid by a measuring cylinder

(iii) Wait for sometime till the liquid becomes stationary in the cylinder. You will notice that the meniscus (*i.e.*, upper surface) of liquid is curved when the liquid becomes stationary.

(iv) Read the level of liquid in the measuring cylinder by keeping your eye horizontally in line with the lower surface of liquid as shown in Fig. 1.6. In Fig. 1.6., the reading is 70 mL.

Thus, the volume of the given liquid is 70 mL.

(2) By using a measuring beaker

A measuring beaker is used to measure a fixed volume of liquid from a large volume. Suppose it is required to measure 500 mL of milk from the milk contained in a bucket.

For this, take the measuring beaker of capacity 500 mL. Wash it and dry it.

Then, immerse the measuring beaker well inside the milk contained in the bucket so that the beaker gets completely filled with the milk.

Take out the measuring beaker from the bucket gently so that no milk splashes out and then pour the milk from the measuring beaker into another empty vessel.

MEASUREMENT OF VOLUME OF REGULAR OBJECTS

The volume of a regular object is measured by finding its three dimensions *i.e.*, length, breadth, height or radius and then using the following relations as applicable :

1. Volume of a cube = (one side)^3
2. Volume of a cuboid

   = length × breadth × height
3. Volume of a sphere = $\frac{4\pi}{3}$ × (radius)^3
4. Volume of a cylinder = π × (radius)^2 × height
5. Volume of a cone = $\frac{\pi}{3}$ × (radius)^2 × height

   where $\pi = 3{\cdot}14$ or $\frac{22}{7}$.

MEASUREMENT OF VOLUME OF AN IRREGULAR BODY

The volume of a solid of irregular shape can be measured by using a measuring cylinder by the method of displacement of liquid. Each body occupies space equal to its own volume. Therefore, if a body of irregular shape is immersed in a liquid, it displaces the volume of liquid equal to its own volume so as to occupy the space of liquid. Thus

Volume of a body of irregular shape
= Volume of liquid displaced by the body when it is immersed completely into the liquid.

To find the volume of the displaced liquid, we note the initial level of liquid in the measuring cylinder and then the level of liquid after immersing the given body completely into the liquid inside the measuring cylinder. The difference in the final level from the initial level, gives the volume of the liquid displaced which is equal to the volume of the given irregular body.

This can be demonstrated by the following activity.

ACTIVITY 2

To measure the volume of a piece of stone.

Take a piece of stone, a measuring cylinder, fine thread of sufficient length and some water.

Place a measuring cylinder on a flat horizontal surface and fill it partially with water. Note the reading V_1 of the water level very carefully. Now tie the piece of stone with a thread and dip it completely into water (Fig 1.7). We see that the level of water rises. Note the reading V_2 of the new water level. The

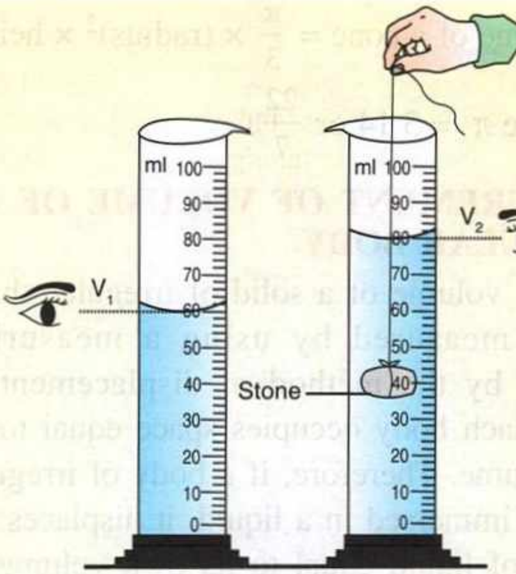


Fig. 1.7 Measuring the volume of a piece of stone (an irregular object)

difference in the two levels of water gives the volume of the piece of stone.

Initial level of water $V_1 = 60$ mL

Level of water when stone is immersed

$V_2 = 80$ mL

$\therefore$ Volume of water displaced $= V_2 - V_1$

$= 80\text{ mL} - 60\text{ mL}$

$= 20$ mL

$\therefore$ Volume of the piece of stone $= 20\text{ cm}^3$

Note : 1 mL = 1 cm^3.

Note : The volume of an empty vessel like a bottle, can be found by filling it completely with water and then pouring the water in a clean measuring cylinder.

AREA

We have learnt in class VI that the surface occupied by an object is called its area. The S.I. unit of area is **square metre** (symbol m^2). It is equal to the area of a square of side 1 m. *i.e.*,

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

To express the area of a play ground, a football field, a village or a town, square metre is a small unit. The bigger units of area are square decametre (or are), **hectare** and **square kilometre**.

One are is the area of a square with each side measuring 10 m. *i.e.*,

$$1\text{ are} = 10\text{ m} \times 10\text{ m} = 100\text{ m}^2$$

One hectare is the area of a square with each side measuring 100 m. *i.e.*,

$$1\text{ hectare} = 100\text{ m} \times 100\text{ m}$$
$$= (10{,}000\text{ m}^2) = 10^4\text{ m}^2 = 100\text{ ares}$$

One square kilometre (symbol km^2) is the area of a square with each side measuring 1 km. *i.e.*,

$$1\text{ km}^2 = 1\text{ km} \times 1\text{ km}$$
$$= 1000\text{ m} \times 1000\text{ m} = 10^6\text{ m}^2$$

On the other hand, to express the area of small objects like pencil, rubber etc., square metre is a big unit. The smaller units of area are square centimetre (symbol cm^2) or square millimetre (symbol mm^2).

$$1\text{ cm}^2 = 1\text{ cm} \times 1\text{ cm} = \frac{1}{100}\text{ m} \times \frac{1}{100}\text{ m}$$
$$= 10^{-4}\text{ m}^2$$

$$1\text{ mm}^2 = 1\text{ mm} \times 1\text{ mm} = \frac{1}{1000}\text{ m} \times \frac{1}{1000}\text{ m}$$
$$= 10^{-6}\text{ m}^2.$$

Thus, the units of area are related as

1 are $= 10^2\text{ m}^2$

1 hectare $= 10^4\text{ m}^2$

1 km^2 $= 10^6\text{ m}^2$

1 cm^2 $= 10^{-4}\text{ m}^2$

1 mm^2 $= 10^{-6}\text{ m}^2$

Measurement of area of regular objects

The area of a regular object can be found by measuring the two dimensions *i.e.*, length, breadth or radius of the object and using the following relations as applicable :

Area of a square = (one side)^2

Area of a rectangle = length × breadth

Area of a circle = π × (radius)^2

Surface area of a cylinder

$$= 2\pi \times (\text{radius}) \times \text{length}$$

Surface area of a sphere $= 4\pi \times (\text{radius})^2$

where $\pi = 3{\cdot}14$ or $\frac{22}{7}$.

Measurement of area of an irregular object

To estimate the area of an irregular object (lamina), graph paper is used.

Graph paper : It is a sheet of paper on which horizontal and vertical lines are ruled at a regular interval of 1 mm. The lines showing the spacing of 1 cm between them, are made thick. Then the area of one big square becomes 1 cm × 1cm = 1 cm^2 while the area of one small square is 1 mm × 1 mm = 1 mm^2. The graph paper is shown in Fig. 1.8.

Procedure : First, place the lamina over a graph paper and draw its boundary line on the graph paper with a pencil. Then remove the lamina and count and note the number of complete squares as well as the number of squares half and more than half within the boundary line (only the squares less than half, are left while counting). The area of lamina is equal to the sum of the areas of complete squares and that of squares half and more than half. Let n be the total number of complete and more than half or half squares within the boundary of lamina. Since area of one big square is 1 cm × 1cm = 1 cm^2, so the area of lamina will be $n \times 1$ cm^2 or n cm^2.

This can be explained by the following activity.

ACTIVITY 3

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 half and more than half (within the outline). Ignore the squares which are less than half (within the outline). The sum of the areas of the number of complete squares and the number of incomplete squares gives the approximate area of the irregular object.

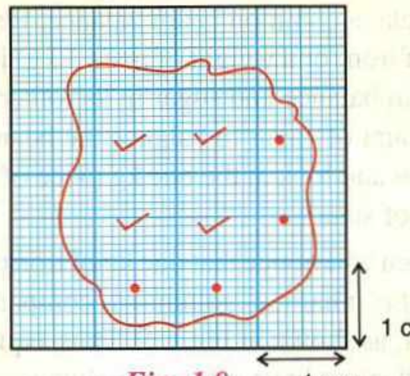


Fig. 1.8

In Fig. 1.8,

No. of complete squares marked as (√) = 4

No. of incomplete squares marked as (•) = 4

Total number of squares $n = 4 + 4 = 8$

Area of irregular object $= 8 \times 1\ cm^2$

$= 8\ cm^2$

The approximate area of the given object is 8 cm^2

Do You Know ?

You may be asked to find the volume of an irregular sheet of finite thickness. For this, find the area by using the graph paper and thickness by metre ruler. Then, use the relation

Volume = area × thickness.

DENSITY

Each body has a certain mass and a definite volume.

Experimentally it is observed that

(1) Equal masses of different substances have different volumes, *e.g.* 1 kg of iron and 1 kg of cotton will have different volumes and

(2) Equal volumes of different substances have different masses, *e.g.* cubes of iron and wood (1 cm × 1 cm × 1 cm dimensions) will weigh differently.

(1) Equal masses of different substances have different volumes : This can be understood by the following simple activity.

ACTIVITY 4

Take a common beam balance. Place a one kg piece of iron (or a weight of mass 1 kg) in one pan of the beam balance and sugar in the other pan. Adjust the amount of sugar to balance the beam. Now take them out and look at the one kg piece of iron and the one kg of sugar.

You will notice that one kg of iron occupies less space (*i.e,* it has less volume) as compared to one kg of sugar, as shown in Fig. 1.9. Thus, equal masses of iron and sugar have different volumes.

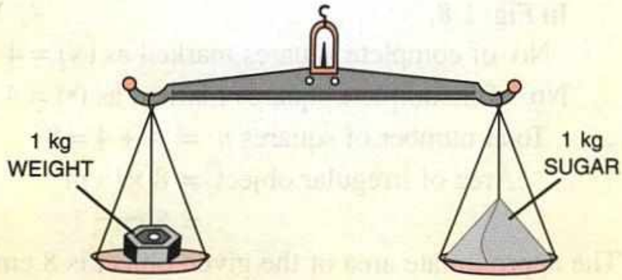


Fig. 1.9 Equal masses of iron and sugar have different volumes

(2) Equal volumes of different substances have different masses : This can be understood by the following activities.

ACTIVITY 5

Take four cubes of same size, but made of different substances such as iron, aluminium, glass and wood. Label these cubes as A, B, C and D respectively. Since all the cubes are of the same size, they have equal volume.

Now take a common beam balance. Place the

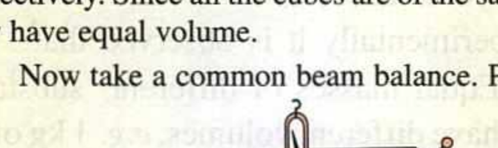


Fig. 1.10 Mass of iron cube is more than the mass of aluminium cube of same volume

iron cube A in one pan and the aluminium cube B in the other pan as shown in Fig. 1.10. You will notice that the mass of iron cube A is more than that of the aluminium cube B.

Now compare the masses of the aluminium cube B and the glass cube C as shown in Fig. 1.11. You will notice that the mass of aluminium cube B is more than that of the glass cube C.

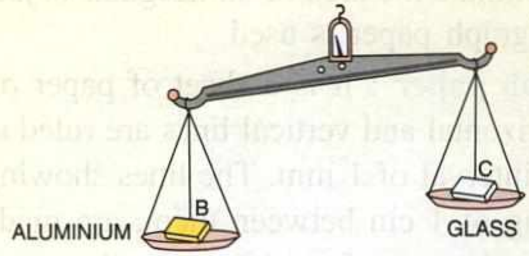


Fig. 1.11 Mass of aluminium cube is more than the mass of glass cube of same volume

Then compare the masses of the glass cube C and the wooden cube D as shown in Fig. 1.12. You will notice that the mass of glass cube C is more than that of the wooden cube D.

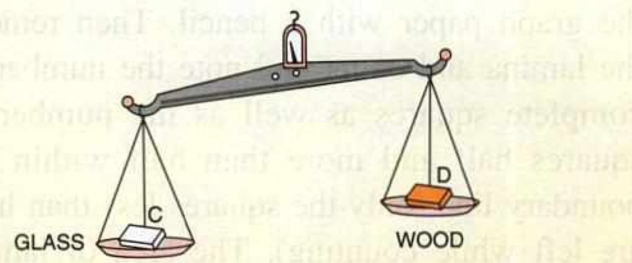


Fig. 1.12 Mass of glass cube is more than the mass of wooden cube of same volume

Thus, equal volumes of different substances iron, aluminium, glass and wood have different masses.

ACTIVITY 6

Take a common beam balance and two identical tumblers A and B. Fill one tumbler A completely with water and the other tumbler B with milk. Place tumbler A in the right pan and the other tumbler B in the left pan of the beam balance as shown in Fig. 1.13. You will notice that the mass of tumbler B containing milk is more than the mass of tumbler A containing water. Since the two

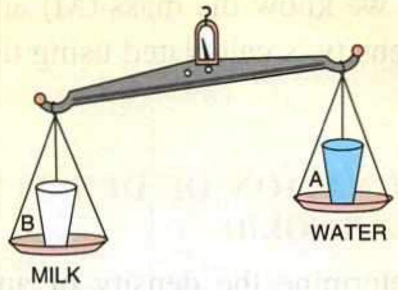


Fig. 1.13 Equal volumes of milk and water have different masses. (Mass of milk is more than the mass of water)

tumblers are identical, they contain equal volumes of milk and water, but they are different in their masses.

Thus, equal volumes of milk and water have different masses. In general we can say that *equal volumes of different substances have different masses.*

From the above activities, it is noted that

(i) One kg of sugar occupies more volume than one kg of iron, so we say that iron is denser than sugar. In other words, the particles of iron are closely packed while those of sugar are loosely packed.

(ii) The mass of iron cube is more than the mass of identical aluminium cube, so we say that **iron is denser than aluminium**.

(iii) The mass of aluminium cube is more than the mass of identical glass cube, *i.e.*, **aluminium is denser than glass**.

(iv) The mass of glass cube is more than the mass of identical wooden cube, so **glass is denser than wood**.

(v) A certain volume of milk has more mass than an equal volume of water, so **milk is denser than water**.

Thus, to distinguish between different substances, we use a term called **density**.

Definition of density :

The density of a substance is defined as the mass of a unit volume of that substance.

If a volume V of a substance has a mass M, the density d of the substance is given as

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \quad \text{or} \quad d = \frac{M}{V}$$

Examples :

(i) The mass of an iron cube of volume 10 cm^3 is found to be 78 g.

$$\text{Therefore, density of iron} = \frac{78\text{ g}}{10\text{ cm}^3} = 7{\cdot}8\text{ g cm}^{-3}$$

(ii) The mass of 1 cm^3 of water is 1 g, hence

$$\text{density of water} = \frac{1\text{ g}}{1\text{ cm}^3} = 1\text{ g cm}^{-3}$$

Note : The density of a substance does not change with the change in its shape or size.

Units of density :

$$\text{Unit of density} = \frac{\text{Unit of mass}}{\text{Unit of volume}}$$

The S.I. unit of mass is kilogram (symbol kg) and of volume is cubic metre (symbol m^3). Therefore S.I. unit of density is $\frac{\text{kg}}{\text{m}^3}$ or kg m^{-3}.

The C.G.S. unit of mass is gram (symbol g) and of volume is cubic centimetre (symbol cm^3). Therefore, the C. G. S. unit of density is $\frac{\text{g}}{\text{cm}^3}$ or g cm^{-3}.

Relationship between kg m^{-3} and g cm^{-3}

We know that 1 kg = 1000 g

$$\text{or } 1\text{ g} = \frac{1}{1000}\text{ kg}$$

and $1\ m^3 = (100\ cm)^3$

$= 100 \times 100 \times 100\ cm^3$

$= 10{,}00{,}000\ cm^3$

or $1\ cm^3 = \frac{1}{1000000}\ m^3$

Now $1\ g\ cm^{-3} = \frac{1\,g}{1\,cm^3}$

$$= \frac{\frac{1}{1000}\,kg}{\frac{1}{1000000}\,m^3}$$

$$= \frac{1000000}{1000}\ kg\ m^{-3}$$

$$= 1{,}000\ kg\ m^{-3}$$

Thus, $1\ g\ cm^{-3} = 1{,}000\ kg\ m^{-3}$

Do You Know ?

1. The density of almost all solids, liquids and gases decreases with the increase in temperature, because they all expand on heating with the exception of water. Water contracts on heating from 0°C to 4°C and expands on heating above 4°C.

2. The density of water is maximum at 4°C. It decreases when it is cooled from 4°C to 0°C or it is heated above 4°C.

DETERMINATION OF DENSITY OF REGULAR SOLIDS

To find the density of a regular solid by using the formula, density (d) = $\frac{\text{mass (M)}}{\text{volume (V)}}$ we proceed as follows :

(1) Using a beam balance, measure the mass M of the solid.

(2) Using the metre ruler, measure the length, breadth and height of the regular solid and find the volume (V) using the relation V = length × breadth × height.

Once we know the mass (M) and volume (V), the density is calculated using the relation $d = \frac{M}{V}$.

DETERMINATION OF DENSITY OF AN IRREGULAR SOLID

To determine the density of an irregular solid (such as a coin or a piece of stone), we have to measure its mass and volume. For this, proceed as follows :

1. Measure the mass of the given solid using a beam balance. Let the mass be M gram.
2. To measure the volume of the solid, we use displacement method. For this, take a measuring cylinder. Fill it partly with water as shown in Fig. 1.14(a).
3. Note the level of water. Let it be V_1 mL.
4. Now tie the given solid with a thread and gently immerse the solid in water contained in the measuring cylinder as shown in Fig. 1.14 (b). Take care that no water splashes out. Note the level of water again. Let it be V_2 mL.

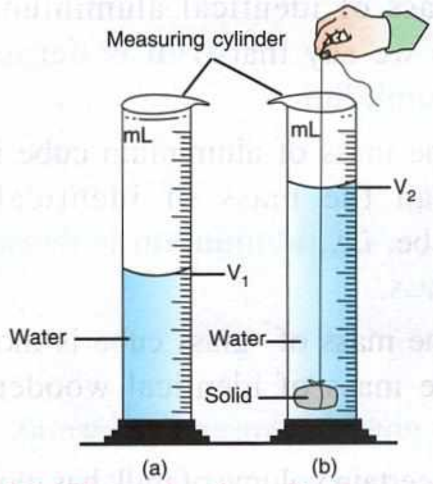


Fig. 1.14 Determination of volume of a solid

5. Find the difference $V_2 - V_1$ which gives the volume (V) of the solid. *i.e.,* $V = (V_2 - V_1)\ cm^3$ (since $1\ mL = 1\ cm^3$).

6. Then calculate the density of the solid by using the following relation :

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{M}{V} \text{ g cm}^{-3}.$$

ETERMINATION OF DENSITY OF A LIQUID

To determine the density of a liquid (say, ilk), follow the procedure given below :

1. Take a beaker. Measure the mass of the empty beaker using a common beam balance. Let the mass be M_1 gram.
2. Now take a measuring cylinder and pour milk into it to a certain level say 50 mL. Thus, volume of milk, V = 50 cm^3 (since 1 mL = 1 cm^3).
3. Transfer the milk into the empty beaker. Measure its mass again. Let its mass be M_2 gram.
4. The difference between M_2 and M_1 will give the mass M of the milk. Thus, mass of the milk $M = (M_2 - M_1)$ gram. Let M = 51·5 gram.
5. Calculate the density of milk using the following relation :

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{M}{V} \text{ g cm}^{-3}$$

$$= \frac{51\cdot 5 \text{ g}}{50 \text{ cm}^3} = 1\cdot 03 \text{ g cm}^{-3}.$$

Different substances have different ensities.

The table given alongside gives the ensities of some common substances.

Do You Know ?

The barometer, used to measure the atmospheric pressure, makes use of mercury because of its high density.

Table : Densities of some common substances

Substances	Density	
	in g cm^{-3}	in kg m^{-3}
Solid		
1. Cork	0·25	250
2. Wood	0·7	700
3. Ice	0·92	920
4. Glass	1·97	1,970
5. Aluminium	2·7	2,700
6. Iron	7·8	7,800
7. Brass	8·4	8,400
8. Silver	10·3	10,300
9. Lead	11·5	11,500
Liquid		
1. Alcohol	0·8	800
2. Water (at 4°C)	1·0	1,000
3. Milk	1·03	1,030
4. Mercury	13·6	13,600

SPEED

In class VI, we have learnt that a body is said to be at rest when it does not change its position with respect to its surroundings, while a body is said to be in motion when it changes its position with respect to its surroundings.

When a body is in motion, the length of path travelled by it in a certain time is called the distance moved by it in that duration. This is expresed in the unit metre (symbol m).

We see many moving objects around us. To find which one is moving fast or slow, we measure the distance travelled by different objects in the same time interval.

For example, if we compare the motions of a car and a bullock-cart on the road, we find that a car travels more distance than the bullock-cart in the same time interval. So we say that the car moves faster than the bullock-cart.

Similarly, a boy on a bicycle travels a longer distance than a boy on foot in the same time. Thus, the boy on foot is moving slower than the boy on bicycle. The idea about the motion of a body, that is, how fast or slow it is moving, is obtained by a quantity known as speed.

Definition of speed

The distance covered or travelled by a body in unit time is called the speed of the body. *i.e.*,

$$\text{Speed} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

Speed is usually denoted by the symbol v.

If a body travels a distance D in time t, then its speed is given as

$$\text{Speed } (v) = \frac{D}{t}$$

Units of Speed

In S.I. system, distance is measured in metre and time is measured in second, so the S.I. unit of speed is metre/second (read as metre per second). Its symbol is $m\ s^{-1}$.

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

Relationship between $km\ h^{-1}$ and $m\ s^{-1}$

$$1\ km\ h^{-1} = \frac{1\ km}{1\ h} = \frac{1000\ m}{3600\ s} = \frac{5\ m}{18\ s}$$

$$= \frac{1}{3{\cdot}6}\ m\ s^{-1}$$

or $3{\cdot}6\ km\ h^{-1} = 1\ m\ s^{-1}$

However, if distance is measured in centimetre and time in second, then the unit of speed is centimetre per second (in short form, $cm\ s^{-1}$). Obviously,

$$100\ cm\ s^{-1} = 1\ m\ s^{-1}.$$

Do You Know ?

1. $18\ km\ h^{-1} = 5\ m\ s^{-1}$
2. The speedometer of vehicles such as scooter, car etc. shows the speed of the vehicle at that instant.

Note : If distance is measured in km and ti in minute, then speed has the unit km min⁻

$$1\ km\ min^{-1} = \frac{1000\ m}{60\ s} = 16{\cdot}67\ m\ s^{-1}$$

The table below gives approximate spe of some common objects.

Table : Approximate speed of some common objects

Object	Speed	
	in $m\ s^{-1}$	in $km\ h^{-1}$
1. Man while walking	1	3·6
2. Man when running	5	18
3. Bicycle	7	25
4. Scooter	11	40
5. Car	14	50
6. Train	17	60
7. Sound	330	1188
8. Light	3×10^8	$1{\cdot}08 \times 10^9$

SOLVED EXAMPLES

1. A box is of dimensions 2·4 m × 1·0 × 75 cm. Find the volume of the box.

   Given : length $l = 2{\cdot}4$ m, breadth $b = 1{\cdot}0$ and height $h = 75$ cm $= 0{\cdot}75$ m.

   Volume of box $V = l \times b \times h$

   $= 2{\cdot}4\ m \times 1{\cdot}0\ m \times 0{\cdot}75\ m =$ **1·8 m**

2. Calculate the volume of a book which 24 cm in length, 15 cm in breadth a 1 cm in height, in (a) cm^3 (b) m^3.

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

   (a) Volume of book $V = l \times b \times h$

   $= 24\ cm \times 15\ cm \times 1\ cm$

   $=$ **$360\ cm^3$**

   (b) Since $1\ cm^3 = \frac{1}{1000000} = 10^{-6}\ m^3$

   Volume of book $V = 360 \times 10^{-6}\ m^3$

   $=$ **$3{\cdot}6 \times 10^{-4}\ m^3$**

3. A measuring cylinder contains water to a level of 22 mL. The water level rises to 30 mL when a piece of copper is completely immersed in it. Find the volume of copper piece in (a) cm^3 (b) m^3.

Given : Initial level of water $V_1 = 22$ mL

Final level of water $V_2 = 30$ mL

(a) Volume of copper piece $V = V_2 - V_1$

$= 30 \text{ mL} - 22 \text{ mL} = 8 \text{ mL}$

Since $1 \text{ mL} = 1 \text{ cm}^3$, $V =$ **8 cm^3**

(b) Since $1 \text{ cm}^3 = 10^{-6} \text{ m}^3$

Volume of copper piece = **$8 \times 10^{-6} \text{ m}^3$**

4. The diameter of a circular park is 30 m. Find its surface area.

Given : Diameter = 30 m

Radius $r = \frac{1}{2} \times \text{diameter} = \frac{1}{2} \times 30 \text{ m}$

$= 15 \text{ m}$

Surface area of circle = πr^2 when $\pi = 3{\cdot}14$

$= 3{\cdot}14 \times (15)^2 =$ **$706{\cdot}5 \text{ m}^2$**

5. The boundary line of an irregular lamina, on a graph paper is shown in Fig. 1.15. Find the approximate area of the lamina.

In Fig. 1.15, the number of complete squares = 14

The number of squares more than half = 11

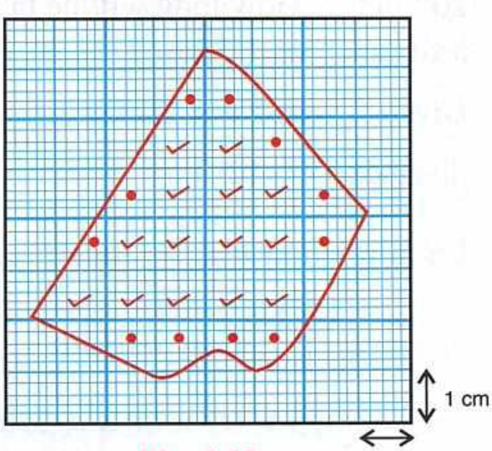


Fig. 1.15

Total number of squares $n = 14 + 11 = 25$

Area of the square = $1 \text{ cm} \times 1 \text{ cm} = 1 \text{ cm}^2$

Area of lamina = $25 \times 1 \text{ cm}^2 =$ **25 cm^2**

6. A piece of iron has a volume of 25 cm^3 and mass 195 g. Find the density of iron in

(a) g cm^{-3} (b) kg m^{-3}

(a) *Given :* mass M = 195 g,

Volume $V = 25 \text{ cm}^3$

$$\text{Density } d = \frac{\text{mass M}}{\text{volume V}}$$

$$= \frac{195 \text{ g}}{25 \text{ cm}^3} = \mathbf{7{\cdot}8 \text{ g cm}^{-3}}$$

(b) Since mass M = 195 g = 0·195 kg

Volume $V = 25 \text{ cm}^3 = 25 \times 10^{-6} \text{ m}^3$

$$\text{Density d} = \frac{0{\cdot}195 \text{ kg}}{25 \times 10^{-6} \text{ m}^3}$$

$$= \mathbf{7{\cdot}8 \times 10^3 \text{ kg m}^{-3}}$$

7. The density of silver is $10{\cdot}3 \text{ g cm}^{-3}$. Find the mass of a silver block of volume 200 cm^3.

Given : $d = 10{\cdot}3 \text{ g cm}^{-3}$, $V = 200 \text{ cm}^3$

From relation $d = \frac{M}{V}$

Mass, $M = d \times V$

$= 10{\cdot}3 \times 200$

= **2,060 g or 2·06 kg**

8. The mass of a wooden block is 56 g. If the density of wood is $0{\cdot}8 \text{ g cm}^{-3}$, find the volume of block.

Given : Mass M = 56 g,

Density $d = 0{\cdot}8 \text{ g cm}^{-3}$

Since, $d = \frac{M}{V}$; $V = \frac{M}{d}$

Hence, volume of block $V = \frac{56}{0{\cdot}8} =$ **70 cm^3**

9. The mass of 1 litre of water is 1 kg. Find the density of water in (a) g cm^{-3}, (b) kg m^{-3}.

Given : Mass M = 1 kg = 1000 g, volume V = 1 litre = 1000 cm^3

(a) Density of water $d = \frac{M}{V} = \frac{1000\ g}{1000\ cm^3}$

$= \mathbf{1\ g\ cm^{-3}}$

(b) Since 1 g cm^{-3} = 1000 kg m^{-3}

Density of water = 1 × 1000 kg m^{-3}

$= \mathbf{1000\ kg\ m^{-3}}$

Alternative method :

M = 1 kg, V = 1 litre = 10^{-3} m^3

$$d = \frac{M}{V} = \frac{1\ kg}{10^{-3}\ m^3} = \mathbf{10^3\ kg\ m^{-3}}$$

10. The length, breadth and height of a room are 8 m, 5 m and 3 m respectively. If density of air is 1·29 kg m^{-3}, find the mass of air in the room.

Given : l = 8 m, b = 5 m, h = 3 m, density of air d = 1·29 kg m^{-3}.

Volume of room V $= l \times b \times h$

$= 8\ m \times 5\ m \times 3\ m$

$= 120\ m^3$

From relation $d = \frac{M}{V}$,

mass of air M = V × d

or M = 120 m^3 × 1·29 kg m^{-3}

$= \mathbf{154{\cdot}8\ kg}$

11. A copper piece of mass 88 g when immersed completely into water contained in a measuring cylinder, raises the level of water from 15 mL to 25 mL.

Find :

(a) the volume of copper piece and

(b) the density of copper.

Given : M = 88 g, V_1 = 15 mL, V_2 = 25 mL

(a) Volume of copper piece V = $V_2 - V_1$

= 25 mL – 15 mL = 10 mL = **10 cm^3**

(since, 1 mL = 1 cm^3)

(b) Density of copper $d = \frac{M}{V}$

$= \frac{88\ g}{10\ cm^3} = \mathbf{8{\cdot}8\ g\ cm^{-3}}$

12. Convert the following speeds in m s^{-1}.

(a) 3 km min^{-1} and (b) 36 km h^{-1}.

(a) 3 km min^{-1} = $\frac{3 \times 1000\ m}{60\ s}$ = **50 m s^{-1}**.

(b) 36 km h^{-1} = $\frac{36 \times 1000\ m}{60 \times 60\ s}$ = **10 m s^{-1}**.

13. A car travels a distance of 200 km in 3 h. Find the speed of car in m s^{-1}.

Given : D = 200 km = 200 × 1000 m

t = 3 h = 3 × 60 × 60 s

Speed V = $\frac{\text{Distance D}}{\text{time } t}$

$= \frac{200 \times 1000\ m}{3 \times 60 \times 60\ s} = \mathbf{18{\cdot}5\ m\ s^{-1}}$

14. A cyclist is moving with a speed of 20 km h^{-1}. How long will he take to travel a distance of 1·5 km ?

Given : Speed v = 20 km h^{-1},

distance D = 1·5 km

From relation $v = \frac{D}{t}$; time taken $t = \frac{D}{v}$

or $t = \frac{1{\cdot}5\ km}{20\ km\ h^{-1}} = 0{\cdot}075\ h$

= 0·075 × 60 × 60 s = **270 s**

15. A car travels for 20 min with a constant speed of 54 km h^{-1}. Find the distance travelled by the car.

Given : time $t = 20$ min $= 20 \times 60$ s $= 1200$ s

Speed $v = 54$ km h^{-1}

$$= \frac{54 \times 1000 \text{ m}}{3600 \text{ s}} = 15 \text{ m s}^{-1}$$

From relation $v = \frac{D}{t}$, distance $D = v \times t$

or $D = 15 \text{ m s}^{-1} \times 1200 \text{ s}$

$= $ **18000 m or 18 km.**

16. A body A travels a distance 600 m in 1 min while body B travels a distance 1 km in 20 s. Which body moves faster ? Give reason.

Given : For body A distance $D_1 = 600$ m, time $t_1 = 1$ min $= 60$ s.

$\therefore$ Speed of body A, $(V_1) = \frac{D_1}{t_1} = \frac{600 \text{ m}}{60 \text{ s}}$

$= 10 \text{ m s}^{-1}$

For body B distance $D_2 = 1$ km $= 1000$ m, $t_2 = 20$ s

$\therefore$ Speed of body B, $(V_2) = \frac{D_2}{t_2} = \frac{1000 \text{ m}}{20 \text{ s}}$

$= 50 \text{ m s}^{-1}$

Thus, body B moves faster than body A.

RECAPITULATION

- The space occupied by an object is called its volume.
- The S.I. unit of volume is cubic metre (symbol m^3).
- Other units of volume are cm^3 and mm^3, where
  $1 \text{ cm}^3 = 10^{-6} \text{ m}^3$ and $1 \text{ mm}^3 = 10^{-9} \text{ m}^3$
- The volume of liquids is expressed in litre (symbol L) and millilitre (symbol mL) where
  $1 \text{ L} = 10^{-3} \text{ m}^3 = 1000 \text{ cm}^3$ and $1 \text{ mL} = 1 \text{ cm}^3$
- The volume of an irregular solid is found by the method of displacement of a liquid using a measuring cylinder.
- The area of an object is the surface occupied by it.
- The S.I. unit of area is square metre (symbol m^2).
- Another unit of area is cm^2 where $1 \text{ cm}^2 = 10^{-4} \text{ m}^2$.
- The area of an irregular lamina is approximately found by using a graph paper.
- Equal masses of different substances have different volumes.
- Equal volumes of different substances have different masses.
- The density of a substance is defined as mass per unit volume of that substance.
- If a body has mass M and volume V, its density d is given as $d = \frac{M}{V}$.
- Density $= \frac{\text{Mass}}{\text{Volume}}$, Mass = Volume × Density, Volume $= \frac{\text{Mass}}{\text{Density}}$

- The S.I. unit of density is kg m^{-3} and its C.G.S. unit is g cm^{-3}.
- 1 g cm^{-3} = 1000 kg m^{-3}.
- The density of a substance does not change with change in its size or shape.
- The density of a substance decreases with the increase in its temperature because the substance expands on heating. This decrease is more in gases, less in liquids and still less in solids for the same rise in temperature. However, the density of water increases when heated from 0°C to 4°C and then decreases on heating above 4°C.
- The density of water is maximum at 4°C, equal to 1 g cm^{-3} or 1000 kg m^{-3}.
- Speed is a quantity which tells us about the motion of a body *i.e.* how fast or slow it is moving.
- Speed of a moving body is defined as the distance travelled by it in unit time.
- Speed of a body = $\dfrac{\text{Distance travelled by the body}}{\text{Time of travel}}$ or $v = \dfrac{D}{t}$

  Distance D = speed v × time t and time $t = \dfrac{\text{distance D}}{\text{speed } v}$
- The S.I. unit of speed is metre per second (symbol m s^{-1}).
- Other units of speed are km h^{-1} and cm s^{-1} where

  1 m s^{-1} = 3·6 km h^{-1} (or 5 m s^{-1} = 18 km h^{-1})

  1 m s^{-1} = 100 cm s^{-1}.

TEST YOURSELF

A. Objective Questions :

1. Write true or false for each statement :
   (a) The S.I. unit of volume is litre.
   (b) A measuring beaker of capacity 200 mL can measure only the volume of 200 mL of a liquid.
   (c) cm^2 is a smaller unit of area than m^2.
   (d) Equal volumes of two different substances have equal masses.
   (e) The S.I. unit of density is g cm^{-3}.
   (f) 1 g cm^{-3} = 1000 kg m^{-3}.
   (g) The density of water is maximum at 4°C.
   (h) The speed 5 m s^{-1} is less than 25 km h^{-1}.
   (i) The S.I. unit of speed is m s^{-1}.

   Ans. True — (b), (c), (f), (g), (h), (i)
   False — (a), (d), (e)

2. Fill in the blanks :
   (a) 1 m^3 = ... cm^3
   (b) The volume of an irregular solid is determined by the method of ....
   (c) Volume of a cube = ...
   (d) The area of an irregular lamina is measured by using a ....
   (e) Mass = density × ....
   (f) The S.I. unit of density is ....
   (g) 1 g cm^{-3} = ... kg m^{-3}.
   (h) 36 km h^{-1} = ... m s^{-1}.
   (i) Distance travelled D = ... × time t.

   Ans. (a) 10^6, (b) displacement of liquid, (c) (one side)^3, (d) graph paper, (e) volume, (f) kg m^{-3}, (g) 1000, (h) 10, (i) speed v.

3. Match the following :

	Column A	Column B
(a)	Volume of a liquid	(i) kg m^{-3}
(b)	Area of a leaf	(ii) m^3
(c)	S.I. unit of volume	(iii) graph paper
(d)	S.I. unit of density	(iv) m s^{-1}
(e)	S.I. unit of speed	(v) measuring cylinder

Ans. (a)–(v), (b)–(iii), (c)–(ii), (d)–(i), (e)–(iv).

4. Select the correct alternative :

(a) One litre is equal to :
 (i) 1 cm^3 (ii) 1 m^3
 (iii) 10^{-3} cm^3 (iv) 10^{-3} m^3

(b) A metallic piece displaces water of volume 15 mL. The volume of piece is :
 (i) 15 cm^3 (ii) 15 m^3
 (iii) 15×10^3 cm^{-3} (iv) 15×10^3 cm^3

(c) A piece of paper of dimensions 1·5 m × 20 cm has area :
 (i) 30 m^2 (ii) 300 cm^2
 (iii) 0·3 m^2 (iv) 3000 m^3

(d) The correct relation is :
 (i) $d = M \times V$ (ii) $M = d \times V$
 (iii) $V = d \times M$ (iv) $d = M + V$

(e) The density of alcohol is 0·8 g cm^{-3}. In S.I. unit, it will be :
 (i) 0·8 kg m^{-3} (ii) 0·0008 kg m^{-3}
 (iii) 800 kg m^{-3} (iv) 8×10^3 kg m^{-3}.

(f) The density of aluminium is 2·7 g cm^{-3} and of brass is 8·4 g cm^{-3}. For the same mass, the volume of :
 (i) both will be same
 (ii) aluminium will be less than that of brass
 (iii) aluminium will be more than that of brass
 (iv) nothing can be said.

(g) A block of wood of density 0·8 g cm^{-3} has a volume of 60 cm^3. The mass of block will be :
 (i) 60·8 g (ii) 75 g
 (iii) 48 g (iv) 0·013 g

(h) The correct relation for speed is :
 (i) Speed = distance × time
 (ii) $\text{Speed} = \frac{\text{distance}}{\text{time}}$
 (iii) $\text{Speed} = \frac{\text{time}}{\text{distance}}$
 (iv) $\text{Speed} = \frac{1}{\text{distance} \times \text{time}}$

(i) A boy travels a distance 150 m in 1 minute. His speed is :
 (i) 150 m s^{-1} (ii) 2·5 m s^{-1}
 (iii) 25 m s^{-1} (iv) 9 m s^{-1}.

Ans. (a)–(iv), (b)–(i), (c)–(iii), (d)–(ii), (e)–(iii), (f)–(iii), (g)–(iii), (h)–(ii), (i)–(ii).

B. Short/Long Answer Questions :

1. Define the term volume of an object.
2. State and define the S.I. unit of volume.
3. State two smaller units of volume. How are they related to the S.I. unit ?
4. How will you determine the volume of a cuboid ? Write the formula you will use.
5. Name two devices which are used to measure the volume of an object. Draw their neat diagrams.
6. How can you determine the volume of an irregular solid (say a piece of brass) ? Describe in steps with neat diagrams.
7. You are required to take out 200 mL of milk from a bucket full of milk. How will you do it ?
8. Describe the method in steps to find the area of an irregular lamina using a graph paper.
9. Define the term density of a substance.
10. State the S.I. and C.G.S. units of density. How are they related ?
11. 'The density of brass is 8·4 g cm^{-3}'. What do you mean by the statement ?
12. Arrange the following substances in order of their increasing density :
 (a) iron (b) cork
 (c) brass (d) water
 (e) mercury.

13. How does the density of water change when :
    (a) it is heated from 0°C to 4°C,
    (b) it is heated from 4°C to 10°C ?
14. Write the density of water at 4°C.
15. Explain the meaning of the term speed.
16. Write the S.I. unit of speed.
17. A car travels with a speed 12 m s^{-1}, while a scooter travels with a speed 36 km h^{-1}. Which of the two travels faster ?

C. Numericals

1. The length, breadth and height of a water tank are 5 m, 2·5 m and 1·25 m respectively. Calculate the capacity of the water tank in (a) m^3 (b) litre.
   Ans. (a) 15·625 m^3 (b) 15,625 litre.
2. A solid silver piece is immersed in water contained in a measuring cylinder. The level of water rises from 50 mL to 62 mL. Find the volume of silver piece.
   Ans. 12 cm^3.
3. Find the volume of a liquid present in a dish of dimensions 10 cm × 10 cm × 5 cm.
   Ans. 500 mL.
4. A rectangular field is of length 60 m and breadth 35 m. Find the area of the field.
   Ans. 2100 m^2
5. Find the approximate area of an irregular lamina of which boundary line is drawn on the graph paper shown in Fig. 1.16. below.

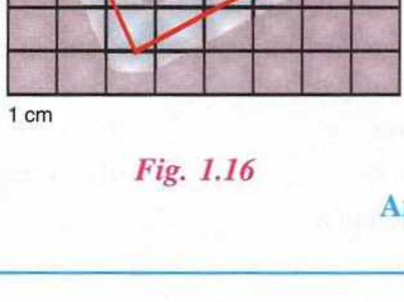


Fig. 1.16

   Ans. 21 cm^2

6. A piece of brass of volume 30 cm^3 has a mass 252 g. Find the density of brass in (i) g cm⁻ (ii) kg m^{-3}.
   Ans. (i) 8·4 g cm^{-3} (ii) 8400 kg m
7. The mass of an iron ball is 312 g. The density of iron is 7·8 g cm^{-3}. Find the volume of the bal
   Ans. 40 cm
8. A cork has a volume 25 cm^3. The density of cor is 0·25 g cm^{-3}. Find the mass of the cork.
   Ans. 6·25
9. The mass of 5 litre of water is 5 kg. Find th density of water in g cm^{-3}. **Ans.** 1 g cm⁻
10. A cubical tank of side 1 m is filled with 800 of a liquid. Find : (i) the volume of tan (ii) the density of liquid in kg m^{-3}.
    Ans. (i) 1 m^3 (ii) 800 kg m⁻
11. A block of iron has dimensions 2 m × 0·5 × 0·25 m. The density of iron is 7·8 g cm^{-3}. Fin the mass of block. **Ans.** 1950 k
12. The mass of a lead piece is 115 g. When it i immersed into a measuring cylinder, the wat level rises from 20 mL mark to 30 mL mark Find :
    (i) the volume of the lead piece,
    (ii) the density of the lead in kg m^{-3}.
    Ans. (i) 10 cm^3 (ii) 11500 kg m^{-3}
13. The density of copper is 8·9 g cm^{-3}. What wil be its density in kg m^{-3} ?
    Ans. 8900 kg m^{-3}
14. A car travels a distance of 15 km in 20 minute Find the speed of the car in (i) km h^{-1}, (ii) m s^{-1}.
    Ans. (i) 45 km h^{-1} (ii) 12·5 m s^{-1}
15. How long a train will take to travel a distance of 200 km with a speed of 60 km h^{-1} ?
    Ans. 3h 20 min
16. A boy travels with a speed of 10 m s^{-1} for 30 minute. How much distance does he travel ?
    Ans. 18000 m or 18 km
17. Express 36 km h^{-1} in m s^{-1}.
    Ans. 10 m s^{-1}
18. Express 15 m s^{-1} in km h^{-1}.
    Ans. 54 km h^{-1}.

2

Motion

Theme : An object is said to be in motion if its position changes with time. When walking, running or cycling or when a bird is flying there is motion involved. Various objects have different types of motion. They can be classified into translatory motion, circular motion and oscillatory motion. Motion of an object can also be classified as periodic and non-periodic. If an object travels equal distance in equal time, its motion is said to be uniform, if not, the motion is said to be non-uniform. A physical quantity used to distinguish between uniform and non-uniform motion is average speed.

In this chapter you will learn to

- define motion
- identify objects in motion and at rest
- describe different types of motion with examples from daily life
- define uniform and non-uniform motion with examples from daily life
- define concept of speed (average speed)
- calculate average speed of objects based on data provided
- define weight
- relate weight of an object with its mass

LEARNING OBJECTIVES

- Demonstrating objects at rest and in motion
- Demonstrating different types of motion
- Asking children to work in groups and list objects with different types of motion in a table
- Demonstrating motion of a pendulum as case of periodic motion
- Demonstrating uniform and non-uniform motion, examples from daily life
- Explaining the concept of speed, unit of speed, simple numericals for calculating average speed of objects in daily life
- Explaining the concept of weight
- Explaining the difference between mass and weight

KNOWING CONCEPTS

- Motion as a change in position of an object with respect to time
- Types of motion:
  - Translatory • Circulatory • Oscillatory
  - Repetitive (periodic and non periodic)
  - Random
- Uniform and non-uniform motion, concept of distance and speed (average speed)
- Weight
  - Concept
  - Differences between mass and weight

REST AND MOTION

If we look around us, we observe that many objects do not appear to move and thus we consider them to be at rest. **A body is said to be at rest if it does not change its position with respect to a fixed point in its surroundings.**

Examples : (i) A book lying on the table will not change its position if it is not disturbed and will be considered to be in a state of rest.

(ii) A bench fixed under a tree is at rest as there is no change in the position of the bench with respect to the tree and other stationary objects.

Therefore, when the position of a body with respect to its surroundings does not change with time, the body is said to be at rest.

Similarly, we find that many things around us move from one place to another. A flying bird, a moving bus, a boy playing football, oscillating pendulum of a wall clock, a moving train, a sailing ship, a walking man, etc. are some of the examples of motion.

A moving object keeps on changing its position continuously with time with respect to a fixed point in its surroundings.

Examples : (i) When a moving car changes its position with respect to a tree or a lamp post by the side of the road, the car is said to be in motion.

(ii) A flying bird is also said to be in motion as it changes its position with respect to the fixed objects such as a tree.

Hence, **when the position of a body with respect to its surroundings changes with time, the body is said to be in motion.**

Some other examples of rest and motion :
(1) Suppose we are sitting on a railway platform and looking at a tree nearby, we say that the tree is at rest because the tree does not change its position with respect to us. But when we see a train passing out of the station, we say that the train is in motion because it is continuously changing its position with respect to us.

(2) For a passenger sitting inside a moving bus, the driver of the bus is at rest because he does not appear to change his position with respect to the passenger. On the other hand the objects outside the bus such as trees, buildings, etc. appear to be in motion since they appear to change positions relative to the passenger.

Do You Know ?

Every body in the universe is in motion. Everyday we see bodies moving around us e.g. birds flying, cars and buses moving, people walking, insects crawling, animals running etc. Our earth also moves around the sun. We often say that a stone lying on the ground is at rest. But indeed, the stone is also moving along with the earth around the sun.

REST AND MOTION ARE RELATIVE

An object can be in motion relative to one set of objects while at rest relative to some other set of objects. Thus, rest and motion are relative terms. This can be understood by the following examples.

Examples : (i) Suppose you are sitting in a room. You are at rest in relation to all other stationary objects inside the room. But the room (or home) is on earth and the earth itself is not at rest. The earth revolves around the sun. It takes one year to complete one revolution around the sun. Thus, you are also revolving with the earth around the sun.

nce, in relation to the sun you are in tion.

(ii) In Fig. 2.1 a bus is in motion with spect to a boy sitting on a bench outside the s, but the trees around him appear to be at st. But to a boy sitting inside the bus, the ‿es and the boy outside the bus will appear move in opposite direction and the roof of bus or driver of the bus will appear to be rest.

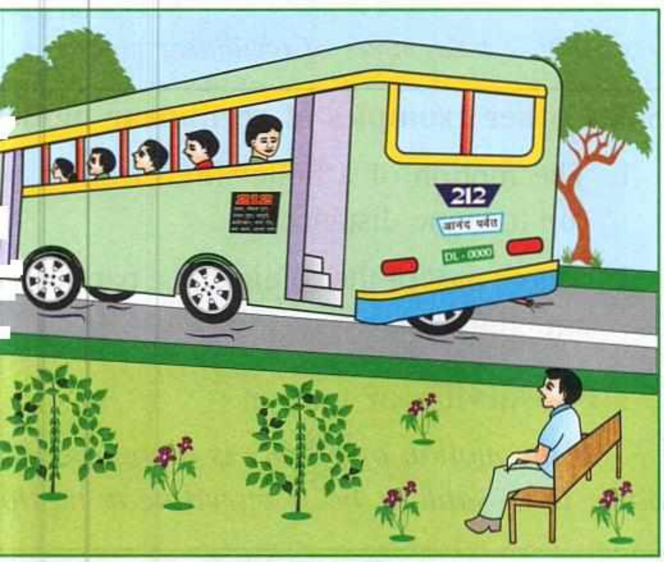


Fig. 2.1 A moving bus

For a passenger in a moving train the her train moving with the same speed and in same direction appears to be at rest while e train moving in the opposite direction pears to be in motion.

Thus, we conclude that an object while motion with respect to a set of objects can pear at the same time in a state of rest with spect to some other set of objects (moving th the same speed and in the same direction). is the observer and the surroundings that cide whether a given object is at rest or in otion.

ACTIVITY 1

List ten objects each, which you observe around yourself in the (a) state of rest, and (b) state of motion

State of rest	State of motion
1.	1. ....
2.	2. ....
3.	3. ....
4.	4. ....
5.	5. ....
6.	6. ....
7.	7. ....
8.	8. ....
9.	9. ....
10..........................	10. ....

DIFFERENT TYPES OF MOTION

Different objects have different types of motion. *For example*, a train moves straight along its track, a fan rotates and the earth revolves around the sun. There can be many more such examples. These different kinds of motion can be classified into the following types.

1. Translatory motion
2. Rotatory motion
3. Circular motion
4. Oscillatory motion
5. Vibratory motion
6. Periodic motion, and
7. Non-periodic motion

1. Translatory motion

If an object like a vehicle, moves in a line in such a way that every point of the object moves through the same distance in the same time, then the motion of the object is called translatory motion.

Examples : (i) When a cycle moves from position 1 to position 2, as shown in Fig. 2.2, the front wheel moves from A to A', the back wheel moves from B to B', the handle moves from C to C' and the cyclist moves from D to D' such that all the distances AA', BB', CC' and DD' are equal. Thus, the motion of a cycle is a translatory motion.

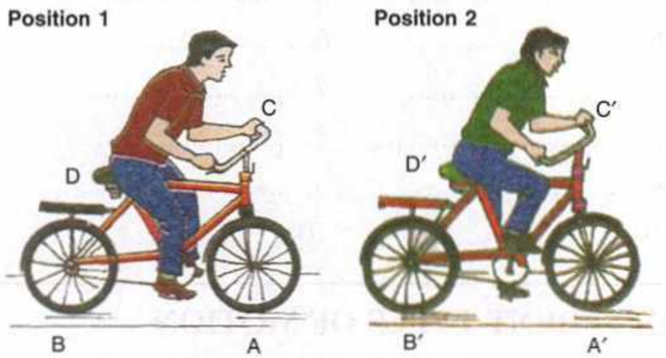


Fig. 2.2 Translatory motion of a cycle

(ii) The motion of an apple falling from a tree, the motion of a man walking on a road and the motion of a box when pushed from one corner of a room to the other, are all examples of translatory motion.

Translatory motion can be of *two* types :

(a) Rectilinear or linear motion, and

(b) Curvilinear motion

(a) Rectilinear or linear motion :

If the motion of a body is along a straight line, it is said to be a rectilinear or linear motion.

Examples : A ball falling from a height straight towards the surface of the earth, a car moving on a straight road and a coin moving over a carom board as shown in Fig. 2.3 (a), (b) and (c) respectively.

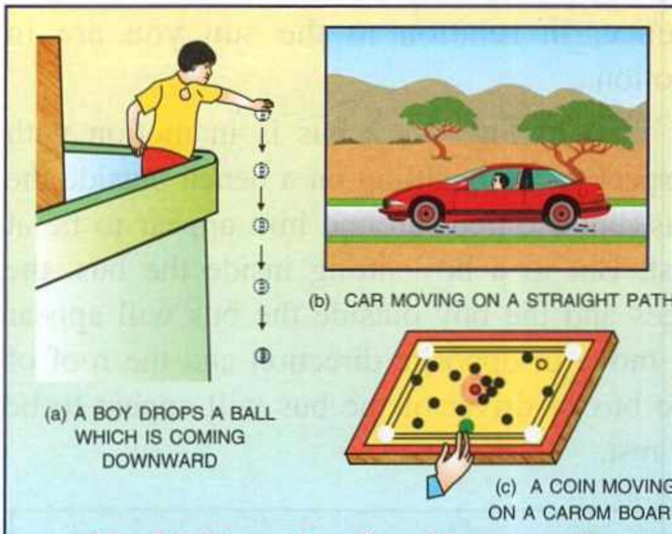


Fig. 2.3 Examples of rectilinear motion

Some other examples of rectilinear motio

1. The motion of a bullet fired from a gu (up to some distance)
2. March past of the soldiers in a parade on straight road.

(b) Curvilinear motion :

If the motion of a body is along a curve path, it is said to be a curvilinear motio

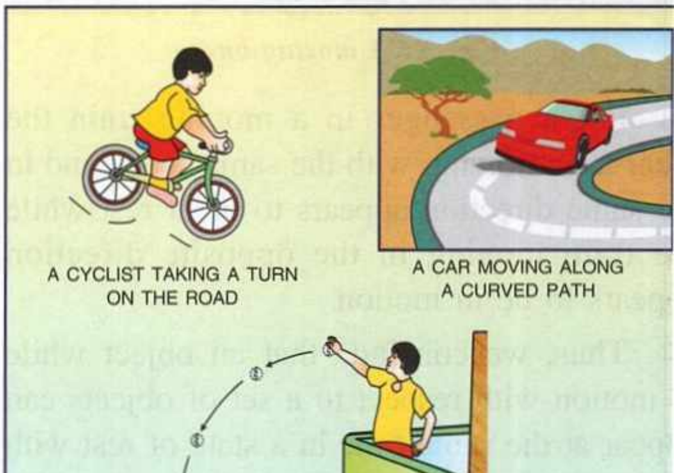


Fig. 2.4 Examples of curvilinear motion

ɔr *example*, the motion of a cycle while ꞌing a turn on the road, a car moving along curved path and a ball thrown by an athlete ꞌe in curvilinear motion (Fig. 2.4).

2. Rotatory motion

A body is said to be in a rotatory motion it moves about a fixed axis. *For example*, e blades of a fan, a spinning top, a spinning heel or a potter's wheel, a merry-go-round, tation of the earth about its own axis etc. ꞌig. 2.5).

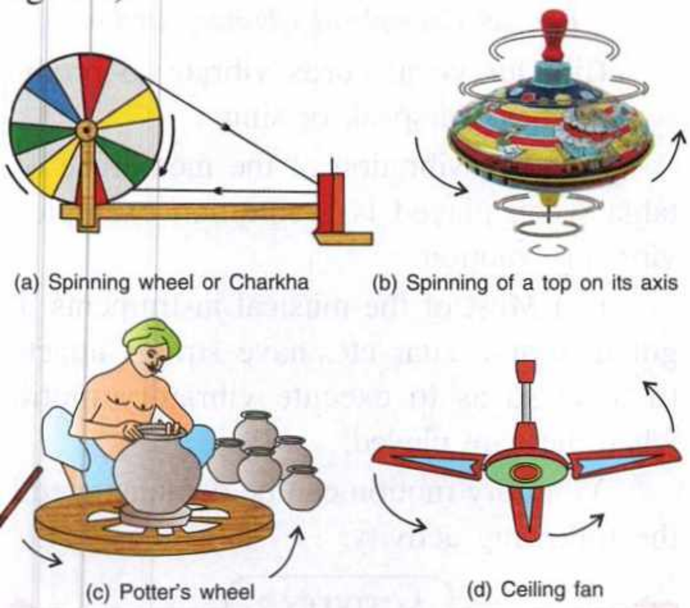


Fig. 2.5 Some examples of rotatory motion

Note : A rotatory motion is different from translatory motion, because in rotatory ıotion, different parts of the object move ırough different distances during the same ꞌme. The part of the body near the axis of otation travels a smaller distance than the istant parts of the body.

3. Circular motion

The motion of a body along a circular ath is called circular motion. Circular motion s a special type of curvilinear motion in ꞌhich the distance of a moving object from

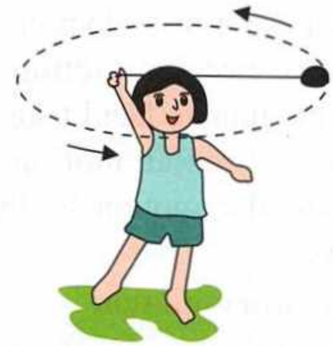
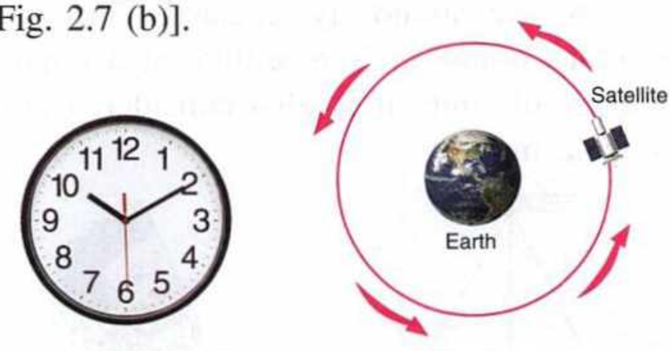


Fig. 2.6 Circular motion

a fixed point (called the centre) does not change. *For example*, in Fig. 2.6 a girl is whirling a stone tied at the end of a string in a circular path.

The other examples of circular motion are the motion of a car around a circular path, the motion of the hands of a clock [Fig. 2.7(a)] and the motion of a satellite around the earth [Fig. 2.7 (b)].



(a) Motion of the hands of a clock.

(b) Motion of an satellite around the earth.

Fig. 2.7 Examples of circular motion

Remember

1. In rotatory motion, the axis of rotation passes from a point in the body itself whereas in circular motion, the axis of revolution passes through a point outside the body. Thus, the motion of a satellite around the earth is a circular motion whereas the motion of earth about its own axis is a rotational motion.

2. In circular motion, the distance of a point of the body from a fixed point always remains the same, whereas it is not the same in curvilinear motion.

The hour hand of a clock takes 12 hours to complete a circular motion around the clock while the minute hand takes 60 minutes to complete a circular motion around the clock. The circular motion is, thus, periodic and repetitive.

4. Oscillatory motion

The to and fro motion of a body from its rest position (or mean position) is called the oscillatory motion. *For example*, the motion of the pendulum of a wall clock and the motion of a swing represent oscillatory motion (Fig. 2.8). In this motion, the bob of pendulum from its rest position O moves to one side A, comes back to the rest position O, then moves to the other side B and then again comes back to the rest position O. This process is continuously repeated. Since, the oscillatory motion is repetitive at a regular interval of time, it is also considered as a periodic motion.

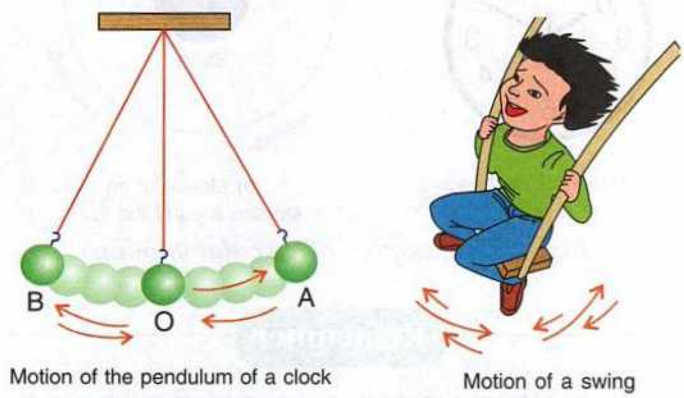


Fig. 2.8 Examples of oscillatory motion

5. Vibratory motion

It is also an oscillatory motion with the difference that in vibratory motion, a part of the body always remains fixed and the rest part moves to and fro about its mean position. During the vibratory motion, the shape and size of the body changes.

Examples : (i) In Fig. 2.9, a wire stretched between two fixed rods A and B on a table. As the wire is plucked and release from the middle, it starts moving to and fro

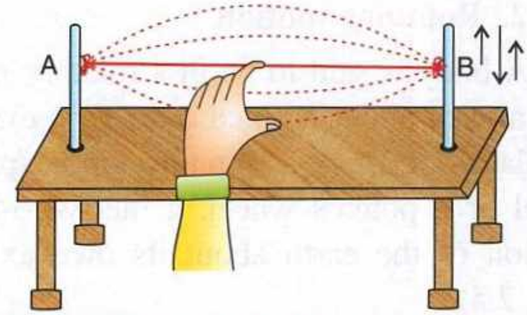


Fig. 2.9 Example of vibratory motion

(ii) Our vocal cords vibrate to produc sound when we speak or sing.

(iii) The vibration of the membrane of tabla when played is a common example vibratory motion.

(iv) Most of the musical instruments lik guitar, violin, sitar etc. have strings attache to them so as to execute vibratory motion when they are played.

Vibratory motion can be demonstrated b the following activity.

ACTIVITY 2

To demonstrate vibratory motion, take a metallic strip (say a metallic ruler). Fix its one end O on the table, as shown in Fig. 2.10. Thus, OA is the rest position of the strip.

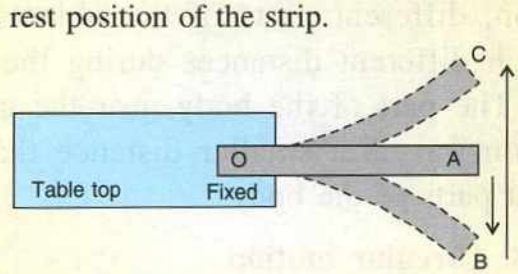


Fig. 2.10 Vibratory motion of a strip

Now lower the end A of the strip slightly and then release. The strip will start vibrating from A to B, B to C and then from C to A and so on.

6. Periodic motion

A motion which gets repeated after a regular interval of time is called a periodic motion.

Examples : (i) The earth completes one revolution about the sun in 365¼ days and this motion is repeated after every 365¼ days.

(ii) The moon revolves around the earth and completes one revolution in nearly 27·3 days and then repeats this motion.

(iii) A normal person's heart beats every 0.8 seconds.

(iv) The pendulum of a wall clock repeats its motion after every 2 s (Fig. 2.11).

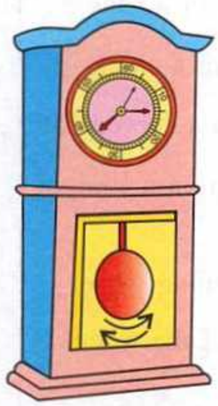


Fig. 2.11 Swinging pendulum of a wall clock

The other examples of periodic motion are : the motion of the needle of a sewing machine (Fig. 2.12) and the movement of membrane of a tabla when played.

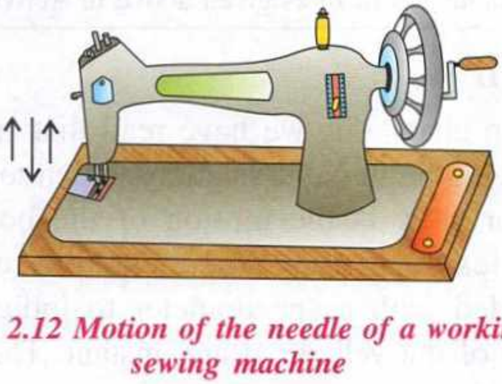


Fig. 2.12 Motion of the needle of a working sewing machine

7. Non-periodic motion

The motion which does not repeat itself after a regular interval of time is called non-periodic motion.

Examples : A footballer running on a field, application of brakes in a moving vehicle, a ball rolling down the ground gradually slows down and finally stops and motion of tides in the sea.

Do You Know ?

The motion of particles (called molecules) of a liquid or a gas is random or zig-zag or irregular because they do not take a specific path and specific direction of motion as shown in Fig. 2.13.

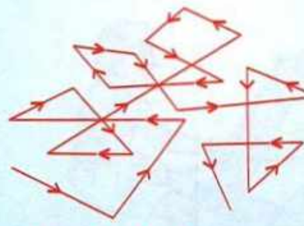


Fig. 2.13 Zig-zag motion.

MIXED MOTION

Sometimes a body can have more than one type of motion simultaneously. Such a motion is called a mixed motion.

Examples : (i) The wheels of a moving vehicle such as cycle, car, train, etc. have both translatory as well as rotatory motions (Fig. 2.14) as it moves from position A to position B while rotating.

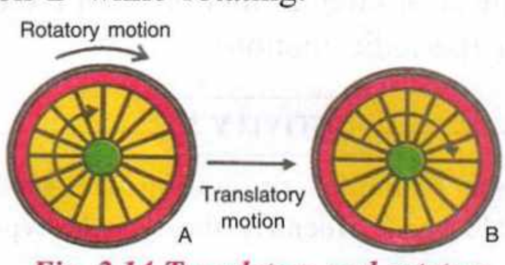


Fig. 2.14 Translatory and rotatory motions of a wheel

(ii) A drill used by a carpenter has both rotatory as well as translatory motions (Fig. 2.15) as its tip moves ahead inside the wood while rotating.

Fig. 2.15 Translatory and rotatory motions of a drill used by a carpenter

(iii) A carpenter's saw has translatory as well as oscillatory motion (Fig. 2.16) as it moves down while oscillating.

Fig. 2.16 The translatory and oscillatory motions of a carpenter's saw

(iv) A ball rolling on the ground has rotatory motion as well as translatory motion as it moves on the ground.

(v) The earth rotates about its axis (rotatory motion) and at the same time it revolves around the sun in a curved path (curvilinear or circular motion) in a fixed time interval (periodic motion).

ACTIVITY 3

Some examples of motion are given in the table ahead. Identify the type or types of motion.

Examples of motion	Type/types of motion
Soldiers in a march past on a straight road	....
The movement of our chest while breathing	....
Hands of an athlete in a race	....
Pedal of a bicycle in motion	....
Motion of earth around the sun	....
Motion of a swing	....
Motion of a pendulum	....
A stone falling from a certain height	....
A plucked string of a sitar	....
Tip of the hand of a clock	....
A car moving on a curved path	....
Motion of a train on a straight bridge	....
Motion of a spinning wheel	....
The movement of the wheel of a bicycle	....

ACTIVITY 4

Each group of 4 students of the class should sit together and list at least 10 objects in motion and state the type/types of motion of each object in a tabulated form as given above in Activity 3.

SPEED

In chapter 1, we have read that speed of a moving body is the quantity which tells how fast or slow is the motion of the body. All vehicles such as scooter, car, bus etc. are provided with a speedometer to indicate the speed of the vehicle at any instant. The speed of a moving body is defined as the distance travelled by the body in unit time *i.e.*

$$\text{Speed } v = \frac{\text{Distance travelled } (d)}{\text{Time taken } (t)}$$

The S.I. unit of speed is metre per second (symbol $m\ s^{-1}$). The other commonly used unit is kilometre per hour (symbol $km\ h^{-1}$) where $1\ m\ s^{-1} = 3{\cdot}6\ km\ h^{-1}$ or $18\ km\ h^{-1} = 5\ m\ s^{-1}$.

UNIFORM MOTION

If a moving body travels equal distances in equal intervals of time, its motion is said to be uniform. Thus for a uniform motion, the speed of the moving body remains constant.

Example : The table given below shows the position of a moving car at different instants.

Instant	Position
9 a.m.	0
10 a.m.	30 km
11 a.m.	60 km
12 noon	90 km

From the above table we can find the distance travelled by the car and the time taken to travel that distance. This is given below :

Time taken	Distance travelled
1. From 9 a.m. to 10 a.m. = 1 h	30 km – 0 = 30 km
2. From 10 a.m. to 11 a.m. = 1 h	60 km – 30 km = 30 km
3. From 11 a.m. to 12 noon = 1 h	90 km – 60 km = 30 km

Fig. 2.17 shows the distance travelled by the car in an interval each of 1 h.

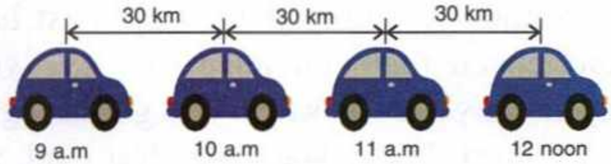


Fig. 2.17 Uniform motion of a car

From the table above, it is clear that the car has travelled a distance of 30 km in each 1 h, so the motion of the car is uniform with a constant speed $= \frac{30\ km}{1\ h} = 30\ km\ h^{-1}$.

Do You Know ?

In a clock, the second arm moves in a circular path with a constant speed, (*i.e.*, it covers equal distance along the periphery in equal interval of time) so its motion is also uniform.

NON UNIFORM MOTION

If a moving body travels unequal distances in equal intervals of time, its motion is said to be non-uniform.

Example : Fig 2.18 shows the position of a car at different time instants, when it starts and then travels to reach its destination. The car is initially at rest at 9 a.m. Now it starts moving slowly, then it picks up speed and moves at a constant speed. When it is near its destination, it slows down and then comes to a stop at 12 noon. The car travels 4 km in the first hour, 8 km in the second hour and then 3 km in the last hour. Thus, the car does not travel equal distances in equal intervals of time. So, the motion of the car is non-uniform.

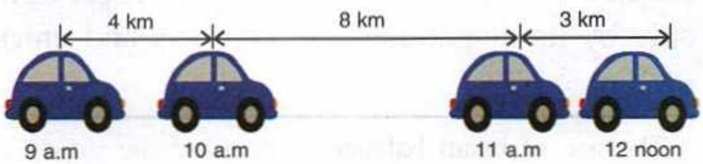


Fig. 2.18 Non-uniform motion of a car

Similarly, while cycling you must have experienced that you have to move your bicycle very slowly when you go through a busy market. But as you get a clear road, you begin to ride it fast. Thus, the motion of your bicycle is non-uniform. In cases when bodies move with non-uniform speed, we specify their average speed.

AVERAGE SPEED

The average speed is calculated by finding the ratio of the total distance travelled by the body to the total time taken in the journey, *i.e.*

$$\text{Average speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

For example in Fig. 2.18, the car has travelled a total distance 4 km + 8 km + 3 km = 15 km and the time of travel is from 9 a.m. to 12 noon *i.e.* 3 h. Hence the average speed of car is $\frac{15\text{ km}}{3\text{ h}} = 5\text{ km h}^{-1}$.

MASS AND WEIGHT

Mass : In class VI, we have learnt that *mass of a body is the quantity of matter contained in it*. The mass of a body is constant and it does not change with change in the position of the body. It is represented by the symbol m or M. The S.I. unit of mass is kilogram (in short form **kg**). The smaller unit of mass is gram (abbreviation **g**) which is one-thousandth part of a kilogram. The mass of a body is measured by a beam balance*. The mass of a body is expressed only by its magnitude (*i.e.* numbers and unit) such as 5·0 kg.

* The use of beam balance to measure the mass of an object has been described in class VI.

Weight : *The weight of a body is the force with which earth attracts the body i.e.* the weight of a body is the force of gravity on it. The weight of a body is not constant, but it changes from place to place. It is represented by the symbol W. The S.I. unit of weight is newton (which is abbreviated as N). One newton is nearly the force of attraction of earth on a mass of 0·1 kg (or 100 g). The other unit of weight is kilogram force (symbol kgf) where 1 kgf = 10 N (nearly)*. The weight of a body is measured by a spring balance. It is expressed by stating both the magnitude and direction. The direction of weight is always vertically downwards.

If force of gravity on a mass of 1 kg at a place is g newton, the weight W of mass m kg at that place is given as

$$W = mg$$

where $g = 10\text{ N kg}^{-1}$ (nearly)*.

Note : 1. Mass and weight are not the same.

2. kg is the unit of mass whereas kgf is the unit of weight. *For example*, a body of mass 5 kg will have weight 5 kgf (or about 50 N).

Do You Know ?

In a spring balance used to measure the weight of an object, the object is suspended at one end of the spring keeping its other end fixed. The force of gravity on the object (*i.e.*, weight of the object) elongates the spring. The increase in length of spring is directly proportional to the weight suspended, so it is calibrated to directly measure weight in kgf.

* More precisely 1 kgf = 9·8 N

3. The mass of a body can never be zero but the weight of a body is zero at the centre of earth and in an artificial satellite.

EFFECT OF CHANGE IN PLACE ON MASS AND WEIGHT

The mass of a body remains constant every where on the surface of earth or on any other heavenly body. But the weight of the body changes from place to place because it depends on the force of attraction of earth (or other heavenly body) on the body which differs from place to place. *For example*, the mass of a body is same on earth's surface as well as on moon's surface, but the weight of the body on moon's surface is 1/6th of the weight of the body on earth's surface because the force of attraction of moon on that body is $\frac{1}{6}$th of the force of attraction exerted by the earth.

Difference between mass and weight

Mass	Weight
1. It is the quantity of matter contained in a body	1. It is the force with which the earth attracts the body
2. Its S.I. unit is kilogram (kg)	2. Its S.I. unit is newton (N) and another unit is kilogram-force (kgf) where 1 kgf = 10 N (nearly).
3. It is constant for a body and it does not change by changing the place of the body	3. It is not constant for a body, but changes from place to place.
4. It is measured by a beam balance	4. It is measured by a spring balance.

SOLVED EXAMPLES

1. A boy walks first a distance of 0·5 km in 10 minutes, next 1·0 km in 20 minutes and last 1·5 km in 30 minutes. Is the motion uniform ? Find the average speed of the boy in m s^{-1}.

The motion of the boy can be considered in three parts.

In the first part, he walks a distance D = 0·5 km in time t = 10 minutes.

$$\text{Speed } v = \frac{D}{t} = \frac{0{\cdot}5 \text{ km}}{10 \text{ min}}$$

$$= 0{\cdot}05 \text{ km min}^{-1}$$

In the second part, he walks a distance D = 1·0 km in time t = 20 minutes.

$$\therefore \text{Speed } v = \frac{D}{t} = \frac{1{\cdot}0 \text{ km}}{20 \text{ min}}$$

$$= 0{\cdot}05 \text{ km min}^{-1}$$

In the third part, he walks a distance D = 1·5 km in time t = 30 minutes.

$$\therefore \text{Speed } v = \frac{D}{t} = \frac{1{\cdot}5 \text{ km}}{30 \text{ min}}$$

$$= 0{\cdot}05 \text{ km min}^{-1}$$

Thus, the speed of the boy remains same throughout his journey. Hence, his motion is uniform.

Now 1 km =1000 m and 1 minute = 60 s.

Average speed of the boy = 0·05 km min^{-1}

$$= \frac{0{\cdot}05 \times 1000 \text{ m}}{60 \text{ s}} = \frac{50 \text{ m}}{60 \text{ s}} = 0{\cdot}83 \text{ m s}^{-1}.$$

2. A car travels 100 km with a speed of 50 km h^{-1} and another 200 km with a speed of 20 km h^{-1}. Is the motion uniform ? Find the average speed of the car.

As the speed does not remain constant throughout the journey, the motion is not uniform.

From relation $v = \frac{D}{t}$

Time taken $t = \frac{\text{Distance travelled (D)}}{\text{Speed } (v)}$

The journey of the car can be considered in two parts.

In the first part of journey,

distance $D_1 = 100$ km, speed $v_1 = 50$ km h^{-1}

Time taken $t_1 = \frac{D_1}{v_1} = \frac{100 \text{ km}}{50 \text{ km h}^{-1}} = 2$ h

In the second part of journey,

distance $D_2 = 200$ km, speed $v_2 = 20$ km h^{-1}

Time taken $t_2 = \frac{D_2}{v_2} = \frac{200 \text{ km}}{20 \text{ km h}^{-1}} = 10$ h

Total distance travelled $D = D_1 + D_2$

$= 100 \text{ km} + 200 \text{ km} = 300 \text{ km}$

Total time of travel $t = t_1 + t_2$

$= 2 \text{ h} + 10 \text{ h} = 12 \text{ h}$

Average speed $= \frac{\text{Total distance travelled}}{\text{Total time of travel}}$

$= \frac{300 \text{ km}}{12 \text{ h}} = 25$ km h^{-1}.

3. A train travels from Agra to Delhi with a constant speed of 50 km h^{-1} and returns from Delhi to Agra with a constant speed of 40 km h^{-1}. Find the average speed of the train.

Suppose the distance between Agra and Delhi is D km.

From relation $v = \frac{D}{t}$, time taken $t = \frac{D}{v}$

In the first part of the journey from Agra to Delhi, speed $v_1 = 50$ km h^{-1}

Time taken $t_1 = \frac{D}{v_1} = \frac{d \text{ km}}{50 \text{ km h}^{-1}}$

$= \left(\frac{D}{50}\right)$ h

In the second part of the journey from Delhi to Agra, speed $v_2 = 40$ km h^{-1}

Time taken $t_2 = \frac{D}{v_2} = \frac{D \text{ km}}{40 \text{ km h}^{-1}}$

$= \left(\frac{D}{40}\right)$ h

Total distance travelled = D + D = 2D km

Total time of travel

$= \frac{D}{50} + \frac{D}{40} = \left(\frac{9D}{200}\right)$ h

Average speed $= \frac{\text{Total distance travelled}}{\text{Total time of travel}}$

$= \frac{2D \text{ km}}{\left(\frac{9D}{200}\right) \text{h}}$

$= \frac{2 \times 200}{9}$ km h^{-1} = 44·4 km h^{-1}.

4. A boy walks from his home to a post office at a distance of 0·5 km in 20 min. He then returns to his home in time 25 min. Find the average speed of the boy.

Given : Distance of post office from home = 0·5 km = 500 m

Total distance travelled in going and coming back

D = 500 m + 500 m = 1000 m

Total time taken in going and coming back

$t = 20$ min + 25 min

= 45 min = 45 × 60 s = 2700 s

Average speed $= \frac{\text{Total distance travelled}}{\text{Total time to travel}}$

$= \frac{1000 \text{ m}}{2700 \text{ s}} = 0{\cdot}37$ m s^{-1}.

5. A train takes 3 h to reach from station A to station B at a distance of 400 km and

5 h in its return journey. Find the average speed of the train.

Given : Distance between the two stations A and B = 400 km

Total distance travelled from A to B and then from B to A

$$D = 400 \text{ km} + 400 \text{ km} = 800 \text{ km}$$

Total time of journey $t = 3 \text{ h} + 5 \text{ h} = 8 \text{ h}$

$$\text{Average speed} = \frac{\text{Total distance travelled}}{\text{Total time of travel}}$$

$$= \frac{800 \text{ km}}{8 \text{ h}} = 100 \text{ km h}^{-1}.$$

6. The mass of a body is 20·0 kg. Taking the pull of gravity on mass 1 kg equal to 10 N, express the weight of the body in (i) kgf, and (ii) newton.

Given : Mass of body = 20·0 kg

(i) Weight = 20·0 kgf

(ii) Since 1 kgf =10 N

Weight = 20·0 × 10 N = 200·0 N.

7. A boy is of mass 40 kg. If the pull of gravity on 1 kg on the surface of earth is 9·8 N and at the surface of moon is 1·6 N, find (a) the weight of boy at the earth's surface, (b) mass and weight of the boy at the moon's surface.

Given : Mass of the boy = 40 kg

(a) At the earth's surface,

Weight = 40 kgf

Since 1 kgf = 9·8 N,

Weight = 40 × 9·8 N = 392 N

(b) At the moon's surface

Mass of boy will remain same as at the earth surface = 40 kg

But 1 kgf = 1·6 N

so weight = 40 × 1·6 N = 64 N

RECAPITULATION

- A body is said to be at rest if it does not change its position with respect to its immediate surroundings.
- A body is said to be in motion if it changes its position with respect to its immediate surroundings.
- A body is said to have translatory motion if every point on the moving body moves through the same distance in the same interval of time.
- The motion of a body in a straight line is called rectilinear or linear motion.
- The motion of a body in a curved path, is called curvilinear motion.
- When a body moves about a fixed point (or a fixed axis), the body is said to have rotatory motion.
- If a body moves in a circular path, the motion is said to be circular motion or revolving motion. It is a case of curvilinear motion.
- The to and fro motion of a body from its rest position (or mean position) is called oscillatory motion.
- The to and fro motion of a part of the body keeping its rest part fixed, is called vibratory motion.
- If a motion is repeated at a regular interval of time, it is called periodic or repetitive motion.
- If a motion is not repeated at a regular interval of time, it is called non-periodic motion.
- The motion of an object which takes path in no specific direction is called random, zig-zag or irregular motion.
- A body can have more than one type of motion simultaneously.

- The distance covered by a body in unit-time is called the speed of the body. Thus,

$$\text{Speed} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

- The S.I. unit of speed is metre per second ($m\ s^{-1}$)
- Other units of speed are $km\ h^{-1}$ and $cm\ s^{-1}$ where

  $1\ km\ h^{-1} = 0{\cdot}277\ m\ s^{-1}$ or $1\ m\ s^{-1} = 3{\cdot}6\ km\ h^{-1}$

  $1\ cm\ s^{-1} = 0{\cdot}01\ m\ s^{-1}$ or $1\ m\ s^{-1} = 100\ cm\ s^{-1}$
- If a moving body travels equal distances in equal intervals of time, its motion is said to be uniform.
- If a moving body travels unequal distances in equal intervals of time, its motion is said to be non-uniform.
- In a non-uniform motion, the average speed of a body is calculated by dividing the total distance travelled by the body, with the total time of its journey. Thus,

$$\text{Average speed} = \frac{\text{Total distance travelled by the body}}{\text{Total time of journey}}$$

- The mass of a body is the quantity of matter contained in it. Its S.I.unit is kilogram (kg). It does not change by changing the place of the body. It is measured by a beam balance.
- The weight of a body on earth is the force with which earth attracts the body. Its S.I. unit is newton (N). It changes by changing the place of the body. It is measured by a spring balance.

TEST YOURSELF

A. Objective Questions :

1. Write **true** or **false** for each statement :
   (a) Two trains going in opposite directions with the same speed are at rest relative to each other.
   (b) A ball is thrown vertically upwards. Its motion is uniform throughout.
   (c) The motion of a train starting from one station and reaching at another station is non-uniform.
   (d) A motion which repeats itself after a fixed interval of time is called periodic motion.
   (e) A ball thrown by a boy from a roof-top has oscillatory motion.
   (f) Mass has both magnitude and direction.
   (g) Weight always acts vertically downwards.
   (h) Mass varies from place to place but weight does not.

Ans. True—(c), (d), (g) **False**—(a), (b), (e), (f), (h)

2. Fill in the blanks :
   (a) Two boys cycling on the road with the same speed are .... relative to each other.
   (b) The motion in a .... is rectilinear motion.
   (c) One to and fro motion of a clock pendulum takes time = ...
   (d) $36\ km\ h^{-1}$ = ... $m\ s^{-1}$.
   (e) Total distance travelled = ... × total time taken.
   (f) The weight of a girl is 36 kgf. Her mass will be ....
   (g) The weight of a body is measured using ....

Ans. (a) at rest, (b) straight line (c) 2 s (d) $10\ m\ s^{-1}$ (e) average speed (f) 36 kg (g) a spring balance

3. Match the following :

Column A	Column B
(a) Circular motion	(i) a running fan
(b) Periodic motion	(ii) a car moving in a market
(c) Vibratory motion	(iii) movement of the hands of a clock
(d) Rotatory motion	(iv) motion of wire of a guitar
(e) Non uniform motion	(v) motion of pendulum of a clock

Ans. (a)–(iii), (b)–(v), (c)–(iv), (d)–(i), (e)–(ii)

4. Select the correct alternative :

(a) A book lying on a table is an example of :

(i) a body at rest

(ii) a body in motion

(iii) a body neither at rest nor in motion

(iv) none of these.

(b) The motion of a pendulum is :

(i) rotatory (ii) oscillatory

(iii) curvilinear (iv) rectilinear

(c) A car moving on a straight road is an example of :

(i) rotatory motion

(ii) rectilinear motion

(iii) oscillatory motion

(iv) periodic motion

(d) A ball falls down vertically. Its motion is :

(i) periodic (ii) linear

(iii) circular (iv) vibratory

(e) If a body covers equal distances in equal intervals of time, the motion is said to be :

(i) uniform (ii) non-uniform

(iii) oscillatory (iv) rotatory

(f) A boy goes from his house to school by bus at a speed of 20 km h^{-1} and returns back through the same route at a speed of 30 km h^{-1}. The average speed of his journey is :

(i) 24 km h^{-1} (ii) 25 km h^{-1}

(iii) 30 km h^{-1} (iv) 20 km h^{-1}

(g) The earth attracts a body of mass 1 kg with a force of 10 N. The mass of a boy is 50 kg. His weight will be :

(i) 50 kg (ii) 500 N

(iii) 50 N (iv) 5 N

Ans. (a)–(i), (b)–(ii), (c)–(ii), (d)–(ii), (e)–(i), (f)–(i), (g)–(ii)

B. Short/Long Answer Questions :

1. Explain the meaning of the terms rest and motion.
2. Comment on the statement 'rest and motion are relative terms'. Give an example.
3. Fill in the blanks using one of the words : at rest, in motion.

   (a) A person walking in a compartment of a stationary train is .... relative to the compartment and is .... relative to the platform.

   (b) A person sitting in a compartment of a moving train is .... relative to the other person sitting by his side and is............ relative to the platform.
4. Name *five* different types of motion you know.
5. What do you mean by translatory motion ? Give *one* example.
6. Explain the meanings of (i) rectilinear motion, and (ii) curvilinear motion. Give *one* example of each.
7. What is rotatory motion? Give *two* examples.
8. What is meant by circular motion? Give *one* example.
9. How does rotatory motion differ from circular motion?
10. Explain oscillatory motion by giving *one* example.
11. What is vibratory motion? Give *one* example
12. Differentiate between periodic and non-periodic motions by giving an example of each.
13. What is random motion? Give an example.

14. Name the type/types of motion being performed by each of the following :
    (a) Vehicle on a straight road
    (b) Blades of an electric fan in motion
    (c) Pendulum of a wall clock
    (d) Smoke particles from chimney
    (e) Hands of a clock
    (f) Earth around the sun
    (g) A spinning top.
15. Give *two* examples to illustrate that a body can have *two* or more types of motion simultaneously.
16. State the types of motion of the following :
    (a) The needle of a sewing machine
    (b) The wheel of a bicycle
    (c) The drill machine
    (d) The carpenter's saw
17. Distinguish between uniform and non-uniform motions, giving an example of each.
18. How do you determine the average speed of a body in non-uniform motion ?
19. Define the term weight and state its S.I. unit.
20. How are the units of weight, kgf and newton related ?
21. State three differences between mass and weight.
22. Which quantity : mass or weight, does not change by change of place ?
23. State which of the quantities, mass or weight is always directed vertically downwards.

C. Numericals

1. A car covers a distance of 160 km between two cities in 4 h. What is the average speed of the car ? **Ans.** 40 km h^{-1}
2. A train travels a distance of 300 km with an average speed of 60 km h^{-1}. How much time does it take to cover the distance ?
   Ans. 5 h
3. A boy travels with an average speed of 10 m s^{-1} for 20 min. How much distance does he travel ?
   Ans. 12 km
4. A boy walks a distance of 30 m in 1 minute and another 30 m in 1·5 minute. Describe the type of motion of the boy and find his average speed in m s^{-1}.
   Ans. non-uniform. 0·4 m s^{-1}
5. A cyclist travels a distance of 1 km in the first hour, 0·5 km in the second hour and 0·3 km in the third hour. Find the average speed of the cyclist in (i) km h^{-1}, (ii) m s^{-1}.
   Ans. (a) 0·6 km h^{-1}, (b) 0·167 m s^{-1}
6. A car travels with speed 30 km h^{-1} for 30 minutes and then with speed 40 km h^{-1} for one hour. Find :
   (a) the total distance travelled by the car
   (b) the total time of travel, and
   (c) the average speed of car
   Ans. (a) 55 km, (b) 1·5 h, (c) 36·67 km h^{-1}
7. On earth the weight of a body of mass 1.0 kg is 10 N. What will be the weight of a boy of mass 37 kg in (a) kgf (b) N ?
   Ans. (a) 37 kgf, (b) 370 N
8. The weight of a body of mass 6·0 kg on moon is 10 N. If a boy of mass 30 kg goes from earth to the moon surface, what will be his (a) mass, (b) weight ?
   Ans. (a) 30 kg, (b) 50 N

3 Energy

Theme : This theme aims at enabling children to know about energy and the different forms namely, kinetic energy, potential energy, heat energy, electrical energy. They will also understand that one form of energy can be converted into another form and that this is known as transformation of energy. Energy is conserved during transformation. This is known as the law of conservation of energy.

In this chapter you will learn to

- define energy;
- express energy in proper units;
- discuss about different forms of energy;
- describe conversion of energy from one form to another in different situations;
- state law of conservation of energy, with examples.

LEARNING OBJECTIVES

- Explanation of the term energy and promoting children to share their experiences with examples from daily life.
- Explanation of the relation between work and energy.
- Discussion with children about the different forms of energy, with examples.
- Demonstration of inter-conversion of energy, examples from daily life
- Demonstration of the law of conservation of energy.
- Providing examples of different applications of conservation of energy (Roller coaster, Production of hydroelectricity etc.) and encouraging children to carefully make energy conversion diagrams and deduce that energy is conserved.

KNOWING CONCEPTS

- Energy:
- Energy as capacity to do work.
- Units of energy (joule and calorie).
- Different forms of energy.
- Inter-conversion of energy.
- Law of conservation of energy.
- Real world examples.

ENERGY

We have read that a force when applied can move a stationary body. When the force applied on a body moves it, work is said to be done by the force on the body. But if the body does not move on applying a force on it, no work is said to be done by the force on the body.

The work done by a force is measured as the product of the force and the distance moved by the body in the direction of force.

Work done = Force × Distance moved in the direction of force

The S.I. unit of force is newton (symbol N) and the S.I. unit of distance is metre (symbol m), so the S.I. unit of work will be newton × metre which is written as joule, after the name of the scientist J.P. Joule. In short form we write joule as J. Thus,

$$1\ J = 1\ N \times 1\ m$$

i.e, **1 joule of work is said to be done when a force of 1 N moves a body by a distance of 1 m in the direction of force.**

When work is done on a body, its energy increases. In other words, the work done on the body is stored in it in the form of energy. But if **work is done by the body, its energy decreases**. In other words, energy is spent when a body does work.

Example : When a girl rides a bicycle to a distance, she spends energy in doing work [Fig 3.1]. She will continue to ride the bicycle and do work till she possesses energy.


A girl cycling

Fig. 3.1 Energy is spent in doing work

We can define energy as follows.

Energy is the capacity to do work.

Relationship between work and energy : You must have experienced that more you ride on a bicycle or more you run all around the play ground, more you feel tired. The reason is that a lot of energy has been spent in doing work by you. Thus, to do more amount of work, you need more amount of energy. Hence, we can say that there is a direct relationship between work and energy.

Similarly, the work done on a body in changing its state is said to be the energy possessed by the body.

For example, if a body is moved from the ground to a height, work is done on the body against the force of gravity and the body at the height is said to possess energy. Similarly, if a body initially at rest is made to move, work is done on the body and the body in motion is said to possess the amount of energy equal to the work done on the body in producing motion in it.

UNITS OF ENERGY

Energy is measured in the same unit as work. Therefore, the S.I. unit of energy is joule (symbol J).

A body is said to possess an energy of one joule if one joule work is done to bring the body in that state *i.e.*, a force of 1 newton moves the body by a distance of 1 metre in the direction of force.

Another unit of energy is **calorie** (symbol cal) where 1 cal = 4·2 J (nearly)*. A bigger unit is kilo-calorie (symbol kcal) where 1 kcal = 1000 cal.

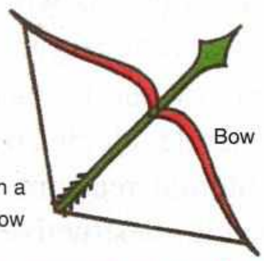
* More precisely 1 cal = 4·18 J

DIFFERENT FORMS OF ENERGY

In nature, we find energy in various forms such as (1) mechanical energy, (2) heat energy, (3) light energy, (4) chemical energy, (5) sound energy, (6) magnetic energy, (7) electrical energy, and (8) atomic energy or nuclear energy. They are briefly described below.

(1) Mechanical energy : The energy possessed by a body due to its state of rest or state of motion is called mechanical energy. Mechanical energy is found in two forms namely (a) potential energy, and (b) kinetic energy. The total mechanical energy of a body is the sum of potential and kinetic energies. A car in motion and an arrow on a stretched bow, all have mechanical energy.

(a) Car in motion



(b) Arrow on a stretched bow

Fig. 3.2 Bodies possessing mechanical energy

(2) Heat energy : The energy released when we burn anything like coal, oil, wood or gas is called heat energy. Steam possesses heat energy and it is capable to do work. It is our common experience that if we heat some water in a kettle with a lid on it, we notice that as the water begins to boil, the steam makes the lid to lift up (Fig. 3.3). This is actually the heat energy of the steam which moves the lid up. James Watt in the year 1765 invented the steam engine in which the heat energy of steam was used to do work (*i.e.* to drive a train).

Fig. 3.3 Heat energy of steam moves up the lid

(3) Light energy : Light is a form of energy in the presence of which other objects are seen. We do not feel light energy because ordinary light does not move the objects around us. But a strong beam of light can move small particles like electrons. We have read in class VI that light travels in a straight line and casts shadows of opaque objects. The plants convert light energy into chemical energy (food) by the process of photosynthesis.

(4) Chemical energy : The energy possessed by fuels such as coal, oil, gas etc. is called chemical energy. The chemical energy of petrol or diesel is capable to move a car or a truck. The food that we eat, possesses chemical energy and makes us do work.

(5) Sound energy : A vibrating body possesses sound energy. When sound produced by a vibrating body reaches our ear membrane, it begins to vibrate and we hear the sound of the vibrating body. We can hear sound when the number of vibrations per second are in the range of 20 to 20,000. On the other hand, some animals (like bat etc.) can hear sound of vibrations per second above 20,000. *For example,* a tuning fork when struck gently on a rubber pad, starts vibrating as shown in Fig. 3.4. When these vibratons reach the ear of a boy (Fig 3.4), he hears the sound of the fork.

Fig. 3.4 A boy hearing the sound produced by a vibrating tuning fork

(6) Magnetic energy : A magnet can attract an iron nail from a distance and thus the force exerted by the magnet causes the nail to move towards the magnet. Since a magnet can attract iron, it is said to possess a form of energy. This energy is called magnetic energy.

An electric motor which is used to run a fan or other household machines is also provided with a magnet. In factories or in mines, cranes fixed with electromagnets are used to separate iron particles from heaps of waste materials. An electromagnet is a temporary magnet in which a magnetic field is produced due to electric current.

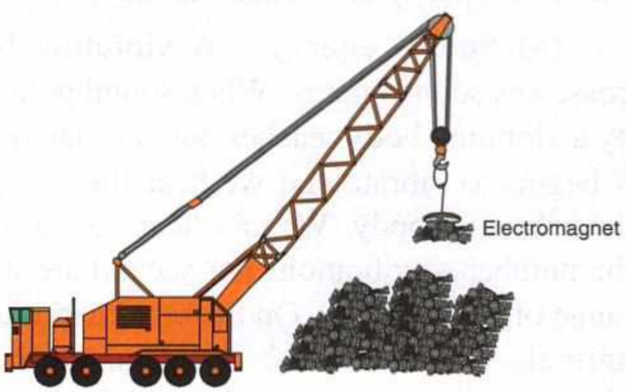


Fig. 3.5 Using an electromagnet in a factory to lift iron

(7) Electrical energy : Electrical energy is the energy we get when we use a battery, electricity supplied by the electricity board or a generator. Electric energy is used to run appliances at home, in offices and other places. Electric energy can be converted into other forms of energy such as sound, light, heat, etc.

Fig. 3.6 A computer running on electricity

(8) Atomic energy or nuclear energy : The energy stored in atoms is called atomic energy. Atomic energy is the energy released due to loss in mass when either a heavy nucleus splits into two light nuclei or two light nuclei combine to form one nucleus under certain conditions. This is why atomic energy is also called nuclear energy.

Atomic energy can be beneficial when it is used to generate electricity from atomic energy using atomic reactors. Atomic energy can also be used for destructive purposes when weapons like atom bombs are used in times of war.

Do You Know ?

The sun is a major source of energy. The energy which we receive on earth from the sun is called solar energy. Nowadays solar energy is used for making solar cells, solar cookers etc. Efforts are being made to obtain electricity by using solar panels. The Government of India is also promoting to produce electricity for household purposes by using solar energy.

TWO FORMS OF MECHANICAL ENERGY

We have read above that the mechanical energy is of two forms :

(1) Potential energy, and

(2) Kinetic energy.

(1) Potential energy

The energy of a body at rest is called its potential energy. It is defined as follows :

Potential energy of a body is the energy possessed by it due to its state of rest or position. Actually, it is equal to the work done in bringing the body to that state of rest or position.

It is written as P.E. or U

Examples :

(1) A wound up watch spring has potential energy because of the wound up state of its coils. As the spring unwinds itself, it does work to move the arms of the watch.

(2) A compressed spring has potential energy stored in it which is equal to the work done on the spring in brining it to the compressed state.

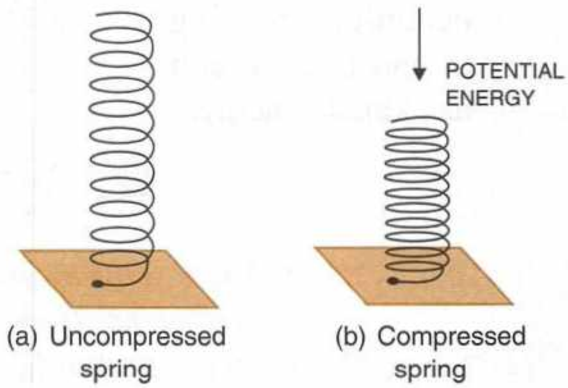


Fig. 3.7 A compressed spring has potential energy

(3) A stretched rubber band has potential energy. It does work in restoring itself to its original state. In Fig. 3.8, a pebble placed on the stretched rubber catapult, is thrown away when it is released to restore its original state.

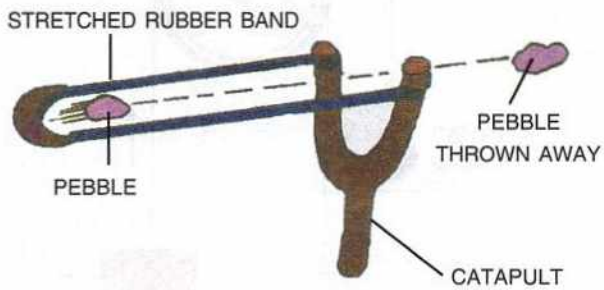


Fig. 3.8 A stretched rubber catapult has potential energy

In stretching a rubber band, work is done. This work is stored in the rubber band in the form of potential energy.

(4) A hammer at a height has potential energy stored in it. The hammer has this energy because of its position at a height. In Fig. 3.9 (a), the hammer is dropped on a nail fixed on a piece of wood. It drives the nail into the wood as shown in Fig. 3.9(b).

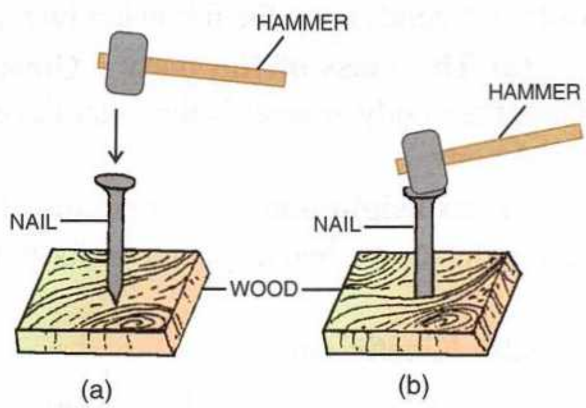


Fig. 3.9 A falling hammer drives the nail into the wood

(5) In Fig.3.10, a falling stone when reaches a pan, attached at one end of a pulley, lifts up a weight at its other end because of its potential energy.

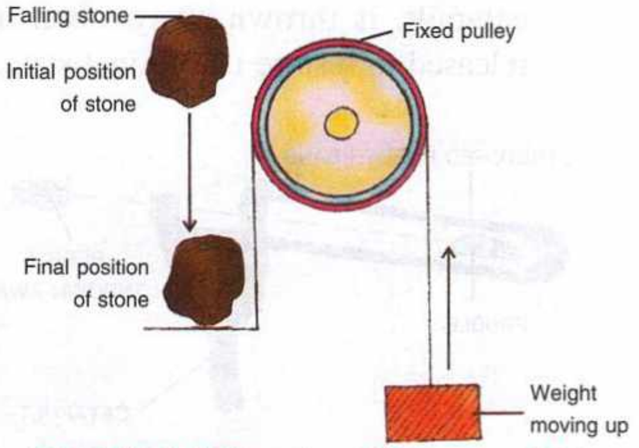


Fig. 3.10 A falling stone lifts up a weight

(6) Water at a height has potential energy stored in it. Falling water from a height can be used to do work such as turning a wheel.

Similarly, when a stone (or water) is lifted from the ground to a height, work is done against the force of gravity. This work is stored in the stone (or water) in the form of potential energy.

Factors affecting the potential energy of a body placed at a height:

The potential energy of a body in the raised position depends upon the following two factors:

(a) The mass of the body : Greater the mass of the body, greater is the potential energy of the body.

(b) Its height above the ground : Higher the height of the body, greater is its potential energy.

(2) Kinetic energy

The energy of a body in motion is called its kinetic energy. It is defined as follows :

Kinetic energy of a body is the energy possessed by it due to its state of motion. Actually, it is the work done on the body in bringing it to the state of motion. In short form it is written as K.E. or K.

Examples :

(1) Fig.3.11 shows that a fast moving stone has the capacity of breaking a window pane when it strikes the pane. Thus, the fast moving stone has kinetic energy.

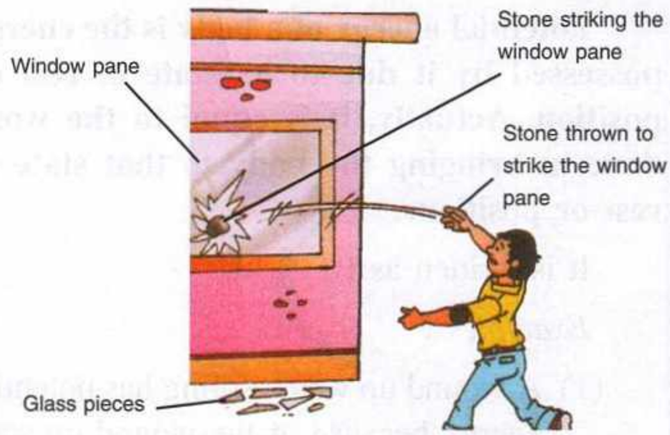


Fig. 3.11 A fast moving stone breaks the window pane due to its kinetic energy

(2) A falling hammer (*i.e.*, in motion) when strikes a nail fixed on a wooden block, moves it further into the block. Thus a moving hammer has kinetic energy and it does work on the nail.

(3) In a swinging pendulum, moving to and fro, the bob has kinetic energy.

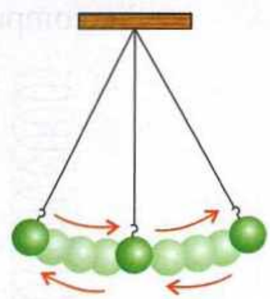


Fig. 3.12 In a swinging pendulum, the bob has kinetic energy

(4) In a river or sea, the flowing water has kinetic energy which makes a wooden boat or a log of wood to move in it (Fig. 3.13).

Fig. 3.13 A moving boat in flowing water

(5) A bullet fired from a gun, a rolling ball, an apple falling from a tree, etc. all have kinetic energy.

Factors affecting kinetic energy of a moving body:

The kinetic energy of a moving body depends on the following two factors :

(a) The mass of the body

Greater the mass of the body, higher is its kinetic energy.

(b) The speed of the body

More the speed of the body, more is its kinetic energy.

This can be demostrated by the following activity.

ACTIVITY 1

Take a hockey stick and a ball. Place the ball on the ground and hit it with the stick gently. You will notice that the ball moves slowly. Now hit the ball hard with the stick. You will notice that the ball moves fast and covers a longer distance. Thus, more the force applied on the ball (*i.e.*, more work done on the ball), more is the gain in the kinetic energy of the ball.

CONVERSION OF POTENTIAL ENERGY INTO KINETIC ENERGY

Potential energy changes into kinetic energy when it is put to use:

The following examples will make it clear.

Examples : (1) A hammer at a height has the potential energy due to its lifted or raised position. In Fig. 3.9, when the hammer is dropped from that position, it begins to fall. The falling hammer has kinetic energy. Thus, the potential energy stored in the hammer in its raised position changes into kinetic energy when the hammer is falling. This kinetic energy does work on the nail as the hammer strikes the nail and causes the nail to move into the wood.

Similarly, in Fig.3.10, the potential energy possessed by the stone at a height changes into its kinetic energy when it falls. The kinetic energy of the falling stone does work in raising the weight upwards.

(2) A wound up watch spring in Fig. 3.14 has potential energy because of its wound up state. As the spring unwinds itself, the potential energy changes into kinetic energy. This kinetic energy does work in moving the arms of the watch.

Fig. 3.14 When the spring unwinds, potential energy changes into kinetic energy to move the arms of the watch

(3) A stretched bow in Fig.3.15 (a) has potential energy because of its stretched position. In Fig. 3.15 (b), when the stretched bow is released, the potential energy of the

bow changes into its kinetic energy. This kinetic energy does work on the arrow and makes the arrow move.

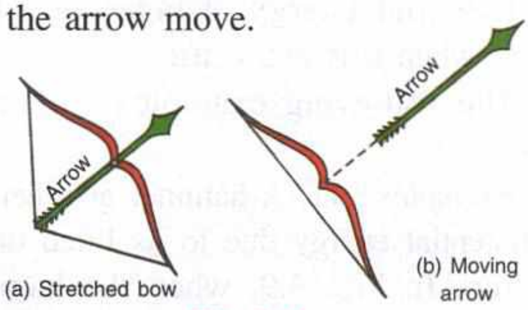


Fig. 3.15

(4) A compressed spring in Fig. 3.16 (a) has potential energy in it due to its compressed state. In Fig. 3.16(b), when the compressed spring is released, the potential energy changes into its kinetic energy which does work on the ball placed on it and makes the ball to fly away.

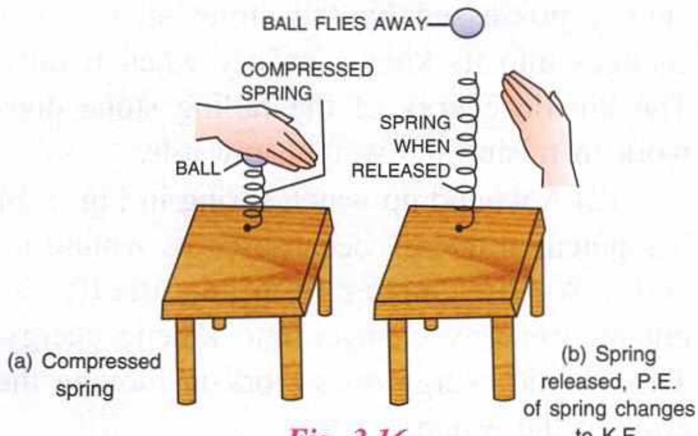


Fig. 3.16

The above examples show that potential energy converts into kinetic energy, when it is put to use.

CONVERSION OF ONE FORM OF ENERGY INTO ANOTHER FORM OR TRANSFORMATION OF ENERGY

We have read that energy exists in various forms such as mechanical, heat, light, sound, electrical, etc. One form of energy can be converted into another form. Some examples of conversion of energy from one form into other forms are given alongside.

Examples : (1) In a steam engine, chemical energy of coal first changes into heat energy of the steam. Then the heat energy of steam changes into mechanical energy which causes the train to move.

(2) In an electric motor (or in a fan), the electrical energy changes into mechanical energy. This energy rotates the axle of motor (or the blades of the fan).

Fig. 3.17 Table fan
(electrical energy → mechanical energy)

(3) In an electric iron, heater, oven, geyser, toaster etc., the electrical energy changes into heat energy.

(4) In a dry cell (battery) while in use, the chemical energy changes into electrical energy.

(5) In a glowing bulb (Fig. 3.18) the electrical energy changes into heat energy and light energy.

Fig. 3.18 Glowing electric bulb
(electrical energy → heat and light energy)

(6) In an electric bell while ringing, the electrical energy changes into sound energy.

(7) In an electric generator (or dynamo), the mechanical energy changes into electrical energy.

(8) In a microphone, the sound energy changes into electrical energy.

(9) In a loudspeaker (Fig. 3.19) the electrical energy changes into sound energy.

Fig. 3.19 Loudspeaker (electrical energy → sound energy)

(10) Plants during photosynthesis change the light energy received from sun into chemical energy of food. (Fig. 3.20).

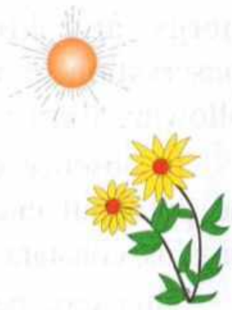


Fig. 3.20 Photosynthesis (light energy → chemical energy of food)

(11) When fire crackers burst, the chemical energy changes to heat, sound and light energy (Fig. 3.21).

Fig. 3.21 Bursting of fire crackers (chemical energy → heat, light and sound energy)

(12) When you do physical exercises or run (Fig. 3.22), the chemical energy of food stored in you changes into kinetic or mechanical energy.

Fig. 3.22 Physical exercise (chemical energy of food → mechanical energy)

Some examples of conversion of one form of energy into another form are given in the following table.

Examples of Transformation of Energy	
1. Photosynthesis	Light energy to chemical energy
2. Table fan	Electrical energy to mechanical energy
3. Tube light and bulbs	Electrical energy to light energy
4. Door bell	Electrical energy to sound energy
5. Electric motor	Electrical energy to mechanical energy
6. Dry cell	Chemical energy to electrical energy
7. Heater	Electrical energy to heat energy
8. Loudspeaker	Electrical energy to sound energy
9. Microphone	Sound energy to electrical energy
10. Electromagnet	Electrical energy to magnetic energy
11. Washing machine	Electrical energy to mechanical energy
12. Mixer grinder	Electrical energy to mechanical energy
13. Generator	Mechanical energy to electrical energy
14. Solar cell	Light energy to electrical energy
15. Burning of wood, coal, petrol, diesel	Chemical energy to heat energy
16. Windmill	Mechanical energy to electrical energy
17. Photo voltaic cell	Light energy to electrical energy
18. Steam engine	Heat energy to mechanical energy
19. Biogas	Chemical energy to heat energy
20. Automobile engine	Chemical energy to mechanical energy
21. Cooking gas (LPG)	Chemical energy to heat energy

22. Television	Electrical energy to sound and light energy
23. Car.	Chemical energy into heat and Mechanical energy
24. Campfires	Chemical energy into heat energy.

ACTIVITY 2

List *five* examples of conversion of energy from one form into another form which you find around you in daily life.

Example	Conversion
1.	....
2.	....
3.	....
4.	....
5.	....

Do You Know ?

In transformation of energy when one form of energy is changed to another useful form of energy, a part of energy gets converted with the non-useful form which is called dissipation of energy. For example, to light a bulb, the electrical energy is converted into light energy but a part of electrical energy converts into heat energy which is radiated to warm the bulb. This part of electrical energy is the dissipated part.

CONSERVATION OF ENERGY

We have read that in transformation of energy from one form to the other required form, some part of energy changes to non-useful (or unrequired) form also. *For example,* if 100 J of electrical energy is converted to mechanical energy in an electric motor, it is possible that 60 J is the mechanical energy and remaining 40 J may be heat and sound energy. But the total sum of the useful and non-useful energy is same as the energy being transformed *i.e.,* energy remains conserved. In other words, energy can neither be created nor destroyed. Thus the **law of conservation of energy** can be stated as follows:

The total energy is always conserved in each transformation of energy.

All forms of energy follow the law of conservation of energy. In mechanical energy, for transformation between the potential energy and kinetic energy, the law of conservation of mechanical energy takes the following form :

In absence of friction, the total sum of the potential energy and the kinetic energy remains constant.

This can be easily understood by the following examples.

Examples :

(1) Roller coaster : A roller coaster operates on the principle of conservation of energy. In Fig. 3.23, initially some work is done to put the roller coaster car at the position A. This work done is stored in the roller coaster in the form of potential energy (= E, say), since it is stationary at A, its kinetic energy is zero. As it starts coming down, the potential energy changes into kinetic energy, so the potential energy decreases and the kinetic energy increases.

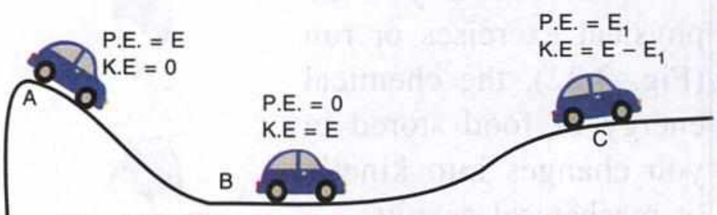


Fig. 3.23 Conservation of mechanical energy in a moving roller coaster

When the roller coaster reaches at B on ground, the potential energy becomes zero as it has converted into kinetic energy. So the kinetic energy at B is E. Due to this kinetic energy, the roller coaster rises to reach the point C.

During the motion from B to C, the kinetic energy changes into potential energy, therefore the potential energy increases and becomes E_1, while the kinetic energy decreases to $E - E_1$.

Thus, at each position A, B or C, the total sum of potential energy and kinetic energy remains same, equal to E.

Note : Here we have neglected friction.

Fig. 3.24 also illustrates the conservation of energy in a roller coaster showing that at each point, the sum of potential energy and kinetic energy is 40,000 J.

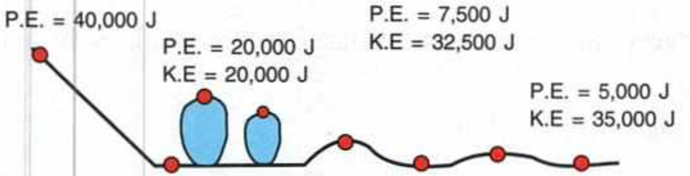


Fig. 3.24 conservation of energy in the motion of a roller coaster

(2) A vertically falling ball : A ball falling vertically downwards from a height is another example of conservation of mechanical energy. In Fig. 3.25, when the ball is stationary at point A at a height h above the ground, potential energy (P.E.) is maximum = E (say) which is equal to the work done in lifting the ball from the ground to the point A, while the kinetic energy (K.E.) is zero.

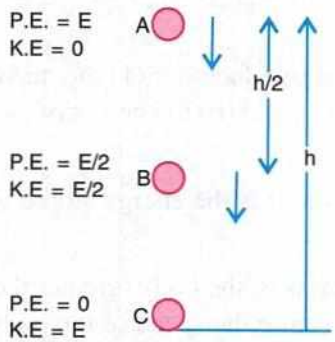


Fig. 3.25 Conservation of energy in a falling ball

As the ball starts falling down, its potential energy changes to kinetic energy, At the point B (at height h/2 above the ground), half of the potential energy converts into the kinetic energy. So at B, potential energy is E/2 and kinetic energy is also E/2.

On reaching the point C on ground, whole of the potential energy has converted into kinetic energy. So at C, potential energy is zero and kinetic energy is E.

Thus, we notice that during the vertical fall of a ball, if friction due to air is neglected, the total sum of potential energy and kinetic energy at each point of its path remains same.

ACTIVITY 3

Take a tennis ball. Release it from a height on a hard ground. You will observe that the ball after striking the ground bounces several times. Answer the following questions :

(a) What is the potential energy and kinetic energy when you release the ball ?

(b) Why does the ball bounce back after striking the ground ?

(c) From where does the ball get the kinetic energy for motion after striking the ground ?

PRODUCTION OF HYDRO ELECTRICITY

Water in motion in a river or sea has kinetic energy. The energy possessed by the flowing water is called hydro energy. The most important use of hydro energy is to produce electricity from it.

Fig. 3.26 shows the principle of a hydroelectric power plant. The flowing water of a river is collected in a dam at a high altitude. The water stored in the dam has the potential energy. When water from a dam falls on the water turbine, the potential energy

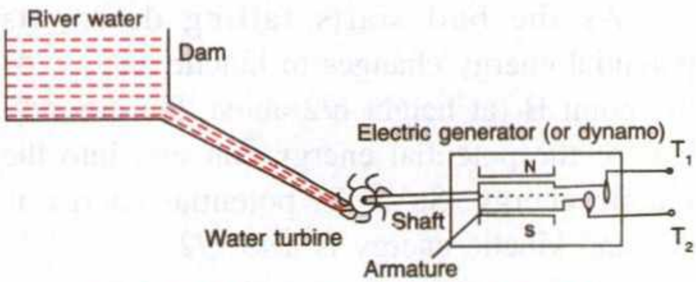


Fig. 3.26 Proudction of hydroelectricity

of the water stored in the dam changes into its kinetic energy and this kinetic energy of water is transferred to the blades of the turbine as kinetic energy which rotates the turbine. As the turbine rotates, it rotates the armature of a generator (or dynamo) to produce electricity.

RECAPITULATION

- Work is said to be done, if the applied force on the body moves it. If no motion takes place, no work is said to be done.
- The amount of work done depends on two factors : (1) on the magnitude of force applied (greater the force applied, greater is the work done), and (ii) on the distance moved in the direction of force (greater the distance moved, greater is the work done).
- The work done by a force on a body is equal to the product of the force and the distance moved by the body in the direction of force, *i.e.*

  Work done = Force × distance moved in the direction of force

  or $W = F \times d$
- The S.I. unit of work is joule (J), where

  1 joule (J) = 1 newton (N) × 1 metre (m).
- One joule of work is said to be done if one newton force when acts on a body, moves it by 1 metre in the direction of force.
- The energy of a body is its capacity (or ability) to do work. The energy of a body in a state is equal to the work done on the body to bring it to that state.
- The S.I. unit of energy is joule (J).
- In nature, energy exists in different forms : mechanical, heat, light, chemical, sound, magnetic, electrical and atomic energy.
- Mechanical energy is of two kinds : potential energy and kinetic energy.
- Potential energy of a body is the energy possessed by it due to its state of rest or position. It is the energy stored when work is done on the body to bring it to that state or position.
- Potential energy of a body in the raised (or lifted) position depends on two factors : (1) the mass of the body (greater the mass of the body, greater is the potential energy of the body), and (ii) the height of the body above the ground (greater the height of the body, greater is its potential energy).
- Kinetic energy of a body is the energy possessed by it due to its motion. It is the energy stored when work is done to bring the body in motion.
- Kinetic energy of a moving body depends on two factors : (i) on the mass of the body (greater the mass of the body, greater is its kinetic energy), and (iii) on the speed of the body (more the speed of the body, more is its kinetic energy).

- The potential energy changes into kinetic energy when it is put to use.
- One form of energy can be converted into another form.
- In transfomration of energy, the total sum of useful and non-useful energy obtained after conversion is equal to the energy converted, *i.e.* the total energy remains conserved.
- According to the conservation of mechanical enregy, if friction is neglected, the total sum of potential energy and kinetic energy remains constant. Examples are : motion of a roller coaster, free vertical fall of a body etc.
- The electricity obtained from the energy possessed by flowing water is called hydro-electricity.

TEST YOURSELF

A. Objective Questions

1. Write **true** or **false** for each statement :

   (a) A man going up has potential energy and kinetic energy both.

   (b) A gum bottle lying on a table has no energy.

   (c) In an electric fan, electrical energy changes into mechanical energy.

   (d) Potential energy changes into kinetic energy when it is put to use.

   (e) One form of energy cannot be converted into another form.

   (f) There is always some loss of energy in conversion from one form of energy to another form, so the total energy is not conserved.

   (g) The energy of flowing water can be converted into electric energy (electricity).

   Ans. True (a), (c), (d), (g)

   False (b), (e) (f)

2. Fill in the blanks :

   (a) An electric fan converts electrical energy into .... energy.

   (b) Cooking gas converts .... energy into heat energy.

   (c) Energy possessed by a compressed spring is .... energy.

   (d) The ability to do work is called ....

   (e) The energy possessed by a body due to its position is called .... energy.

   (f) The energy possessed by a body due to its motion is called .... energy.

   (g) Green plants convert .... energy into chemical energy.

   (h) The S.I.unit of energy is ....

   (i) An object falling freely from the roof of a multistorey building has .... and .... energy when halfway down the building.

   Ans: (a) mechanical (b) chemical (c) potential (d) energy (e) potential (f) kinetic (g) light (h) joule (i) potential energy and kinetic

3. Match the following columns :

Column A	Column B
(a) Running water	(i) heat energy
(b) Burning	(ii) vibrations
(c) Energy	(iii) atom bomb
(d) Sound energy	(iv) kinetic energy
(e) Nuclear energy	(v) joule

   Ans: (a)–(iv), (b)–(i), (c)–(v), (d)–(ii), (e)–(iii)

4. Select the correct alternatives :

   (a) When we rub our hands

   (i) kinetic energy changes into potential energy.

   (ii) mechanical energy changes into heat energy.

   (iii) potential energy changes into kinetic energy.

   (iv) heat energy changes into mechanical energy.

(b) A ball rolling on the ground possesses
   (i) kinetic energy
   (ii) potential energy
   (iii) no energy
   (iv) heat energy.

(c) The energy stored in an electric cell is
   (i) chemical energy
   (ii) electrical energy
   (iii) heat energy
   (iv) mechanical energy.

(d) When a bulb lights up on passing current, the change of energy is
   (i) from electrical energy to heat energy
   (ii) from electrical energy to light energy
   (iii) from electrical energy to heat and light energy
   (iv) from electrical energy to mechanical energy.

(e) The correct statement is
   (i) Both work and energy have the same units
   (ii) Potential energy of a body is due to its motion
   (iii) Kinetic energy of a body is due to its position or state
   (iv) Kinetic energy can change into potential energy, but potential energy cannot change into kinetic energy

(f) According to law of conservation of energy, energy changes from one form to another form, but the total energy of that system
   (i) increases (ii) decreases
   (ii) alternates (iv) remains the same

Ans. (a)–(ii), (b)–(i), (c)–(i), (d)–(iii), (e)–(i), (f)–(iv)

B. Short/Long Answer Questions

1. Define the term energy.
2. State the unit of energy and define it.
3. Name five different forms of energy.
4. What are the two kinds of mechanical energy.
5. What is potential energy ? State its unit.
6. Give one example of a body that has potential energy, in each of the following : (i) due to its position, (ii) due to its state.
7. State two factors on which the potential energy of a body at a certain height above the ground depends.
8. Two bodies A and B of masses 10 kg and 20 kg respectively are at the same height above the ground. Which of the two has greater potential energy ?
9. A bucket full of water is on the first floor of your house and another identical bucket with same quantity of water is kept on the second floor. Which of the two has greater potential energy ?
10. Define the term kinetic energy. Give *one* example of a body which possesses kinetic energy.
11. State *two* factors on which the kinetic energy of a moving body depends.
12. Two toy-cars A and B of masses 500 g and 200 g respectively are moving with the same speed. Which of the two has greater kinetic energy ?
13. A cyclist doubles his speed. How will his kinetic energy change : increases, decreases or remains the same ?
14. Name the form of energy which a wound up watch spring possesses.
15. Can a body possess energy even when it is not in motion ? Explain your answer with an example.
16. Name the type of energy (kinetic or potential) possessed by the following :
   (i) A moving cricket ball.
   (ii) A stone at rest on the top of a building.
   (iii) A compressed spring.
   (iv) A moving bus.
   (v) A bullet fired from a gun.
   (vi) Water flowing in a river.
   (vii) A stretched rubber band.

17. Give one example to show the conversion of potential energy to kinetic energy when put in use.

18. State the energy changes that occur in the following :
    (i) The unwinding of a watch spring.
    (ii) Burning coal while operating a steam engine.
    (iii) Lighting of a torch bulb.
    (iv) An electric generator (or dynamo).

19. Energy can exist in several forms and may change from one form to another. Give two examples to show the conversion of energy from one form to another.

20. Give one relevant example for each of the following transformations of energy :
    (i) Electrical energy to heat energy.
    (ii) Electrical energy to mechanical energy.
    (iii) Electrical energy to light energy.
    (iv) Chemical energy to heat energy.
    (v) Chemical energy to light energy.

21. What do you mean by conservation of mechanical energy ? State the condition when it holds.

22. Give one example to show that the sum of potential energy and kinetic energy remains constant if friction is ignored.

23. A ball is made to fall freely from a height. State the kind / kinds of energy possessed by the ball when it is
    (a) at the highest point
    (b) just in the middle
    (c) at the ground.

24. State the changes in form of energy while producing hydro electricity.

25. A truck starts from rest on a plane road. What are the possible energy changes taking place while the truck is in motion ?

4 Light Energy

Theme : Light travels in a straight line. Light from an object can move through space and reach the human eye that enables one to see this page, or a face in a mirror. This process is known as reflection. It obeys a law known as law of reflection. Light travels in air at a constant speed of 3×10^8 m/s or 3 lakh kilometre per second. In other mediums, like glass or water, it slows down. Light from sun is composed of seven colours. The colours of objects fascinates everybody. Physicists have found that all colours can be explained as addition of three primary colours. The primary colours are red, green and blue. Colours that are seen on a TV or computer screen arise due to combination of these primary colours. Appearance of colour of an object is due to process of absorption and reflection of different colours by the object.

In this chapter you will learn to

- explain the phenomenon of reflection
- define the terms, plane, normal to the plane, point of incidence, angle of incidence and angle of reflection
- state the law of reflection
- describe reflection of light from a plane mirror
- use law of reflection to show formation of image by a plane mirror
- describe the characteristics of image formed by a plane mirror
- state the value of speed of light
- state primary colours
- describe formation of secondary colours by addition of primary colours
- explain the observed colour of an object based on reflection and absorption of light of different colours from the object.

LEARNING OBJECTIVES

- Demonstrating on plane mirror the reflection of light. Explaining the point of incidence, normal, angle of incidence and angle of reflection.
- Engaging children in activities to show reflection of light.
- Helping children to draw a diagram to show the reflection by mirror
- Demonstrating primary colours and formation of secondary colours using primary colours and asking children to do the same in pairs/ groups.
- Explaining the colour of an object based on absorption and reflection
- Showing children a video on primary colours and mixing of primary colours and then discussing the same with them.
- Explaining the children how rainbow is formed.

KNOWING CONCEPTS

- Reflection
  - Definition and examples
  - Terms related to reflection — normal, plane, point of incidence, angle of incidence, angle of reflection
- Laws of reflection
- Plane mirror
- Uses
- Ray diagram (no mention of virtual image)
- Characteristics of the image formed (lateral, inversion, same size, distance is preserved)
- Speed of light (3×10^8 m/s)
- Primary colours (RGB)
- Formation of secondary colours by colour addition
- Appearance of colour of an object (based on reflection and absorption)
- Colour subtraction

LIGHT

We have learnt that light is a form of energy which gives us the sensation of sight. We cannot see light, but objects around us can only be seen in the presence of light. The objects around us are not seen in dark (*i.e.* in absence of light). Objects are seen when light after striking them, returns in the same medium and reach our eyes. Light travels in straight lines. This is called **rectilinear propagation of light**. It is due to the rectilinear propagation of light that it casts the shadow of an opaque object. The medium through which light passes easily is called a **transparent medium**. It does not produce any shadow. Light can travel in vacuum, therefore we receive light from the sun through the space. Everyday when you comb your hair, you stand in front of a mirror and see your image in it. You can also see your image in the still water of a tank (or pond or lake), the surface of a polished table, a silver polished utensil or a shining steel plate. This image is formed when light reflected by you strikes the surface and after striking, it returns so as to reach your eye. This returning of light in the same medium is called reflection of light.

REFLECTION OF LIGHT

If you throw a ball on the ground, you notice that it rebounds after striking the ground. Similarly, when light falls on a shiny surface such as a mirror, it returns back into the same medium after striking the surface. **The returning of light in the same medium after striking a surface, is called reflection of light.** When light falls on an object, a part of light is reflected. Different objects reflect light to different extents. A highly polished and smooth surface, such as a plane mirror, reflects maximum light falling on it, while a transparent object reflects the least amount of light. Black objects absorb all the light and do not reflect any.

PLANE MIRROR

A plane mirror is made by silvering one side of a thin plane glass plate. It is represented as in Fig. 4.1. The surface on which silvering is done is called the *silvered surface*, while

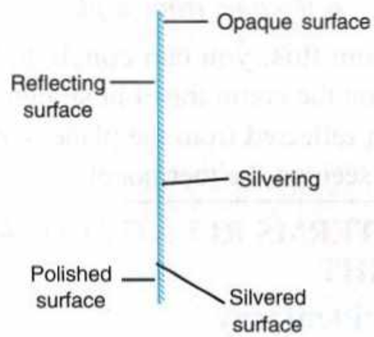


Fig. 4.1 Plane mirror

the other surface of glass plate is called the *reflecting surface* from where light is reflected. The silvered surface is coated with some opaque material so as to safeguard the silvering on it.

The light incident on a plane mirror enters from the front side of the polished surface and is reflected from the silvered surface. The coating being opaque, does not allow the light to pass through it.

This can be demostrated by the following activity.

ACTIVITY 1

Fix a comb on one side of a large thermocol sheet and fix a mirror at an angle on the other side as shown in Fig. 4.2. Pass a beam of light from a torch through the comb. You will get a pattern similar to the one shown in Fig. 4.2. However, the silvered surface of the mirror being opaque, doesn't allow any light to pass through it. As a result, no reflection of the comb can be seen behind the mirror.

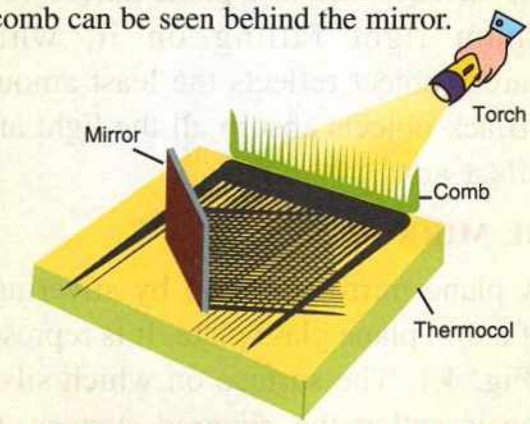


Fig. 4.2 The straight line path of light and its reflection from a plane mirror

From this, you can conclude that light rays falling on the comb travel in straight lines and then they get reflected from the plane mirror to form the pattern seen on the thermocol.

SOME TERMS RELATED TO REFLECTION OF LIGHT

1. Incident ray

The ray of light that strikes the surface is called the incident ray.

2. Point of incidence

The point at which the incident ray strikes the surface, is the point of incidence.

3. Reflected ray

The ray of light which is returned back into the same medium, after striking the reflecting surface, is called the reflected ray.

4. Normal

The perpendicular drawn on the surface at the point of incidence, is called the normal.

5. Angle of incidence

The angle between the incident ray and the normal is called the angle of incidence. It is represented by the letter i.

6. Angle of reflection

The angle between the reflected ray and the normal is called the angle of reflection. It is represented by the letter r.

Fig. 4.3 shows the labelled diagram for the reflection of light from a plane mirror. In Fig. 4.3, MM_1 is the plane mirror, AO is the incident ray, O is the point of incidence, OB is the reflected ray, ON is the normal. $\angle AON$ is the angle of incidence i, and $\angle BON$ is the angle of reflection r. *i.e.*

$$i = \angle AON, \text{ and}$$
$$r = \angle BON$$

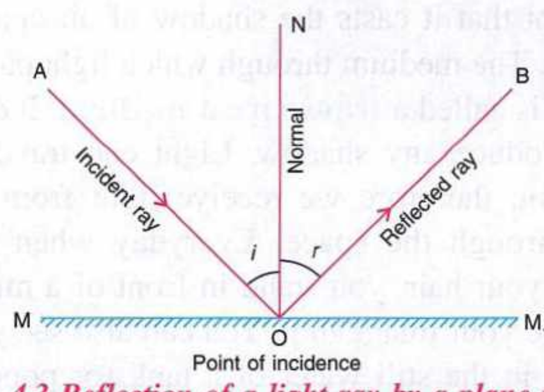


Fig. 4.3 Reflection of a light ray by a plane mirror

LAWS OF REFLECTION OF LIGHT

The reflection of a light ray at a surface obeys the following two laws of reflection :

(i) The angle of incidence is always equal to the angle of reflection.

In Fig. 4.3, $\angle AON = \angle BON$

or $\angle i = \angle r$

(ii) The incident ray, the reflected ray and the normal, all lie in the same plane.

In Fig. 4.4, PQRS is the plane mirror on which EFGH is the plane normal to the plane mirror at the point of incidence O which contains the incident ray AO, the reflected ray OB and the normal ON.

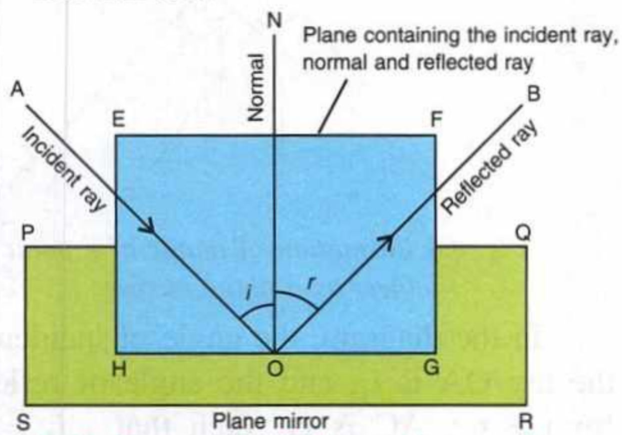


Fig. 4.4 Reflection of a light ray from a plane mirror showing the incident ray, normal and reflected ray in one plane

VERIFICATION OF LAWS OF REFLECTION

The laws of reflection can be verified by the following simple experiment.

Experiment :

1. Take a drawing board and a white sheet of paper. Fix the white sheet of paper on the drawing board. Draw a straight line MM_1 on the paper as shown in Fig. 4.5.
2. On the line MM_1, take a point O nearly at its middle and draw a line OA such that ∠MOA is less than 90°. Draw a normal ON on MM_1 at the point O.
3. Now take a small plane mirror and place its long edge along the line MM_1. Use plasticine to fix the mirror on the paper so that it stands upright.
4. Now fix two pins P and Q vertically on the line OA as shown in Fig. 4.5.

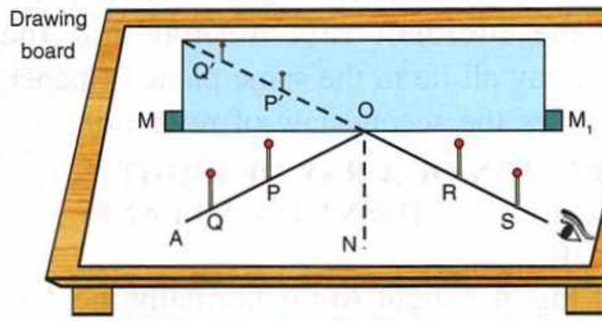


Fig. 4.5 Verification of the laws of reflection

5. Then set your eye on the other side of the normal ON, along the direction as shown in the diagram. You will see the images P' and Q' of the pins P and Q in the mirror.
6. Set your eye in line with the two images P' and Q' and fix two more pins R and S on the paper in front of the mirror such that both of them are in line with P′ and Q′.
7. Now remove the mirror. Draw small circles around the pins P, Q, R and S to mark their positions as shown in Fig. 4.6.

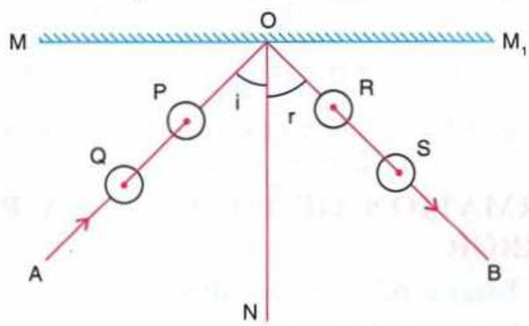


Fig. 4.6 Verification of laws of reflection

8. Draw a line OB joining the points R and S. AO is the incident ray, OB is the reflected ray and ON is the normal at the point of incidence O.
9. Now using a protractor, measure the angles $i = \angle AON$ and $r = \angle BON$. You will find that the two angles are equal.

This verifies that the angle of incidence i is equal to the angle of reflection r. Since the incident ray, normal and the reflected ray all lie in the same plane of paper, this verifies the second law of reflection.

REFLECTION OF A RAY OF LIGHT NORMALLY INCIDENT ON A PLANE MIRROR

In Fig. 4.7, light AO is normally incident on a plane mirror MM_1 at the point of incidence O. Since the angle of incidence is measured with the normal to the mirror and not with the surface of the mirror, the angle of incidence for this ray will be $i = 0°$ (and not 90°). According to the law of reflection of light, the angle of reflection r will also be 0°, so the reflected ray of light will also be OA. It simply shows that a ray of light incident normally, after reflection from the plane mirror, retraces its path as shown below.

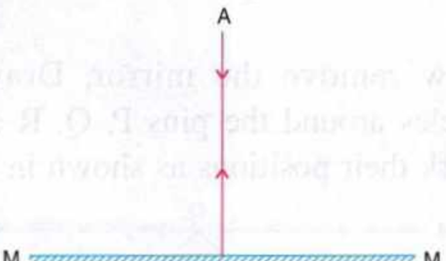


Fig. 4.7 Reflection of a ray of light normally incident on a plane mirror

FORMATION OF IMAGE BY A PLANE MIRROR

1. Image of a point object :

Fig. 4.8 shows how a plane mirror forms the image of a point object. A point object O is placed in front of a plane mirror MM_1. From the object O, rays of light travel in all directions. Here only the two rays OA and OB are shown which are reflected as AC and BD from the mirror. These reflected rays enter our eyes and they appear to come from a point I behind the mirror. Thus, I is the virtual image of the point object O.

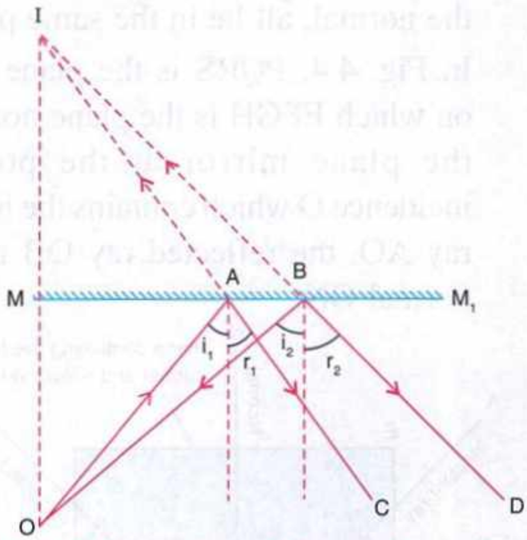


Fig. 4.8 Formation of image of a point object by a plane mirror

In the diagram, the angle of incidence of the ray OA is i_1, and the angle of reflection for the ray AC is r_1, such that $\angle i_1 = \angle r_1$. Similarly, the angle of incidence of the ray OB is i_2 and the angle of reflection for the ray BD is r_2 such that $\angle i_2 = \angle r_2$.

To locate the position of image, the reflected rays AC and BD are produced backwards. They meet at the point I. Thus, I is the image of the object O.

Measure the distances OM and IM using a ruler. You will find that OM = IM. Thus, the perpendicular distance of the object from the mirror is equal to the perpendicular distance of the image from the mirror. In other words, the image is as far behind the mirror as the object is in front of it.

Note : (a) At least two incident rays of light from the point object are required to find the position of the image formed by the mirror.

(b) The ray incident normally on the mirror can also be taken as one of the incident rays.

2. Image of an object of finite size :

Fig. 4.9 shows how a plane mirror forms the image of an object of finite size such as a pencil AB. For this, we have taken two incident rays from each of the extreme points A and B of the object. For each incident ray, the reflected ray is drawn obeying the laws of reflection (*i.e.* $\angle i = \angle r$). The reflected rays are produced backwards so that the images of the extreme points A and B of the object are obtained as A' and B' respectively. Thus the image of the object (pencil) AB is A'B'.

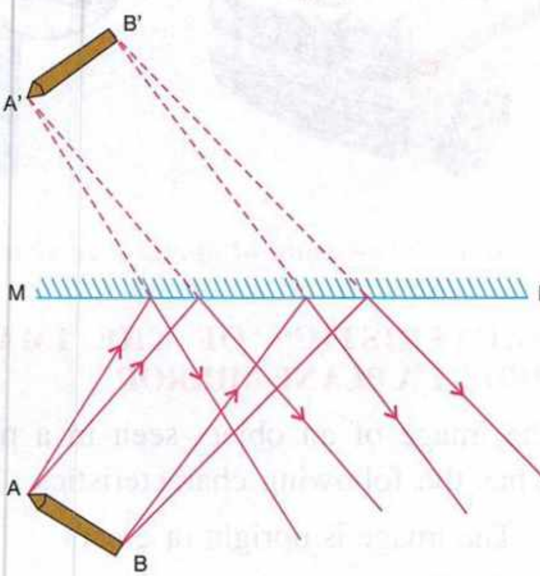


Fig. 4.9 Formation of image of a finite size object by a plane mirror

If you measure the sizes AB and A'B' using a ruler, you will find that AB = A'B'. Thus, the size of the image is same as that of the object.

Conclusion :

1. For an object in front of a plane mirror, the image is formed behind the mirror. It cannot be obtained on a screen. Therefore it is a virtual image. This image is formed when the reflected rays are produced backwards.
2. The image is erect.
3. The image is of the same size as that of the object.
4. The image is as far behind the mirror as the object is in front of the mirror.

Do You Know ?

A real image is formed when the rays after reflection actually intersect at a point. This image can be obtained on a screen and is always inverted. A plane mirror does not form a real image.

REAL AND VIRTUAL IMAGES

In class VI, you have learnt that in a pinhole camera, the image is obtained on the screen. Thus, the image formed in a pinhole camera is a real image. When you look at a plane mirror, you see your image in the mirror. The light rays from every point of your body fall on the mirror and get reflected from the mirror obeying the laws of reflection. The reflected rays enter your eyes and you see the image. The image so formed is behind the mirror. If a screen is placed behind the mirror, you do not receive the image on it. This image is called virtual image *i.e.* the image formed by a plane mirror is a virtual image.

Thus, a virtual image is an image which cannot be obtained on a screen while a real image is an image that can be obtained on a screen.

Table showing differences between real and virtual images

Real image	Virtual image
1. It can be obtained on a screen.	1. It cannot be obtained on a screen.
2. The rays of light after reflection meet at a point.	2. The rays of light after reflection appear to diverge from a point.
3. It is always inverted.	3. It is always erect.
4. It is formed in front of the mirror.	4. It is always formed behind the mirror.

LATERAL INVERSION

If you stand in front of a plane mirror, you see your image on it. The image looks exactly like you and it is of the same size. Now if you hold a pen in your right hand, you will see in the image that the pen is in your left hand. Thus, the right of the object becomes the left of the image and the left of the object becomes the right of the image as shown in Fig. 4.10(a). This is called lateral inversion. Thus, the interchange of left and right sides in the object and image formed by the plane mirror is called lateral inversion.

Fig. 4.10(b) shows how the letter F looks like in a plane mirror.

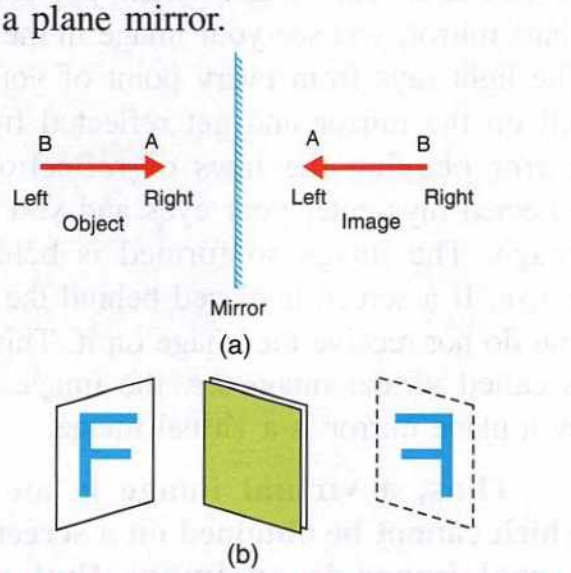


Fig. 4.10 Lateral inversion in image of letter F in a plane mirror

The lateral inversion produced by a plan mirror is similar to the inversion that occurs on a blotting paper used to dry ink while writing. The lateral inversion of letters like A, H, I, M, O, T, U, V, W, X and Y is not noticeable because these letters have symmetry about a vertical line passing through them.

Note : The front of an ambulance has letters written in form ƎƆИA⅃UBMA, so that the driver of the vehicle moving ahead of the ambulance reads the word laterally inverted as AMBULANCE in his rear view mirror as shown in Fig. 4.11.

Fig. 4.11 Phenomenon of lateral inversion

CHARACTERISTICS OF THE IMAGE FORMED BY A PLANE MIRROR

The image of an object seen in a plane mirror has the following characteristics :

1. The image is upright or erect
2. The image is virtual
3. The image is of same size as the object
4. The image is laterally inverted
5. The image is as far behind the mirror as the object is in front of it.

ACTIVITY 2

Stand in front of a plane mirror in your house and see your image.

State whether the image is erect or inverted :

....

State whether the image can be obtained on a screen or not :

....

State whether the image is smaller, longer or of same size :

....

Estimate the distance of yourself and your image from the mirror. State whether they are equal or not :

....

Touch your nose with your right hand and note which hand of the image touches the nose.

....

REGULAR AND IRREGULAR (OR DIFFUSED) REFLECTION

1. Regular reflection

The reflection of light from a smooth and polished surface, such as a plane mirror is called regular reflection. If a parallel beam of light is incident on a plane mirror, the reflected beam of light is also parallel and it has a fixed direction. Fig. 4.12 shows the regular reflection at a plane mirror.

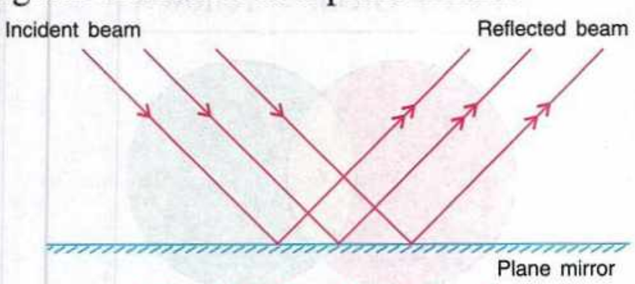


Fig. 4.12 Regular reflection

2. Irregular (or diffused) reflection

The objects other than the plane mirror are not perfectly smooth (*i.e.* they have an uneven surface). *When a beam of light falls on such a surface which is not perfectly smooth and polished such as a wall, wood, paper etc., the different portions of the surface reflect light in different directions. Such a reflection of light from an uneven surface is called irregular or diffused reflection.* For a parallel incident beam, the reflected beam is not parallel (Fig. 4.13). Thus, it is the diffused light obtained after reflection from uneven surfaces of objects which enables us to see them and their surroundings.

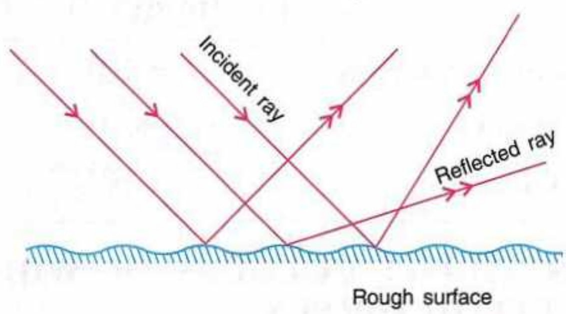


Fig. 4.13 Irregular or diffused reflection

USES OF A PLANE MIRROR

Some uses of a plane mirror are :

1. As a dressing mirror.
2. In the opticians room to double the effective length of the room, a mirror is kept on the opposite wall of the room.
3. In a barber's shop for seeing the rear view at the back, two mirrors are fixed on the opposite walls facing each other.
4. In periscope, kaleidoscope and solar cooker, plane mirrors are used as reflectors.
5. As a rear view mirror in front of the driver in a vehicle.

SPEED OF LIGHT

Light travels in vacuum or air covering a distance of nearly 299,792,458 metre (or nearly 3×10^8 metre) in one second. Thus, the speed of light in vacuum (or air) is 3×10^8 m s^{-1} nearly. It is the maximum speed of light. In a transparent medium such as water, glass etc., light slows down. The speed of light in water is $2{\cdot}25 \times 10^8$ m s^{-1} and in glass it is 2×10^8 m s^{-1}. Thus, light speeds up while passing from water or glass to air but it slows down while passing from air to water or glass.

Speed of light in different mediums

Medium	Speed of light (in m s^{-1})
1. Air or vacuum	3×10^8
2. Water	$2{\cdot}25 \times 10^8$
3. Glass	2×10^8

CONSTITUENT COLOURS OF WHITE LIGHT FROM THE SUN

If white light from the sun is seen through a glass prism, it splits into its constituent colours and a rainbow type pattern is seen. The prominent colours of white light are :

1. Violet
2. Indigo
3. Blue
4. Green
5. Yellow
6. Orange, and
7. Red

These colours can be remembered in order by the word 'VIBGYOR'.

Do You Know ?

(1) In rainy season, the rainbow is seen in the sky, sometimes after the rains, in a direction opposite to the sun. It is due to sunlight falling on the rain drops, present in the atmosphere. The rain drops behave like small prisms and split the white light of sun into its constituent colours.

(2) Actually the white light is made of a number of colours mixed together without a separate boundary in between them, out of which seven colours named as VIBGYOR are prominent.

PRIMARY COLOURS

Primary colours are the colours of light by mixing which white light is obtained. These are (i) red (ii) green and (iii) blue. If red, green and blue lights are projected on a white screen at the same point, white light is obtained. It is impossible to obtain either red, or green, or blue light by mixing the light of any two other colours. But light of all other colours can be obtained by mixing the light of any two of the three colours red, green and blue. Hence red, green and blue are called primary colours. Thus,

Red + Green + Blue = White

SECONDARY COLOURS

Secondary colours are the colours of light which are obtained by mixing two primary colours together. These are (i) yellow, (ii) cyan, and (iii) magenta. If red and green lights are projected on a white screen, yellow light is obtained (Fig. 4.14). Thus,

Red + Green = Yellow

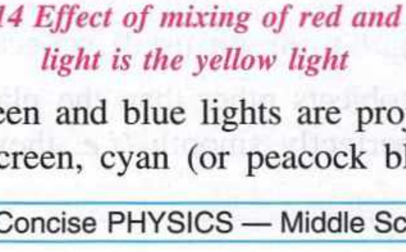


Fig. 4.14 Effect of mixing of red and green light is the yellow light

If green and blue lights are projected on a white screen, cyan (or peacock blue) light is obtained (Fig. 4.15). Thus,

Green + Blue = Cyan

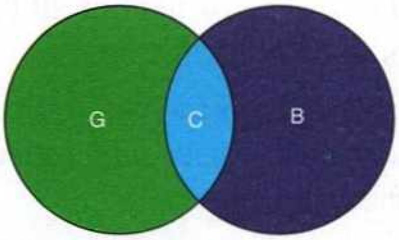


Fig. 4.15 Effect of mixing of green and blue lights gives the cyan light

If blue and red lights are projected on a white screen, we get magenta (or purple) light (Fig. 4.16). Thus,

Blue + Red = Magenta

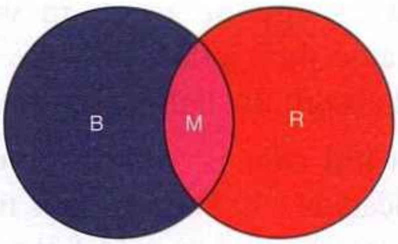


Fig. 4.16 Mixing of blue and red lights gives the magenta light

Thus secondary colours are yellow, cyan and magenta.

The following table summarizes the primary and secondary colours.

Primary colours	Secondary colours
Blue	Yellow (Red + Green)
Green	Cyan (Green + Blue)
Red	Magenta (Blue + Red)

A colour TV or computer screen has an array of tiny spots. Each spot is composed of three phosphor dots corresponding to the primary colours red, green and blue. The colours seen on the screen are due to combination of these primary colours.

The effect of mixing of primary colours is shown in Fig. 4.17 in which Y stands for yellow, C for cyan, M for magenta and W for white.

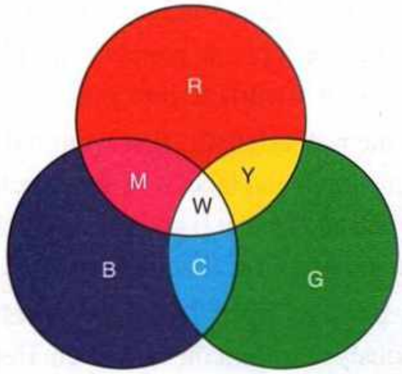


Fig. 4.17 Effect of mixing of primary colours

From Fig. 4.17, we find

Red + Green = Yellow
Green + Blue = Cyan
Blue + Red = Magenta, and
Red + Green + Blue = White

Do You Know ?

1. The pigment colours are not pure.
2. Yellow + Blue = White
   Magenta + Green = White
   Cyan + Red = White
3. A washerman uses a little blue indigo after washing the white clothes so as to make the yellowish tint of clothes white.

SUBTRACTION OF COLOURS

A transparent object allows the light of a certain colour to pass through it and absorbs the light of rest of the colours. Its colour is the colour of light that passes through it.

For example, a red cellophane paper passes only the red light through it. A blue cellophane paper passes the light of only blue colour through it.

The effect of mixing of primary colours can be demonstrated by the following activity.

ACTIVITY 3

To study the effect of mixing of primary colours.

You are given three torches, a white screen, red, green and blue cellophane papers, and rubber bands. Ask two of your friends to join you.

Using the rubber bands, first wrap red cellophane paper on one torch and label it A, green cellophane on the other torch and label it B and blue cellophane on the third torch and label it C. Each of you hold one torch.

First, project light from the torch A and B simultaneously at a point on the screen. Repeat it with torch B and C and then with torch A and C. Observe the effect in each case and note them in the table below.

Torch	*Colours of light projected*	*Effect on screen*
A and B		
B and C		
C and A		

COLOUR OF AN OPAQUE OBJECT

When white light (or sun light) falls on an opaque object, it reflects the light of some colours and absorbs the light of rest of the colours. The colour of an opaque object is the colour of light which it reflects and that reaches our eyes.

Case 1 : If the body reflects light of all the colours, it appears white

Case 2 : If the body reflects none of the colours (*i.e.* it absorbs light of all the colours), it appears black.

Thus, a red object will reflect only the red light, a blue object will reflect only the blue light and so on.

Examples :

1. A piece of white paper appears white in sunlight because it reflects light of all the colours.
2. A red rose appears red in white light because it reflects the light of red colour and absorbs the light of rest of the colours.
3. Leaves appear green in white light because they reflect only the green light and absorb the light of all other colours.
4. If a red rose is seen in green light, it appears black. The reason is that the rose absorbs the green light falling on it and reflects none.
5. If a red rose is seen in red light, it appears bright red. This is because the rose reflects the red light falling on it and absorbs none of it.

RECAPITULATION

- Light is a form of energy which gives us the sensation of vision.
- Light travels in a straight line.
- The bouncing of light after striking a surface is called reflection of light.
- A highly polished and smooth surface, such as a plane mirror, reflects most of the light incident on it.
- A plane mirror is made by silvering one side of a plane glass plate.

- The reflection of a light ray from a surface obeys the following two laws of reflection :
  - (a) The angle of incidence is equal to the angle of reflection.
  - (b) The incident ray, the reflected ray and the normal, all lie in the same plane.
- An image which can be obtained on a screen is called real image but an image which cannot be obtained on a screen is called a virtual image. A real image is inverted but a virtual image is erect.
- A plane mirror forms the image by the reflection of light.
- The image formed by a plane mirror has the following characteristics :
  - (a) The image is virtual.
  - (b) The image is upright.
  - (c) The image is as far behind in the mirror as the object is in front of it.
  - (d) The image is of the same size as that of the object.
  - (e) The image is laterally inverted.
- The interchange of left and right sides in the object and its image, is called lateral inversion.
- The reflection of light from a smooth and polished surface, such as a plane mirror, is called regular reflection.
- The reflection of light from a rough surface, such as wall, paper or wood, is called irregular or diffused reflection.
- We are able to see the objects around us because of the diffused reflection of light from them in all directions.
- The speed of light in air (or vacuum) is 3×10^8 m s^{-1}, in water is $2{\cdot}25 \times 10^8$ m s^{-1} and in glass is 2×10^8 m s^{-1}.
- A plane mirror is used :
  - (a) as a looking glass
  - (b) in an optician's room
  - (c) in a barbar's shop
  - (d) in periscope, kaleidoscope etc.
- Primary colours are those colours by mixing which white light is obtained but they themselves cannot be obtained by mixing any other colours of white light.
- Red, Green and Blue are the three primary colours. They combine to form white light.

  Red + Green + Blue = White
- Secondary colours are those colours which are obtained by mixing any of the two primary colours.
- Yellow, cyan (or peacock blue) and magenta (or purple) are secondary colours.
- Red + Green = Yellow

  Green + Blue = Cyan (or peacock blue)

  Blue + Red = Magenta (or purple)
- When white light falls on an opaque object, light of some colours is reflected by it and the light of rest of the colours is absorbed.
- The colour of an opaque object is the colour of light which it reflects.
- A white opaque body reflects the light of all colours while a black opaque body absorbs the light of all colours and reflects none.
- A transparent object passes the light of some colours and absorbs the light of rest of the colours.

TEST YOURSELF

A. Objective Questions :

1. Write **true** or **false** for each statement :

(a) The image formed by a plane mirror is real.

(b) When a light ray is reflected from a wall, the angle of incidence is not equal to the angle of reflection.

(c) The image of the right hand in a plane mirror looks like that of a left hand.

(d) The image formed by a plane mirror is upright.

(e) The image formed by a plane mirror can be obtained on a screen.

(f) The objects around us are seen due to irregular reflection of light.

(g) The speed of light in vacuum is 3×10^8 m s^{-1}.

(h) A rose appears red in light of all the colours.

(i) A black paper absorbs light of all the colours and reflects none.

(j) The primary colours are red, blue and green.

Ans: True (c), (d), (f), (g) (i), (j)
False (a), (b), (e), (h)

2. Fill in the blanks :

(a) Angle of incidence = ...

(b) The incident ray, the reflected ray and the normal lie ....

(c) The image formed by a plane mirror is at a distance behind the mirror as ....

(d) The image formed by a plane mirror is .... and ....

(e) We are able to see the objects around us due to .... reflection.

(f) A .... image cannot be obtained on a screen.

(g) One surface of mirror is made opaque by .... it followed by a thin coating of paint of lead oxide.

(h) A plane mirror .... reflect 100 percent light falling on it.

(i) The colour of an opaque object is the colour of light which it ....

(j) Magenta, cyan and yellow are the .... colours.

Ans: (a) angle of reflection (b) in one plane (c) the object is in front of it (d)erect, virtual (e) irregular (f) virtual (g) silvering (h) does not (i) reflects (j) secondary.

3. Match the following :

Column A	Column B
(a) A light ray passes from air to glass	(i) speeds up
(b) A light ray passes from glass to water	(ii) reflects red light
(c) Virtual image	(iii) primary colours
(d) Red rose	(iv) plane mirror
(e) Red, green and blue	(v) slows down

Ans: (a)–(v), (b)–(i), (c)–(iv), (d)–(ii), (e)–(iii)

4. Select the correct alternative :

(a) A man standing in front of a plane mirror finds his image to be at a distance of 6 metre from himself. The distance of man from the mirror is :

(i) 6 m (ii) 3 m
(iii) 2 m (iv) 12 m

(b) The angle between the incident ray and the ray reflected from the plane mirror is 70°. The angle of incidence will be :

(i) 70° (ii) 30°
(iii) 35° (iv) 90°

(c) The image formed by a plane mirror is

(i) virtual and inverted
(ii) virtual and of same size
(iii) real and inverted
(iv) real and of same size

(d) The angle of incidence on a plane mirror is 30°. The angle of reflection will be :

(i) 30° (ii) 60°
(iii) 15° (iv) 0°

(e) The angle of incidence on a plane mirror is 30°. The angle between the incident ray and the reflected ray is

(i) 30° (ii) 15°

(iii) 60° (iv) 90°

(f) The property due to which a light ray striking a surface is returned back into the same medium is called

(i) refraction (ii) reflex action

(iii) reflection (iv) regression

(g) A ray of light after reflection from a mirror is known as

(i) reflected ray (ii) normal

(iii) incident ray (iv) refracted ray

(h) The speed of light is maximum in

(i) glass (ii) water

(iii) air (iv) wood

(i) A red rose is seen in green light. It will appear

(i) red (ii) blue

(iii) yellow (iv) black

(j) The primary colours are

(i) Red, Blue and Yellow

(ii) Magenta, Yellow and Cyan

(iii) Red, Blue and Cyan

(iv) Blue, Green and Red.

Ans: (a)–(ii), (b)–(iii), (c)–(ii), (d)–(i), (e)–(iii), (f)–(iii), (g)–(i), (h)–(iii), (i)–(iv) (j)–(iv)

B. Short/Long Answer Questions :

1. What do you mean by the term reflection of light ?
2. How is a plane mirror made ?
3. Explain the following terms :

   Incident ray, Reflected ray, Angle of incidence, Angle of reflection, Normal.
4. Draw a diagram showing the reflection of a light ray from a plane mirror. Label on it the incident ray, the reflected ray, the normal, the angle of incidence *i* and the angle of reflection *r*.
5. State the two laws of reflection of light.
6. Describe an experiment to verify the laws of reflection of light.
7. A ray of light falls normally on a plane mirror. What is the angle of incidence ?
8. Draw a diagram to show the reflection of a light ray incident normally on a plane mirror.
9. The diagram in Fig 4.18 shows an incident ray AO and the reflected ray OB from a plane mirror. The angle AOB is 30°. Draw normal on the plane mirror at the point O and find :

   (a) the angle of incidence

   (b) the angle of reflection

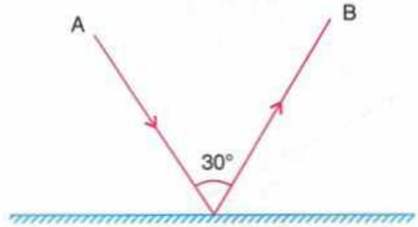


Fig. 4.18

10. In the following diagrams (Fig 4.19), measure and write the angle of incidence and draw the reflected ray in each case.

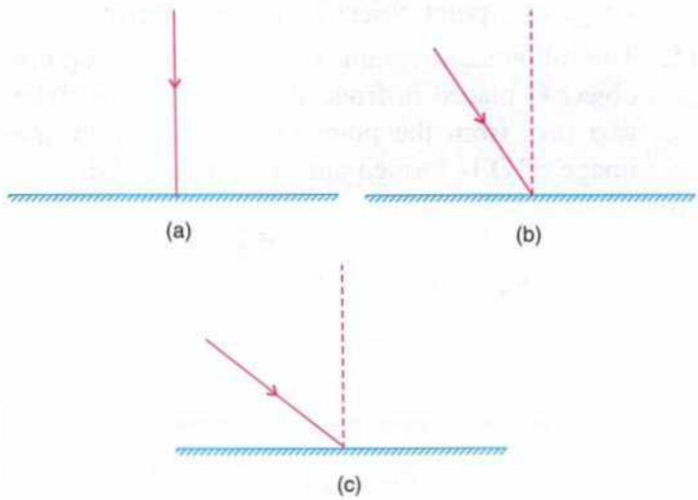


Fig. 4.19

11. The diagram in Fig 4.20 shows an incident ray AO and the normal ON on a plane mirror. Draw the reflected ray. State the law you use to draw the direction of the reflected ray.

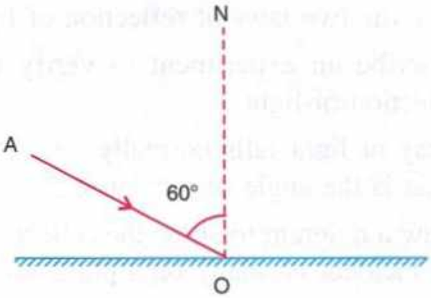


Fig. 4.20

12. The following diagram (Fig 4.21) shows an incident ray AO and the normal ON on a plane mirror. Find the angle of incidence and angle of reflection.

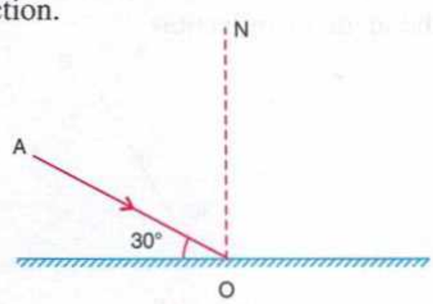


Fig. 4.21

13. State in words, how do you find the location of image of an object formed by a plane mirror.
14. Draw a ray diagram showing the formation of image of a point object by a plane mirror.
15. The following diagram (Fig. 4.22) shows a point object O placed in front of a plane mirror. Take two rays from the point O and show how the image of O is formed and seen by the eye.

Fig. 4.22

16. State *four* characteristics of the image formed by a plane mirror.
17. How is the position of image formed by a plane mirror related to the position of the object ?
18. You are standing at a distance 2 metre from a plane mirror.
    (a) What is the distance of your image from the mirror ?
    (b) What is the distance between you and your image ?
19. What is meant by lateral inversion of an image in a plane mirror ? Explain it with the help of a diagram.
20. Write down the letter C and I as seen in a plane mirror.
21. What is irregular reflection ? Give an example.
22. How do we see objects around us ?
23. State two uses of a plane mirror.
24. Can light travel in vacuum ?
25. State the speed of light in (a) air, (b) glass.
26. State whether light slows down or speeds up in the following cases :
    (a) Light going from air to glass.
    (b) Light going from glass to water.
    (c) Light going from water to air.
27. What are primary colours ? Name the three primary colours.
28. What are secondary colours ? Name the three secondary colours.
29. Fill in the blanks with the appropriate colour :
    (a) Blue + ... = Cyan
    (b) Red + Blue + ... = White
    (c) Red + Blue = ...
    (d) Green + Red = ...
30. The leaves appear green when seen in white light. Give a reason.
31. A rose appears red in white light. How will it appear in (i) green light, (ii) red light ? Give a reason for each of your answers.
32. Why does a piece of paper appear white in sunlight ? How would you expect it to appear when viewed in red light ?
33. A piece of paper appears black in sunlight. What will be its colour when seen in red light ?

5

Heat

Theme : Heat is a form of energy. Sunlight carries heat that gives warmth when exposed to it. When water is heated, its energy in the form of heat increases and becomes hot. When heat energy of an object increases, it can result in (i) change of temperature, (ii) change in size and/or (iii) change in state of an object. Some materials like aluminum are good conductors of heat and some, like wood are bad conductors of heat. Heat from a hot object is transferred to a cold object in three different ways — conduction, convection and radiation. Previous learning included topics on temperature and its measurement in degree Celsius. Further two other frequently used temperature scales, Fahrenheit scale and Kelvin scale have been introduced for a better understanding of concepts related to temperature.

In this chapter you will learn to

- define heat as energy
- define units of heat
- describe temperature scales: degree Celsius, Fahrenheit and Kelvin
- describe different effects of heat
- explain different modes of heat transfer
- decide about conductor and insulator of heat in different applications
- describe construction and working of thermos flask.

LEARNING OBJECTIVES

- Demonstration and explanation of use of thermometers marked in °F.
- Engaging children in an activity to measure temperature of water in °F.
- Demonstration of heat transfer through different modes : conduction, convention and radiation.
- Children have to deduce where conduction, convention or radiation is taking place in some real world applications.
- Children use thermocol and other materials to make a cooling pack (emphasizing on the process of heat transfer).
- Explanation of the construction and working of a thermos flask.

KNOWING CONCEPTS

- Heat as a form of energy and its units , joule (J) and calorie (cal).
- Different units of Temperature (°C, °F, K)
- Effects of heat
  - (i) Change in temperature
  - (ii) Change in size (expansion and contraction)
  - (iii) Change in state
- Good conductors and bad conductors of heat and their examples.

- Choice of conductors and insulators in day to day life (Pan handles, cooking utensils etc.).
- Methods of heat transfer
  (i) Conduction (ii) Convection
  (iii) Radiation
- Thermos flask (application of heat transfer)
  (i) Construction (ii) Working

HEAT IS A FORM OF ENERGY

In winter, we sit in the sun (or near a heater) to feel warm. The reason is that we receive heat from the sun (or the heater) which we feel, although we do not see heat coming from the sun (or the heater). Thus, heat is a form of energy which we can feel, but cannot see.

The sun is a vast source of heat energy. We, on earth, receive heat energy mainly from the sun. The heat energy of sun makes water to become warm and evaporate from the ponds and lakes as water vapour and form clouds. The water vapour from the clouds on condensation turns into rain. Plants use heat from the sun to prepare their food by photosynthesis.

Fig. 5.1 Sun as a source of heat

In daily life, we observe that on rubbing our palms, they get heated because the mechanical energy spent in rubbing palms changes into heat energy. Similarly, on burning coal or cooking gas, heat is produced *i.e.* the chemical energy changes into heat energy. On passing current in the filament of a bulb, it becomes hot because the electrical energy changes into heat energy. All these examples show that heat is a form of energy.

When we touch hot water, we feel warm and when we touch an ice cube, we feel cold. This happens because when we touch hot water, heat energy flows from hot water to our hand and when we touch an ice cube, heat energy flows from our hand to the ice cube.

Thus, we can define heat as follows :

Heat is a form of energy which flows from a hot body to a cold body when they are kept in contact. This process of heat transfer continues till the temperature of both the bodies becomes equal.

We have read in class VI that the degree of hotness or coldness of a body is a measure of a quantity called temperature. When heat is absorbed by a body, its temperature rises while if it loses heat energy, its temperature falls.

Do You Know ?

Each body is made up of particles called molecules. The molecules are in motion as well as they have the force of attraction amongst them. Due to motion, the molecules have the kinetic energy and due to forces of attraction, they have the potential energy. When a body is heated or it absorbs heat, the motion becomes rapid and kinetic energy increases. Thus, heat energy is the internal energy of the molecules of a body, (*i.e.* the sum of its internal potential energy and internal kinetic energy).

UNITS OF HEAT

Since heat is a form of energy, therefore the S.I. unit of heat is joule (symbol J). The other common units of heat are calorie (symbol cal) and kilocalorie (symbol kcal).

One calorie is defined as the heat

energy required to raise the temperature of 1 g of water by 1°C.

One kilocalorie is the heat energy required to increase the temperature of 1 kg of water by 1°C.

$$1 \text{ kcal} = 1000 \text{ cal}$$

Relationship between joule and calorie :

$$1 \text{ cal} = 4{\cdot}2 \text{ J (nearly)}^*$$

or $$1 \text{ J} = 0{\cdot}24 \text{ cal}$$

TEMPERATURE

In our daily life, we often come across hot and cold bodies, and use the words like, very cold (chilly), cold, warm, lukewarm, hot, very hot etc. If we touch a lump of ice, we feel cold and we say that ice is cold. Similarly, if we touch water from a geyser, we feel hot and we say that water from the geyser is hot. Following activity illustrates that our sense of touch does not actually measure how hot or cold the body is.

ACTIVITY 1

Take equal volumes of water in two vessels A and B. In vessel A, put some ice and heat the water in vessel B. Now if we put our fingers in the two vessels A and B one by one (Fig. 5.2), we notice that the water in the vessel A is cold while the water in the vessel B is hot. But we cannot tell exactly how hot or how cold the water is, just by touching it.

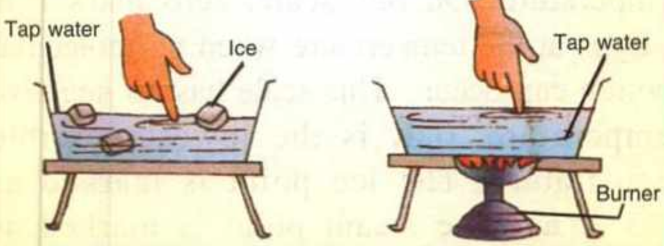


Fig. 5.2 Sense of touch does not meausre the degree of hotness or coldness

* More precisely 1 cal = 4·18 J

We have seen that our sense of touch is not reliable to find the degree of hotness or coldness of a body. So in scientific language, we use the term temperature to express how hot or cold a body is. By saying that the lump of ice is cold, we mean that ice is at a lower temperature than our body. When we say that water from a geyser is hot, we mean that water from the geyser is at a higher temperature than our body. Thus, we can define temperature as follows :

Temperature is a quantity which tells us the degree of hotness or coldness of a body. When a body is heated, its temperature rises and when it is cooled, its temperature falls.

UNITS OF TEMPERATURE

Generally, temperature is measured in unit degree Celsius. In short form, it is written as °C. Another unit of temperature is degree Fahrenheit which is written in short form as °F. The S.I. unit of temperature is Kelvin (symbol K).

Note : For unit kelvin, symbol is not written as °K. It is written simply as K.

MEASUREMENT OF TEMPERATURE

The temperature of a body is measured by using a device called thermometer. A thermometer works on the thermal expansion of liquids. The most common type of thermometer which we use in the laboratory is the mercury thermometer. Fig. 5.3 shows a thermometer. It consists of a glass capillary tube with a bulb at one end. The bulb is filled with mercury. The long part of the capillary is called the stem. The stem has the markings from –10°C to 110°C, with one hundred twenty equal divisions in between. Its zero mark which is called the ice point or lower fixed point is at

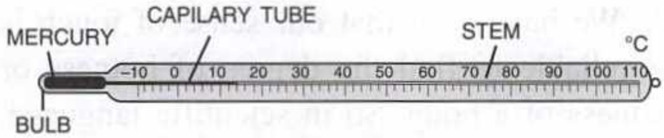


Fig. 5.3 Thermometer

the level of mercury in the capillary, when its bulb is kept in melting ice. The 100 mark (which is called steam point or upper fixed point) is at the level of mercury in the capillary, when its bulb is kept in boiling water.

Measuring the temperature of a body using a thermometer :

To measure the temperature of a body with the help of a thermometer, the bulb of the thermometer is kept in contact with the body. The mercury rises in the capillary. Wait for some time. When the mercury does not rise further and gets stabilized at a level, note the reading of the mark up to which the mercury has risen, keeping your eye in the horizontal line of the level of mercury. It will be the temperature of the body. This can be demonstrated by the following activity.

ACTIVITY 2

To measure the temperature of water, take water in a beaker. Place the thermometer vertically inside the beaker such that its bulb is completely immersed in water and does not touch the body of the beaker (Fig. 5.4). Wait till mercury rises. When it becomes stationary, read the mark of level of mercury by keeping your eye as shown in Fig. 5.4. Temperature of water is 30°C.

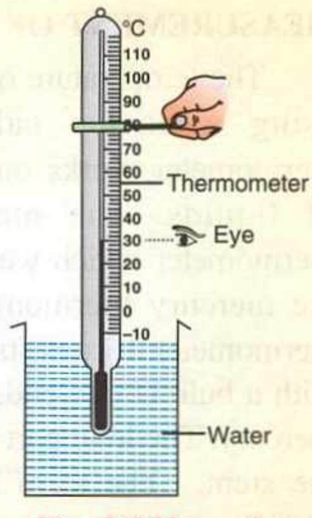


Fig. 5.4 Measuring the temperature of water

SCALES OF TEMPERATURE

Generally, we use the following three scales of temperature :

(i) The Celsius scale or centigrade scale,

(ii) The Fahrenheit scale, and

(iii) The Kelvin scale

(i) The Celsius scale (or centigrade scale)

This scale was introduced by the Swedish astronomer Celsius and is known after his name. On this scale, the ice point is marked as 0°C and the steam point is marked as 100°C. The interval between the ice point and the steam point is divided into one hundred equal parts. Each division is called one degree Celsius and is written as 1°C.

(ii) The Fahrenheit scale

This scale was introduced by Fahrenheit. This scale is generally used for clinical purposes. On this scale, the ice point is marked as 32°F and the steam point is marked as 212°F. The interval between the ice point and the steam point is divided into 180 equal parts. Each division is called one degree fahrenheit and is written as 1°F.

(iii) The Kelvin scale

This scale was introduced by the scientist Kelvin. It is also called the absolute scale of temperature. On this scale, zero mark (*i.e.* 0 K) is at the temperature when no molecular motion can occur. This scale has no negative temperature. 0 K is the lowest possible temperature. The ice point is marked as 273 K and the steam point is marked as 373 K. The interval between the ice point and the steam point is divided into 100 equal parts. Each division of the Kelvin scale is equal to that of the Celsius scale.

The three scales of temperature are shown . Fig. 5.5.

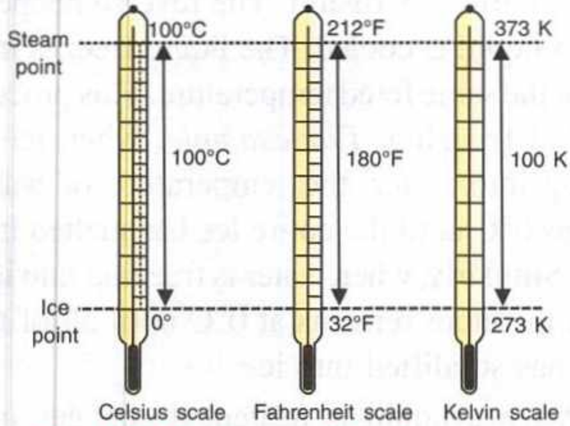


Fig. 5.5 The three scales of temperature

The table below represents the two fixed oints (ice point and steam point) and the umber of divisions between them on the three cales.

[Celsius, Fahrenheit and Kelvin scales].

Scale	Symbol	Ice point	Steam point	Number of divisions between the ice point and steam point
Celsius	°C	0	100	100
Fahrenheit	°F	32	212	180
Kelvin	K	273	373	100

Relationship between the three scales of emperature

1. Between Celsius and Kelvin scales : We have seen that ice point 0°C = 273 K and steam point 100°C = 373 K

$$\therefore \quad t°C = (273 + t)\ K$$

Thus, by simply adding 273 to the temperature on Celsius scale, we get the temperature on Kelvin scale.

2. Between Celsius and Fahrenheit scales :
Ice point 0°C = 32°F and
Steam point 100°C = 212°F.

100 divisions on Celsius scale = 180 divisions on Fahrenheit scale

∴ 1 division on Celsius scale

$$= \frac{180}{100} \text{ divisions on Fahrenheit scale}$$

$$= \frac{9}{5} \text{ divisions on Fahrenheit scale}$$

$$\therefore \quad °F = \frac{9}{5}°C + 32 \qquad \text{...(i)}$$

$$\Rightarrow \quad °F - 32 = °C \times \frac{9}{5}$$

$$\therefore \quad °C = \frac{5}{9}(°F - 32) \qquad \text{...(ii)}$$

$$\text{or} \quad \frac{°C}{5} = \frac{°F - 32}{9} \qquad \text{...(iii)}$$

Examples :

(i) To convert 0°C in °F

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

we put 0 in place of C and solve for F. *i.e.*

$$\frac{0}{5} = \frac{F-32}{9}$$

$$0 \times 9 = 5(F - 32)$$

$$0 = 5F - 160$$

$$5F = 160$$

$$F = \frac{160}{5} = 32$$

∴ 0°C is equal to 32°F.

(ii) To convert 100°C into °F.

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

$$\frac{100}{5} = \frac{F-32}{9}$$

$$900 = 5(F - 32)$$

$$900 = 5F - 160$$

$$900 + 160 = 5F$$

$$\text{or} \quad F = \frac{1060}{5} = 212$$

∴ 100°C is equal to 212°F.

(iii) To convert normal human body temperature 98·6 °F into °C.

From $°C = \frac{5}{9}(F - 32)$

$$°C = \frac{5}{9}(98{\cdot}6 - 32)$$

$$°C = \frac{5}{9} \times 66{\cdot}6$$

$$C = \frac{333}{9} = 37$$

∴ 98·6°F is equal to 37°C.

(iv) To convert the temperature of water at 30°C to °F

From $°F = \frac{9}{5}C + 32$

$$°F = \frac{9}{5} \times 30 + 32$$

$$°F = 9 \times 6 + 32$$

$$°F = 54 + 32 = 86$$

Thus, 30°C = 86°F

EFFECTS OF HEAT

Heat produces mainly the following three effects :

1. Change in temperature of the body,
2. Change in size or shape of the body, and
3. Change in state of the body.

1. Change in temperature of the body : When a body is heated, its temperature rises and when it is cooled, its temperature falls. The change in temperature of the body depends on (a) the quantity of heat imparted to (or released from) the body, (b) the material of the body, and (c) mass of the body.

2. Change in size of the body : When a body is heated, it expands and when it is cooled, it contracts. The increase in size of the body due to heating is called thermal expansion.

3. Change in state of the body : Matter exists in three different states, namely solid, liquid and gas.

The process of change from one state to another at a constant temperature is called change of state.

When a solid is heated, it changes into it liquid at a fixed temperature. This process is called **melting or fusion**. The reverse happens when a liquid is cooled. The liquid freezes into solid at the same fixed temperature. This process is called **freezing**. *For example*, when ice is melting into water, the temperature of water remains 0°C until the entire ice has melted into water. Similarly, when water is freezing into ice, the temperature remains at 0°C until all of the water has solidified into ice.

When a liquid is heated, it changes into its vapour (or gas) at a fixed temperature. This process is called **vaporization or boiling**. The reverse happens when vapour is cooled. The vapour condenses into liquid at the same fixed temperature. This process is called **condensation**. *For example*, when water is boiling, its temperature keeps on increasing and eventually reaches 100°C at which point all water changes into steam. Similarly, when steam is condensed, the temperature remains constant at 100°C until all of the steam has cooled down to water.

When a solid on heating changes directly into vapour at a fixed temperature, the process is called **sublimation**. Similarly, the change directly from vapour to solid at a fixed temperature is called **deposition**. *For example*, camphor on heating changes directly into its gaseous state, while on cooling changes from its gaseous state to solid state.

The change of state from liquid to gas at all temperatures is called **evaporation**. Thus, evaporation differs from boiling. Boiling is at a fixed temperature while evaporation takes place at all temperatures. For example, drying of clothes is due to evaporation of water. Evaporation is a slow process, while boiling s a rapid process. Fig. 5.6 shows the change n different states of matter.

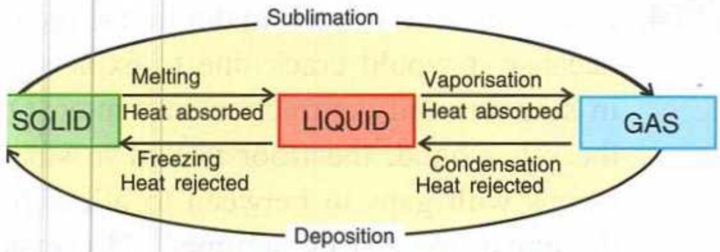


Fig. 5.6 Change in different states of matter

During change of state at a fixed emperature, heat is either absorbed or released out this heat does not change the temperature of the substance. It is called the **latent heat**. The melting of ice can be demonstrated by the following activity.

ACTIVITY 3

To show melting of ice

Take about 200-300 g of crushed ice in a 500 ml beaker. Immerse a thermometer in ice and note its temperature. Gently heat the beaker containing the ice from below and record the temperature after every 30 seconds till the ice melts. Continue to heat the water and record its temperature for five minutes more. Record your observations in the following table.

Time	*State of matter*	*Temperature*
0 s	Solid	0°C
....	....	....
....	....	....
....	....	....
....	....	....

From the above table you will notice that the temperature remains constant at 0°C till the whole ice melts. Though heat is continuously supplied to ice during this period, its temperature does not increase. The heat supplied during this period is used up by the ice in changing its state from solid to liquid. Once the ice is completely melted, the temperature of water begins to rise.

The temperature at which a substance changes its state from solid to liquid is called its **melting point**. Thus, melting point of ice is 0°C.

THERMAL EXPANSION

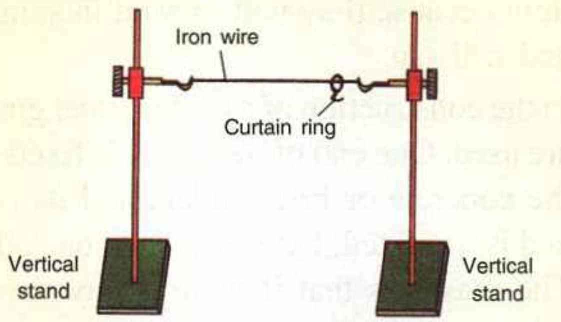
It has been experimentally observed that when a substance (solid, liquid or gas) is heated, it expands and when it is cooled, it contracts. We will now consider the thermal expansion in solids, liquids and gases separately.

1. Thermal expansion in solids :

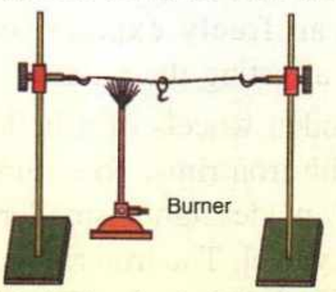
A solid has a definite shape and size. When a solid is heated, it expands in all directions. Hence, the length, area and volume all increase on heating a solid. The increase in length of a solid is called **linear expansion**. The increase in area is called **superficial expansion** and the increase in volume is called **cubical expansion**. Linear expansion of a solid can be demonstrated by the following activity.

ACTIVITY 4

(i) Take a piece of iron wire. Slip a curtain ring through the wire. Stretch the wire between the two vertical stands. Adjust the position of stands in such a way that the wire is just tight as shown in Fig. 5.7 (a).



(a) Before heating, the wire is tight



(b) On heating, the wire becomes loose

Fig. 5.7 Linear expansion of a wire

(ii) Now heat the wire over a low flame using a burner (or candle) as shown in Fig. 5.7 (b). You will notice that the wire no longer remains taut, but it becomes loose. This shows that on heating, the wire expands.

(iii) Now remove the burner (or candle) and allow the wire to cool. You will notice that on cooling, the wire contracts and again becomes tight.

Note : (1) Different solids expand by different amounts for the same rise in temperature; *e.g.* brass expands 1·5 times more than iron.

(2) Some substances such as invar, pyrex glass, etc. expand negligibly on heating.

Some applications in daily life

1. Telephone and electric wires when connected in summer between two poles, they are kept loose so that they may not break when they contract in winter. On the other hand, if the wires are connected in winter between two poles, they are kept tight because they will expand in summer and will sag.
2. In the construction of a bridge, steel girders are used. One end of the girder is fixed into the concrete or brick pillars and its other end is not fixed, but it is placed on rollers. The reason is that if there is any rise (or fall) in temperature of atmosphere, the girder can freely expand (or contract) without affecting the pillars.
3. The wooden wheels of a bullock-cart are fitted with iron rims. To ensure a tight fit, the rim is made slightly smaller in diameter than the wheel. The iron rim is first heated due to which it expands. The heated rim is then fitted on the wheel. When the rim cools, it contracts and makes a tight fit c the wheel.
4. A cement floor is not laid out in one piec because it would crack due to expansio in summer and contraction in winter. O the other hand, the floor is laid in sma pieces with gaps in between to allow f the expansion during summer. Howeve glass strips can be placed in the gaps.
5. The rails of railway track are made of stee While laying the railway track, a small ga is left between two successive lengths o rails. The reason is that the rails expand ir summer. The gap is provided to allow fc this expansion. If no gap is left, th expansion in summer will cause the rail to bend sideways. This may result in trair accidents.
6. A bimetallic strip which consists of twc rods of same length but of different materials (say one of iron and other of copper) rivetted together, is commonly used in a thermostat. A thermostat is a device used to control temperature. A thermostat is used in electrical gadgets like refrigerator, electric iron, oven etc.

2. Thermal expansion of liquids

Like solids, liquids also usually expanc on heating. Liquids expand much more thar solids when heated. Liquids do not have a definite shape, but they have a definite volume therefore liquids have only the cubical expansion.

Exception : Water on heating from 0°C to 4°C contracts and then on further heating it expands. The cubical expansion of a liquid car be demonstrated by the following activity.

ACTIVITY 5

(i) Take an empty bottle with a tight fitting cork having a hole drilled in its middle, a drinking straw, two bricks, a wire guaze and a burner.

(ii) Fill the bottle completely with water and add few drops of ink in it to make it coloured.

(iii) Fix the cork in the mouth of the bottle and pass the drinking straw through the cork. Put some molten wax around the hole so as to avoid the leakage of water.

(iv) Pour some more water into the drinking straw so that water level in the straw can be seen. Mark the water level in the straw as shown in Fig. 5.8 (a).

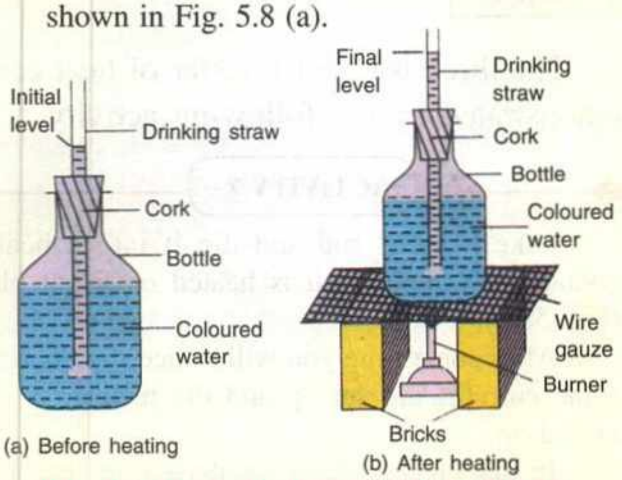


Fig. 5.8 Thermal expansion of a liquid

(v) Place the bottle on the wire gauze kept over the two bricks as shown in Fig. 5.8 (b). Then heat the bottle by means of a burner.

(vi) Look at the level of water in the straw.

You will notice that as the water is heated more and more, the level of water in the drinking straw rises. This shows that water expands on heating.

Do You Know ?

Different liquids expand by different amounts for the same rise in temperature.

Mercury expands more uniformly over a wide range of temperature. So mercury is used as a thermometric liquid.

3. Thermal expansion of gases

Gases also expand when they are heated. Gases expand much more than liquids and solids. Like liquids, gases do not have a definite shape, so they also have only the cubical expansion. The thermal expansion of air can be demonstrated by the following acitity.

ACTIVITY 6

(i) Take an empty bottle. Actually the empty bottle contains air. Attach a rubber balloon to its neck as shown in Fig. 5.9 (a). Initially, the balloon is deflated.

(ii) Place the bottle in a water bath containing boiling water. After some time you will notice that the balloon gets inflated as shown in Fig 5.9 (b). The reason is that the air inside the bottle expands on heating and it fills the balloon.

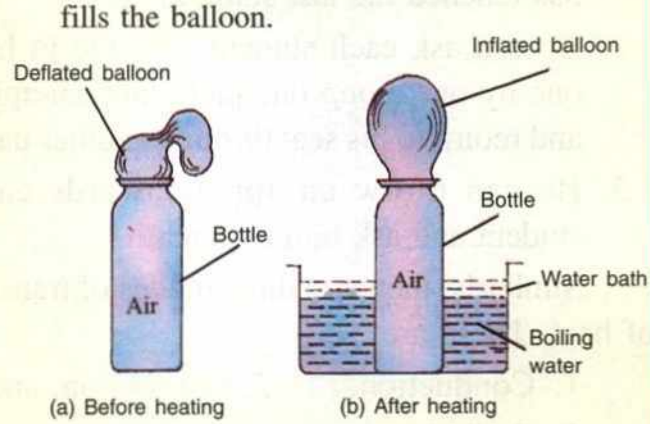


Fig. 5.9 Thermal expansion of air

(iii) Take the bottle out of the water bath and allow it to cool by itself. You will notice that the balloon gets deflated again and collapses. This is because the air inside the balloon and the bottle, has contracted on cooling. The air from the balloon passes to the bottle, so the balloon gets deflated.

THREE MODES OF TRANSFER OF HEAT

We have read that if two bodies at different temperatures are placed in contact, heat always flows from a body at a higher temperature to a body at a lower temperature.

This flow of heat continues till both the bodies acquire the same temperature. We shall study that the transfer of heat from a high temperature to a low temperature is possible in three different ways. This can be easily understood by the following analogy.

Analogy : Suppose a teacher wants to distribute apples to each student of a class. For this, there are the following three different ways:

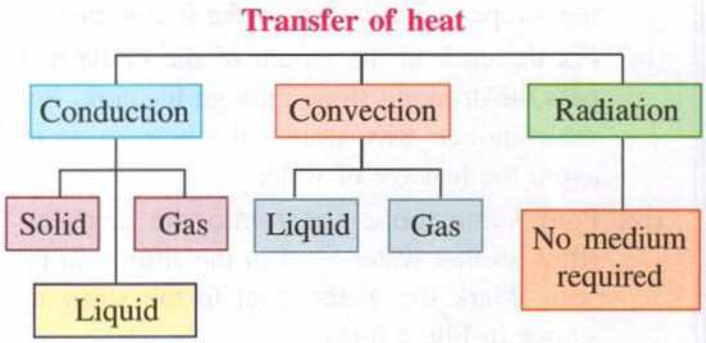
1. He gives the apples to the first student of a row who keeps one apple with himself and passes rest of them to the second one. The second student in the same way keeps one apple with himself and passes the rest of them to the third, and so on till an apple has reached the last student.
2. He can ask each student to come to him one by one along one path, take an apple and return to his seat through another path.
3. He can throw an apple towards each student and ask him to catch it.

Similarly, there are three modes of transfer of heat. These are :

1. Conduction, 2. Convection, and
3. Radiation

Conduction is analogous to the first method of distribution of apples. Convection is analogous to the second method of distribution of apples, and radiation is analogous to the third method of distribution of apples. The apples represent the transference of heat, whereas the students represent the molecules of the medium. The transfer of heat by conduction takes place mainly in solids, and also in liquids but only to some extent in gases. The transfer of heat by convection occurs only in liquids and gases but not in solids. The transfer of heat by radiation requires no medium. It is possible in vacuum also. Heat from the sun reaches us by radiation.

Thus, the modes of transfer of heat can be summarized as below :



The three ways of transfer of heat can be demonstrated by the following activity.

ACTIVITY 7

Take a metal rod and dip it into a beaker containing water which is heated on a hot plate (Fig. 5.10).

After some time you will notice that in water some currents are set up and the metal rod gets heated up.

In this process, there are three ways in which heat flows. Firstly, the hot plate gives off heat into the surrounding air by radiation. Secondly, the heat moves from bottom to the surface of water in the beaker by convection with the warm water rising up and cold water sinking down. Lastly, the heat moves along the rod by conduction, from the heated end to the cooler end. Thus, this activity shows all the three modes of heat transfer.

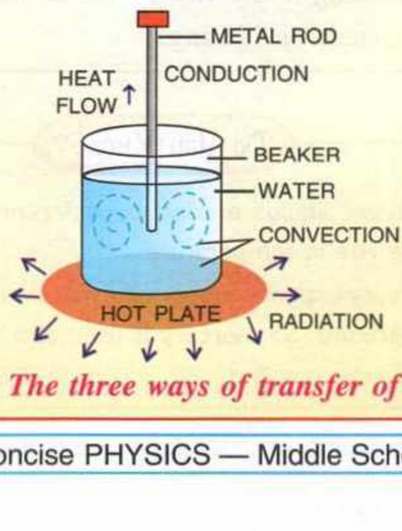


Fig. 5.10 The three ways of transfer of heat

1. Conduction

Conduction is the process of transfer of heat from the hot end to the cold end from molecule to molecule of the medium. Thus, a medium is required for the transfer of heat by conduction. It is a process of transfer of heat mainly in solids. The transfer of heat by conduction also occurs in liquids and gases but only to some extent. This can be demonstrated by the following activities.

ACTIVITY 8

Take a knife and put some butter on its entire blade. Now hold its tip in the flame as shown in Fig. 5.11. You will notice that the butter starts melting and dripping, first at the tip and then farther and farther from that end. The reason is that the heat of the flame first heats the tip of the blade. This heat is then passed on from molecule to molecule through the entire length of the blade, which melts the butter along the length of the blade.

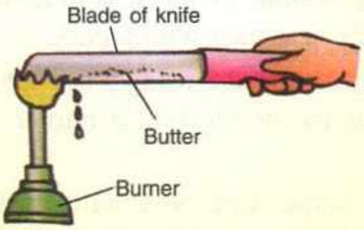


Fig. 5.11 Transfer of heat by conduction

ACTIVITY 9

Take an aluminium rod about 30 cm long. Hold one end A of the rod in the hand and keep the other end B in the flame of a candle as shown in Fig. 5.12. After some time, you will notice that the end A of the rod becomes warmer and warmer, and you find it difficult to hold it at the end A. The reason is that heat is passed from the hot end B to the cold end A through the particles of the rod by way of conduction.

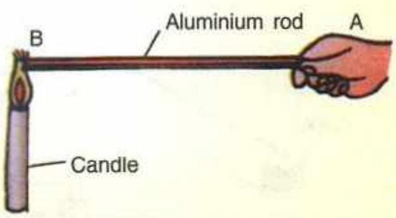


Fig. 5.12 Transfer of heat by conduction

CONDUCTORS

The substances which allow heat to pass through them easily are called *conductors of heat*. *For example*, silver, copper, iron, aluminium and mercury are conductors of heat. All metals are conductors of heat. On the other hand, substances like glass, stone, wood plastics, etc do not conduct heat easily as metals do. These substances are not as good conductors of heat as the metals are. The following activity will show that iron is a good conductor than glass.

ACTIVITY 10

To show that iron is a better conductor than glass.

Take an iron rod and a glass rod. Hold one end of both the rods in your hands and keep their other ends over the flame of a burner as shown in Fig. 5.13. You will notice that it is easy to hold the glass rod for a much longer time than the iron rod. This shows that iron is a better conductor of heat than glass.

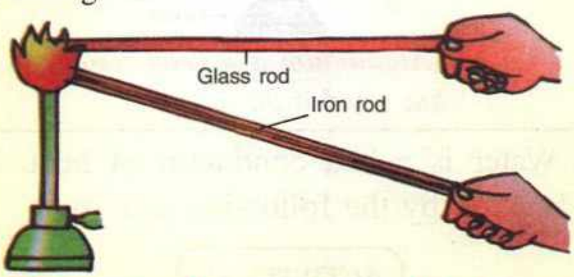


Fig. 5.13 Iron is a better conductor of heat than glass

INSULATORS

The substances which do not allow heat to pass through them are called *insulators (or bad conductors) of heat*. *For example*, wood, plastic, mud, cork, cotton, wool, asbestos and still air are insulators of heat. All pure liquids (except mercury) and gases are bad conductors of heat.

Note : The flowing air is a conductor of heat, but still air (*i.e.* the trapped air) is an insulator.

The following activity will show that aluminium is a good conductor of heat while wood is an insulator.

ACTIVITY 11

Take a hollow aluminium pipe partly fitted at one end on a wooden cylinder. Wrap a piece of paper on the composite rod at its middle as shown in Fig. 5.14. Heat the composite rod over the flame of a burner near the middle. You will notice that the paper chars only where it covers the wooden cylinder and remains unscorched where it covers the aluminium pipe. This shows that aluminium conducts heat while the wood does not. Thus, we can say that aluminium is a good conductor of heat and wood is a bad conductor of heat.

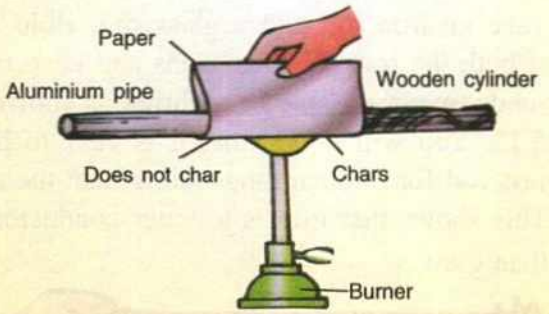


Fig. 5.14 Aluminium is a good conductor but wood is an insulator

Water is a bad conductor of heat. This can be seen by the following activity.

ACTIVITY 12

Take some water in a test tube. Take a piece of ice. If you keep the piece of ice in the water of the test tube, it will float. To sink the ice piece into water, surround the ice piece with an iron gauze. Drop the ice piece in the test tube. It will sink to the bottom in the test tube. Hold the test tube using the holder and heat it near its mouth by a burner as shown in Fig. 5.15. You will find that water near the mouth of the test tube begins to boil, but the ice piece at the bottom of the tube does not start melting. This shows that water is a bad conductor of heat.

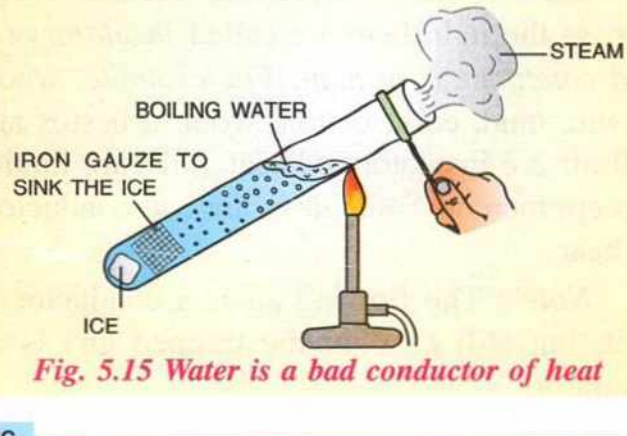


Fig. 5.15 Water is a bad conductor of heat

Do You Know ?

Mercury is a good conductor of heat, so it is used in thermometers.

Air is also a poor conductor of heat. This can be demonstrated by the following activity.

ACTIVITY 13

To show that air is a bad conductor of heat.

Take an empty test tube. Put some solidified wax at the bottom of the test tube and close the mouth of the test tube with a cork.

Hold the test tube using a test tube holder and heat it near its mouth with a burner as shown in Fig. 5.16.

After some time, you will observe that the cork blows away but the wax at the bottom does not melt.

This happens because the air near the mouth upon heating exapnds and its pressure increases. The high pressure of the air pushes the cork and it blows away but the wax remains solid showing that air is a poor conductor of heat.

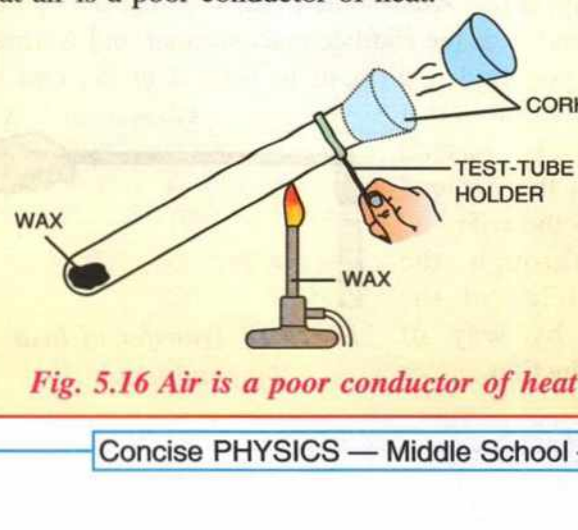


Fig. 5.16 Air is a poor conductor of heat

SOME APPLICATIONS OF CONDUCTORS AND INSULATORS IN DAILY LIFE

1. An oven is made of double walls and the space between them is filled with wool, cork etc. The wool and cork are insulators of heat. They prevent the heat of the oven to escape.
2. Cooking utensils and pans are made of metals such as copper, brass, steel etc. The reason is that metals are conductors of heat and so they heat up rapidly.
3. Cooking utensils, pans and tea kettles are provided with wooden or ebonite handles. The wood or the ebonite being insulators of heat, does not pass heat from the utensils to our hand. Thus, we can hold the hot utensils or pans comfortably by their handles.
4. An ice box is a double-walled box. The space between the walls is filled with cork, glass, wool etc. These filling materials are insulators of heat. They prevent heat from outside to pass into the ice box. Thus, ice kept inside the ice box does not melt.
5. In summer, ice is kept wrapped in a gunny bag or it is covered with saw dust. The air filled in the fine pores of the gunny bag or saw dust, is insulator of heat. The air does not allow heat from outside to pass through it to the ice. Thus, ice is prevented from melting rapidly.
6. We use woollen clothes in winter. Woollen clothes have fine pores which are filled with air. Wool and air are insulators of heat. Therefore, heat from our body does not escape through them and they keep us warm.
7. During very cold weather, water pipes are covered with cotton. Cotton has air trapped in its fine pores. Cotton and air are insulators of heat. They do not pass heat from the water inside the pipes to the outside atmosphere. Thus, cotton prevents the water in the pipes from freezing.
8. Quilts are filled with fluffy cotton. Air is trapped in the fine pores of cotton. Cotton and air are insulators of heat. They prevent heat from our body to escape and thus keep us warm.

   Newly made quilts are warmer than old ones because in old quilts, there is less air trapped in the cotton.

Do You Know ?

On a cold day, a steel chair feels colder than a wooden chair. This is because steel is a good conductor of heat. It takes heat from your hand, so you feel cold. Wood is an insulator of heat. It does not take heat from your hand, so you feel warm. On the other hand, on a hot day the steel chair will feel warmer than a wooden chair because steel will pass heat from the chair to the hand while wood will not.

2. Convection

Convection is the process of heat transfer by the actual movement of the molecules of the medium. Liquids and gases are poor conductors of heat. They are heated mainly by convection. In solids, the particles do not leave their positions, so solids are not heated by convection. In convection, the transfer of heat is always vertically upwards. The reason being that the molecules of the medium near the source of heat after absorbing heat start moving faster, so they move farther *i.e.* the medium expands. As a result, the density of medium near the source of heat becomes less *i.e.* it becomes lighter. The less dense medium rises up and the denser medium from above moves down to take its place. Thus, a current is set up in the medium which is called a *convection current*.

Convection in liquids : The process of convection in a liquid can be easily demonstrated by the following activity.

ACTIVITY 14

Take a bottle. Fill the bottle about three-fourths with water. Gently drop few crystals of potassium permanganate into the bottle to make the water coloured. Fix the bottle on a vertical stand and heat it over the flame of a burner as shown in Fig 5.17. You will notice that a fine stream of coloured water starts from the centre of the bottom of the bottle. It rises upwards, reaches the top of water and circles downwards along the sides of the bottle. These streams represent the convection current.

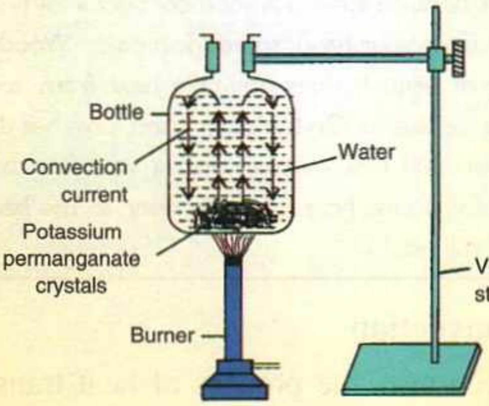


Fig. 5.17 Convection in water

Convection in a gas : The process of convection in a gas can be demonstrated easily by the following activity.

ACTIVITY 15

Take a rectangular cardboard box. Cut the longer side of it and then cover it with a transparent polythene. Keep this side of the box upwards, facing towards you. Then cut a window on the adjacent side of the box as shown in Fig. 5.18 (a), so that you may insert your hand through it. Cut two holes on the top of the box. Roll two pieces of paper and insert them in the holes. They serve as paper chimneys. Mark them

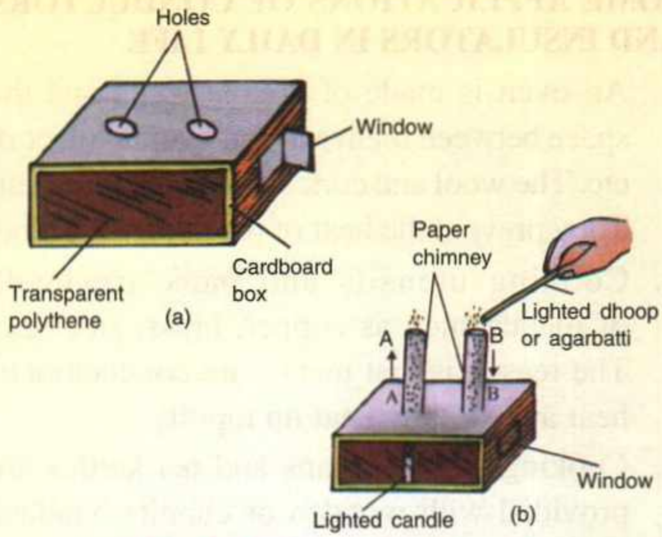


Fig. 5.18 Convection in a gas

as A and B. Now take a small candle. Light it and insert it inside the box just below the chimney A, through the window. Close the window. Then hold a lighted dhoop or agarbatti near the mouth of the chimney B as shown in Fig. 5.18(b). You will notice that the smoke of dhoop (or agarbatti) kept near the mouth of chimney B enters through the chimney B inside the box and comes out of the chimney A. You can also see the convection currents moving from the chimney B to the chimney A, through the polythene.

Reason : The candle heats the air surrounding it as well as the air in the chimney A. This air becomes less dense *i.e.* lighter and it rises upwards. Its place is taken by the cold air rushing down the box through the chimney B which carries the smoke of the dhoop or agarbatti with it. Now this incoming air gets heated up and rises up. Thus, it forms a convection current of smoke through the chimney A.

SOME APPLICATIONS OF CONVECTION IN DAILY LIFE

Some important practical applications of convection are given below.

1. Ventilators and windows are provided in rooms for proper ventilation. The reason

is that when we breathe out in a room, the air in the room becomes warm and impure. The warm air is less dense *i.e.* lighter, so it rises up and moves out through the ventilators. Then the cold fresh air comes in the room through the windows to take its place. Thus, the continuous circulation of fresh air keeps the air in the room fresh.

2. Chimneys are provided over the furnace in factories. This is because the hot gases coming out of the furnace are less dense than the air. They rise up through the chimney. The smoke, fumes etc. around the furnace rush in so as to take their place and they are sucked out. Thus, the chimney helps to remove undesired fumes, smoke etc. from the premises.
3. Land and sea breezes are formed at places near the sea. During summer in places near the sea, it is noticed that a breeze blows from the land towards the sea during the night which is called land breeze and from the sea towards the land during the day which is called sea breeze. The land and sea breezes are actually local convection currents.

Land breeze : At night, the land cools much faster than the sea, therefore, the sea water is warmer than the land. The air near the sea

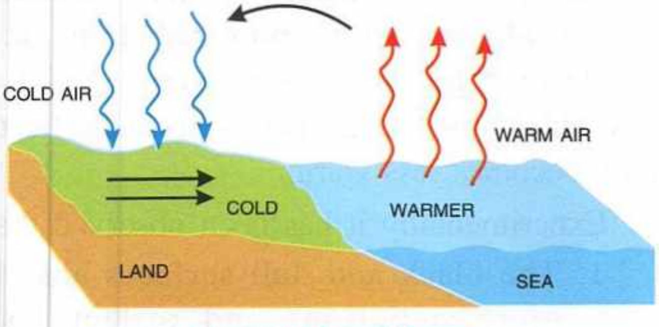


Fig. 5.19 Land breeze

being warm, is less dense (*i.e.* lighter) so it rises up and cold current of air blows from the cold land to the warm sea to take its place (Fig. 5.19). This is called land breeze.

Sea breeze : During the day, the land becomes more warm than the sea, so the air above the land being warm becomes less dense (*i.e.* lighter). It rises up and the cold air from the sea blows towards the land to take its place as shown in Fig. 5.20. This is called sea breeze.

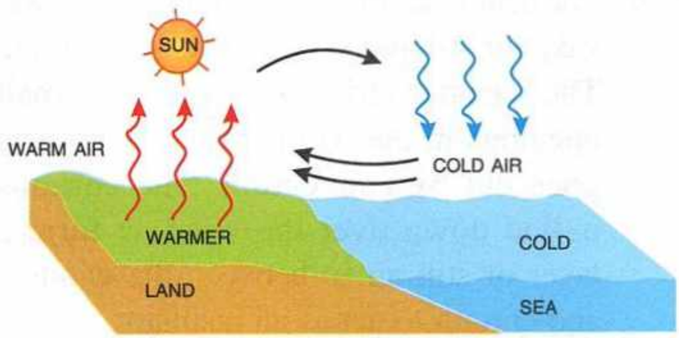


Fig. 5.20 Sea breeze

4. Ocean currents flow on the surface and below the surface of oceans. Ocean currents are caused due to convection currents in the ocean. The ocean water near the equator is heated by the sun more than the water near the poles of the earth. Thus, ocean water near the equator is warmer than that near the poles. Therefore, convection currents of warm water flow on the surface of the ocean from the equator to the poles, while below the surface of the ocean, currents of cold water flow from the poles to the equator. These currents are called ocean currents. They control the temperature of the sea.
5. A refrigerator is provided with its

cooling (or freezing) chest near its top. The reason is that the air near the top in contact with the freezing chest gets cooled. It becomes denser (*i.e.* heavier) and therefore descends down. The hot air from the lower part rises up. Thus, the convection currents are formed. The cold air coming down from the cooling chest cools the entire space along with the things present in the refrigerator below the cooling chest.

6. For heat insulation of a room in a house, weather strippings and curtains are used. The weather strippings close the small openings in the window so that no heat goes out by convection. The curtains pulled down over the window form a layer of still air in between the window and curtain to act as an insulator.
7. The room heaters and blowers are kept on or near the floor of the room so that the hot air may rise up to warm the entire room.
8. Firemen usually crawl while entering a building where fire has broken out because the hot air and smoke rise upwards.

3. Radiation

Radiation is the process of heat transfer in which heat directly passes from one body at high temperature to another body at lower temperature without affecting the medium. No medium is required for the transfer of heat by the process of radiation. In vacuum, heat transfer takes place only by the process of radiation.

Example 1 :

When we sit in the sun, we feel warm. We cannot get heat from the sun by the process of conduction or convection because most of the space between the sun and the earth is a vacuum and both of these modes of heat transfer require a medium. Hence, we must be getting heat from the sun by mode of radiation.

Example 2 :

When we sit near a fire, we feel warm. Similarly, if we keep our hand below a lighted bulb, our hand feels warm. In these cases, we do not get heat by conduction because air is a bad conductor of heat. We do not get heat by convection also because hot air always rises up, it does not move sideways or downwards. Thus, we must be getting heat from the fire (or lighted bulb) by the process of radiation.

Heat radiations are also called **thermal radiations**, or simply, **radiations**. They travel in straight lines with a speed of 3×10^8 m s^{-1} in vacuum or air. They are similar in properties to light with the only difference being heat radiation does not give the sensation of sight as light does, but heat radiations give the sensation of hotness.

When radiations fall on a body, the body absorbs some of them and reflects the rest. The body becomes warm because of the absorbed radiations. Different substances absorb different amounts of radiations falling on them. A body which absorbs more radiations and reflects less, becomes more warm, while a body which absorbs less radiations and reflects more, becomes less warm.

Experimentally it has been observed that

1. The black and dull surfaces absorb more radiations and reflect less radiations.

2. The white and shiny surfaces reflect more radiations and absorb less radiations.

Do You Know ?

Solar cookers use the heat energy of the sun to cook food. The inner surface is painted black so that it absorbs maximum solar energy falling on them.

The following activity demonstrates that black surfaces are better absorbers of heat than white surfaces.

ACTIVITY 16

To prove that black bodies absorb heat better than white bodies.

1. Take two identical cold drink cans filled with equal amount of water.
2. Paint one can black and the other white, from outside.
3. Place a thermometer in each can with the bulb of the thermometer properly dipped in water.
4. Now place both the cans at an equal distance from the room heater.
5. Switch the heater on and let it remain on for 15 minutes.

You will observe that the temperature reading in the thermometer placed in the black can is higher than the reading in the thermometer placed in the white can. This is so because a black surface is a better absorber of heat radiations than a white surface.

SOME APPLICATIONS OF BLACK AND WHITE SURFACES IN DAILY LIFE

Some important applications of black and white surfaces are given below :

1. We prefer to wear white clothes in summer. The reason is that white clothes reflect most of the sun's heat and absorb very little of it, thus they keep our body cool.
2. We prefer to wear black and dark coloured clothes in winter. The reason is that black or dark coloured clothes absorb most of the sun's heat and keep our body warm.
3. The bottom part of a cooking utensil or pan is painted black. The reason is that a black surface absorbs more heat and so the contents of the utensil or pan get cooked rapidly if its bottom part is painted black.
4. Room heaters are provided with shiny reflectors. The reason is that the shiny surface absorbs very little heat and reflects most of it, so almost the entire heat produced by the filament of heater is reflected.

Do You Know ?

(1) It is cool in the shade below a tree but not a little away from it. The reason is that heat radiations travel in a straight line. Therefore, the heat radiations from the sun cannot reach the shade below the tree as they are obstructed by the leaves. Apart from it, the air trapped between the leaves is a bad conductor of heat so it does not allow the heat to pass from above the tree to the shade.

(2) If a red hot ball is suspended from the roof of a room by a thin metallic wire, it will loose heat (i) by conduction and convection through the air moving around the ball (ii) by conduction through the metal wire and (iii) by radiation from the ball and wire to the surroundings.

(3) To reduce heat loss by radiation from a surface, it is made shiny.

Differences between conduction, convection and radiation

CONDUCTION	CONVECTION	RADIATION
1. Medium is necessary for transfer of heat by conduction.	Medium is necessary for transfer of heat by convection.	No medium is required for transfer of heat by radiation.
2. Conduction is not possible in vacuum.	Convection is not possible in vacuum.	Radiation is possible in vacuum.
3. The particles of the medium do not leave their mean positions. They transfer heat by vibrating about their mean positions.	The particles of the medium leave their mean positions and move in upward direction carrying heat from the source.	The medium remains unaffected.
4. The transfer of heat can be in any direction.	The transfer of heat is only in vertically upward direction.	Transfer of heat is in all directions along a straight path.
5. This process is slow.	This process is faster than conduction.	This process is the fastest and transfer of heat takes place with the speed of light, *i.e.*, 3×10^8 m s^{-1}.

THERMOS FLASK

The thermos flask is a special kind of flask or bottle. It is used to keep a hot liquid hot and a cold liquid cold for a long time. A thermos flask is shown in Fig. 5.21. It consists of a double-walled glass bottle. There is a vacuum in between the walls. Both the walls are made shiny on the vacuum side. The mouth of the bottle is fitted with a cork (or plastic) stopper. The bottle is enclosed in a plastic case with the help of cork pieces or spring as shock absorber. The case is provided with a cap over the stopper.

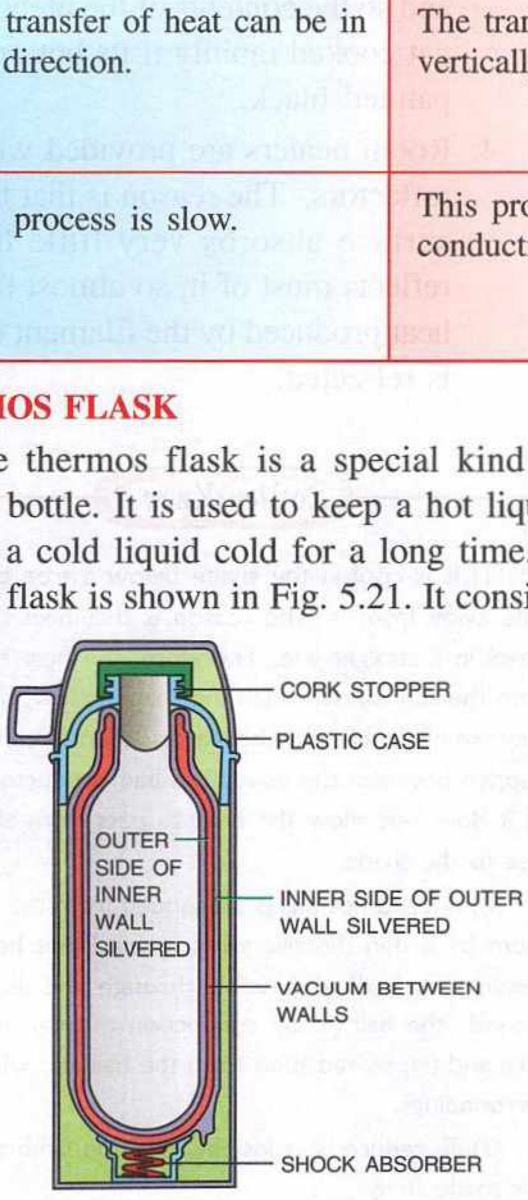


Fig. 5.21 Thermos flask

The vacuum in between the walls of the bottle prevents any transfer of heat by conduction and convection. The shining surface on the outer side of inner wall and inner side of the outer wall reduces the transfer of heat by radiation. The cork stopper prevents the transfer of heat by convection. Thus, the transfer of heat either from inside to outside or from outside to inside is very little and the contents of the bottle can remain at the same temperature for a long time.

SOLVED EXAMPLES

1. The temperatures of two bodies differ by 10°C on the Celsius scale. How much will they differ on the (i) Fahrenheit scale, (ii) Kelvin scale ?

   (i) 100 divisions on the Celsius scale

   = 180 divisions on the Fahrenheit scale

   ∴ 10 divisions on the Celsius scale

   $= \frac{180}{100} \times 10 = 18$ divisions in the Fahrenheit scale.

   Thus, the temperature of two bodies will differ by 18°F on the Fahrenheit scale.

   (ii) 100 divisions on Celsius scale

   = 100 divisions on Kelvin scale

   10 divisions on Celsius scale

   = 10 divisions on Kelvin scale

   Hence the temperature of two bodies will differ by 10 K on the Kelvin scale.

2. Convert 10°C in (a) degree farhenheit (b) kelvin

   (a) From $°F = \frac{9}{5}C + 32$

   $$°F = \frac{9}{5} \times 10 + 32$$

   or $$F = 18 + 32 = 50$$

   Thus, 10°C = 50°F

   (b) $$t°C = (273 + t)\ K$$

   $$10°C = (273 + 10)\ K$$

   $$= 283\ K$$

3. The normal temperature of human body is 37°C. What will be its value on the (a) Fahrenheit scale, (b) Kelvin scale ?

   (a) From $°F = \frac{9}{5}C + 32$

   $$= \frac{9}{5} \times 37 + 32$$

   $$= 66{\cdot}6 + 32$$

   $$= 98{\cdot}6$$

   Thus, 37°C = 98·6°F

   (b) Since $t°C = (273 + t)\ K$

   $$37°C = (273 + 37)\ K = 310\ K$$

RECAPITULATION

- Heat is a form of energy which we can feel.
- The S.I. unit of heat is joule (symbol J). The other common units of heat are calorie (symbol cal) and kilocalorie (symbol kcal).

  1 kcal = 1000 cal

  1 cal = 4·2 J

  1 J = 0·24 cal (nearly)
- Temperature tells us how hot or cold a body is. In other words, temperature is a quantity which tells us the degree of hotness or coldness of a body.
- Generally used units of temperature are degree celsius (°C), degree fahrenheit (°F) and kelvin (K).
- A thermometer is a device which is used to measure the temperature of a body.
- The working of a mercury thermometer is based on the thermal expansion of mercury.
- The lower fixed point of a thermometer is the ice point (*i.e.* the melting point of pure ice at one atmospheric pressure).
- The upper fixed point is the steam point (*i.e.* the boiling point of pure water at one atmospheric pressure).
- On the Celsius scale, the ice point (or lower fixed point) is 0°C and the steam point (or the upper fixed point) is 100°C. The interval between the ice point and steam point is divided into 100 equal parts.
- On the Fahrenheit scale, the ice point (or lower fixed point) is 32°F and the steam point (or the upper fixed point) is 212°F. The interval between the ice point and steam point is divided into 180 equal parts.
- 100 Celsius degrees = 180 Fahrenheit degrees
- The temperatures on the Celsius scale and Fahrenheit scale are related as

$$C = \frac{5}{9}(F - 32) \text{ or } F = \frac{9}{5}C + 32$$

- One degree on Celsius scale is equal to 9/5 degree of Fahrenheit scale
- On Kelvin scale, zero mark is when no molecular motion occurs. Ice point is at 273 K and steam point is at 373 K. Thus 0 K = –273°C and one degree on Kelvin scale is same as one degree on celsius scale.
- t°C = (273 + t) K
- The temperature of a normal person is 37°C or 98·6°F or 310 K
- When a solid, liquid or gas is heated, it expands.
- The expansion of a substance when heated, is called thermal expansion
- A solid on being heated expands in length, area as well as in volume. Thus, a solid has linear expansion, superficial expansion and cubic expansion.
- Liquids when heated expand more than solids.
- Liquids have only cubical expansion.

- Thermal expansion of liquids is used in the working of a mercury thermometer.
- Gases expand much more than solids and liquids when heated. They undergo only cubical expansion.
- There are three methods of transfer of heat, namely, conduction, convection and radiation.
- Conduction is the process of transfer of heat from the hot end to the cold end from particle to particle of the medium.
- Convection is the process of transfer of heat by the actual movement of the particles of the medium.
- Radiation is the process of transfer of heat in which heat directly passes from the hot body to the cold body without affecting the medium.
- Conduction and convection require a medium, while radiation does not require any medium.
- Transfer of heat in solids is mainly by conduction. In liquids and gases, transfer of heat is mainly by convection.
- In conduction, the particles of the solid at the hot end absorb heat energy. They begin to vibrate more rapidly and collide with their neighbouring particles. During collision, they pass heat to the neighbours without moving themselves from their positions.
- In convection, the particles of liquid or gas absorb heat from the source. They themselves move upwards and the particles from the upper part move downwards to take their place.
- In radiations, heat is directly transferred from the hot body to the cold body without affecting the medium.
- Substances which allow heat to pass through them easily are called good conductors of heat.
- Substances which do not allow heat to pass through them are called bad conductors or insulators of heat.
- Metals are the good conductors of heat. Liquids and gases are bad conductors of heat.
- Solids are not heated by convection.
- By convection, transfer of heat is always vertically upwards.
- In vacuum, transfer of heat takes place only by the process of radiation.
- We get heat from the sun by radiation.
- Black and dull surfaces absorb more radiations while white and shiny surfaces reflect more radiations.
- Thermos flask is a device in which the transfer of heat by conduction, convection and radiation is reduced to a minimum. Hence, it keeps the contents in it at the same temperature for a long time.

TEST YOURSELF

A. Objective Questions :

1. Write **true** or **false** for each statement :

(a) On touching a lump of ice, we feel cold because some heat passes from our body to the ice.

(b) Heat flows from a body at a high temperature to a body at a low temperature when they are kept in contact.

(c) All solids expand by the same amount when heated to the same rise in temperature.

(d) Telephone wires are kept tight between two poles in summer.

(e) Equal volumes of different liquids expand by different amounts when they are heated to the same rise in temperature.

(f) Solids expand the least and gases expand the most on being heated.

(g) A mercury thermometer makes use of the property of expansion of liquids on heating.

(h) Kerosene contracts on heating.

(i) Water is a bad conductor of heat.

(j) Medium is necessary for the transfer of heat by radiation.

(k) Land and sea breezes are convection currents of cold and warm air.

(l) Liquids are heated by conduction and radiation.

(m) Black surfaces are poor absorbers of heat radiations.

Ans: True (a), (b), (e), (f), (g), (i) (k)
False (c), (d), (h), (j), (l), (m)

2. Fill in the blanks :

(a) Heat is a form of ....

(b) .... determines the degree of hotness or coldness of a body.

(c) On heating a body, its temperature ....

(d) We use a .... for measuring the temperature of a body.

(e) The S.I. unit of temperature is ....

(f) In a thermometer, the commonly used liquid is ....

(g) The temperature of a normal human body is .... °C.

(h) A person is said to have fever if his body temperature is more than .... °F.

(i) A hot metallic piece is placed in tap water contained in a bucket. Heat will flow from .... to ....

(j) The temperature of boiling water is ....

(k) Liquids expand .... than solids.

(l) Gases expand .... than liquids.

(m) Heat transfer in solids is by ....

(n) Heat transfer in liquids and gases is by ....

(o) Metals are .... of heat.

(p) Still air is an .... of heat.

(q) Black and dull surfaces are .... of heat.

Ans: (a) energy, (b) temperature, (c) rises, (d) thermometer (e) kelvin, (f) mercury, (g) 37, (h) 98·6, (i) metallic piece, water, (j) 100°C (k) more (l) more (m)conduction, (n) convection, (o) conductors, (p) insulator (q) good absorbers

3. Match the following :

Column A	Column B
(a) mercury	(i) insulator
(b) wood	(ii) water from 0°C to 4°C
(c) aluminium	(iii) absorbs
(d) contracts	(iv) conductor
(e) black surface	(v) thermometer

Ans: (a)–(v), (b)–(i), (c)–(iv), (d)–(ii), (e)–(iii)

4. Select the correct alternative :

(a) If we add a lump of ice to a tumbler containing water :

(i) heat flows from water to ice

(ii) heat flows from ice to water

(iii) heat flows from water to ice if water is more

(iv) heat flows from ice to water if ice is more.

(b) The temperature of pure melting ice is :

(i) 0°C (ii) 100°C

(iii) 95°C (iv) 98·6°F

(c) A thermometer uses :

(i) water (ii) mercury

(iii) air (iv) none of the above

(d) Which statement is correct :

(i) Iron rims are cooled before they are placed on cart wheels

(ii) A glass stopper gets tight on warming the neck of the bottle

(iii) Telephone wires sag in winter, but become tight in summer

(iv) A little space is left between two rails on a railway track.

(e) Heat in a liquid is transferred by :

(i) conduction

(ii) convection

(iii) radiation

(iv) conduction and radiation

(f) In the process of convection, heat travels :

(i) sideways

(ii) downwards

(iii) upwards

(iv) in all directions

(g) The vacuum kept in between the walls of a thermos flask reduces the heat transfer by :

(i) conduction only

(ii) convection only

(iii) radiation only

(iv) conduction and convection.

Ans: (a)–(i), (b)–(i), (c)–(ii), (d)–(iv), (e)–(ii), (f)–(iii), (g)–(iv)

B. Short/Long Answer Questions :

1. What is heat ? State its S.I. unit
2. What is meant by the term, 'temperature' ?
3. State the *three* units of temperature.
4. Name the instrument used to measure the temperature of a body.
5. What is the Celsius scale of temperature ?
6. What is the Fahrenheit scale of temperature ?
7. What is the Kelvin scale of temperature ?
8. How are the Celsius and Fahrenheit scales inter-related ?
9. How is the size of a degree defined on a Celsius scale ?
10. How is the size of a degree defined on a Fahrenheit scale ?
11. State the temperature of (i) ice point and (ii) steam point, on the Celsius scale.
12. Write down the temperature of (i) lower fixed point, and (ii) upper fixed point, on the Fahrenheit scale.
13. The Fig. 5.22 shows a glass tumbler containing hot milk which is placed in a tub of cold water. State the direction in which heat will flow.

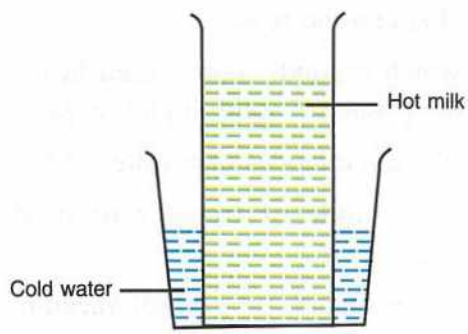


Fig. 5.22

14. Draw a neat labelled diagram of a laboratory thermometer.
15. Write down the body temperature of a healthy person.
16. What do you understand by thermal expansion of a substance ?
17. Name two substances which expand on heating.
18. Why do telephone wires sag in summer ?
19. Iron rims are heated before they are fixed on the wooden wheels. Explain the reason.
20. Why are gaps left between successive rails on a railway track ?
21. A glass stopper stuck in the neck of a bottle can be removed by pouring hot water on the neck of the bottle. Explain why ?
22. Why is a cement floor laid in small pieces with gaps in between ?
23. One end of a steel girder in a bridge is not fixed, but is kept on rollers. Give the reason.
24. Describe one experiment to show that liquids expand on heating.
25. State one application of thermal expansion of liquids.
26. Describe an experiment to show that air expands on heating.
27. An empty glass bottle is fitted with a narrow tube at its mouth. The open end of the tube is kept in a beaker containing water. When the bottle is heated, bubbles of air are seen escaping into the water. Explain the reason.
28. State which expands more, when heated to the same temperature : solid, liquid or gas ?
29. Name the three modes of transfer of heat.
30. Name the mode of transfer of heat in the following :

    (a) solid, (b) liquid, (c) gas, (d) vacuum
31. What are good and bad conductors of heat ? Give two examples of each.
32. Name a liquid which is a good conductor of heat.
33. Name a solid which is a good conductor of heat.
34. Select good and bad conductors of heat from the following :

    copper, mercury, wood, iron, air, saw-dust, cardboard, silver, plastic, wool.
35. Why is an oven made of double walls with the space in between filled with cork ?
36. Why do we use cooking utensils made up of copper ?
37. Why is a tea kettle provided with an ebonite handle ?
38. In summer, ice is kept wrapped in a gunny bag. Explain the reason.
39. Explain why

    (a) we wear woolen clothes in winter ?

    (b) the water pipes are covered with cotton during very cold weather ?
40. Why are quilts filled with fluffy cotton ?
41. State the direction of heat transfer by way of convection.
42. Why is a ventilator provided in a room ?
43. Why are chimneys provided over furnaces in factories ?
44. What are land and sea breezes ? Explain their formation.
45. Why is the freezing chest in a refrigerator fitted near its top ?
46. Explain briefly the process of heat transfer by radiation.
47. Give one example of heat transfer by radiation.
48. Why do we prefer to wear white or light coloured clothes in summer and black or dark coloured clothes in winter ?
49. The bottom of a cooking utensil is painted black. Give the reason.
50. Draw a labelled diagram of a thermos flask. Explain how the transfer of heat by conduction, convection and radiation is reduced to a minimum in it.

C. Numericals

1. The temperature of a body rises by 1°C. What is the corresponding rise on the (a) Fahrenheit scale (b) Kelvin scale?

   Ans: (a) 1·8°F (b) 1 K

2. The temperature rises by 18°F. What is the rise on the Celsius scale ?

   Ans: 10°C

3. Convert 5°F to the Celsius scale.

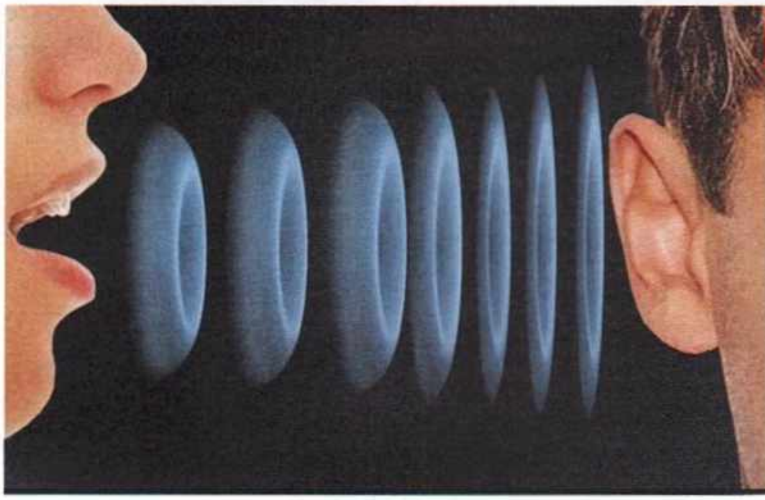
   Ans: –15°C

4. Convert 40°C to the (a) Fahrenheit scale (b) Kelvin Scale.

   Ans: (a) 104°F (b) 313K

5. Convert – 40°F to the Celsius scale.

   Ans: – 40°C



6 Sound

Theme : Sound is produced by the vibration of objects and different types of instruments are used to produce sound. In humans sound is produced by the voice box or larynx. Sound needs a medium to propagate hence in space it is not possible to hear one another. Sound wave is a longitudinal wave. A wave is characterized by amplitude and frequency. Like light, sound is also reflected from a surface. Sound is also absorbed by a medium. Therefore, walls of a theatre are lined with layers of materials that absorb sound. Sound travels with different speeds in different medium and travels the fastest in solids. This theme will enable children to know and understand sound, different sources of sound and how it travels.

In this chapter you will learn to

- identify different sources of sound;
- describe sound as a longitudinal wave;
- define amplitude and frequency of sound;
- demonstrate that sound requires a medium to transmit;
- list examples of reflection and absorption of sound;
- analyse the relative speed of sound in different mediums;
- design a sound-proof box

LEARNING OBJECTIVES

- Demonstration of production of sound using simple objects within the classroom followed by discussion.
- Children place their hand on their throats and when they speak they feel vibration.
- Explanation of the characteristics of sound.
- Demonstration that sound needs a medium to propagate.
- Engaging children in design of an activity to show that sound need a medium to propagate, using two mobiles and a tumbler.
- Demonstration of reflection of sound.
- Demonstration of absorption of sound.
- Explanation of relative speed of sound in solid, liquid and gas.
- Design of sound proof box

KNOWING CONCEPTS

- Sources of sound.
- Sound as a longitudinal wave.
- Characteristics of a sound wave: Amplitude (relate amplitude with loudness) and Frequency.
- Sound needs a medium to propagate.
- Reflection and absorption of sound.
- Relative speed of sound in different mediums.

SOUND

In our daily life, we hear different types of sounds like, the ringing of a school bell, the sound from a clock, the honking of vehicles, the sound of playing guitar or tabla, etc. We also hear the different voices of different persons and different sounds produced by different animals such as, barking of dogs, roar of a lion, etc.

> Sound is a form of energy that produces the sensation of hearing in our ears.

SOUND IS PRODUCED DUE TO VIBRATIONS

We have read that the to and fro motion of a body from its rest position is called oscillatory motion. *For example*, motion of a swing and motion of the pendulum of a wall clock are oscillatory motions. In this motion, the body from its rest position moves to one side, comes back to the rest position, then moves to the other side and then again comes back to the rest position. The process is then repeated again and again. The oscillatory motion is repetitive at a regular interval of time.

The oscillatory motion in which the body assumes a new shape during its motion, is called vibratory motion. In vibratory motion, a part of the body oscillates keeping its other part fixed.

Sound is produced when a body vibrates. In other words, each source of sound is a vibrating body.

Examples : (1) When you blow a whistle, the vibrations of particles in air produce sound.

(2) When we speak, our vocal cords vibrate to produce sound in the larynx (also known as the voice box). This can be felt by placing our hand on the throat.

(3) When a bell is struck, it vibrates to produce sound.

From the above discussion, we conclude that

(i) Sound is produced by the vibrations in a body.

(ii) When the body stops vibrating, the sound produced by it also ceases (*i.e.*, no sound is then heard).

The production of sound by a vibrating body can be demonstrated by the following activities.

ACTIVITY 1

Take a ruler. Press its one end on the table with the left hand as shown in Fig.6.1 Pull down the other end of the ruler with the right hand and then leave it.

You will notice that the ruler vibrates *i.e.*, the ruler moves to and fro and a humming sound is heard.

After some time, the ruler stops vibrating. No sound is then heard.

This shows that the humming sound is produced only because of the vibrations of the ruler.

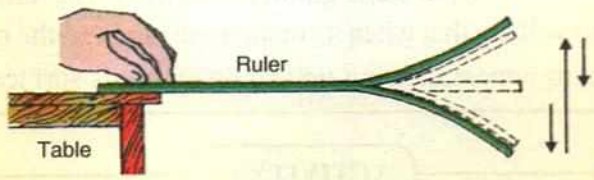


Fig. 6.1 A vibrating ruler produces sound

ACTIVITY 2

Take a rubber band. Cut it to get a string. Hold one end of the string in your mouth under the teeth

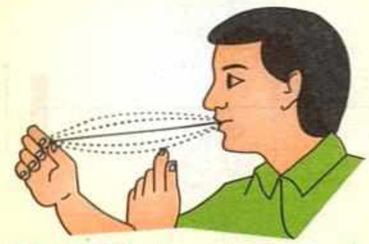


Fig. 6.2 A virbating string produces sound

and the other end in your hand. Stretch it as shown in Fig. 6.2. Now pluck the string at its middle, a little to one side with the help of a finger of the other hand and leave it.

You will notice that the string starts vibrating and a feeble sound is heard. After some time when the string stops vibrating, no sound is heard. This shows that vibrations in the rubber string produce sound.

ACTIVITY 3

Take a drum and beat it as shown in Fig. 6.3 You will hear the sound of the drum. If you touch the membrane of the drum, you will feel its vibrations. When the membrane stops vibrating, then no sound is heard. This shows that a vibrating drum produces sound.

Fig. 6.3 The vibrating membrane of drum produces sound

Note : If you put some grains of dry rice on the drum, you will see that when its membrane vibrates, the rice grains appear dancing up and down on its surface.

ACTIVITY 4

Pluck a string of a sitar or a guitar. You will notice that the string moves to and fro from its rest position as shown in Fig. 6.4.The motion of the string is vibratory motion. As the string vibrates, sound is heard. As soon as the vibrations stop, no sound is heard.

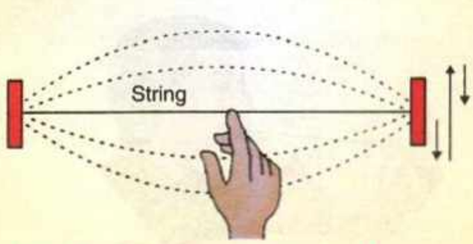


Fig. 6.4 A vibrating string produces sound

SOURCES OF SOUND

Some sources of sound are given below

1. Tuning fork

A tuning fork is a U-shaped metalli piece with a stem in the middle as shown i Fig. 6.5. Its arms are known as prongs. The are set into vibrations when either of the tw prongs is struck gently on a rubber pad and sound is produced.

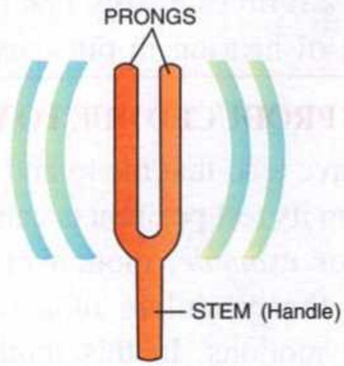


Fig. 6.5 Tuning fork

ACTIVITY 5

Take a tuning fork and strike it against a rubber pad. You will hear its feeble sound. Now bring the tuning fork near a table tennis ball suspended by a thread as shown in Fig. 6.6, you will notice that the ball jumps to and fro on touching the prong of the tuning fork. This shows that the prongs of the tuning fork are vibrating. When its prongs stop vibrating, ball stops oscillating and no sound is heard. This shows that the vibrations of the prongs of a tuning fork produce sound.

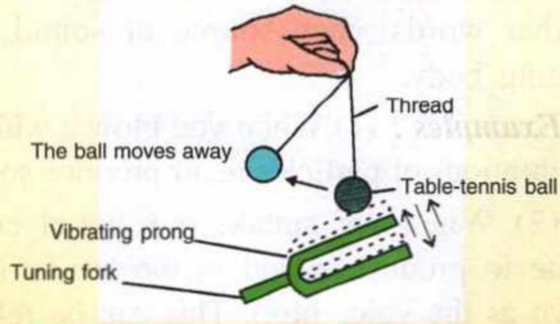


Fig. 6.6 A vibrating tuning fork produces sound

2. Musical Instruments

All musical instruments produce sound due to vibrations. The musical instruments such as whistle, flute and clarinet (Fig. 6.7) which are in form of pipes, produce sound when air is blown into them. Thus the column of air inside them vibrates producing sound.

Fig. 6.7 Musical instruments in form of pipe

The musical instruments like harmonium and mouth organ (Fig. 6.8) contain metal reeds (thin strips of metal) and they produce sound when air is blown through them.

Fig. 6.8 Musical instruments with metal reeds

The stringed musical instruments such as sitar, guitar, piano, violin (Fig. 6.9) have strings stretched on them. In a sitar and guitar, the string is plucked; in a piano, the string is struck and in a violin, a bow is drawn across the string, to make the string vibrate and produce sound.

Fig. 6.9 Stringed musical instruments

In musical instruments such as drum, tabla, dholak etc. the leather membrane is made to vibrate (Fig. 6.10) by striking it with sticks or with hand, so as to produce sound.

Fig. 6.10 Musical instruments with leather membrane

3. Human beings

We human beings, produce sound when our vocal cords vibrate on blowing air through them by our lungs.

Our throat has a larynx. The voice is produced in the larynx. Larynx is also called the voice box. It is designed to produce voice. It is a box-like structure with walls of tough tissues. Inside two folds of the tissue, there is a gap. They are the vocal cords. When we breathe, the vocal cords become loose and the gap between them increases. When we talk, shout or sing, the cords become tight and hence they vibrate and produce sound. Fig. 6.11 shows the part of the body which vibrates to produce sound.

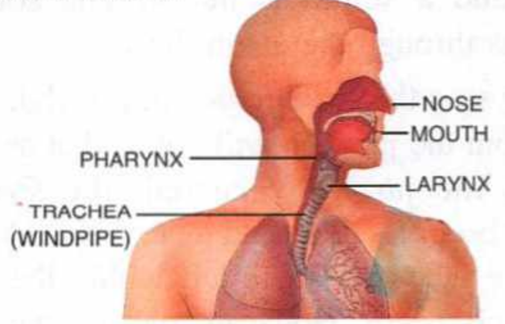


Fig. 6.11 Parts of the human body which vibrate to produce sound

We can feel the vibrations of the vocal cords when reciting or speaking, if we put our fingers on our throat.

Note : Some animals like birds, frogs etc. also produce sound due to vibration of their vocal cords. But bees do not have voice-boxes. They make sound by moving their wings up and down very fast.

SOUND NEEDS A MEDIUM FOR PROPAGATION

Sound cannot travel through a vacuum. Sound requires a medium for its propagtion i.e. for travelling from one point to another. The following simple experiment demonstrates this fact.

Experiment : Take an electric bell and an air-tight glass jar connected to a vacuum pump. Suspend the electric bell inside the jar as shown in Fig. 6.12.

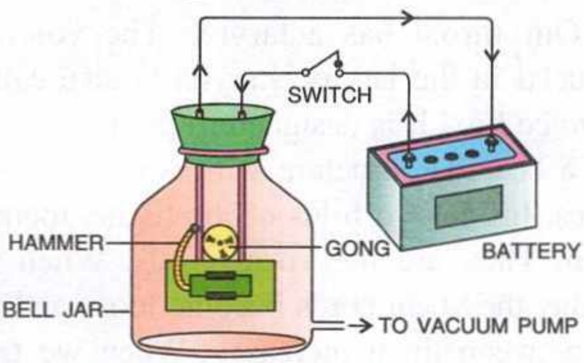


Fig. 6.12 Sound needs a medium for propagation

Connect the bell to a battery through a switch. On pressing the switch, the bell starts ringing and a sound is heard. The sound reaches us through the air in the jar.

Now start the vacuum pump. It withdraws the air from the jar. You will notice that as the air from the jar is evacuated, the sound gradually becomes more and more feeble. After some time when no air is left within the jar, no sound is heard. However, the hammer of the electric bell can be still seen striking the gong. The reason is that when no air is left in the jar, sound does not propagate to reach us, although the bell is still ringing (or vibrating).

Thus, sound cannot travel through a vacuum.

Do You Know ?

On the moon and in space, there is no atmosphere. Therefore, two persons cannot hear each other.

The need of a medium for the propagation of sound can be demonstrated by the following activity.

ACTIVITY 6

Take a tumbler and place a mobile phone A into it. Now ring the mobile phone A from another mobile phone B outside the tumbler as shown in Fig. 6.13(a). You can hear the sound of ring of mobile phone A outside the tumbler because there is air in the tumbler through which sound of the ring propagates to reach your ear.

Now cover the mouth of the tumbler with a card board lid having a small hole, with the help of cello-tape so that it becomes air tight. Then pass a straw through the hole in the lid and suck the air of the tumbler, as shown in Fig. 6.13(b). Again ring the mobile A from mobile B. You will find that the sound of ring gradually decreases as air is withdrawn from the tumbler and ultimately when almost all the air of the tumbler has been sucked out, no sound is heard. This shows that the presence of a medium is necessary for the propagation of sound.

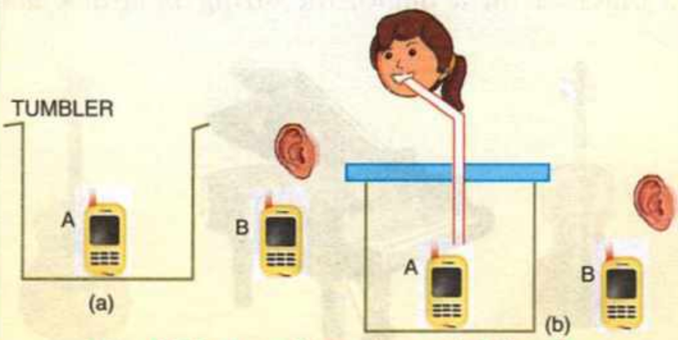


Fig. 6.13 A medium is needed for the propagation of sound

Sound can travel in all mediums, solids, liquids and gases. This can be demonstrated by the following simple activities.

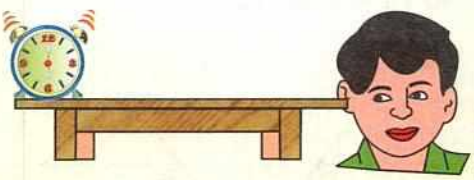
ACTIVITY 7

To show that sound travels in a solid.

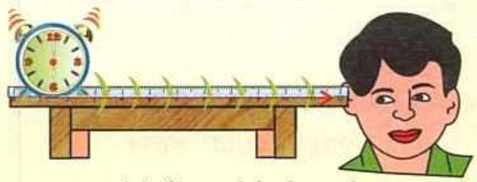
Place a clock on one end of a table and bring your ear close to that end (or near the clock) as shown in Fig. 6.14(a).

Slowly move the clock away from yourself, till you stop hearing the sound of the clock [Fig. 6.14(b)]. Now place one end of a ruler or a metal rod below the clock and the other end very close to your ear, as shown in Fig. 6.14(c). You will again be able to hear the sound of the clock.

(a) Sound is heard



(b) No sound is heard



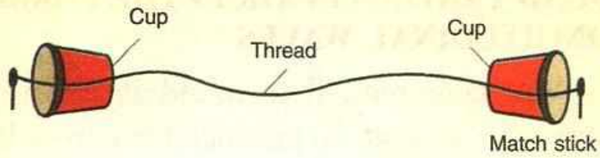
(c) Sound is heard

Fig. 6.14 Sound propagates in a solid

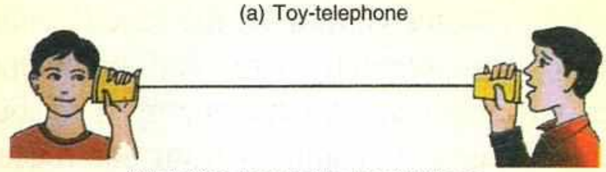
ACTIVITY 8

To show that sound travels in a solid.

Take two empty ice-cream cups. Make a small hole at the bottom of each cup and pass a long thread (about 20 m long) through them. Tie a knot or match-stick at each end of the thread so that the thread does not slip out through the holes. This makes a toy-telephone [Fig.6.15(a)].



(a) Toy-telephone



(b) Talking through the boy-telephone

Fig. 6.15 Sound travels in a solid

Now use the toy-telephone as shown in Fig.6.15(b) and talk to your friend. You will be able to hear the sound of your friend. This shows that sound travels through the thread and reaches your ear. So, sound can travel through a solid.

ACTIVITY 9

To show that sound travels in a liquid.

Fill a balloon with water as shown in Fig. 6.16. Hold it near your ear. Now keep a watch gently to the other side of the balloon. You will hear the ticking sound of the watch.

This shows that sound can travel through a liquid.

Fig. 6.16 Sound travels through a liquid

ACTIVITY 10

To show that sound travels in air.

Ask your friend to ring a bell. You will notice that the sound of the bell can be heard from any place near the bell. This shows that sound can travel through air or gas.

Fig. 6.17 Sound travels in air

SOUND TRAVELS IN AIR IN THE FORM OF LONGITUDINAL WAVES

We have read that sound is a form of energy because it is produced when a body vibrates. During vibrations, the kinetic energy changes into potential energy and the potential energy changes into kinetic energy. The sound energy in air is transmitted from one place to another place by wave motion. In wave motion, the particles of the medium do not leave their mean positions but they vibrate about their mean positions.

When a body vibrates, the particles of air surrounding it start vibrating about their mean positions. During vibrations, they push or pull the nearby particles and transfer some energy to them. They then start vibrating faster and transfer energy to the next surrounding particles. This process continues till the vibrations reach the ear of a person.

Such vibrations of particles in air are in the direction of propagation of sound and they form longitudinal waves. In a longitudinal wave, at points C on either side of which the particles of air move towards the point C, is called *compression* and the point R on either side of which particles of air move away from the point R is called *rarefaction* as shown in Fig. 6.18. The arrows in the diagram show the direction of movement of air particles.

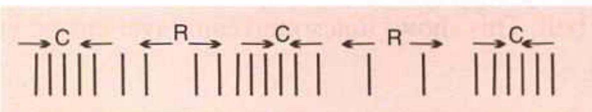


Fig. 6.18 Formation of a longitudinal wave when sound travels in air

One wave is from a compression to the next compression or from a rarefaction to the next rarefaction.

A longitudinal wave is graphically represented by the displacement-distance graph as shown in Fig. 6.19. This graph shows the displacement of particles of medium at different distances at the same time.

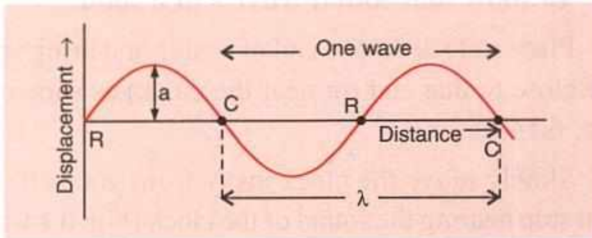


Fig. 6.19 Displacement-distance graph of a longitudinal wave

Another way to represent a longitudinal wave is displacement-time graph which represents the displacement of particles of the medium with time at a given position. Fig. 6.20 shows the displacement-time graph in which time of one wave is represented by letter T called *time-period* of the wave.

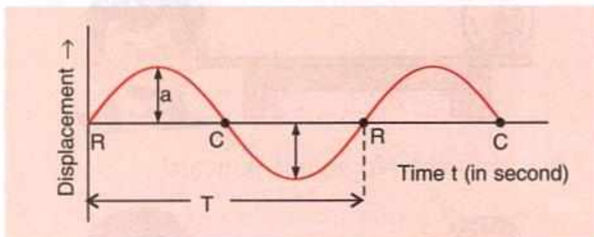


Fig. 6.20 Displacement-time graph of a longitudinal wave

Do You Know ?

(1) The distance travelled in one direction is called displacement.

(2) In a longitudinal wave, the distance moved towards right is on +Y axis and distance moved towards left is on –Y axis.

(3) Frequency of wave $f = \dfrac{1}{\text{Time period (T)}}$

(4) Speed of wave V = frequency f × wavelength (λ).

(5) In displacement – distance graph if there are more waves in the same distance, then wave length is less, but frequency of sound is the same.

(6) In displacement-time graph, if there are more waves in a given time period, then T is less and frequency is more.

SOME TERMS RELATED TO A WAVE

One vibration : The to and fro motion vhich constitutes one full wave is called one ibration. In Fig. 6.19, one wave is from one arefaction to the next rarefaction or from one ompression to the next compression.

Wavelength : The length of a wave orresponding to one vibration is known as ts wave length. It is represented by the symbol ambda (λ) as shown in Fig. 6.19. It is neasured in metre.

Amplitude : The maximum displacement f a wave on either side of its mean position s known as the amplitude. In Fig. 6.19 and ig. 6.20, '*a*' is the amplitude of the wave. It s measured in metre.

Time period : The time taken by a wave o complete one vibration is known as its time eriod. It is always denoted by the letter T and s measured in second, as shown in Fig. 6.20.

Frequency : The number of vibrations roduced by the source of sound wave in one econd is known as its frequency. It is denoted y *f* or *n*. The unit of frequency is hertz which s denoted by the symbol Hz.

Do You Know ?

1. The amplitude of vibrations of a body in air gradually decreases due to friction of air and ultimately it dies out.

2. The frequency of a wave is equal to the inverse of its time period. *i.e.*, frequency = 1/time period.

AUDIBLE SOUND

We have read that all vibrations cause sound. But the human ear cannot hear sounds of all frequencies. We can hear sounds of frequencies in the range from 20 hertz to 20,000 hertz. We cannot hear sounds of frequency below 20 Hz and above 20,000 Hz. The range of frequency from 20 Hz to 20,000 Hz is called the audible range for the normal human ear.

ULTRASONIC SOUND

Sounds of frequency higher than 20,000 Hz are called ultrasonic (or supersonic) sound. We cannot hear ultrasonic sounds.

Some animals like dogs, bats, monkeys, deers, leopards, etc., can hear ultrasonic sounds. Dogs can hear sounds of frequency upto 50,000 Hz. Bats can hear sounds of frequency upto 100,000 Hz.

Use of ultrasonics by bats : At night, bats easily move about without colliding with any object (or obstacle). The reason is that they produce ultrasonic sound as they fly. When this ultrasonic sound comes back after reflection from any object (or obstacle) in their way, they hear it and thus, they detect the presence of the object (or obstacle) and change their path.

INFRASONIC OR SUBSONIC SOUND

Sounds of frequency lower than 20 Hz are called infrasonic (or subsonic) sounds. We cannot hear the infrasonic sounds. *For example*, the pendulum of a clock makes one vibration in 2 second. The frequency of sound produced due to its vibrations is 0·5 Hz. It is infrasonic sound and hence we can not hear it.

The frequency range of different sounds can be summarized as follows :

Frequency range	Sound
1. Below 20 Hz	Infrasonic or subsonic
2. 20 Hz – 20,000 Hz	Audible
3. Above 20,000 Hz	Ultrasonic

Do You Know ?

1. Both ultrasonic and infrasonic sounds are inaudible for human beings.

2. The speed of audible or inaudible (*i.e.*, ultrasonic or infrasonic) sound is same in a given medium.

3. An infant (about 1 year old) can hear sounds up to 35,000 Hz. This limit gradually decreases to 20,000 Hz for an adult.

CHARACTERISICS OF SOUND

A sound wave is characterized by its amplitude and frequency. Depending upon the amplitude and frequency of the sound wave, we have the following two characteristics of sound :

(1) Loudness, and

(2) Pitch.

(1) Loudness

The loudness of a sound depends on the amplitude of vibration of the vibrating body producing the sound.

Greater the amplitude of vibrations, louder is the sound produced.

Fig. 6.21 shows two waves A and B of amplitudes a_1 and a_2 respectively. The amplitude a_2 of wave B is greater than the amplitude a_1 of wave A. Therefore, the wave B produces a louder sound than the wave A.

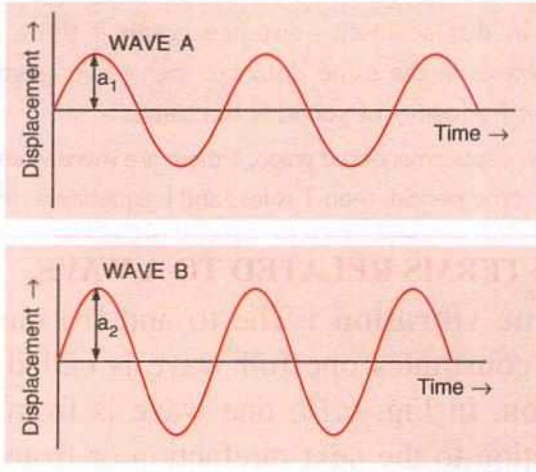


Fig. 6.21 Wave B produces a louder sound than wave A

If you gently pluck the string of a sitar o. guitar, a soft (or feeble) sound is heard. But if you pluck the string hard, it moves more from its rest position *i.e.*, the amplitude of vibration increases and so a loud sound is heard.

Similarly, if you strike a drum gently, a feeble sound is heard. But if you strike it hard, you hear a loud sound.

Thus, loudness is a characteristic of sound which distinguishes a loud sound from a feeble sound.

The loudness of sound also depends on the area of the vibrating body. Greater the area of the vibrating body, louder is the sound produced.

If you take two drums, one small and the other big, and beat both of them to produce vibrations in them, you will notice that the sound produced from the big drum is louder than that produced from the small drum. In temples, you must have noticed that a bell with a big case produces a louder sound than that with a small case. Dependence of loudness on amplitude of vibration can be demonstrated by the following activity.

ACTIVITY 11

Place a ping-pong ball on the membrane of a drum. Beat the membrane gently with a drum stick. A feeble sound is heard and the ball hops up and down slowly. Now beat the membrane harder with a drum stick. The drum produces louder sound and the ball jumps higher.

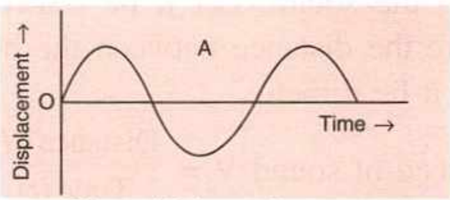
(2) Pitch

Pitch is the high or low frequency of a sound.

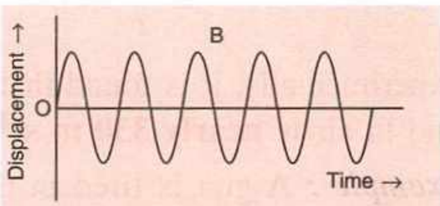
The pitch of a sound depends on its frequency (*i.e.*, number of vibrations produced per second by the body).

A sound of high frequency is said to have a higher pitch while a sound of low frequency is said to have a low pitch.

Fig. 6.22 shows two waves A and B in which the wave B is of higher frequency than the wave A, so the pitch of wave B is higher than that of A.



Wave with lower frequency
(Low pitch sound)



Wave with higher frequency
(High pitch sound)

Fig. 6.22 Wave B is of higher pitch than the wave A

Higher the pitch, shriller is the sound. But if the pitch is low, the sound is flat or grave.

The voice of a girl is shriller than that of a boy because the voice of the girl is of a higher pitch. The voice of a child is shriller than that of an adult.

Pitch is a characteristic of sound which distinguishes a shrill sound from a flat (or grave) sound.

Fig. 6.23 (a) shows a test tube with a little water in it. If you blow air in the tube by placing your lip on the mouth of the test tube, you will hear a flat sound (*i.e.*, a sound of low pitch). Now add more and more water in the test tube as shown in Fig. 6.23 (b), (c) and (d) so that the length of vibrating air column above the water level decreases. You will notice that the sound produced becomes more and more shrill.

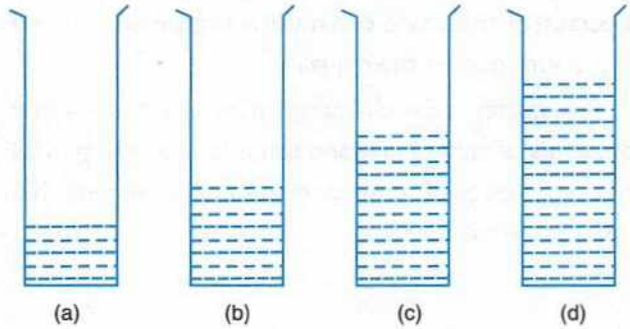


Fig. 6.23 The sound becomes shriller as the length of air column decreases

If you place a pitcher below a water tap, you will notice that the sound produced due to vibrations in its air column also becomes shriller as the level of water in the pitcher increases.

If you take a post card and rub it slowly against the teeth of a comb, you will hear a grave sound. But if you rub the same post card against the teeth of the comb rapidly you will notice that the sound produced now is shriller than before.

In musical instruments like flute and clarinet, the pitch of sound is changed by changing the length of vibrating air column when different holes in it are closed. In stringed instruments such as guitar, sitar, piano, violin, the pitch of sound can be changed in two ways.

(a) By changing the place of plucking (or striking) on the string.

(b) By changing the tensions and thickness of string. The stringed instruments are provided with a number of strings of different thickness and under different tensions so that each string produces sound of a different pitch.

Do You Know ?

1. Two sounds of same loudness and same pitch may differ in quality of wave form. We recognize the voice of a person or the sound of a musical instrument without seeing them, due to their quality.

Thus, quality is the characteristic which distinguishes two sounds of same pitch and same loudness. Fig. 6.24 shows two waves of same loudness and same pitch but of different wave forms.

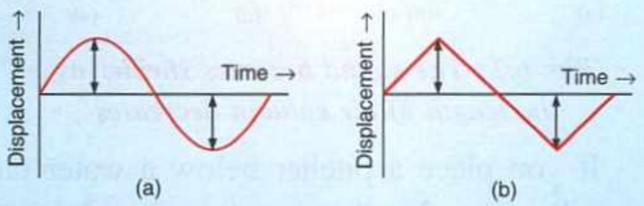


Fig. 6.24 Two sounds of different wave forms

2. A loud, harsh, irregular and undesirable sound which may cause headache, is called noise.

SPEED OF SOUND

We have read that sound cannot travel in vacuum. It can travel only in a medium whether solid, liquid or gas.

If you watch a blacksmith while working, you will notice that the sound produced on striking the hammer is heard a little later than when the hammer actually strikes. This shows that sound takes some time to travel a certain distance in a medium.

Similarly, you must have noticed that in the rainy season, the sound of thunder is heard much later than the flash of light is seen. The reason is that light travels much faster than sound. It takes negligible time for light to reach us, while sound takes a much longer time to reach us. This fact is used to estimate the speed of sound in air.

Estimation of speed of sound in air

To estimate the speed of sound in air, suppose we choose two hills A and B about a kilometre apart. A person at the hill A fires a gun. Another person at the hill B starts a stop watch as he sees the flash of the fire and stops it on hearing the sound. Thus, he measures the time interval between the sight of flash and hearing the sound. Let it be t second. Then measure the distance between the hills A and B. Let it be d metre.

$$\text{The speed of sound } V = \frac{\text{Distance } (d)}{\text{Time } (t)}$$

$$= \frac{d}{t} \text{ m s}^{-1}.$$

Experimentally, it is found that the speed of sound in air is **nearly 330 m s^{-1}**.

Example : A gun is fired in the air at a distance of 660 m from a person. He hears the sound of the gun after 2 second. Find the speed of sound.

Given : Distance travelled by the sound = 660 m

Time taken by the sound = 2 second

Speed of sound

$$= \frac{\text{Distance travelled by the sound}}{\text{Time taken by the sound}}$$

$$= \frac{660 \text{ m}}{2 \text{ s}} = 330 \text{ m s}^{-1}$$

Thus, the speed of sound in air is 30 m s^{-1}.

peed of sound in different media

Sound travels faster in liquids than in ases. The speed of sound in water is nearly 500 m s^{-1}, while in air it is nearly 330 m s^{-1}.

Sound travels much faster in solids than n liquids or gases. The speed of sound in steel s nearly 5960 m s^{-1}. This is the reason why eople living near railway tracks often press heir ears against the track and predict whether train is coming or not. The sound produced y the moving wheels of train travels much aster through the track than through air. Therefore, they hear the sound through the rack much before it is heard through air.

Speed of Sound in different media

Medium	Speed of sound
1. **Solid**	
Iron	5100 m s^{-1}
Steel	5960 m s^{-1}
2. **Liquid**	
Water	1500 m s^{-1}
3. **Gas**	
Air	330 m s^{-1}

ACTIVITY 12

To show that sound travels faster in solids than air.

Take a long metal rod. Keep it on a flat surface such as a table. Bring your ear close to one end of the rod as shown in Fig.6.24. Ask your friend to gently strike the other end of the rod by a hammer.

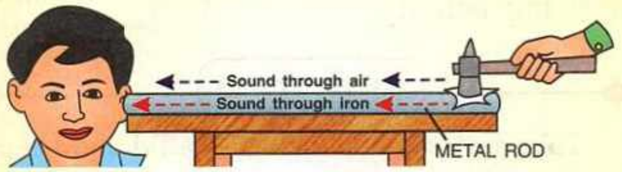


Fig. 6.25 Sound travels faster through a solid medium than through air

You will hear the sound two times. First, through the metal rod and second, through the air.

Thus, it is concluded that sound travels faster through a solid than through air.

Do You Know ?

1. The speed of sound in a medium increases with increase in temperature. It increases by 0·61 m s^{-1} in air for each 1°C rise in temperature.

2. The speed of sound is more in humid air than in dry air.

REFLECTION OF SOUND

When sound strikes a hard surface, it returns within the same medium like light. The return of sound after striking a surface is called reflection of sound. The reflection of sound takes place obeying the two laws of reflection :

(1) the angle of incidence is equal to the angle of reflection, and

(2) the incident sound, reflected sound and normal are all in one plane. These laws of reflection are same as obeyed by light in reflection.

For reflection of sound, the surface must be of bigger size. It may be smooth or hard. The reflection of sound is used in making the speaking tube (or megaphone), sound board and trumpet. This can be demonstrated by the following activity.

ACTIVITY 13

Take a glass container with a lid and keep a ticking clock inside as shown in Fig. 6.26 You will not be able to hear the ticking sound very clearly when the container is closed. Now slowly lift the lid from one end. You will notice that when the lid is at a particular angle, the sound is heard most distinctly. The reason is that sound is reflected by the lid obeying the laws of reflection as shown in Fig.6.26

Fig. 6.26 Reflection of sound waves

Echo : You might have experienced that if you stand closer to a well, facing the water or at a large distance from the wall of a big empty hall (or a hill side) and produce a sharp sound, you will hear two sounds — the original sound and the other sound after a fraction of a second. The second sound which is heard after some time is the sound produced after reflection from the water in the well or from the wall of a hall (or hill side). This sound is called echo.

Echo is the distinct sound heard after reflection from a distant rigid surface such as a cliff, a hillside, the wall of a building, etc.

To hear echo, the sound after reflectio from the rigid surface should reach the ear least 0·1 s after the original sound is hear This is because the original sound persists i the ear for about 0·1 s. If the reflected soun reaches the ear before this interval of time, will intermingle with the original sound and i will not be possible for us to distinguish th two sounds.

We know that the speed of sound in air i nearly 330 m s^{-1}. In 0·1 s, the sound will trave a distance = 330 m s^{-1} × 0·1 s = 33 m.

Since sound has to travel an equa distance in going up to the reflecting surfac and in coming back from the reflecting surface therefore it must travel nearly 33/2 = 16·5 m either way. Thus, to hear the echo clearly i air, the reflecting surface should be at a minimum distance of 16·5 m* from the sourc of sound.

ABSORPTION OF SOUND

When sound falls on sofa, fluffs and light substances such as clothes, papers, thermocol, coating of plaster of paris, carpets, curtains, furniture, wood etc., it is absorbed to a good extent. These substances are called *good absorbers of sound.*

A sound proof box means an enclosure such as theatre, auditorium etc. which does not allow the internal sound to come out and the external sound to enter in. In order to design such a box, we take the following measures :

1. The roof of the enclosure must be covered by plaster of paris after putting the sheets of thermocol.

* This distance is different for different media.

2. The walls of the enclosure should be covered by wooden strips.
3. The floor must be laid down by thick carpets.
4. The machine parts of all the electrical equipments such as fan, air conditioner etc. must be placed outside the enclosure.
5. Thick curtains should be used to cover the doors and keep them closed.
6. Thick stripping must be used to cover the openings of doors and windows.

A sound proof box can be designed by .e following activity.

ACTIVITY 14

To design a sound-proof box

Take a card board shoe box. Fix a lining of bubble wrap plastic or egg carton on the internal six surfaces of the box. Tightly close the cover of the box with the help of cellotape. This box will work as a sound-proof box.

To check, a clock may be placed inside the box. You will find that no ticking sound of clock is heard outside the box.

SOLVED EXAMPLES

1. A boy fires a gun and another boy at a distance of 1360 m hears the sound of firing the gun 4 s after its smoke is seen. Find the speed of sound.

Given: Distance $d = 1360$ m, time $t = 4$ s

$$\text{Speed of sound } V = \frac{\text{Distance } d}{\text{Time } t} = \frac{1360\,\text{m}}{4\,\text{s}}$$

$$= 340 \text{ m s}^{-1}.$$

2. During a thunderstorm, the thunder is heard 2·5 seconds after the flash of lightning is seen. If the speed of sound is 330 m s^{-1}, find the distance at which lightning took place.

Given : Time taken by sound $t = 2{\cdot}5$ s, speed of sound $V = 330$ m s^{-1}

$$\text{Speed of sound } V = \frac{\text{Distance } d}{\text{Time } t}$$

$$\text{Distance } d = V \times t = 330 \times 2{\cdot}5 = 825 \text{ m}.$$

RECAPITULATION

- The to and fro motion in which a body assumes a new shape during its motion, is called vibratory motion.
- Sound is a form of energy that produces the sensation of hearing in our ears.
- Sound is produced when a body vibrates. In other words, each source of sound is a vibrating body.
- In wind instruments such as flute, clarinet etc., the pitch of sound is changed by changing the length of vibrating air column. As the length of vibrating air column decreases, the pitch of sound increases.
- In stringed instruments such as violin, sitar, piano etc., the pitch of sound is changed either by changing the place of plucking (or striking) or by changing the tension on string. For this, several strings are provided in such instruments which are stretched at different tensions.

- A tuning fork produces sound when its prong is struck gently to a rubber pad.
- The vocal cords of a human vibrate to produce sound.
- Sound needs a medium for its propagation.
- Sound can not travel in vacuum.
- Sound can travel in all mediums : solid, liquid and gas.
- Sound travels in air in the form of longitudinal wave.
- In a longitudinal wave, the particles of air vibrate to and fro about their mean positions in the direction of propagation of sound.
- We can hear sounds of frequency in the range from 20 Hz to 20,000Hz. This is called audible range for the normal human ear.
- Sounds of frequency higher than 20,000 Hz are called ultrasonics and sounds of frequency lower than 20 Hz are called infrasonics. We can neither hear ultrasonics nor infrasonics.
- Some animals like dogs, bats, monkeys, leopards and deers can hear ultrasonic sounds. Bats make use of ultrasonics for finding their way when flying at night.
- One complete to and fro motion of the particle of medium is called one vibration.
- The maximum displacement of a vibrating particle from its rest (or mean) position is called its amplitude. It is expressed in metre.
- The time taken by a vibrating particle to complete one vibration is called its time period. It is expressed in second.
- The number of complete vibrations that a vibrating particle makes in one second is called its frequency. It is expressed in hertz (symbol Hz).
- Different sounds can be differentiated by their loudness, pitch and quality.
- The loudness of sound depends on the amplitude of vibration of the vibrating body producing the sound. Greater the amplitude, louder is the sound produced.
- Loudness is the characteristic of sound which distinguishes a loud sound from a feeble sound.
- The loudness of sound increases if the vibrating area of the body is increased.
- The pitch of a sound depends on the frequency of the vibrating body. A sound of high frequency is said to have a high pitch, while a sound of low frequency is said to have a low pitch.
- Higher the pitch, the shriller is the sound. Lower the pitch, flat (or grave) is the sound.
- Pitch is a characteristic of sound which distinguishes a shrill sound from a flat (or grave) sound.
- Quality is a characteristic of sound which distinguishes two sounds of the same pitch and same loudness since they differ in waveform due to the presence of other frequencies.
- Sound travels much faster in solids, less in liquids and the least in gases. The speed of sound in steel is nearly 5960 m s^{-1}, in water it is nearly 1500 m s^{-1} and in air it is nearly 330 m s^{-1}.
- The return of sound after striking a bigger surface is called reflection of sound. The reflection of sound obeys the laws of reflection *i.e.* $\angle i = \angle r$.
- Echo is the sound heard after reflection from a rigid surface such as cliff, a hillside, the wall of a big hall etc.

- A sound persists in the human ear for about 0·1 s.
- To hear an echo in air clearly, the reflecting surface should be at a minimum distance of 16·5 m from the source of sound.
- If d is the distance of the reflecting surface from the source of sound and t is the time interval in which the echo is heard, then speed of sound $V = 2d/t$.
- Some substances such as cloth, wood, paper, thermocol, etc. absorb the sound falling on them.

TEST YOURSELF

A. Objective Questions :

1. Write **true** or **false** for each statement :

(a) Sound can travel in vacuum.

(b) Sound is a form of energy.

(c) Sound can only be produced by vibrating bodies,

(d) Larger is the amplitude, feeble is the sound.

(e) The frequency is measured in hertz.

(f) Loudness depends on frequency.

(g) Waveforms of two different stringed instruments can be the same.

(h) Female voice is shriller than the male voice.

(i) A ticking clock sound is heard late when heard through a metal.

Ans. True (b), (c), (e), (h)

False (a), (d), (f), (g), (i)

2. Fill in the blanks :

(a) Sound is produced when a body ....

(b) The number of times a body vibrates in one second is called its ....

(c) The pitch of a sound depends on its ....

(d) Sound can travel in ....

(e) We can hear sounds of frequency in the range of ....

(f) Sound requires a .... for propagation.

(g) Sound travels faster in .... than in liquids.

(h) The sound heard after reflection is ....

(i) .... produces sensation in ears.

Ans. (a) vibrates (b) frequency (c) frequency (d) a medium solid, liquid or gas (e) 20 Hz to 20,000 Hz (f) medium (g) solids (h) echo (i) sound

3. Match the following :

Column A	Column B
(a) Vibrations cause	(i) absorb sound
(b) A shriller sound is	(ii) second
(c) Unit of frequency	(iii) sound
(d) Unit of time period	(iv) of high pitch
(e) Curtains	(v) hertz

Ans. (a)–(iii), (b)–(iv), (c)–(v), (d)–(ii), (e)–(i)

4. Select the correct alternative :

(a) We can distinguish a shrill sound from a flat sound by its :

(i) amplitude

(ii) loudness

(iii) pitch

(iv) none of the above.

(b) We can hear sound of frequency :

(j) 10 Hz (ii) 500 Hz

(iii) 100,000 Hz (iv) 50,000 Hz.

(c) Sound cannot travel in :

(i) gases (ii) liquids

(iv) solids (iv) vacuum.

(d) The minimum distance required between the source and the reflector so as to hear the echo in air is :

(i) 10 m (ii) 17 m

(ii) 34 m (iv) 50 m.

(e) Wavelength is measured in :

(i) kg (ii) second

(ii) litre (iv) metre

(f) The speed of sound in water is :

(i) 332 m s^{-1} (ii) 1500 m s^{-1}

(ii) 5000 m s^{-1} (iv) 1000 m s^{-1}

(g) Sound travels the fastest in :

(i) liquids (ii) solids

(iii) gases (iv) vacuum

Ans. (a)–(iii), (b)–(ii), (c)–(iv), (d)–(ii). (e)–(iv), (f)–(ii), (g)–(ii)

B. Short/Long Answer Questions :

1. What do you mean by a vibratory motion ?
2. What is sound ?
3. How is sound produced ?
4. Describe an experiment to show that each source of sound is a vibrating body.
5. Name two sources of sound.
6. How do we produce sound ?
7. The bees do not have voice-boxes but they still make sound. How ?
8. Can sound travel through a vacuum ? Describe an experiment to explain your answer.
9. Describe an experiment to show that sound can travel in water.
10. Describe an experiment to show that sound can travel in a solid.
11. Can two persons hear each other on moon's surface ? Give reason to support your answer.
12. What is a longitudinal wave ?
13. Define the following terms :

    Amplitude, Time period, Frequency.
14. Write the audible range of frequency for the normal human ear.
15. What are ultrasonics ? Can you hear the ultrasonic sound ?
16. What are infrasonics ? Can you hear them ?
17. How does a bat make use of ultrasonic waves to find its way ?
18. Name the two characteristics of sound which differentiate any two sounds from each other.
19. On what factor does the loudness of a sound depend ?
20. How does the loudness of sound produced depend on the vibrating area of the body ?
21. The outer case of the bell in a temple is made big. Give a reason.
22. State the factors on which the pitch of a sound depends.
23. Differentiate between a high pitch sound and a low pitch sound.
24. How does a man's voice differ from a woman's voice ?
25. Name the characteristic which differentiates two sounds of the same pitch and same loudness.
26. You recognize your friend by hearing his voice on a telephone. Explain.
27. A musician recognizes the musical instrument by hearing the sound produced by it, even without seeing the instrument. Which characteristic of sound makes this possible ?
28. Describe an experiment to show the production of sound having low and high pitch.

29. How does a musician playing on a flute change the pitch of sound produced by it ?

30. Why are musical instruments provided with more than one string ?

31. How can the pitch of sound produced in a piano be changed ?

32. Explain why you can predict the arrival of a train by placing your ear on the rails without seeing it.

33. Write the approximate speed of sound in (i) air, (ii) water and (iii) steel.

34. During a thunderstorm, the sound of a thunder is heard after the lightning is seen. Why ?

35. Describe an experiment to estimate the speed of sound in air.

36. Can sound travel through solids and liquids ? In which of these two does it travel faster ?

37. What do you mean by reflection of sound ?

38. State one use of reflection of sound.

39. What is an echo ?

40. What minimum distance is required between the source of sound and the reflecting surface to hear an echo ? Give reason.

41. List four substances which are good absorbers of sound.

42. List the measures that you will take when designing a sound-proof room.

C. Numericals

1. A boy fires a gun and another boy at a distance of 1020 m hears the sound of firing the gun 3 s after seeing its smoke. Find the speed of sound.

Ans. 340 m s^{-1}

2. A boy on a hill A fires a gun. Another boy on hill B hears the sound after 4 s. If the speed of sound is 330 m s^{-1}, find the distance between the two hills.

Ans. 1320 m

7

Electricity and Magnetism

Theme : The basic law of electromagnetism states that "Like poles of magnets repel one another and unlike poles attract". When an electric current is passed through a coil, the coil behaves like a magnet. This magnet is called an electromagnet. The strength of this magnet is increased by inserting a core of suitable material. Many objects around us, like electric bell, electric motor, loudspeaker, etc. have electromagnets in them. A cell is a source of electricity and are used in torches, watches, calculators, etc. When connected to a device like bulb, it sends current through the bulb and the bulb lights up. Flow of charges constitute current. Materials that allow current to flow through them are called conductors whereas materials that do not allow passage of current through them are called insulators. Children will learn how electric components are arranged in simple series and simple parallel arrangements.

In this chapter you will learn to

- state law of magnetism;
- describe test for a magnet;
- explain the phenomenon of electromagnetism;
- describe an electromagnet and its uses;
- explain construction and working of an electric bell;
- relate current to flow of charge;
- recognize electric cell as a source of electricity;
- define resistors as the component that opposes the flow of current;
- represent different components like cell, battery, key, bulb, connecting wire, resistor by standard symbols;
- make simple series circuits and simple parallel circuits;
- recognize battery as series combination of cells;
- define conductors and insulators of electricity;

LEARNING OBJECTIVES

- Revisiting previous concepts.
- Building on children's previous learning.
- Demonstrating and explaining the law of electromagnetism.
- Demonstrating simple electromagnets.
- Engaging children to demonstrate electromagnets.
- Description of use of electromagnets.
- Demonstrating the construction and working of electric bells.
- Demonstrating electric cell and explanation of its working.
- Familiarizing children with symbols for electric components.
- Explaining the role of key in electric circuits.
- Explaining the precautions to be taken before an electric circuit is switched-on.

- Engaging children in making simple electric circuits.
- Engaging children in practical tasks involving Series and Parallel combinations.
- Engaging children in design of activity to test whether a given object is good or bad conductor of electricity.
- Showing video on earth's magnetic declination from the true north.

KNOWING CONCEPTS

- Laws of magnetism.
- Test of a magnet (by repulsion).
- Electromagnetism, Electromagnets and their applications — Electric bell.
- Electric current as a flow of charges.
- Electric cell as source of electricity.
- Resistors as components that oppose the flow of current.
- Symbolic representation of electrical components (key, battery, bulb, conducting wire, resistor).
- Simple electric circuit — Series and Parallel.
- Battery as a collection of cells connected in series.
- Good and bad conductors of electricity.

INTRODUCTION

We have read that the first magnet was discovered nearly 5000 years ago in a town called Magnesia in Greece (now in Turkey) in the form of a rock. It was called lodestone since it was capable of guiding direction. It was an ore of iron called the magnetite. The word magnet has been derived from the name of the town Magnesia.

The natural magnet (*i.e.*, the ore of lodestone) being irregular in size and weak in magnetic strength was found not of much use. Therefore, artificial magnets such as bar magnet, magnetic needle, horse-shoe magnet, compass etc. are made for practical use.

A magnet has the following useful properties :

(1) A magnet attracts small pieces of iron *i.e.*, it has attractive property.

(2) A magnet always rests in the north-south direction if it is suspended so as to swing freely *i.e.*, it has directive property.

(1) Attractive property of a magnet

A magnet has a property of attracting small pieces of iron towards it. This property of attraction is not the same everywhere along the length of a bar magnet but is maximum near the ends of a bar magnet.

The ends of the magnet where the attractive property is maximum are called the magnetic poles of the magnet.

(2) Directive property of a magnet

If a magnet is suspended with a silk thread from a wooden stand as shown in Fig. 7.1, the magnet swings for some time and then finally

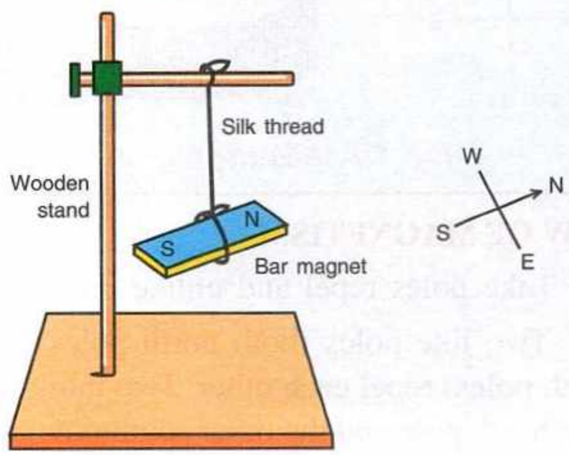


Fig. 7.1 North and south poles

comes to rest in a particular direction, *i.e.*, north-south direction. If we disturb the magnet a little, the magnet again comes to rest in the same north-south direction.

The end of the magnet which points towards the north is called the north seeking pole or simply the north pole and the end which points towards the south, is called the south seeking pole or simply the south pole. North and south poles are marked by the letters N and S respectively. Sometimes a red dot is etched on the north pole.

Do You Know ?

A magnetic compass is used to locate directions at a place.

Fig. 7.2 shows a magnetic compass. It is a small magnetic needle pivoted at the centre of a small brass box which has a glass top. The needle is free to rotate. One end of the needle is painted red which indicates its north pole. When the magnetic compass is placed on a table, the needle rests in north-south direction with the red end pointing towards the north.

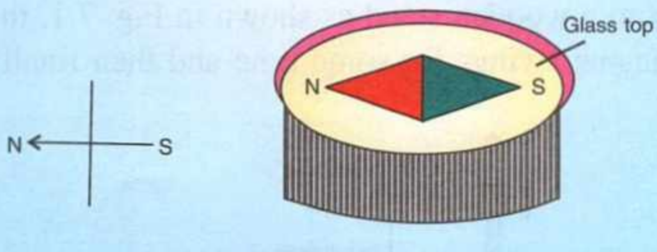


Fig. 7.2 Magnetic compass

LAW OF MAGNETISM

Like poles repel and unlike poles attract.

Two like poles (both north poles or both south poles) repel each other. Two unlike poles (one north pole and the other south pole) attract each other. This can be demonstrated by the following simple activity.

ACTIVITY 1

Take two bar magnets A and B. Suspend one magnet A with a silk thread from a support so that it is free to swing. The magnet A will come to rest in the north-south direction. The north pole of the magnet A is in the north direction and its south pole is in the south direction. Now hold the other magnet B in your hand and bring its north pole near the north pole of the suspended magnet A as shown in Fig. 7.3. You will observe that the two poles repel each other. Care is taken that the two magnets do not touch each other.

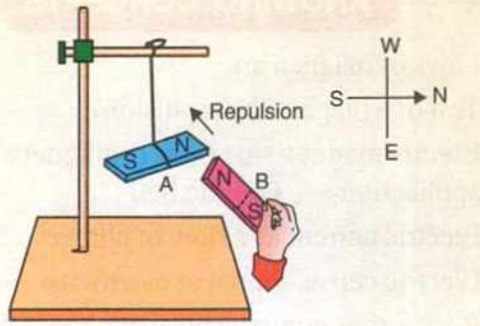


Fig. 7.3 Like poles repel

Now if you bring the south pole of the magnet B near the north pole of the suspended magnet A as shown in Fig. 7.4, without touching it, you will observe that the two poles attract each other.

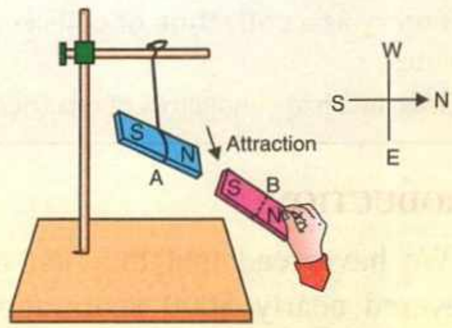


Fig. 7.4 Unlike poles attract

The above experiment shows that like poles repel each other while unlike poles attract each other.

Do You Know ?

1. The magnetic poles always exist in pairs. It is not possible to separate the two poles of a magnet.

If a bar magnet is broken at the middle in two parts, each part is found to be a magnet. Each part has the property to attract small iron pieces. Each part rests in the north-south direction when suspended such as to swing freely. This shows that new poles are formed at the broken ends.

If these pieces are broken again and again, each part will still be a complete magnet. Each part contains both the poles (N pole and S pole). Thus, the two poles of a magnet exist simultaneously.

2. Magnetic materials : Materials which are attracted by a magnet, are called magnetic materials. Iron, steel, cobalt and nickel are magnetic materials.

3. Non-magnetic materials : Materials which are not attracted by a magnet, are called non-magnetic materials. Paper, wood, brass, plastic, copper, aluminum etc., are non-magnetic materials.

Whether a given bar is a magnet or not can be tested by the following activities.

ACTIVITY 2

To identify a magnet.

Suppose you are given two identical bars A and B, out of which only one is a magnet and the other is a simple iron bar. You are to identify the magnet.

Place the bar A on the table. Touch one end of the bar B to the bar A, first at one end, then at the other end and finally at the middle. If the bar B sticks to the bar A at both the ends as well as at the middle of bar A, then the bar A will be an iron bar.

Repeat the above process by placing the bar B on the table and touching the bar A at one end, then at other end and finally in the middle of bar B. You will find that the bar A will be attracted to the ends of bar B, but it will not be attracted at the middle of bar B, so bar B is a magnet.

ACTIVITY 3

To test whether a given rod is a magnet or not.

(1) Take a magnet. First bring its north pole towards one end of the rod to be tested and observe what happens. Reverse the pole of the magnet and again bring it near the same end of the rod. Again observe what happens.

If there is attraction in both the cases, the given rod is not a magnet. However, if there is attraction in one case and repulsion in the other case, the given rod is a magnet.

(2) Suspend the given rod such that it swings freely. Note the direction in which the rod rests. Repeat the process two-three times.

If the rod rests in a particular direction pointing north and south in each case, the rod is a magnet. However, if the rod rests in any direction, it is not a magnet.

REPULSION IS THE SURE TEST FOR A MAGNET

Repulsion is a sure test for a magnet. The reason is that a magnet will attract a magnetic substance (such as iron rod) as well as it will attract another magnet when the unlike poles of the two magnets face each other. However, if two like poles face each other, then repulsion will indicate that both are magnets.

MAGNETIC FIELD

We have read that on placing a magnetic compass on a table, its needle rests in the north-south direction. Now if a bar magnet is placed on the table near a magnetic compass, we observe that the magnetic needle of compass swings and then rests in a direction other than north-south. Now if we place the magnetic compass at different points around a bar magnet, we observe that the direction in which the magnetic needle of compass rests, changes. This shows that the space around the bar magnet has a property to influence the magnetic needle of the compass.

The space around a bar magnet in which the magnetic compass gets influenced is called its magnetic field.

ELECTROMAGNET

Discovery of the electromagnet : A Danish Physicist, Hans Christian Oersted, in 1819, discovered that there is a magnetic field around every wire carrying an electric current. This discovery has proved to be one of the most fruitful achievements in the history of physical science. This was the discovery of electromagnet which is widely used nowadays. Whenever we ring an electric bell, run a motor, talk over a telephone or listen to a transistor, we make use of the magnetic field produced by the current carrying wires. Electromagnets are also used in fans, motors, mixers, air conditioners, etc. They are used for lifting heavy iron loads.

Principle of an electromagnet : If an insulated copper wire is wound around a cylindrical card board of length much more than its diameter, we get a cylindrical coil (called solenoid) as shown in Fig. 7.5.

When the ends of the coil are joined to a dry cell and current is passed through it, the cylindrical coil carrying current behaves like a magnet *i.e.*, it produces a magnetic field around it. This magnet is called an **electromagnet**.

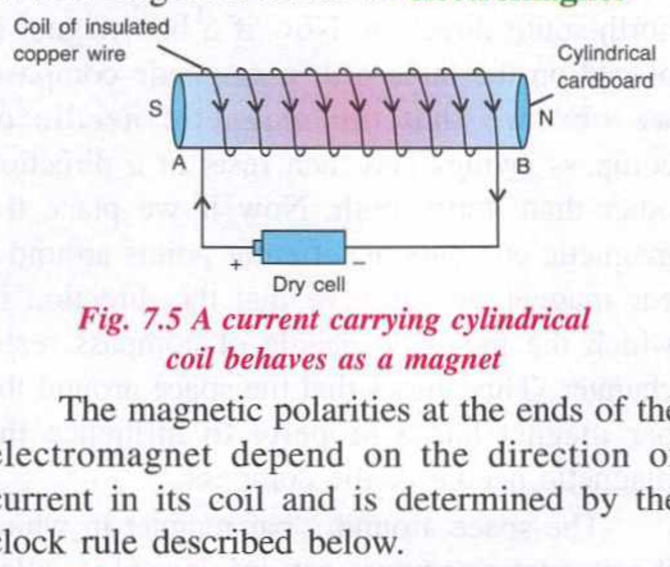


Fig. 7.5 A current carrying cylindrical coil behaves as a magnet

The magnetic polarities at the ends of the electromagnet depend on the direction of current in its coil and is determined by the clock rule described below.

Clock rule : The end of the electromagnet where the direction of current is anticlockwise, becomes the north pole N and the end where the direction of current is clockwise, becomes the south pole S as shown in Fig. 7.6.

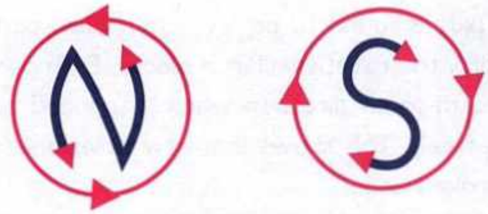


Fig. 7.6 Polarities N and S depending on the direction of flow of current

In Fig. 7.5, the end A becomes south pole because current at this end is clockwise. And the end B becomes north pole. This can be demonstrated by the following activity.

ACTIVITY 4

To show that a current carrying cylindrical coil becomes an electromagnet.

Take a hollow card board cylinder of length much larger than its diameter. Wind an insulated copper wire around the cylinder along its length. Suspend the cylinder by a silk thread from a support. Connect a dry cell with a switch between the ends A and B of the coil as shown in Fig. 7.7.

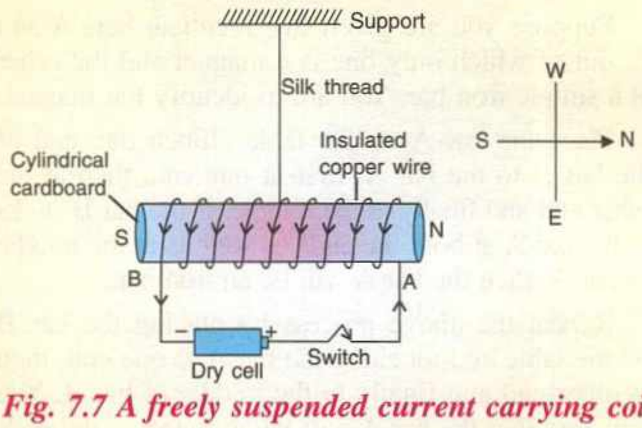


Fig. 7.7 A freely suspended current carrying coil

Now close the switch and watch the cylinder. You will find that after sometime the cylinder comes to rest in north-south direction. The end A at which the current is anticlockwise points towards the north while the end B at which the current flow is clockwise, points towards the south. This shows that a current carrying coil behaves as a magnet.

The polarities at the ends can be checked by bringing a compass box near the end A and B one by one. When the switch is opened, you will find that the cylinder will come to rest in any direction.

Ways of increasing the magnetic field of an electromagnet

The magnetic field of an electromagnet can be increased by the following three ways :

(1) By inserting a rod of soft iron or steel inside the cylindrical tube. This rod is called the core.

(2) By increasing the total number of turns of the coil, and

(3) By increasing the strength of current passing through the coil.

Do You Know ?

For a temporary electromagnet, soft iron is used as the core.

For a permanent electromanget, steel is used as the core.

MAKING AN ELECTROMAGNET

An electromagnet is a temporary magnet. It consists of a soft iron piece called the core on which a coil of insulated copper wire is wound. The ends of the coil are connected to the direct source of current (such as a cell or battery). It acquires the magnetic properties only when a current flows through the coil and loses the magnetic properties as soon as the current is switched off.

Usually, electromagnets are made in two shapes : (i) bar or I shaped magnet and (ii) horse shoe or U shaped magnet.

(1) To make a bar or I shaped electromagnet : Take a soft iron bar PQ and wind a thin insulated copper wire* around the bar. Connect a cell or a battery B, and a key K in series between the ends of the coil. The circuit diagram is shown in Fig. 7.8.

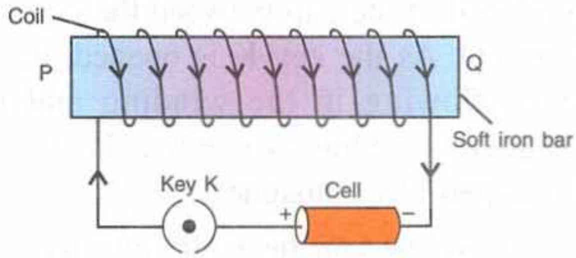


Fig. 7.8 Making a bar electromagnet

When key K is closed, current passes through the winding of the coil and the bar becomes a magnet. As the key K is opened, the current stops flowing in the coil and the bar loses its magnetism. Thus, the bar behaves like an electromagnet when current passes through the coil.

(2) To make a horse shoe or U shaped electromagnet : Take a U shaped soft iron piece and wind a thin insulated copper wire* on its arms such that the winding in the two arms is in opposite direction. In Fig.7.9 winding in the arm P starts from the front and is in clockwise direction (when seen from the bottom). On reaching the upper end of the arm P, winding starts from the back at the top of the arm Q and is in anticlockwise direction. Connect a battery B and a key K between the two ends of the wire.

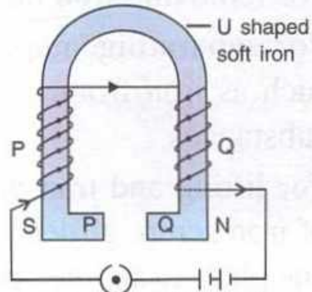


Fig. 7.9 Making a horse-shoe electromagnet

* **The copper wire is insulated by covering it with thread so that no two wires touch each other.**

When key K is closed, the current passes through the winding and the soft iron piece becomes a magnet. A magnetic field is produced in the gap between the ends of arms P and Q. As the key K is opened, the current stops flowing in the winding and it loses magnetism. Thus, we get a horse shoe or U shaped electromagnet.

A screw can be made an electromagnet by the following activity.

ACTIVITY 5

Take a long piece of insulated copper wire and wind it around a large screw as shown in Fig. 7.10 Attach the free ends of the wire to a dry cell. Now you have an electromagnet with which you can pick up small pieces of iron such as paper clips or small pins of iron.

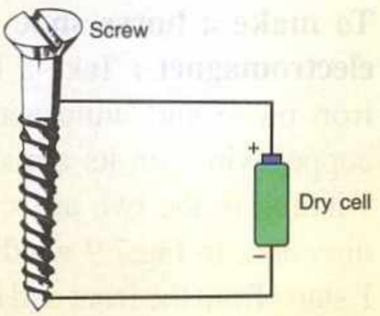


Fig. 7.10 Making of a screw as an electromagnet

USES OF ELECTROMAGNETS

The electromagnets are mainly used for the following purposes :

1. For loading furnaces with iron.
2. For removing iron dust from wounds.
3. For separating magnetic substances such as iron from other non-magnetic substances.
4. For lifting and transporting big pieces of iron scrap, girders, plates etc., from one place to another, particularly where it is inconvenient to take the help of human labour.
5. In electrical gadgets like electric bell, electric tram, electric motor, microphone, loudspeaker etc.

ELECTRIC BELL

An electric bell is one of the most common applications of an electromagnet.

Construction : Fig. 7.11 shows the structure of an electric bell, Its main parts are :

(i) A horse-shoe electromagnet,
(ii) A soft iron armature,
(iii) A hammer,
(iv) A gong,
(v) A metallic springy strip,
(vi) An adjusting screw,
(vii) A switch or bell push, and
(viii) A battery.

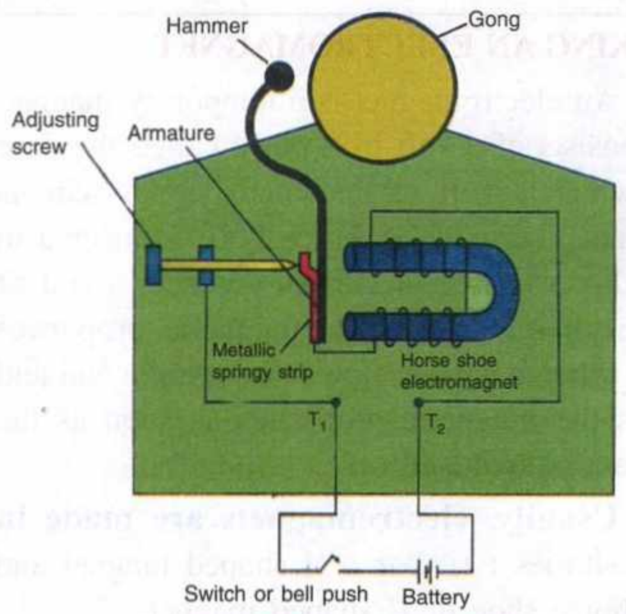


Fig. 7.11 An electric bell

The armature is fixed to the metallic springy strip. The hammer is attached at the end of the armature. The metallic springy strip remains in contact with the adjusting screw when the switch (or bell push) is not pressed.

The horse-shoe electromagnet is a U shaped soft iron piece having a coil wound on it such that the winding on its two arms is in opposite directions. One end of the coil is connected to the terminal T_1 through the metallic springy strip and the adjusting screw, while the other end of coil is connected directly to the terminal T_2. Between the terminals T_1 and T_2, a battery with a switch (or bell push) is joined.

Working of electric bell : Initially when the switch (or bell push) is not pressed, no current flows in the coil of electromagnet. The metallic springy strip remains in contact with the adjusting screw. As the switch (or bell push) is pressed, current flows through the coil of electromagnet. It becomes a magnet and so it attracts the armature. Due to movement of armature, the hammer strikes the gong and the bell rings. At the same time, the contact between the metallic springy strip and the adjusting screw breaks. As a result, the circuit becomes incomplete and current stops flowing in the coil of electromagnet, so it loses its magnetism. As the electromagnet loses its magnetism, the armature comes back to its initial position due to the spring action of the metallic springy strip and again the metallic springy strip comes in contact with the adjusting screw. This completes the circuit and again if the bell push remains pressed, the current flows in the coil of the electromagnet. It again becomes a magnet and attracts the armature with the result that the hammer strikes the gong again and the bell rings.

This process of making and breaking of circuit continues and the bell rings so long as the bell push remains pressed.

ACTIVITY 6

List *five* such electrical gadgets in your house in which electromagnet is used.

1. ....
2. ....
3. ....
4. ....
5. ....

EARTH'S MAGNETIC DECLINATION

We have read that our earth has a magnetic field of its own. This is why a magnetic needle when freely suspended, always rests in the geographic north-south direction. The earth's magnetic South Pole is in geographic north and the North Pole is in the geographic south. Since unlike poles attract, therefore, the north pole of the suspended needle is in geographic north while south pole is in geographic south.

Actually the north pole of the suspended magnet is not exactly along the geographic north, as shown in Fig. 7.12.

Magnetic declination is the angle of the horizontal plane between the magnetic north and the geographic north (or true north). This angle is shown in Fig. 7.12 by the *symbol* θ.

The angle of declination is different at different places on earth's surface and it also changes at a place with time. The declination

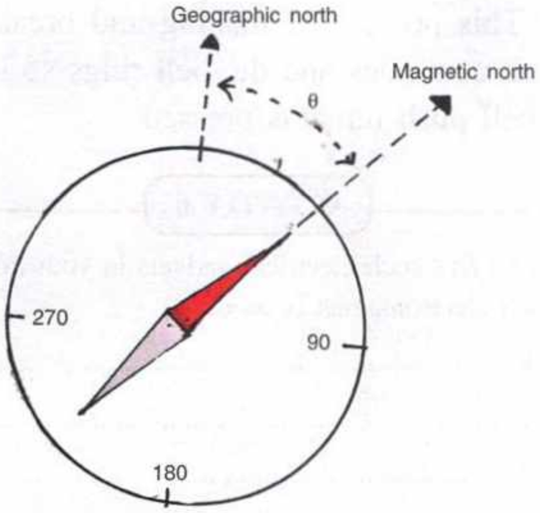


Fig. 7.12 Declination

is taken positive if the magnetic north is towards the east of the true north as in Fig. 7.12 and is negative if the magnetic north is towards the west of the true north.

USE OF ELECTRICITY AND ITS SOURCES

In our daily life, we use electricity in many different ways. We use electricity to light our home, school, office etc. We use electricity to run fan, television, heater, radio, etc. Electricity is used to run movies in the cinema hall, to run machines in the factory, to run trains etc. We use a number of appliances in our homes which run on electricity. Few electrical appliances are shown in Fig. 7.13.

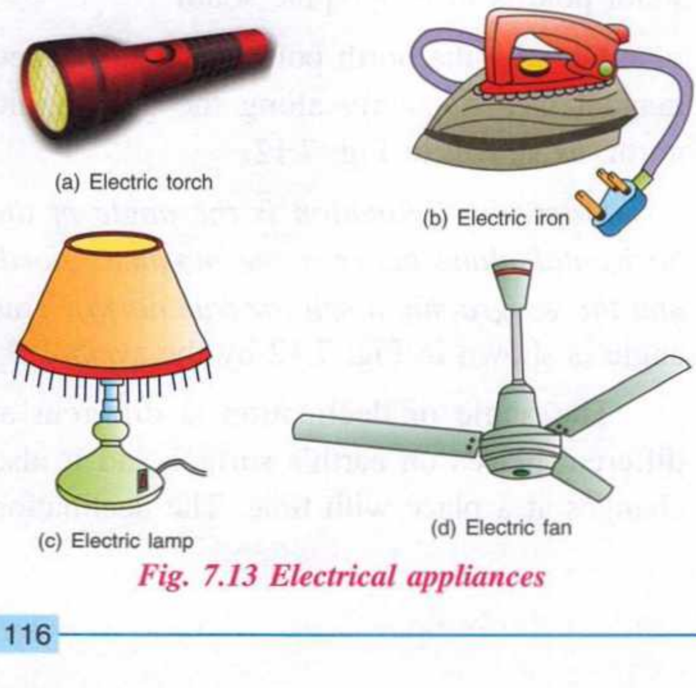


Fig. 7.13 Electrical appliances

SOURCES OF ELECTRICITY

The main sources from where we obtain electricity for our use are :

(i) The electric cell and battery,
(ii) The mains,
(iii) The generator, and
(iv) The solar cells.

(i) The electric cell : An electric cell is the most common source of electricity. A cell consists of a vessel (or container) with two metal rods, called the electrodes and a chemical substance either in the form of solution or paste, called the electrolyte. Fig. 7.14 shows a simple cell.

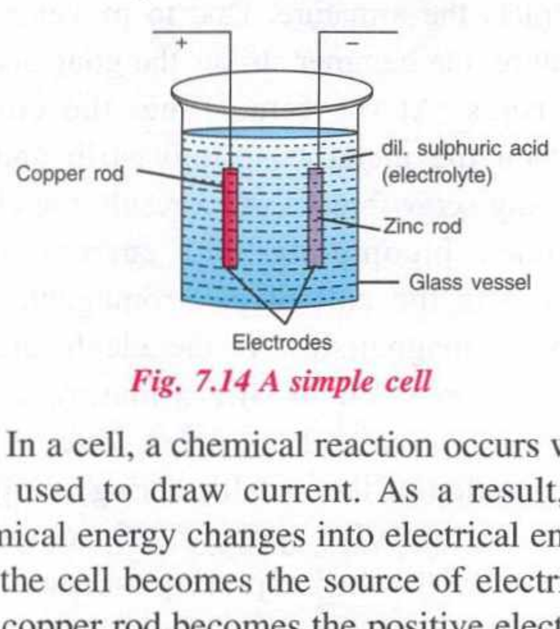


Fig. 7.14 A simple cell

In a cell, a chemical reaction occurs when it is used to draw current. As a result, the chemical energy changes into electrical energy and the cell becomes the source of electricity. The copper rod becomes the positive electrode (or anode) and the zinc rod becomes the negative electrode (or cathode).

The most commonly used cell is a dry cell. This cell cannot be recharged.

Dry cell : A dry cell consists of a zinc container whose base acts as the negative electrode (or cathode). It has a carbon rod placed at the centre with a brass cap. The carbon rod acts as the positive electrode (or anode). The rod is surrounded by a mixture of manganese dioxide and charcoal in a muslin bag. The electrolyte used is mostly a paste of ammonium chloride, plaster of paris, flour, etc. The outer body (except the base) of a zinc container is insulated with a thick cardboard or plastic material. Fig. 7.15 shows a dry cell.

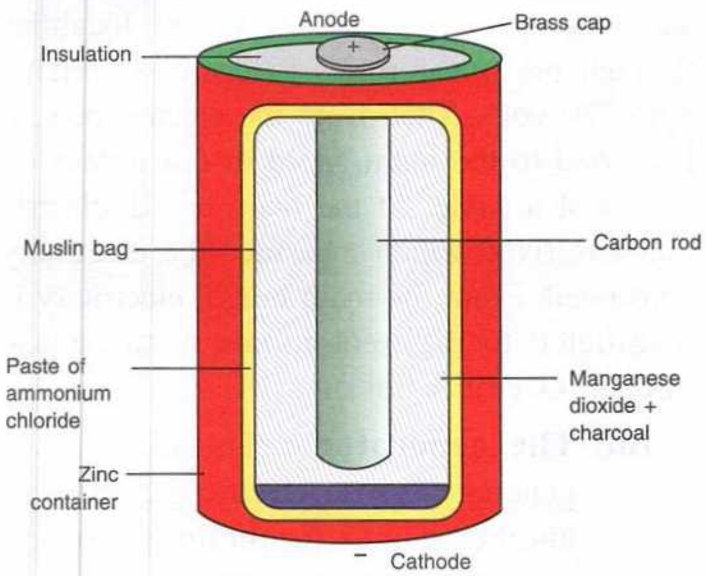


Fig. 7.15 A dry cell

When the cell is connected to a bulb (or in a circuit), the chemical reaction takes place and current flows in the circuit from the anode of the cell towards its cathode through the cell and the bulb glows.

Advantages of dry cells :

1. Dry cells are light in weight and small in size.
2. Dry cells can be easily carried from one place to another.
3. There is no fear of leakage in the dry cells.
4. They can easily be used to run simple electrical devices.

Do You Know ?

A dry cell has two terminals labelled as (+) and (–). The positive (+) terminal has brass cap at its top, whereas the negative (–) terminal is the can at its bottom.

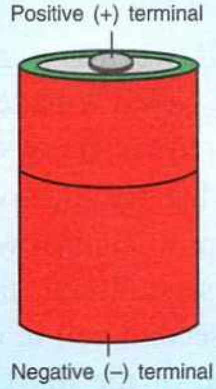


Fig. 7.16 Two terminals of a dry cell

USE OF DRY CELLS IN A TORCH

We use dry cells in a torch as the source of electricity. Fig. 7.17(a) shows a torch with two cells inside it. These cells are joined such that the brass cap (*i.e.*, anode) of one cell is in contact with the container (*i.e.*, cathode) of the other cell, Fig. 7.17(b) shows the outer case of the torch. As we press the switch on, the torch lights up. If we take out the cells from the torch and then press the switch on, the torch does not give any light. This shows that the cells provide electricity to light a torch. Without cells, the torch is useless.

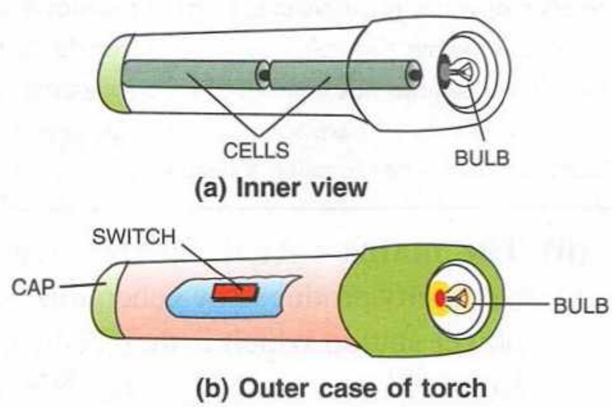


Fig. 7.17 Torch with dry cells

Uses of dry cells

We use dry cells as a source of electricity in many appliances such as radio, tape-recorder, bicycle lamp, car headlight, television set, calculator, wrist watch, transistors, remote of T.V., etc.

Battery : If we use a group of two or more cells, it is called a battery. A battery is used where we require more electricity.

To form a battery, the positive terminal of one cell is kept in contact with the negative terminal of the second cell, then the positive terminal of the second cell in contact with the negative terminal of the third cell and so on, as shown in Fig. 7.18. The bulb or appliance with which battery is to be used, is then connected between the negative terminal of the first cell and the positive terminal of the last cell.

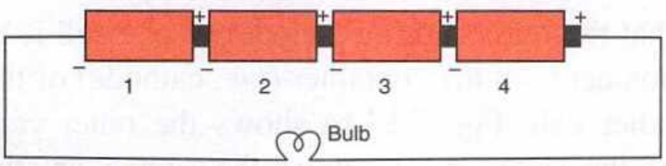
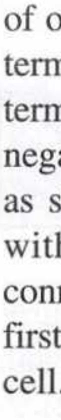


Fig. 7.18 Joining cells to form a battery



Do You Know ?

Dry cells are actually not dry. In fact, a dry cell works only as long as the paste inside it remains moist. The presence of water (or moisture) helps in the movement of the ions within the cell from one electrode to the other. If the cell has not been used for a long time, the chemicals present in it are spent and it stops producing electricity, such a cell is called a dead cell.

(ii) The mains : At the mains, we get electricity produced by generators at the power station which is then distributed to buildings and homes. We use electricity obtained from mains to run all the electrical gadgets such as fan refrigerator, heater, etc., in our homes and to run machines in factories. Cells or batteries are not used for this purpose because they cannot provide as much electricity which these gadgets need.

The electricity produced at a power station is first changed to high voltage and then carried by cables or wires to cities at distant places. It is then carried from the city sub-station to the electric poles in various localities through the transformers to decrease voltage upto 220 volts. Then from the electric pole, it is carried to the main board in our homes by means of a cable. At the main board, electric meter is fixed which measures the electricity consumed. From the main board, electricity is distributed to different rooms in the house through electric wires.

(iii) The generator : These days we generally use an electric generator as another means to obtain electricity whenever there is either shortage of electric supply or an electric failure *i.e.*, when we do not get the supply of electricity from the mains. In an electric generator, the mechanical energy converts into electrical energy when in use.

(iv) The solar cells : With the advances of science, it has become possible to convert the light energy received from the sun *i.e.*, solar energy, in the form of electrical energy in a device called solar cell. The solar cells find many uses to provide electricity just like the dry cells (or torch cells). They are used as a source of electricity in satellites.

FLOW OF ELECTRICITY IN A CIRCUIT

The path along which the electricity flows is called the circuit. Electricity flows only if the circuit is complete. If the circuit is broken or incomplete, electricity does not flow. This can be easily demonstrated by the following activity.

ACTIVITY 7

To demonstrate that electricity only flows through a complete circuit.

Take about one metre long insulated metal wire. Cut the wire in two halves by means of a blade. Remove the plastic covering at the ends of each wire. Now take a torch bulb and with the help of cellotape, fix one end of each wire to each terminal of the bulb as shown in Fig. 7.19. Now take a cell. Fix the other ends of the wires to the terminals (or electrodes) X and Y of the cell. You will notice that the bulb gets lighted. This shows that electricity is flowing in the wires and through the bulb. Electricity flows from the terminal marked X of the cell (*i.e.*, anode) to the bulb along the wire labelled 1, then trough the filament of the bulb and then through the wire labelled 2, to the terminal Y of the cell (*i.e.*, cathode). This path along which electricity flows is called the circuit. When the bulb glows, the circuit is said to be complete or closed.

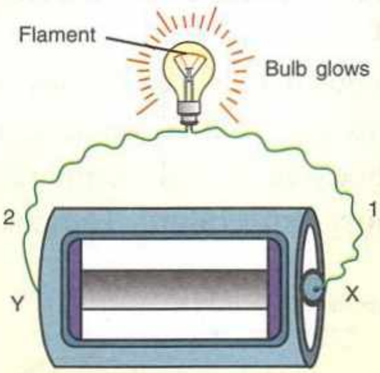


Fig. 7.19 Complete circuit

Now remove the wire 1 from the bulb connected to the terminal X of the cell as shown in Fig. 7.20. You will see that the bulb does not glow now. This shows that now electricity does not flow. The reason is that the circuit is now incomplete or open.

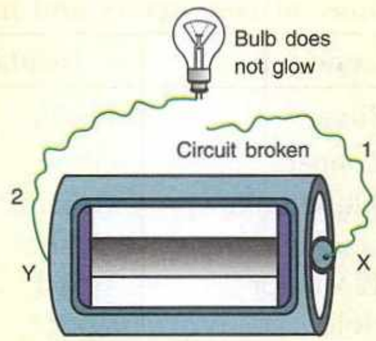


Fig. 7.20 Incomplete circuit

Thus, from the above activity, you conclude that :

(i) Electricity flows only if the circuit is closed or complete.

(ii) If the circuit is broken or incomplete, electricity does not flow.

CONDUCTORS AND INSULATORS

Conductors : The substances which allow electricity to flow through them, are called **conductors**. All metals such as copper, aluminum, silver, iron, brass, steel are conductors. Human body also allows electricity to flow through it, so it is a conductor of electricity. Impure water is also a conductor of electricity.

Insulators : The substances which do not allow electricity to flow through them are called **insulators**. Some examples of insulators are : cotton, rubber, plastic, wood, paper, glass, leather, distilled water, etc.

The table given on the next page lists some examples of conductors and insulators.

Condition for a circuit to be complete

A circuit is said to be complete if all parts of the circuit are connected with the wires made of conductors *i.e.*, the complete path of circuit is of conductors. If there is an insulator in the path of the circuit, it becomes incomplete.

Some examples of conductors and insulators

S.No.	Conductors	Insulators
1.	Silver	Plastic
2.	Copper	Glass
3.	Aluminium	Bakelite
4.	Lead	Cotton
5.	Tap water	Wood
6.	Gold	Cork
7.	Human body	Silk
8.	Living plant	Distilled water
9.	Brass	Rubber
10.	Tin	Leather
11.	Iron	Ebonite
12.	Steel	Nylon

ACTIVITY 8

To check whether the given material is a conductor or an insulator.

Take a dry cell. Connect one end of a copper wire to the + ve terminal of a dry cell and the other end to a bulb. Cut this wire so as to have a gap AB in it as shown is Fig. 7.21(a).

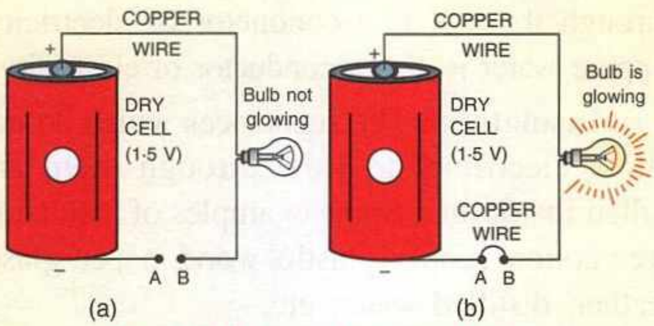


Fig. 7.21 Copper is a conductor

You will find that the bulb does not glow since the circuit is incomplete.

Now place a piece of copper wire in the gap touching the points A and B as shown in Fig. 7.21(b). The bulb starts glowing. This shows that copper is a good conductor of electricity.

Now repeat the experiment with other materials and note down your observations and conclusions in the following table.

Test material	State of the bulb	Conductor or insulator
Plastic	Does not glow	Insulator
Copper	Glows	Conductor
Eraser (Rubber)	....	....
Matchstick (wood)	....	....
Pencil lead (graphite)	....	....

Do You Know ?

When two different insulating objects are rubbed together, some electrons move from one object to the other, due to which they get charged. The object losing electrons becomes positively charged and the object which gains electrons becomes negatively charged. For example, when a glass rod is rubbed on silk, glass rod gets positively charged and silk gets negatively charged because electrons move from glass rod to silk.

On the other hand, to charge a conductor positively, a positively charged glass rod is touched with the conductor so as to share the charge. Similarly to charge a conductor with negative charge, a negatively charged silk is touched with the conductor. Thus, a positively charged conductor has a deficit of electrons while a negatively charged conductor has an excess of electrons.

FLOW OF CHARGES CONSTITUTES CURRENT

We know that if two bodies at different temperatures are kept in contact, heat flows from the body at a high temperature to the body at a low temperature. The heat flows till

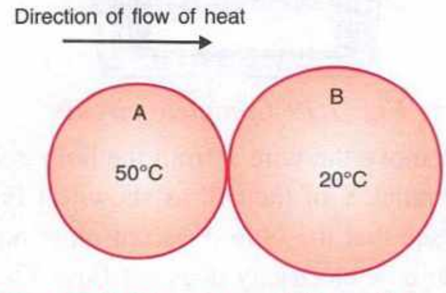


Fig. 7.22 Direction of flow of heat

both the bodies attain the same temperature. In Fig. 7.22, the direction of heat flow is from the body A at temperature 50°C to the body B at temperature 20°C

Similarly Fig. 7.23 shows two jars A and B. The jar A is narrow while the jar B is wide, both containing water and connected by a tube fitted with a stopcock. The level of water in jar A is higher than the level of water in jar B, although jar B contains more volume of water than jar A. On opening the stopcock, we find that water flows from jar A in which water level is higher to jar B in which water level is lower. The flow of water continues till the levels of water in the two jars become equal.

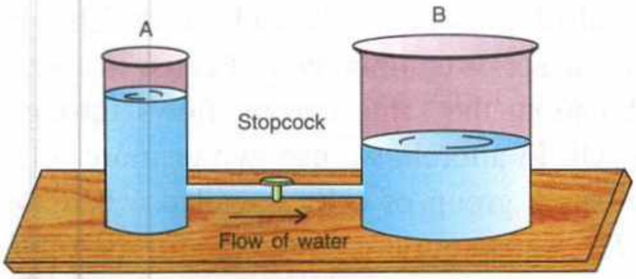


Fig. 7.23 Flow of water from higher level to lower level

Similarly, if we join two charged conductors, the electrons flow from a conductor having more electrons to the conductor having less (or no) electrons. The movement of electrons stops only when the number of electrons in both the conductors becomes equal.

Examples : (1) in Fig. 7.24, a positively charged conductor A is joined to an uncharged conductor B by a metallic wire. The electrons move from the uncharged conductor B to the charged conductor A to balance the deficit of electrons in the conductor A. This movement

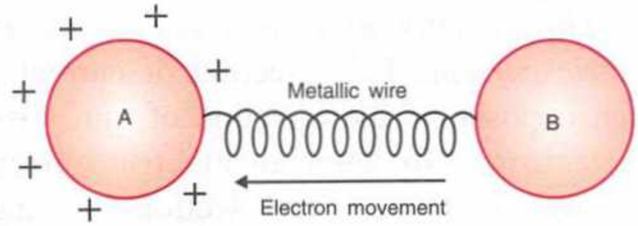


Fig. 7.24 Movement of electrons from an uncharged conductor to a positively charged conductor

of electrons continues till both the conductors have equal number of electrons.

(2) In Fig. 7.25, a negatively charged conductor A is joined to an uncharged conductor B by means of a metallic wire. The electrons move from the conductor A (which has excess of electrons) to the conductor B (which has no electrons). This movement of electrons stops only when the two conductors have equal number of electrons.

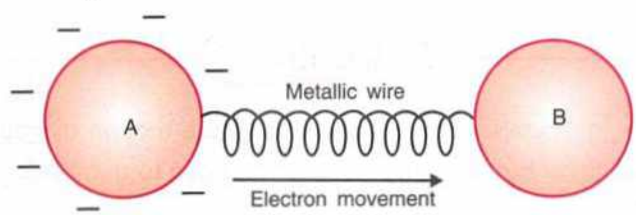


Fig. 7.25 Movement of electrons from a negatively charged conductor to anuncharged conductor

(3) In Fig. 7.26, a positively charged conductor A is joined to a negatively charged conductor B by a metallic wire. The electrons will move from the conductor B (which has excess of electrons) to the conductor A (which has deficit of electrons) till both the conductors acquire the same number of electrons.

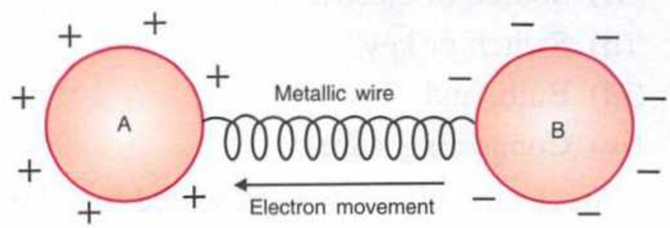


Fig. 7.26 Movement of electrons from a negatively charged conductor to a positively charged conductor

The moving electrons constitute an electric current. The direction of current is taken opposite to the direction of movement of electrons. To keep an electric current flowing (*i.e.*, to keep the electrons moving) between two conductors, it is necessary to maintain an excess of electrons on one conductor and deficit of electrons on the other conductor. This is done in an electric cell by a chemical reaction in the electrolyte which creates deficit of electrons on anode and excess of electrons on cathode.

Current is defined as the rate of flow of charge *i.e.*, the amount of charge flowing in one second. It is measured in the unit ampere (symbol A) named after the name of the scientist Ampere.

Do You Know ?

In metals, current flows due to the motion of free electrons, but in liquids current flows due to the motion of ions.

SYMBOLS AND FUNCTIONS OF VARIOUS COMPONENTS OF AN ELECTRIC CIRCUIT

An electric circuit is formed by a source of electricity connected to various electric components. A cell or a group of cells (*i.e.*, battery) is generally used as a source of electricity. The various electric components are :

(i) Source of electricity,

(ii) Switch or key,

(iii) Bulb, and

(iv) Connecting wires.

An electric circuit is represented by a line diagram for which we use symbols for the various electric components.

(i) Source of electricity : A cell or a group of cells is generally used as a source of electricity. *A group of cells connected in series is called a battery.*

A cell has two terminals : a positive (+) and a negative (–). It is represented by the two vertical lines of unequal lengths. The long vertical line represents the positive terminal and the short line represents the negative terminal as shown in Fig. 7.27.

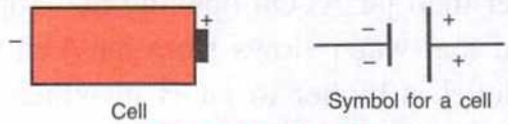


Fig. 7.27 A cell

To use two or more cells, the positive terminal of one cell is joined to the negative terminal of the other cell, and so on. This is called the series combination of cells. In series combination, the same current flows through each cell. In a torch, we use two or more cells in series. A group of cells is called a battery. Fig. 7.28 shows groups of two and three cells.

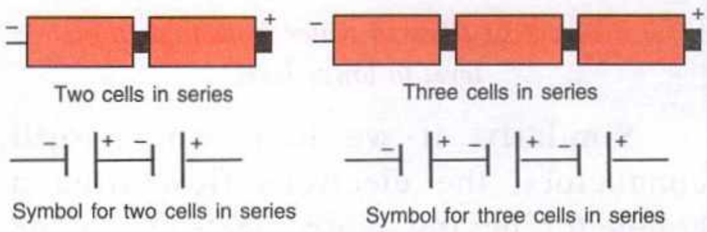
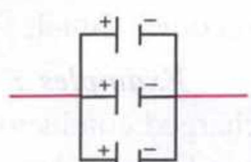


Fig. 7.28 A battery

In a parallel combination of cells, the positive terminals of all the cells are connected together and the negative terminals of all the cells are connected together. Here, the current is divided among the cells.



(ii) Switch or key : A switch or key is used to put the circuit on and off. Fig. 7.29 shows the symbol of a switch or key when it is open (to put the circuit off) and when it is closed (to put the circuit on).

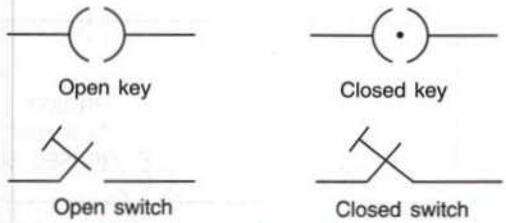


Fig. 7.29 Switch and key

(iii) **Bulb or resistor :** The symbol for the bulb or resistor used in an electric circuit is shown in Fig. 7.30.

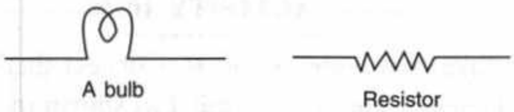


Fig. 7.30 Bulb and resistor

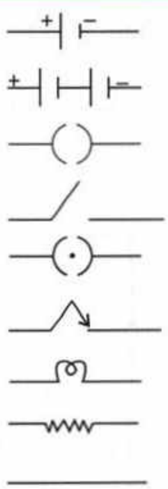
A bulb or resistor is the component which opposes the flow of current in the circuit.

(iv) **Connecting wires :** The connecting wires are used to connect the various components in an electric circuit. They are shown by lines (Fig. 7.31).

Fig. 7.31 Symbol for connection wire

These symbols are summarized below :

Component		Symbol
1.	Cell	
2.	Battery	
3.	Key open	
4.	Switch open	
5.	Closed key	
6.	Switch closed	
7.	Bulb	
8.	Resistance/resistor	
9.	Connecting wire	



Direction of conventional current in a circuit : When the circuit is complete, a current flows through the various components connected in the circuit from the positive terminal of the cell (or battery) to its negative terminal. The direction of current in the circuit is indicated by marking an arrow from the positive terminal of cell to its negative terminal.

Fig. 7.32 (a) shows a circuit containing a cell, a switch and a bulb. The line diagram of this circuit is shown in Fig. 732(b). The arrows in these diagrams represent the direction of current in the complete circuit.

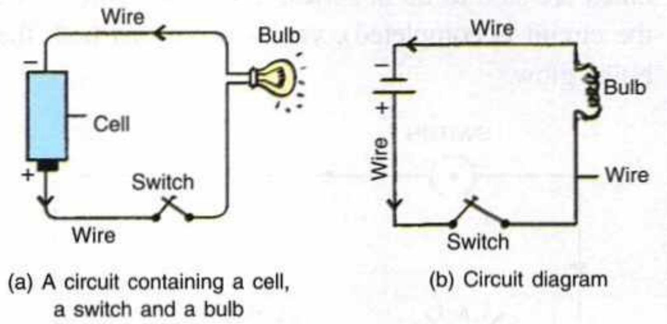


Fig. 7.32 Electric circuit with a cell, switch and bulb

SERIES AND PARALLEL CIRCUITS

Series circuit : In a circuit, if appliances are connected in series, they all will work together *i.e.*, on opening the switches, all appliances will become operative simultaneously. If somehow any one appliance goes out of order, the rest of the appliances also will not operate because the circuit then becomes incomplete. Thus, in a series circuit, the appliances in use are dependent upon each other.

Parallel circuit : When the circuit is in parallel, the appliances work independently. If somehow any one appliance goes out of order the rest of the appliances will not be affected. This is the reason that in our household wiring system, all the circuits are in parallel. Every appliance when switched on, works on its own without the interruption of other appliances. If we switch on a tubelight in a room, the fan and the other gadgets installed are not disturbed *i.e.*, they need not be switched off. This can be demonstrated by the following activities.

ACTIVITY 9

Take two torch bulbs A and B. Connect them to a cell through a switch as shown in Fig. 7.33 The bulbs are said to be in series. Close the switch (*i.e.*, the circuit is completed), you will see that both the bulbs glow.

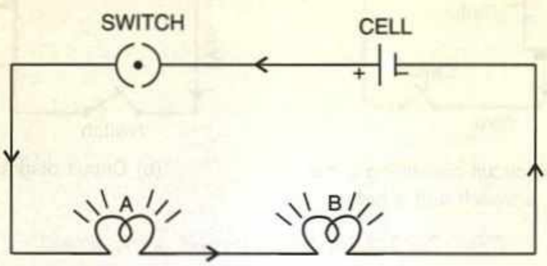


Fig. 7.33 Circuit is complete, both bulbs glow

Now take out the bulb B as shown in Fig. 7.34 Now close the switch, you will observe that the bulb A does not glow, because the circuit is now incomplete.

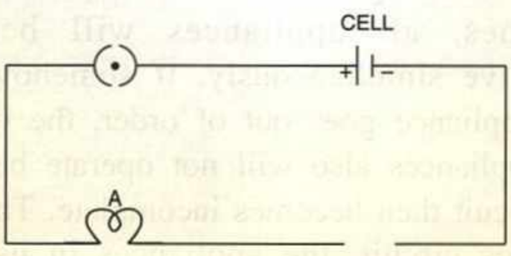


Fig. 7.34 Circuit is incomplete, bulb A does not glow

Now join the fused bulb (Fig. 7.35) in place of bulb B and close the switch. Again you will see that the bulb A does not glow. This is because the circuit being in series, is still incomplete.

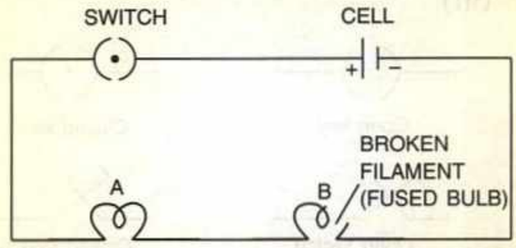


Fig. 7.35 Incomplete circuit, bulb A does not glow

Thus, when appliances are in series, they are dependent on each other.

ACTIVITY 10

Take two bulbs A and B. Connect them through switches S_1 and S_2 in parallel as shown in Fig. 7.36. Close both the switches. You will see that both the bulbs glow.

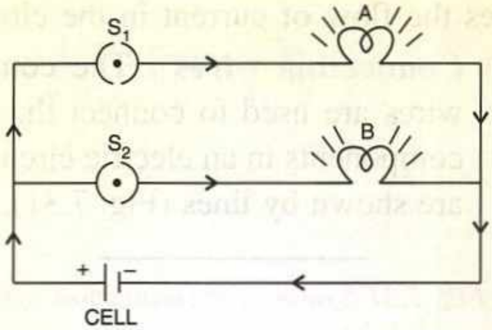


Fig. 7.36 Circuit is complete, both bulbs glow

Now close the switch S_1 and keep the switch S_2 open (Fig 7.37). You will see that only bulb A glows but bulb B does not glow.

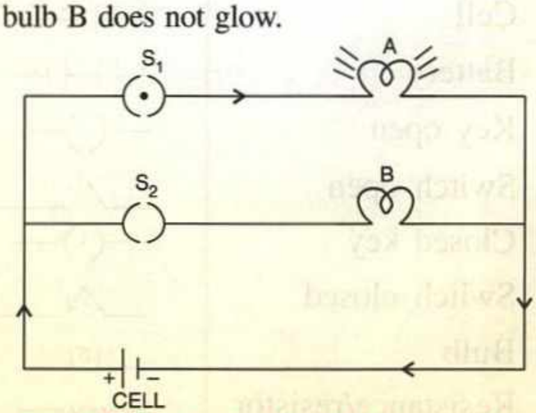


Fig. 7.37 Circuit of bulb B incomplete so it does not glow

Then keep the switch S_1 open and close the switch S_2 (Fig.7.38). You will see that only bulb B will glow and bulb A will not glow.

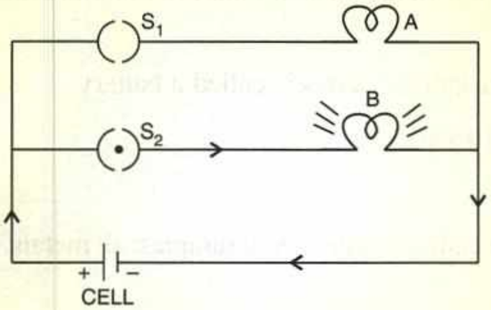


Fig. 7.38 Circuit of bulb A is incomplete, so it does not glow

Thus, when appliances are joined in parallel, they work independently.

PRECAUTIONS TO BE TAKEN BEFORE THE CIRCUIT IS SWITCHED ON

Before the circuit is switched on, following precautions must be taken :

(i) See that all the components of the circuit are properly connected.

(ii) See that the connecting wire is tightly connected to each appliance or component.

(iii) Do not touch the switch or any component with wet hands.

(iv) See that the connecting wire is no where naked, it should be properly insulated everywhere.

(v) See that the source of electricity is properly joined.

RECAPITULATION

- A magnet attracts small pieces of iron.
- A bar magnet, if suspended to swing freely, always rests in north-south direction.
- A magnet has two poles-north pole and south pole. These poles exist in pairs.
- Like poles repel each other, while unlike poles attract each other.
- A magnetic compass is a small magnetic needle pivoted at its centre so as to rotate freely. It is used to indicate the north-south direction at a place.
- Repulsion is a sure test of a magnet.
- The space around a magnet in which the magnetic needle of the magnetic compass gets influenced, is called the magnetic field of that magnet. At different points around a magnet, the magnetic needle of compass rests in different directions.
- Electromagnets are temporary magnets which are made of soft iron by electrical method.
- An electromagnet acquires magnetism so long as current flows in the coil wound around a cylindrical tube.
- The strength of magnetic field of an electromagnet can be increased in three ways: (i) by increasing the number of turns in the coil, (ii) by increasing the strength of current in the coil (*i.e.*, by increasing the number of cells used in the battery to provide current in the coil), and (iii) by inserting a soft iron core in the coil.
- Electromagnets are mainly used (i) to separate iron from other substances, (ii) to lift big pieces of iron scrap, girders, plates etc. and then to transport them from one place to another, (iii) to separate iron dust from wounds, (iv) to load furnaces with iron, and (v) to obtain magnetic field in electrical gadgets like electric bell, electric tram, electric motor, loudspeaker, microphone etc.

- An electric bell is a simple application of electromagnet.
- Electricity plays a very useful role in our daily life.
- We use electricity to light our home, school, office; to run fan, television, heater, radio; to run machines in the factory; to run trains, etc.
- Cell is a common source of electricity. A group of two or more cells in series is called a battery.
- Some other sources of electricity are the mains, generator and solar cells.
- The path along which electricity flows is called a circuit.
- The substances which allow electricity to flow through them are called conductors. Examples: all metals, human body, impure water.
- The substances which do not allow electricity to flow through them are called insulators. Examples: cotton, rubber, ebonite, plastic, wood, paper, glass, leather, pure water etc.
- An electric circuit is incomplete if there is an insulator in its path.
- Every part of a complete circuit must be made of conductors.
- In a symbolic representation of an electric circuit by a line diagram, the direction of conventional current in the circuit is shown by marking an arrow from the positive terminal of the cell (*i.e.*, bigger vertical line) to its negative terminal (*i.e.*, shorter vertical line).
- Switch is a device used to close or open an electric circuit.
- An electric appliance will work only if the electric circuit is made of conductors and also if the circuit is complete.
- In a series circuit, all appliances work together. If one appliance does not work, the others also will not work.
- In a parallel circuit, all appliances work independently.
- Current flows, due to the motion of charges. In metals, the flow of current is due to motion of electrons, but in liquid it is due to motion of ions.
- The rate of flow of charges per unit time is called current. The S.I. unit of current is ampere (symbol A).
- Before the switch of a circuit is on, it should be checked that all the components of the circuit are properly connected and the connection wire is nowhere naked, but is insulated everywhere.
- The switches must not be touched with wet hands.

TEST YOURSELF

A. Objective Questions :

1. Write **true** or **false** for each statement :
   (a) A current carrying coil when suspended freely can rest in any direction.
   (b) A coil carrying current behaves like a magnet.
   (c) In an electromagnet, the core is made up of copper.
   (d) An electric bell uses an electromagnet.
   (e) An electromagnet with soft iron core is a temporary magnet.
   (f) We use cell as the source of electricity to run an electric immersion rod.
   (g) A torch bulb glows if the terminals of the bulb are connected to the terminals of a cell by the metallic wire.
   (h) Wool is a conductor of electricity.

(i) Silver is an insulator of electricity.
(j) Our body is a conductor of electricity.
(k) For a circuit to be complete, every part of it must be made up of conductors.
(l) All metals are conductors of electricity.
(m) The switch should not be touched with wet hands.
(n) A switch is an on-off device in an electric circuit.

Ans. True (b), (d), (e), (g), (j), (k), (l), (m), (n),
False (a), (c), (f), (h), (i)

2. Fill in the blanks :
(a) A magnet has .... poles.
(b) Like poles .... each other and unlike poles ....
(c) An electromagnet is used to separate large mass of .... scrap.
(d) The strength of magnetic field of an electromagnet is increased by inserting a core of ....
(e) In a torch, we use .... as the source of electricity.
(f) To light a table lamp and to run a refrigerator, we use .... as the source of electricity.
(g) A group of two or more cells is called a ....
(h) .... pass electricity through them.
(i) .... do not pass electricity through them.

Ans. (a) Two (b) repel, attract (c) iron (d) soft iron (e) dry cell (f) mains (g) battery (h) conductors (i) insulators

3. Match the following :

Column A	**Column B**
(a) Human body	(i) electric bell
(b) Silk thread	(ii) current
(c) Charge in motion	(iii) conductor
(d) Soft iron	(iv) electromagnet
(e) Electromagnet	(v) insulator

Ans. (a)–(iii), (b)–(v), (c)–(ii), (d)–(iv), (e)–(i)

4. Select the correct alternative :
(a) A freely suspended magnet rests in :
(i) east-west direction
(ii) north-south direction
(iii) north-east direction
(iv) north-west direction.
(b) Electromagnets are made up of :
(i) steel (ii) copper
(iii) brass (iv) soft iron.
(c) An electromagnet is used in :
(i) electric oven (ii) ammeter
(iii) electric bell (iv) radio set.
(d) The purpose of armature in an electric bell is :
(i) to make and break the circuit
(ii) to produce sound
(iii) to produce magnetic field
(iv) to provide spring action.
(e) In a torch, the source of electricity is :
(i) the bulb (ii) the switch
(iii) the cell (iv) the mains.
(f) Electricity can flow through :
(i) wood (ii) rubber
(iii) plastic (iv) copper wire.
(g) Electricity does not flow through :
(i) human body (ii) animal's body
(iii) rubber (iv) silver.
(h) We should not touch the switch with wet hands, otherwise :
(i) electricity may pass through our body
(ii) electricity may not pass through the appliance
(iii) circuit may break
(iv) the switch may get off.

Ans. (a)–(ii), (b)–(iv), (c)–(iii), (d)–(i), (e)–(iii), (f)–(iv), (g)–(iii), (h)–(i)

B. Short/Long Answer Questions :

1. State two properties of a bar magnet.
2. How will you test whether a given rod is a magnet or not ?
3. How will you test whether a given rod is made of iron or not ?

4. You are given two similar bars. One is a magnet and the other is of soft iron. How will you distinguish and identify them ?
5. You are given a magnet. How will you use it to find north-south direction at a place ?
6. Describe a simple experiment to illustrate that like poles of two magnets repel each other while unlike poles attract.
7. "Poles exist in pairs". Comment on this statement.
8. What is a magnetic compass ? State its use.
9. Explain the meaning of the term, 'magnetic field'.
10. What is an electromagnet ?
11. Name the material of an electromagnet.
12. Draw a labelled diagram to make a soft iron bar as an electromagnet. Describe in steps the procedure.
13. You are given a U shaped soft iron piece, insulated copper wire and a battery. Draw a circuit diagram to make a horse shoe electromagnet.
14. Name two factors on which the strength of magnetic field of an electromagnet depends.
15. State two ways by which the strength of magnetic field of an electromagnet can be increased.
16. State two common uses of electromagnets.
17. Name a domestic device in which an electro-magnet is used.
18. Draw a neat and labelled diagram of an electric bell and describe its working.
19. The incomplete diagram of an electric bell is given in Fig. 7.39. Complete the diagram and label its different parts.

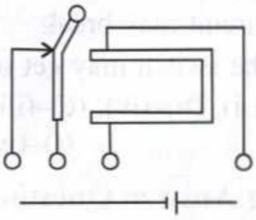
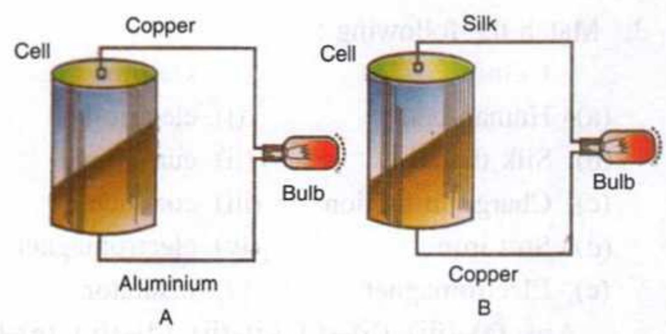


Fig. 7.39

20. What is declination? Draw a diagram to show the angle between the declination and true direction of geographic north.
21. Define the term 'current'.
22. Name four appliances which work using electricity.
23. Name two sources of electricity.
24. What is a battery ?
25. What is an electric circuit ?
26. Describe an experiment to show that electricity flows only if the circuit is complete and it does not flow if the circuit is incomplete.
27. You are provided with a torch bulb, a cell and two plastic coated metal wires. Draw a diagram to show a complete circuit to light the bulb.
28. In which of the following cases the bulb will glow:
   (i) Only one terminal of a cell is joined with a metal wire to one terminal of the bulb.
   (ii) Both terminals of the bulb are joined with two metal wires to one terminal of the cell.
   (iii) One terminal of the cell is joined to one terminal of the bulb and other terminal of the cell to the other terminal of the bulb.
29. Distinguish between conductors and insulators of electricity. Give *two* examples of each.
30. Select conductors and insulators from the following:
   Glass, silver, copper, wood, paper, pure water, impure water, aluminium, iron, leather, plastic, steel, human body and ebonite.
31. The following diagram (Fig. 7.40) shows four circuits A, B, C and D. Each circuit has a cell and a torch bulb. Name the circuits in which the bulb will glow? Give reason to your answer.



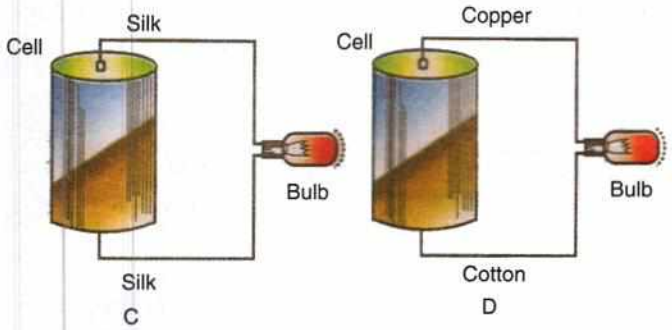


Fig. 7.40

32. The diagram given below (Fig. 7. 41) shows a bulb connected with a cell having terminals A and B. Mark the direction of current in the bulb.

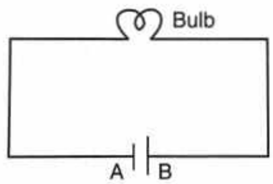


Fig. 7.41

33. State the function of each of the following in an electric circuit and draw its symbolic representation : (i) Switch and (ii) Cell.

34. Draw a circuit diagram for a bulb connected to a cell with a switch. Mark arrows in the diagram to indicate the direction of flow of current.

35. In which arrangement are the appliances connected in the electric circuit of our homes, Series or Parallel? Give one reason for your answer.

36. State two precautions that you must take when switching on an electric circuit.