V. Read the directions given below and answer the questions.

a. If both assertion and reason are true and the reason is the correct explanation of the assertion.

b. If both assertion and reason are true, but reason is not the correct explanation of the assertion.

c. If the assertion is true, but the reason is false.

d. If the assertion is false, but the reason is true.

1. **Assertion:** Radiation is a form of heat transfer which takes place only in vacuum.
   Reason: The thermal energy is transferred from one part of a substance to another part without the actual movement of the atoms or molecules.
2. **Assertion:** A system can be converted from one state to another state.
   Reason: It takes place when the temperature of the system is constant.

VI. Answer briefly.

1. What are the applications of conduction in our daily life?
2. What are the effects of heat?
3. Name three types of heat transfer.
4. What is conduction?
5. Write a note on convection.
6. Define specific heat capacity.
7. Define one calorie.

VII. Answer in detail.

1. With the help of a neat diagram explain the working of a calorimeter.
2. Write a note on thermostat.
3. Explain the working of thermos flask.

VIII. Higher Order Thinking Questions.

1. Why does the bottom of a lake not freeze in severe winter even when the surface is all frozen?
2. Which one of the following statements about thermal conductivity is correct? Give reason.
   a) Steel > Wood > Water
   b) Steel > Water > Wood
   c) Water > Steel > Wood
   d) Water > Wood > Steel

IX. Problems.

1. An iron ball requires 1000 J of heat to raise its temperature by 20°C. Calculate the heat capacity of the ball.
2. The heat capacity of the vessel of mass 100 kg is 8000 J/°C. Find its specific heat capacity.

REFERENCE BOOKS

1. Fundamentals of Statistical and Thermal Physics - F.Reif
2. Statistical Thermodynamics and Microscale Thermo -physics - Carey
3. Heat, Thermodynamics and Statistical Physics - BrijLal and Dr. N. Subramaniyam
4. Thermodynamics and an Introduction to Thermos-statistics byHerbert Hallen
5. Fundamentals of Engineering Thermo dynamics by Michael Moran

INTERNET RESOURCES

https://www.explainthatstuff.com/thermostats.html

https://youtu.be/8-nLHWpgDsM

https://youtu.be/rYwgsF_haAg

https://youtu.be/EwzkYTfHFbo

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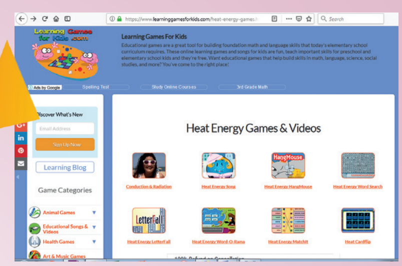
Concept Map

- **Heat**
  - **Effects of Heat**
    - Expansion
    - Increase in temperature
    - Change in state
  - **Transfer of Heat**
    - Conduction
    - Convection
    - Radiation
  - **Calorimetry**
    - Temperature
    - Unit of Heat
    - Heat capacity
    - Specific heat capacity
  - **Calorimeter**
    - Thermostat
      - Thermos flask

ICT CORNER

Heat

Through this activity you will learn about heat energy through Interactive games.

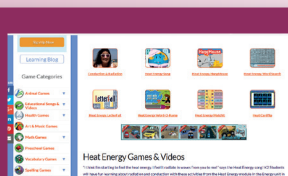


Step 1 Open the Browser and type the URL given below

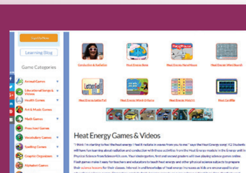
Step 2 You can see lot of games about heat energy.

Step 3 For example, click "Heat Energy match it" game. You will see the match words in the screen. Play and learn about heat energy.

Step 4 Likewise you can explore all the games.

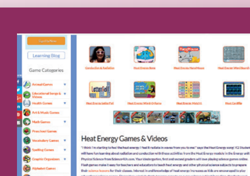


Step1



Step2

Step3



Step4

Browse in the link:

https://www.learninggamesforkids.com/heat-energy-games.html

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UNIT 2

Electricity

Learning Objectives

After completing this lesson, students will be able to:

- know about the basic properties of electric charges.
- explain the transfer of charges between two objects.
- understand the working of Electroscope.
- recognise the effects of electric current.
- assemble different electric circuits.
- list out the applications of electricity.

T6X2D6

Introduction

All things we use in our life are made up of elements. Each element is made up of atoms which is the smallest unit. John Dalton, the scientist considered that atoms cannot be divided further. But, it was found out later through Rutherford's gold foil experiment that atoms are made up of particles like proton, electron and neutron. Movement of electrons in a material constitutes electric current and generates an energy called electric energy or electricity. We use this energy in our life for various needs. Electric bulbs, fans, elctric iron box, washing machines and refrigirators are some of the appliances which work with the help of electricity. In this lesson we will study about electric charges and how they are transferred. This lesson will also cover electric circuits and the effects of electric current.

2.1 Atom

An atom consists of proton, electron and neutron which are called sub-atomic particles. Proton and neutron are found inside the nucleus which is at the centre of an atom. Electrons revolve around the nucleus in different paths called orbits. In an atom, the number of protons and the number of electrons will be equal. There is a force of attraction between the protons in the nucleus and the electrons in the orbits. Electrons in the inner orbits are strongly attracted by the protons and they cannot be removed from the atom easily. But, the electrons in the outermost orbits are loosely bound and they can be easily removed from the atom.

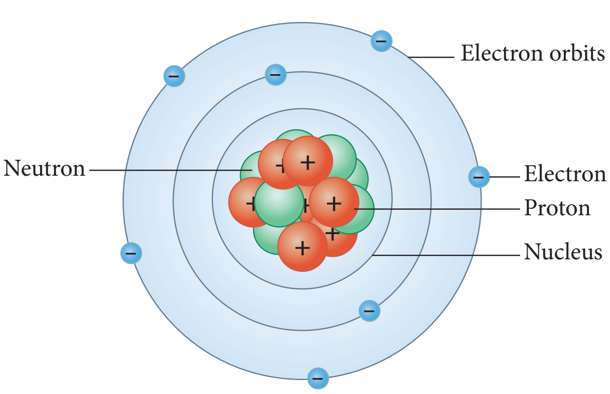

Figure 2.1 Atom model

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2.2 Charges

Charge or electric charge is the basic property of matter that causes objects to attract or repel each other. It is carried by the subatomic particles like protons and electrons. Charges can neither be created nor be destroyed. There are two types of charges: positive charge and negative charge. Protons carry positive charge and the electrons carry negative charge. There is a force of attraction or repulsion between the charges. Unlike charges attract each other and like charges repel each other.

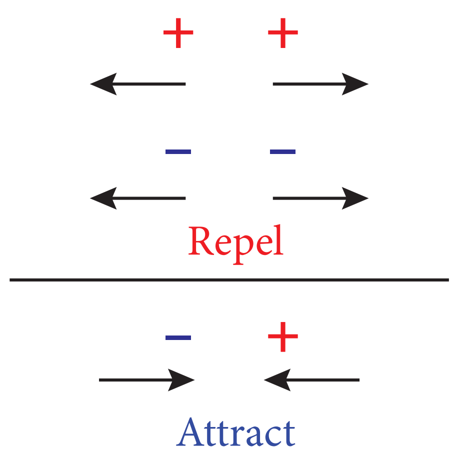

Figure 2.2 Attraction and repulsion between charges.

Electric charge is measured in coulomb (C). Small amount of charge that can exist freely is called elementary charge (e). Its value is 1.602×10^{-19} C. This is the amount of charge possessed by each proton and electron. But, protons have positive elementary charge (+e) and electrons have negative elementary charge (-e). Since protons and electrons are equal in number, an atom is electrically neutral.

2.3 Transfer of Charges

As we saw earlier, electrons (negative electric charges) in the outermost orbit of an atom can be easily removed. They can be transferred from one substance to another. The substance which gains electrons become negatively charged and the substance which looses electrons becomes positively charged. Transfer of charges takes place in the following three ways.

E5F2F1

- Transfer by Friction
- Transfer by Conduction
- Transfer by Induction

2.3.1 Transfer by Friction

Activity 1

Take a comb and place it near some pieces of paper. Are they attracted by the comb? No. Now comb your dry hair and place it near them. What do you see? You can see that the paper pieces are attracted by the comb now. How is it possible?

Comb rubbed with hair gains electrons from the hair and becomes negatively charged. These electrons are accumulated on the surface of the comb. When a piece of paper is teared into bits, positive and negative charges are present at the edges of the bits. Negative charges in the comb attract positive charges in the bits. So, the paper bits are moving towards the comb. While combing hair charges are transferred from the hair to comb due to friction. If the hair is wet, the friction between the hair and the comb reduces which will reduce the number of electrons transferring from hair to comb. Hence, rubbing certain materials with one another can cause the build-up of electrical charges on the surfaces. From this it is clear that charges are transferred by friction.

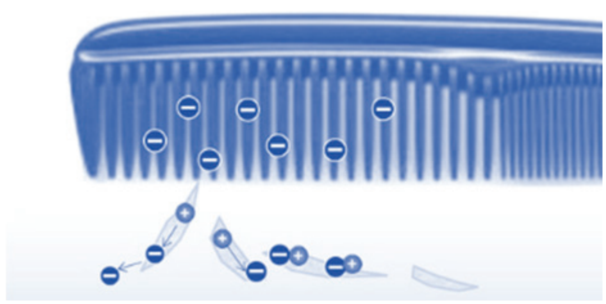

Figure 2.3 Charges in comb.

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DO YOU KNOW?

A neutral object can become positively charged when electrons get transferred to another object; not by receiving extra positive charges.

Similar effect can be seen when we rub few materials with one another. When a glass rod is rubbed with a silk cloth the free electrons in the glass rod are transferred to silk cloth. It is because the free electrons in the glass rod are less tightly bound as compared to that in silk cloth. Since the glass rod looses electrons, it has a deficiency of electrons and hence acquires positive charge. But, the silk cloth has excess of electrons. So, it becomes negatively charged.

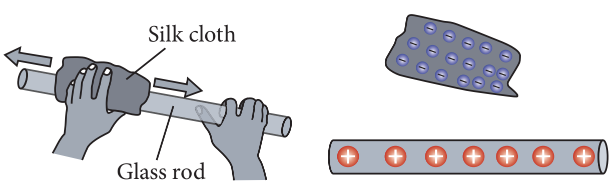


Figure 2.4 Transfer of charges in glass rod.

When an ebonite rod (rod made by vulcanized rubber) is rubbed with fur, the fur transfers electrons to the ebonite rod because the electrons in the outermost orbit of the atoms in fur are loosely bound as compared to the ebonite rod. The ebonite rod which has excess electrons becomes negatively charged and the fur which has deficiency of electrons is positively charged.

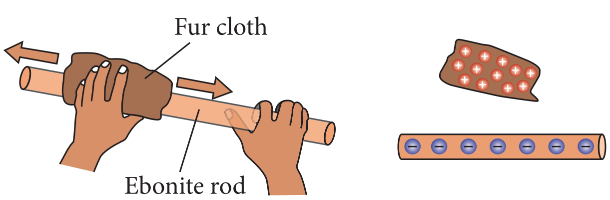
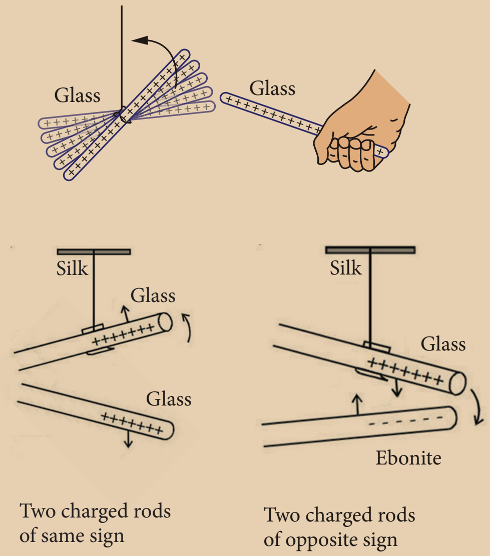


Figure 2.5 Transfer of charges in ebonite rod.

From these we know that when two materials are rubbed together, some electrons may be transferred from one material to the other, leaving them both with a net electric charge.

DO YOU KNOW?

If a negatively charged glass rod is brought near another glass rod, the rods will move apart as they repel each other. If a positively charged glass rod is brought close to a negatively charged ebonite rod, the rods will move toward each other as they attract. The force of attraction or repulsion is greater when the charged objects are closer.



2.3.2 Transfer by Conduction

Activity 2

Take a sheet of paper. Turn it into a hollow cylinder. Tie one end of the cylinder with a silk thread and hang it from a stand. Now take an ebonite rod and charge it by rubbing it with a woollen cloth. Bring this charged ebonite rod near the paper cylinder. The cylinder will be attracted by the rod. If you touch the paper cylinder by the charged rod, you will see the paper cylinder repelling the rod. Can you give the reason?

When the ebonite rod is rubbed with woollen cloth, electrons from the woollen cloth are transferred to the ebonite rod. Now ebonite rod will be negatively charged. When

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it is brought near the paper cylinder, negative charges in the rod are attracted by the positive charges in the cylinder. When the cylinder is touched by the rod, some negative charges are transferred to the paper. Hence, the negative charges in the rod are repelled by the negative charges in the cylinder.

Thus, we can say that charges can be transferred to on object by bringing it in contact with a charged body. This method of transferring charges from one body to other body is called transfer by conduction.

DO YOU KNOW?

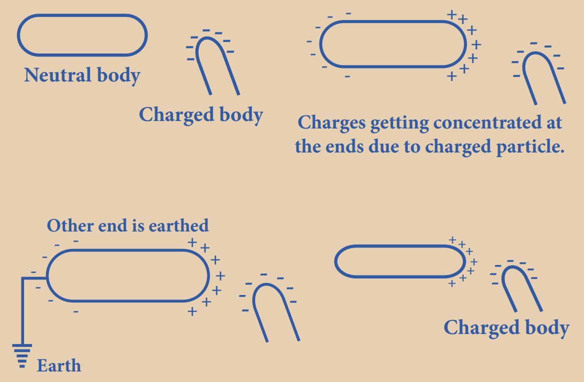
The materials which allow electric charges to pass through them easily are called conductors of electricity. For example, metals like aluminium, copper are good conductors of electricity. Materials which do not allow electric charges to pass through them easily are called insulators. Rubber, wood and plastic are insulators.

2.3.3 Transfer by Induction

We saw that we can charge an uncharged object when we touch it by a charged object. But, it is also possible to obtain charges in a body without any contact with other charges. The process of charging an uncharged body by bringing a charged body near to it but without touching it is called induction. The uncharged body acquires an opposite charge at the near end and similar charge at the farther end.

Activity 3

Bring a negatively charged plastic rod near a neutral rod. When the negatively charged plastic rod is brought close to the neutral rod, the free electrons move away due to repulsion and start piling up at the farther end. The near end becomes positively charged due to deficit of electrons. When the neutral rod is grounded, the negative charges flow to the ground. The positive charges at the near end remain held due to attractive forces and the electrons inside the metal is zero. When the rod is removed from the ground, the positive charge continues to be held at the near end. This makes the neutral rod a positively charged rod.



Similarly, when a positively charged rod is brought near an uncharged rod, negatively charged electrons are attracted towards it. As a result there is excess of electrons at nearer end and deficiency of electrons at the farther end. The nearer end of the uncharged rod becomes negatively charged and far end is positively charged.

2.4 Flow of Charges

Suppose you have two metallic spheres; one having more negative charge (excess of electrons) and the other having more positive charge (deficiency of electrons). When you connect them both with the help of a metallic wire, excess electrons from the negatively charged sphere will start flowing towards the positively charged sphere. This flow continues till the number of electrons in both the sphere is equal. Here, the positively charged sphere is said to be at higher potential and the negatively

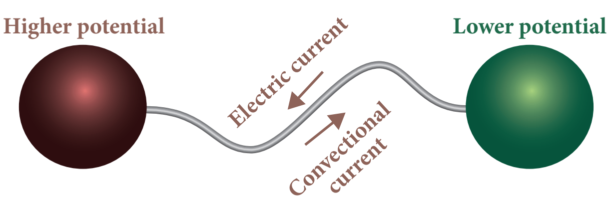


Figure 2.6 Transfer of charges

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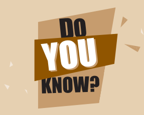
charged sphere is said to be at lower potential. Hence, electrons flow from lower potential to higher potential. This is known electric current (flow of electrons). The difference between these potentials is known as potential difference, commonly known as voltage.

Before the discovery of electrons it was considered that electric current is due to the flow of positive charges. Flow of positive charge is called conventional current. Conventional current flows from higher potential to lower potential.

2.5 Electroscope

An electroscope is a scientific instrument used to detect the presence of electric charge on a body. In the year 1600, British physician William Gilbert invented the first electroscope. It is the first electrical instrument. There are two types of electroscope: pith-ball electroscope and gold-leaf electroscope. An electroscope is made out of conducting materials, generally metal. It works on the principle that like charges repel each other. In a simple electroscope two metal sheets are hung in contact with each other. They are connected to a metal rod that extends upwards, and ends in a knob at the end.



The first electroscope developed in 1600 by William Gilbert was called versorium. The versorium was simply a metal needle allowed to pivot freely on a pedestal. The metal would be attracted to charged bodies brought near.

If you bring a charged object near the knob, electrons will either move out of it or into it. This will result in charges on the metal leaves inside the electroscope. If a negatively charged object is brought near the top knob of the electroscope, it causes free electrons in the electroscope to move down into the leaves, leaving the top positive. Since both the leaves have negative charge, they repel each other and move apart.

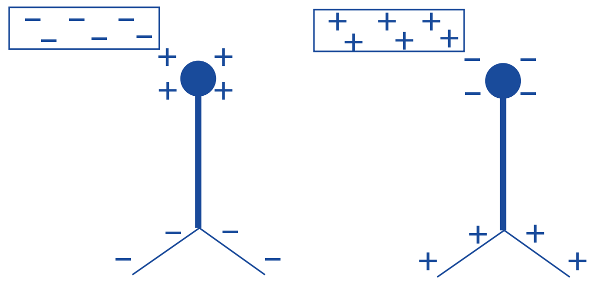


Figure 2.7 Movement of charges in electroscope

If a positive object is brought near the top knob of the electroscope, the free electrons in the electroscope start to move up towards the knob. This means that the bottom has a net positive charge. The leaves will spread apart again.

2.5.1 Gold leaf electroscope

The gold-leaf electroscope was developed in 1787 by a British scientist named Abraham Bennet. Gold and silver are used in electroscope because they are the best conductors of electric current.

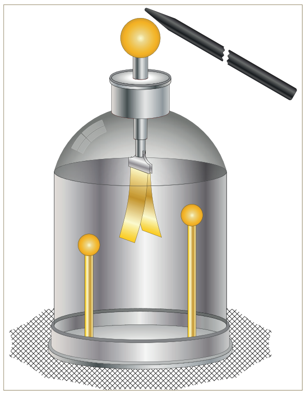


Figure 2.8 Gold leaf electroscope

Structure of Electroscope

It is made up of a glass jar. A vertical brass rod is inserted into the jar through a cork. The top of the brass rod has a horizontal brass rod or a brass disc. Two gold leaves are suspended from the brass rod inside the jar.

Working of Electroscope

When the brass disc of the electroscope is touched by a charged object, electric charge gets transferred to the gold leaf through the rod. This results in the gold leaves moving away from each other. This happens because both the leaves have similar charges.

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Charging

Transfer of charge from one object to another is called charging. In case of the gold leaves charge is transferred through the brass rods.

Electrical Discharge

The gold leaves resume their normal position after some time. This happens because they lose their charge. This process is called electrical discharge. The gold leaves would also be discharged when someone touches the brass rod with bare hands. In that case, the charge is transferred to the earth through the human body.

2.6 Lightning and Thunder

Activity 4

Rub your foot on a carpet floor and touch a door knob. What do you feel? Do you feel the shock in your hand? Why does this happen?

Getting a shock from a doorknob after rubbing your foot on a carpet floor, results from discharge. Discharge occurs when electrons on the hand are quickly pulled to the positively charged doorknob. This movement of electrons, which is felt as a shock, causes the body to lose negative charge. Electric discharge takes place in a medium, mostly gases. Lightning is another example of discharge that takes place in clouds.

Lightning is produced by discharge of electricity from cloud to cloud or from cloud to ground. During thunderstorm air is moving upward rapidly. This air which moves rapidly, carries small ice crystals upward. At the same time, small water drops move downward. When they collide, ice crystals become positively charged and move upward and the water drops become negatively charged and move downward. So the upper part of the cloud is positively charged and the lower part of the cloud is negatively charged. When they come into contact, electrons in the water drops are attracted by the positive charges in the ice crystals. Thus, electricity is generated and lightning is seen.

Sometimes the lower part of the cloud which is negatively charged comes into contact with the positive charges accumulated near the mountains, trees and even people on the earth. This discharge produces lot of heat and sparks that results in what we see as lightning. Huge quantities of electricity are discharged in lightning flashes and temperatures of over 30,000°C or more can be reached. This extreme heating causes the air to expand explosively fast and then they contract. This expansion and contraction create a shock wave that turns into a booming sound wave, known as thunder.

DO YOU KNOW? Lightning's extreme heat will vaporize the water inside a tree, creating steam that may burn out the tree.

Sometimes lightning may be seen before the thunder is heard. This is because the distance between the clouds and the surface is very long and the speed of light is much faster than the speed of sound.

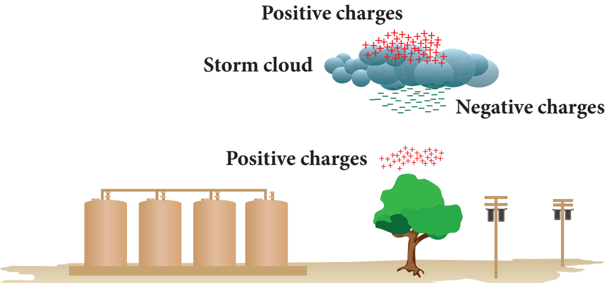

Figure 2.9 Formation of Lightning

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During lightning and thunder, we should avoid standing in ground and open spaces. You should make yourself as small as possible by squating. It is however safe to stay inside a car because the car acts as a shield and protects us from the electric field generated by the storm.

2.6.1 Earthing

A safety measure devised to prevent people from getting shocked if the insulation inside electrical devices fails is called Earthing. Electrical earthing can be defined as the process of transferring the discharge of electrical energy directly to the Earth with the help of low-resistance wire.

We get electrical energy from different sources. Battery is one such source. We use it in wall clocks, cell phones etc. For the working of refrigerators, air conditioners, washing machines, televisions, laptops and water heaters we use domestic power supply. Usually an electric appliance such as a heater, an iron box, etc. are fitted with three wires namely live, neutral and earth. The earth wire is connected to the metallic body of the appliance. This is done to avoid accidental shock.

Suppose due to some defect, the insulation of the live wire inside an electric iron is burnt then the live wire may touch the metallic body of the iron. If the earth wire is properly connected to the metallic body, current will pass into the Earth through earth wire and it will protect us from electric shock. The Earth, being a good conductor of electricity, acts as a convenient path for the flow of electric current that leaks out from the insulation.

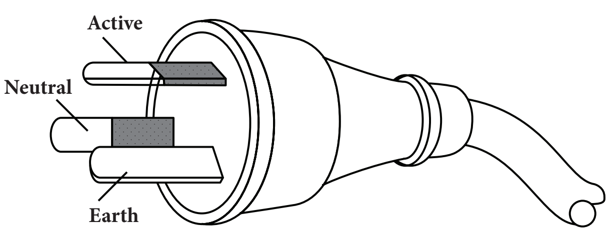

Figure 2.10 Live, Neutral and Earth wire

2.6.2 Lightning Arresters

Lightning arrestor is a device used to protect buildings from the effects of lightning. Lightning conductor consists of a metallic lightning rod that remains in air at the top of the building. Major portion of the metal rod and copper cable are installed in the walls during its construction. The other end of the rod is placed deep into the soil. When lightning falls, it is attracted by the metallic rods at the top of the building. The rod provides easy route for the transfer of electric charge to the ground. In the absence of lightning arrestors, lightning will fall on the building and the building will be damaged.

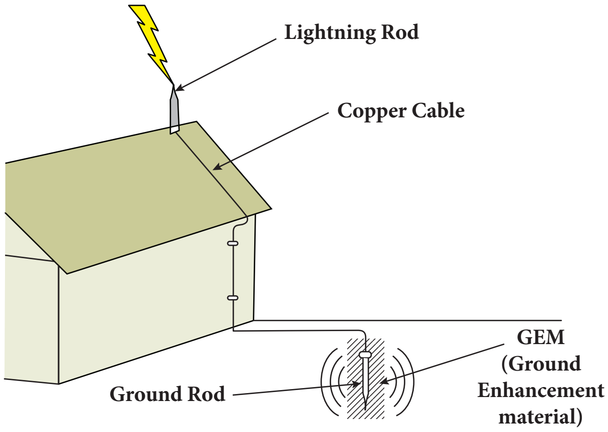

Figure 2.11 Lightning arresters

2.7 Electric Circuits

We saw that when two oppositely charged spheres are connected by a metal wire, electrons flow from the sphere which is at lower potential to the sphere at higher potential. Similarly, if two terminals of a battery which are at different potential are connected by a metallic wire, electrons will flow from negative terminal to positive terminal. The path through which electrons flow from one terminal to another terminal of the source, is called electric circuit.

A simple circuit consists of four elements: a source of electricity (battery), a path or conductor through which electricity flows (wire), a switch to control the circuit and an electrical resistor (lamp) which is any device that requires electricity to operate.

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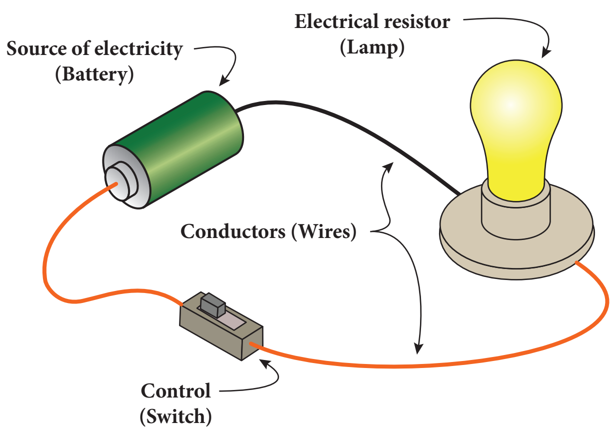
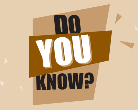


Figure 2.12 Simple electric circuit

The above figure shows a simple circuit containing a battery, two wires, key and an electric bulb. The source can be a battery or the electric outlet in your room. The electrical resistor refers to the device that consumes the energy. Control (key) is the mechanism that is used to start, stop and regulate the electric current. When the key is on, electrons from the battery flow through the circuit from the negative terminal through the wire conductor, then through the bulb and finally back to the positive terminal. The light glows when current is flowing through its filament. There are two basic ways in which we can connect these components. They are: series and parallel.



The electric eel is a species of fish which can give electric shocks of upto six hundred fifty watts of electricity. But if the eel repeatedly shocks, its electric organs become completely discharged. Then a person can touch it without being shocked.

2.7.1 Series Circuit

A series circuit is one that has more than one resistor (bulb) but only one path through which the electrons can travel. From one end of the battery the electrons move along one path with no branches through the resistors (bulbs) to the other end of the cell. All the components in a series circuit are connected end to end. So, current through the circuit remains same throughout the circuit. But, the voltage gets divided across the bulbs in the circuit. In the following series circuit two bulbs are used as resistors.

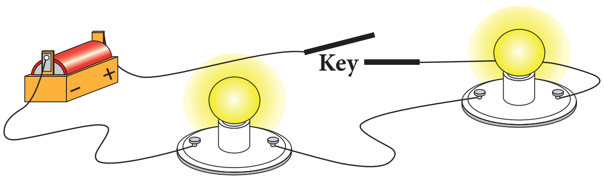


Figure 2.13 Series circuit

In this series circuit, charges (electrons) from the battery have only one path to travel. Here battery, key and two bulbs are connected in series. Charges flow from the battery to each bulb, one at a time, in the order they are wired to the circuit. If one bulb in the circuit is unscrewed, the current flow to another bulb would be interrupted. We put serial lights during festivals. If the lights are in a series circuit, one burned out bulb will keep all the lights off. If the number of bulbs in a circuit with a battery increases, the light will be dimmer because many resistors are acting on the same power from the battery.

We saw that in series circuit same current travels through every resistance and the voltage will be different across each resistance. Let us consider three bulbs connected in series. Let I be the current through the circuit and V_1, V_2, V_3 be the voltage across each bulb. The supply voltage V is the total of the individual voltage drops across the resistances.

$$V = V_1 + V_2 + V_3$$

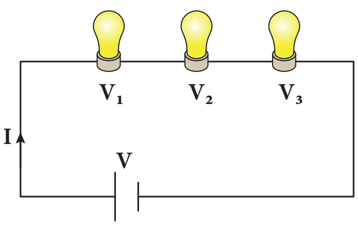


Figure 2.14 Voltage in series circuit

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2.7.2 Parallel Circuit

In a parallel circuit, there is more than one resistor (bulb) and they are arranged on many paths. This means charges (electrons) can travel from one end of the cell through many branches to the other end of the cell. Here, voltage across the resistors (bulbs) remains the same but the current flowing through the circuit gets divided across each resistor.

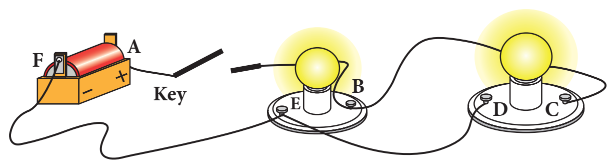


Figure 2.15 Parallel circuit

In the above diagram current can flow in two paths: ABEFA and ABCDEFA. Here, it is clear that electricity from the cell can take either path ABEFA or path ABCDEFA to return to the cell. From the diagram you will notice that even when one resistor (bulb) burns out, the other bulbs will work because the electricity is not flowing through only one path. All the light bulbs in our homes are connected in parallel circuit. If one bulb burns out, the other bulbs in the rooms will still work. The bulbs in a parallel circuit do not dim out as in series circuits. This is because the voltage across one branch is the same as the voltage across all other branches.

Let us consider three bulbs connected in series. Let V be the voltage across the bulbs and I_1, I_2, I_3 be the current across each bulb. The current I from the battery is the total of the individual current flowing through the resistances.

$$I = I_1 + I_2 + I_3$$

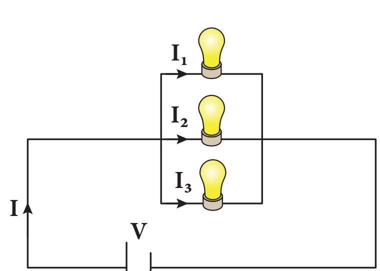


Figure 2.16 Current in parallel circuit

Table 2.1 Difference between series and parallel circuits.

Series circuit	Parallel circuit
Same amount of current flows through all the components.	The current flowing through each component combines to form the current flow.
Voltage is different across different components.	Sum of the voltage through each component will be the voltage drawn from the source.
Components are arranged in a line.	Components are arranged parallel to each other.
If one component breaks down, the whole circuit will burn out.	Other components will function even if one component breaks down.

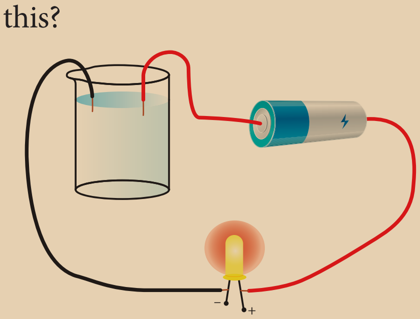
2.8 Effects of Current

When current is flowing through a conductor it produces certain effects. These are known as effects of electric current. These effects result in conversion of electrical energy into different forms of energies such as heat energy, mechanical energy, magnetic energy, chemical energy and so on.

2.8.1 Chemical Effect of Current

Activity 5

Take two pieces of wire, an LED light and a battery, and make a simple electric circuit. Take some water in a glass and put the wires in the water as shown in the figure. Does the LED bulb glow? What do you understand from this?



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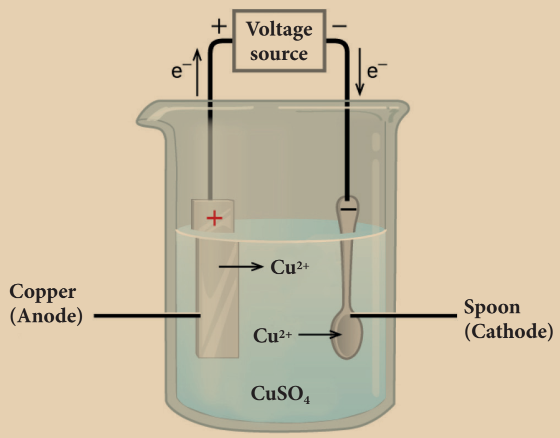
We saw that electricity is conducted by metals. This activity shows that liquids also conduct electricity. When electric current is passed through a conducing solution, some chemical reactions take place in the solution. This chemical reactions produce electrons which conduct electricity. This is called chemical effect of electric current. The decomposition of molecules of a solution into positive and negative ions on passing an electric current through it, is called electrolysis. Electrolysis has a number of applications. It is used in extraction and purification of metals. The most general use of electrolyte is electroplating.

Electroplating

Electroplating is one of the most common applications of chemical effects of electric current. The process of depositing a layer of one metal over the surface of another metal by passing electric current in called electroplating.

Activity 6

Take a glass jar and fill it with copper sulphate solution. Take a copper metal plate and connect it to the positive terminal of battery. Connect an iron spoon to the negative terminal of the battery. Now, dip them in the copper sulphate solution. When electric current is passed through the copper sulphate solution, you will find that a thin layer of copper metal is deposited on the iron spoon and an equivalent amount of copper is lost by the copper plate.

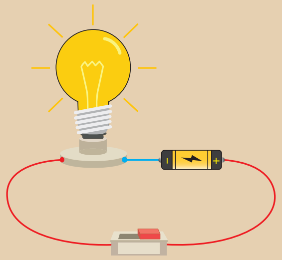


Electro plating is applied in many fields. We use iron in bridges and automobiles to provide strength. However, iron tends to corrode and rust. So, a coating of zinc is deposited on iron to protect it from corrosion and formation of rust. Chromium has a shiny appearance. It does not corrode. It resists scratches. But, chromium is expensive and it may not be economical to make the whole object out of chromium. So, the objects such as car parts, bath taps, kitchen gas burners, bicycle handlebars, wheel rims are made from a cheaper metal and only a coating of chromium is deposited over it.

2.8.2 Heating Effect of Current

Activity 7

Take a battery, a bulb, a switch and few connecting wires. Make an electric circuit as shown in the figure. Keep the switch in the 'OFF' position. Does the bulb glow? Now move the electric switch to the 'ON' position and let the bulb glow for a minute or so. Touch the bulb now. Do you feel the heat?



When electric current passes through a conductor, there is a considerable 'friction' between the moving electrons and the molecules of the conductor. During this process, electrical energy is transformed to heat energy. This is known as heating effect of electric current. The heat produced depends on the amount of resistance offered by the wire.

Copper wire offers very little resistance and does not get heated up quickly. On the other hand, thin wires of tungsten or nichrome which are used in bulbs offer high resistance and gets heated up quickly. This is

8th_Science_Term_II_Unit-2_PHY.indd 21 29-07-2019 12:07:54

the reason why tungsten wire is used in the filaments of the bulbs and nichrome wire is used as a heating element in household heating appliances. Heating effect of electric current can be seen in many devices. Some of them are given below.

Fuse

Fuse is a strip of alloy wire which is made up of lead and tin with a very low melting point. This can be connected to the circuit. The fuse is usually designed to take specific amount of current. When current passing through the wire exceeds the maximum limit, it gets heated up. Due to low melting point it melts quickly disconnecting the circuit. This prevents damage to the appliances.

Figure 2.17 Fuse wire

Electric cookers

Electric cookers turn red hot when electric current is passed through the coil. The heat energy produced is absorbed by the cooking pot through conduction.

Electric kettles

The heating element is placed at the bottom of the kettle which contains water. The heat is then absorbed by the liquid and distributed throughout the liquid by convection.

Electric irons

When current flows through the heating element, the heat energy developed is conducted to the heavy metal base, raising its temperature. This energy is then used to press clothes.

Points to Remember

- Opposite charges attract each other and like charges repel each other.
- Charges can be transferred from one region to another region by any of the following ways: Transfer by friction, Transfer by conduction and Transfer by induction.
- Friction between objects results in transfer of electrons between them.
- When a charged body touches another body, charges can be transferred from one body to another.
- Induction is a process of charging an uncharged body by bringing a charged body near to it but not touching it.
- Electroscope is an instrument used to detect and measure electric charges.
- Earthing is the process of connecting the exposed metal parts of an electrical circuit to the ground.
- Lightning arrester is a device used to protect buildings from the effects of lightning.
- A simple circuit consists of four elements: a source of electricity (battery), a path or conductor through which electricity flows (wire), a switch to control the circuit and an electrical resistor (lamp) which is any device that requires electricity to operate.
- The decomposition of molecules of a solution into positive and negative ions on passing an electric current through it is called electrolysis.
- A fuse is a strip of alloy wire which is made of lead and tin with a very low melting point.

A-Z GLOSSARY

Battery	A device that stores and produces electricity from chemical cells.
Circuit	The path that electricity follows.
Electric charge	Basic property of matter carried by some elementary particles. Electric charge can be positive or negative.

8th_Science_Term_II_Unit-2_PHY.indd 22 29-07-2019 12:07:54

Electric current	Flow of electric charges through a material.
Electron	A tiny particle which rotates around the nucleus of an atom. It has a negative charge of electricity.
Electroscope	A scientific instrument used to detect the presence of electric charges on a metal body.
Friction	The resistance that one surface or object encounters when moving over another.
Fuse	A strip of wire that melts and breaks an electric circuit if the current exceeds a safe level.
Volt	Unit of electrical force or electric pressure.
Voltage	An electromotive force that causes electrons to flow.

E7I4T7

TEXT BOOK EXERCISES

I. Choose the best answer.

1. When an ebonite rod is rubbed with fur, the charge acquired by the fur is
   (a) negative (b) positive
   (c) partly positive and partly negative
   (d) None of these

2. The electrification of two different bodies on rubbing is because of the transfer of
   a) neutrons b) protons
   c) electrons d) protons and neutrons

3. Which of the following a simple circuit must have?
   a) Energy Source, Battery, Load
   b) Energy Source, Wire, Load
   c) Energy Source, Wire, Switch
   d) Battery, Wire, Switch

4. An electroscope has been charged by induction with the help of charged glassrod. The charge on the electroscope is
   a) negative b) positive
   c) both positive and negative
   d) None of the above

5. Fuse is
   a) a switch
   b) a wire with low resistance
   c) a wire with high resistance
   d) a protective device for breaking an electric circuit

II. Fill in the blanks.

1. _______takes place by rubbing objects together.
2. The body which has lost electrons becomes ________
3. ______ is a device that protects building from lightning strike.
4. _____ has a thin metallic filament that melts and breaks the connection when the circuit is overheated.
5. Three bulbs are connected end to end from the battery. This connection is called _______

III. State True or False. If false, correct the statement.

1. The charge acquired by an ebonite rod rubbed with a piece of flannel is negative.

8th_Science_Term_II_Unit-2_PHY.indd 23 29-07-2019 12:07:54

2. A charged body induces an opposite charge on an uncharged body when they are brought near.
3. Electroscope is a device used to charge a body by induction.
4. Water can conduct electricity.
5. In parallel circuit, current remains the same in all components.

IV. Match the following.

Two similar charges	acquires a positive charge
Two dissimilar charges	prevents a circuit from overheating
When glass rod is rubbed with silk	repel each other
When ebonite rod is rubbed with fur	attract each other
Fuse	acquires a negative charge

V. Give reason for the following.

1. When a glass rod is rubbed with silk cloth both get charged.
2. When a comb is rubbed with dry hair it attracts small bits of paper.
3. When you touch the metal disc of an electroscope with a charged glass rod the metal leaves get diverged.
4. In an electroscope the connecting rod and the leaves are all metals.
5. One should not use an umbrella while crossing an open field during thunderstorm.

VI. Choose the correct answer from the following directions.

a) If both assertion and reason are true and reason is the correct explanation of assertion.

b) If both assertion and reason are true and reason is not the correct explanation of assertion.

c) If the assertion is true but reason is false.

d) If the assertion is false but reason is true.

1. **Assertion:** People struck by lightning receive a severe electrical shock.
   Reason: Lightning carries very high voltage.
2. **Assertion:** It is safer to stand under a tall tree during lightning.
   Reason: It will make you the target for lightning.

VII. Answer briefly.

1. How charges are produced by friction?
2. What is earthing?
3. What is electric circuit?
4. What is electroplating?
5. Give some uses of electroplating.

VIII. Answer in detail.

1. Explain three ways of charge transfer.
2. What is electroscope? Explain how it works?
3. Explain series and parallel circuit.
4. How lightning takes place?
5. What is electroplating? Explain how it is done.

REFERENCE BOOKS

1. Concept of physics - HC Verma
2. A Text-Book on Static Electricity - Hobart Mason
3. Fun With Static Electricity - Joy Cowley
4. Frank New Certificate Physics. McMillan Publishers.

INTERNET RESOURCES

1. http://sciencenetlinks.com/lessons/static-electricity-2/
2. https://www.stem.org.uk/resources/community/collection/13389/static-electricity
3. https://www.physicsclassroom.com/class/estatics

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Concept Map

Electricity

- **Transfer of Charges**
  - Friction
  - Conduction
  - Induction
- **Flow of Charges**
  - Gold Leaf Electroscope
- **Lightning and Thunder**
  - Earthing
  - Lightning arrestors
- **Electric Circuits**
  - Series
  - Parallel
- **Effects of Current**
  - Chemical effect
  - Heating effect

ICT CORNER

Electricity

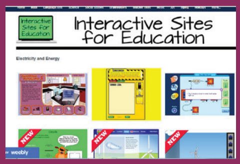
Through this activity you will learn the usage of electricity through Interactive games.

Step 1 Open the Browser and type the URL given below

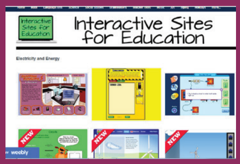
Step 2 You will see lot of games which is related to Electricity

Step 3 Click the Electricity circuits activity (First activity), you will see the sub topics, like Electricity in home, Introduction to circuits etc...

Step 4 Select the sub topic and play the game. Likewise play all the games.



Step1



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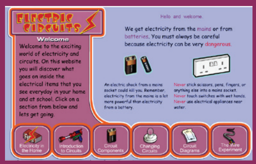

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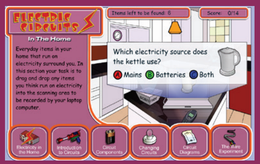

Step4

Browse in the link:

http://interactivesites.weebly.com/electricity-and-energy.html

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*Pictures are indicative only

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UNIT 4

ATOMIC STRUCTURE

N9B5H7

Learning Objectives

After completing this lesson, students will be able to:

- understand the advantages and limitations of Dalton's atomic theory.
- distinguish the fundamental particles and their properties.
- get an idea about Thomson's atom model and its limitations.
- calculate the valency of different elements.
- write the chemical formula and molecular formula of compounds.
- balance the chemical equations.
- state the laws of chemical combinations.

Introduction

Every substance in our surrounding is made up of unique elements. There are 118 elements identified worldwide so far. Out of these elements, 92 elements occur in the nature and the remaining elements are synthesised in the laboratories. Copper, Iron, Gold and Silver are some of the elements found in the nature. Elements like Technetium, Promethium, Neptunium and Plutonium are synthesised in the labaratories. Each element is made up of similar, minute particles called atoms. For example, the element gold is made up of similar atoms which determine its characteristics. The word atom is derived from the Greek word **atomas**. **Tomas** means smallest divisible particle and atomas means smallest indivisible particle. Ancient philosophers like Democritus have spoken about atoms. Even our Tamil poet Avvaiyar has mentioned about atoms in her poem while describing Thirukkural (அணுவைத் துளைத்து ஏழ் கடலைப்புகட்டிக் குறுகத் தரித்த குறள்). But, none of them have scientific base. The first scientific theory about atom was given by John Dalton. Followed by him, J.J.Thomson and Rutherford have given their theory about atom. In this lesson, we will study how atomic theories evolved at different times. We will also study about valency, molecular formula, rules for naming chemical compounds and balancing chemical equations.

4.1 Dalton's Atomic Theory

John Dalton provided a basic theory about the nature of matter. He proposed a model of atom known as Dalton's atomic theory in 1808 based on his experiments. The main postulates of Dalton's atomic theory are:

- All the matters are made up of extremely small particles called atoms (Greek philosopher Democritus used the same name for the smallest indivisible particles).
- Atoms of the same element are identical in all respects (size, shape, mass and properties).

8th_Science_Term_II_Unit-4_CHM.indd 36 30-07-2019 14:26:54

- Atoms of different elements have different sizes and masses and possess different properties.
- Atoms can neither be created nor be destroyed. i.e., atom is indestructible.
- Atoms of different elements may combine with each other in a fixed simple ratio to form molecules or compounds.
- An atom is the smallest particle of matter that takes part in a chemical reaction.

DO YOU KNOW?

John Dalton, son of a poor weaver, began his career as a village school teacher at the age of 12. He became the principal of the school seven years later. In 1793, he moved to Manchester to teach Physics, Chemistry and Mathematics in a college. He proposed his atomic theory in 1803. He carefully recorded each day, the temperature, pressure and amount of rainfall from his youth till the end. He was a meticulous meteorologist.

4.1.1 Advantages of Dalton's Atomic Theory

- Dalton's theory explains most of the properties of gases and liquids.
- This explains the laws of chemical combination and the law of conservation of mass.
- This theory helps to recognize the molecular differences of elements and compounds.

4.1.2 Limitations of Dalton's Atomic Theory

- Atom is no longer considered as the smallest indivisible particle.
- Atoms of the same element have different masses (Isotopes).
- Atoms of the different elements may have same masses (Isobars).
- Substances made up of same kind of atoms may have different properties (Ex. Coal, Graphite and Diamond are made up of carbon atoms but they differ in their properties).

4.2 Fundamental Particles

In 1878, Sir William Crookes, while conducting an experiment using a discharge tube, found certain visible rays travelling between two metal electrodes. These rays are known as Crookes' Rays or Cathode Rays. The discharge tube used in the experiment is now referred as Crookes tube or more popularly as Cathode Ray Tube **(CRT)**.

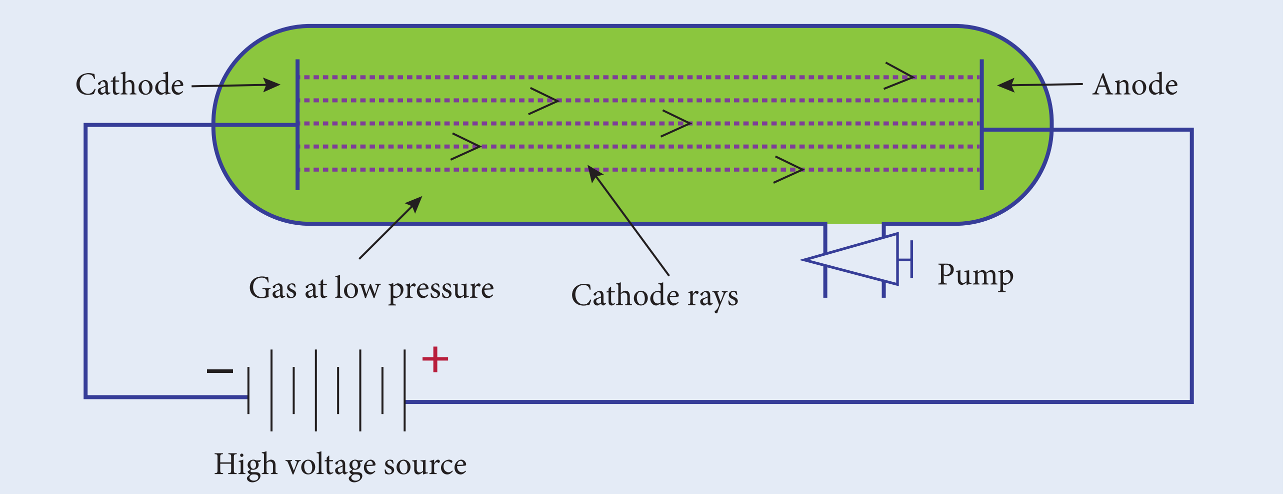

Figure 4.1 Cathode Ray Tube

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Cathode Ray Tube is a long glass tube filled with gas and sealed at both the ends. It consists of two metal plates (which act as electrodes) connected with high voltage. The electrode which is connected to the negative terminal of the battery is called the cathode (negative electrode). The electrode connected to the positive terminal is called the anode (positive electrode). There is a side tube which is connected to a pump. The pump is used to lower the pressure inside the discharge tube.

> **DO YOU KNOW?** Electricity, when passes through air, removes the electrons from the gaseous atoms and produces ions. This is called electrical discharge.

4.2.1 Discovery of Electrons

V7M2U3

When a high electric voltage of 10,000 volts or more is applied to the electrode of a discharge tube containing air or any gas at atmospheric pressure, no electricity flows through the air. However, when the high voltage of 10,000 volts is applied to the electrodes of discharge tube containing air or any gas at a very low pressure of about 0.001 mm of mercury, a greenish glow is observed on the walls of the discharge tube behind anode. This observations clearly show some invisible ray coming from the cathode. Hence, these rays are called cathode rays. Later, they were named as **electrons**.

> **DO YOU KNOW?** The fact that air is a poor conductor of electricity is a blessing in disguise for us. Imagine what would happen if air had been a good conductor of electricity. All of us would have got electrocuted, when a minor spark was produced by accident.

Properties of Cathode rays

- Cathode rays travel in straight line from cathode towards anode.
- Cathode rays are made up of material particles which have mass and kinetic energy.
- Cathode rays are deflected by both electric and magnetic fields. They are negatively charged particles.
- The nature of the cathode rays does not depend on the nature of the gas filled inside the tube or the cathode used.

> **DO YOU KNOW?** In television tube cathode rays are deflected by magnetic fields. A beam of cathode rays is directed toward a coated screen on the front of the tube, where by varying the magnet field generated by electromagnetic coils, the beam traces a luminescent image.

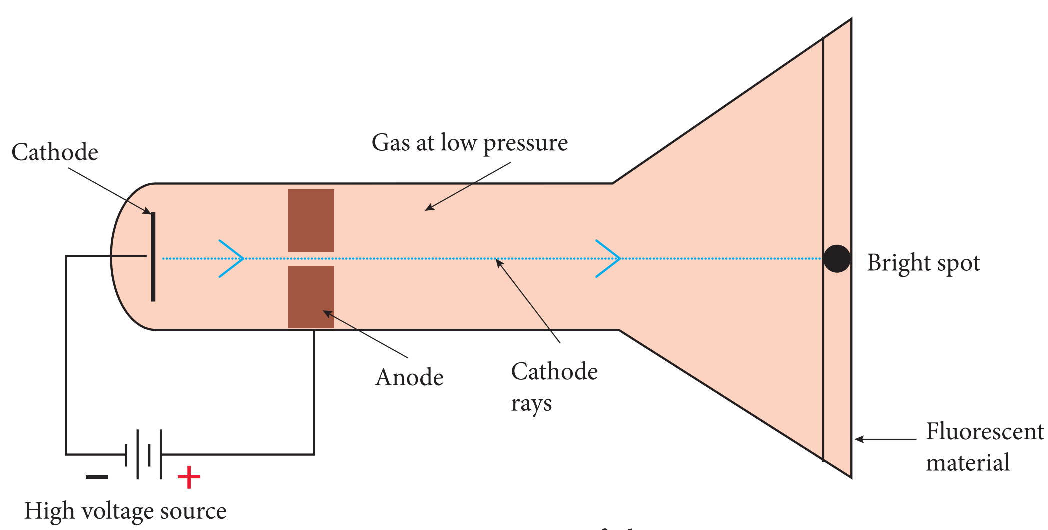

Figure 4.2 Emission of Electrons

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4.2.2 Discovery of Protons

The presence of positively charged particles in the atom has been precisely predicted by Goldstein based on the conception that the atom being electrically neutral in nature, should necessarily possess positively charged particles to balance the negatively charged electrons.

Goldstein repeated the cathode ray experiment by using a perforated cathode. On applying a high voltage under low pressure, he observed a faint red glow on the wall behind the cathode. Since these rays originated from the anode, they were called anode rays or canal rays or positive rays. Anode rays were found as a stream of positively charged particles.

DO YOU KNOW? When invisible radiation falls on materials like zinc sulphide, they emit a visible light (or glow). These materials are called fluorescent materials.

Properties of Anode rays

- Anode rays travel in straight lines.
- Anode rays are made up of material particles.
- Anode rays are deflected by electric and magnetic fields. Since, they are deflected towards the negatively charged plate, they consist of positively charged particles.
- The properties of anode rays depend upon the nature of the gas taken inside in the discharge tube.
- The mass of the particle is the same as the atomic mass of the gas taken inside the discharge tube.

DO YOU KNOW? When hydrogen gas was taken in a discharge tube, the positively charged particles obtained from the hydrogen gas were called protons. Each of these protons are produced when one electron is removed from one hydrogen atom. Thus, a proton can be defined as an hydrogen ion (H^+).

$$H \rightarrow H^+ + e$$

4.2.3 Discovery of Neutrons

At the time of J.J.Thomson, only two fundamental particles (proton and electron) were known. In the year 1932, James Chadwick discovered another fundamental particle, called neutron. But, the proper position of these particles in an atom was not clear till Rutherford described the structure of atom. You will study about Rutherford's atom model in your higher classes.

Properties of Neutrons

- Neutron is a neutral particle, that is, it carries no charge.
- It has mass equal to that of a proton, that is 1.6×10^{-24} grams.

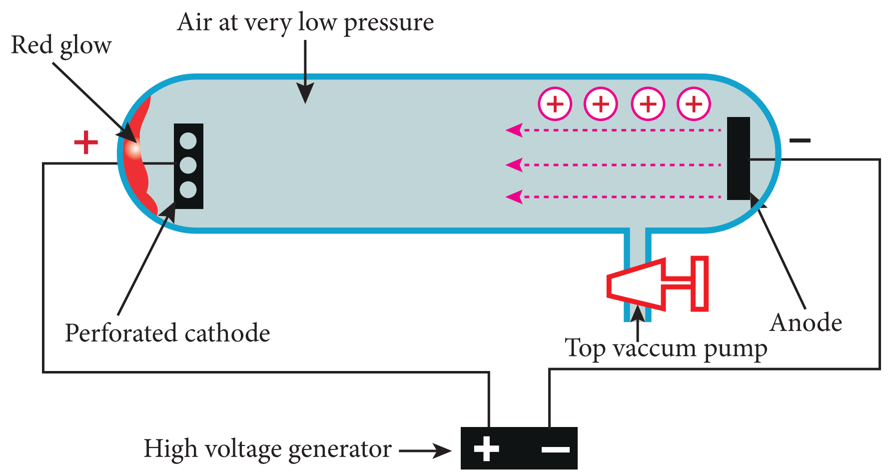

Figure 4.3 Emission of Protons

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Table 4.1 Properties of Fundamental particles.

Particle	Mass	Relative charge
Electron (e)	9.1×10^{-28} grams	−1
Proton (p)	1.6×10^{-24} grams	+1
Neutron (n)	1.6×10^{-24} grams	0

Activity 1

Collect more information about the properties of fundamental particles and prepare a chart.

4.3 Thomson's Atom Model

J.J. Thomson, an English scientist, proposed the famous atom model in the year 1904, just after the discovery of electrons.

Thomson proposed that the shape of an atom resembles a sphere having a radius of the order of 10^{-10} m. The positively charged particles are uniformly distributed with electrons arranged in such a manner that the atom is electrically neutral. Thomson's atom model was also called as the plum pudding model or the watermelon model. The embedded electrons resembled the seed of watermelon while the watermelon's red mass represented the positive charge distribution. The plum pudding atomic theory assumed that the mass of an atom is uniformly distributed all over the atom.

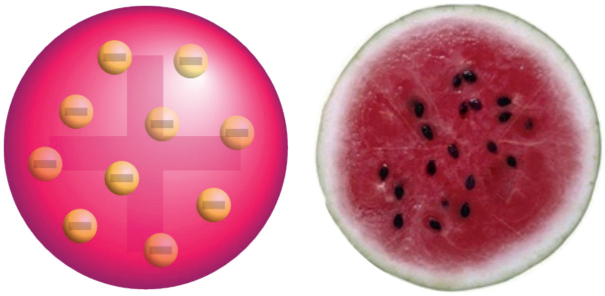


Figure 4.4 Thomson's Atom model

4.3.1 Limitations of Thomson's Atom model

Thomson's atom model could successfully explain the electrical neutrality of atom. However, it failed to explain the following.

1. Thomson's model failed to explain how the positively charged sphere is shielded from the negatively charged electrons without getting neutralised.
2. This theory explains only about the protons and electrons and failed to explain the presence of neutral particle neutron.

4.4 Valency

In order to understand valency of elements clearly, we need to learn a little about Rutherford's atom model here. According to Rutherford, an atom consists of subatomic particles namely, proton, electron and neutrons. Protons and neutrons are found at the centre of an atom, called nucleus. Electrons are revolving around the nucleus in a circular path, called orbits or shells. An atom has a number of orbits and each orbit has electrons. The electrons revolving in the outermost orbit are called valence electrons.

The arrangement of electrons in the orbits is known as electronic configuration. Atoms of all the elements will tend to have a stable electronic configuration, that is, they will tend to have either two electrons (known as duplet)

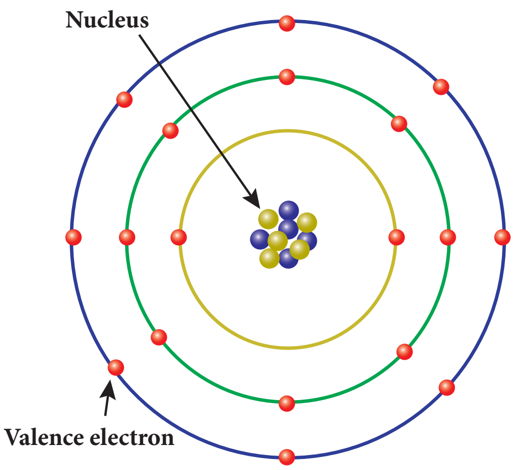


Figure 4.5 Arrangement of electrons in atom

8th_Science_Term_II_Unit-4_CHM.indd 40 30-07-2019 14:26:55

or eight electrons (known as octet) in their outermost orbit. For example, helium has two electrons in the outermost orbit and so it is chemically inert. Similarly, neon is chemically inert because, it has eight electrons in the outermost orbit.

The valence electrons in an atom readily participate in a chemical reaction and so the chemical properties of an element are determined by these electrons. When molecules are formed, atoms combine together in a fixed proportion because each atom has different combining capacity. This combining capacity of an atom is called valency. Valency is defined as the number of electrons lost, gained or shared by an atom in a chemical combination so that it becomes chemically inert.

4.4.1 Types of Valency

As we saw earlier, an atom will either gain or lose electrons in order to attain the stable electronic configuration. In order to understand valency in a better way, it can be explained in two ways depending on whether an atom gains or losses electrons.

Atoms of all metals will have 1 to 3 electrons in their outermost orbit. By loosing these electrons they will have stable electronic configuration. So, they lose them to other atoms in a chemical reaction and become positively charged. Such atoms which donate electrons are said to have positive valency. For example, sodium atom (Atomic number: 11) has one electron in its outermost orbit and in order to have stability it loses one electron and becomes positively charged. Thus, sodium has positive valency.

All non-metals will have 4 to 7 electrons in the outermost orbit of their atoms. In order to attain stable electronic configuration, they need few electrons. They accept these electrons from other atoms in a chemical reaction and become negatively charged. These atoms which accept electrons are said to have negative valency. For example, chlorine atom (Atomic number: 17) has seven electrons in its outermost orbit. By gaining one electron it attains stable electronic configuration. Thus, chlorine has negative valency.

4.4.2 Valency with respect to atoms

Valency of an element is also determined with respect to other atoms. Generally, valency of an atom is determined with respect to hydrogen, oxygen and chlorine.

a. Valency with respect to Hydrogen

Since hydrogen atom loses one elctron in its outermost orbit, its valency is taken as one and it is selected as the standard. Valencies of the other elements are expressed in terms of hydrogen. Thus, valency of an element can also be defined as the number of hydrogen atoms which combine with one atom of it. In hydrogen chloride molecule, one hydrogen atom combines with one chlorine atom. Thus, the valency of chlorine is one. Similarly, in water molecule, two hydrogen atoms combine with one oxygen atom. So, valency of oxygen is two.

Since some of the elements do not combine with hydrogen, the valency of the element is also defined in terms of other elements like chlorine or oxygen. This is because almost all the elements combine with chlorine and oxygen.

Table 4.2 Valency of atoms

Molecule	Element	Valency
Hydrogen chloride (HCl)	Chlorine	1
Water (H_2O)	Oxygen	2
Ammonia (NH_3)	Nitrogen	3
Methane (CH_4)	Carbon	4

b. Valency with respect to Chlorine

Since valency of chlorine is one, the number of chlorine atoms with which one

8th_Science_Term_II_Unit-4_CHM.indd 41 30-07-2019 14:26:55

atom of an element can combine is called valency. In sodium chloride (NaCl) molecule, one chlorine atom combines with one sodium atom. So, the valency of sodium is one. But, in magnesium chloride ($MgCl_2$) valency of magnesium is two because it combines with two chlorine atoms.

c. Valency with respect to oxygen

In another way, valency can be defined as double the number of oxygen atoms with which one atom of an element can combine because valency of oxygen is two. For example, in magnesium oxide (MgO) valency of magnesium is two.

4.4.3 Variable Valency

Atoms of some elements combine with atoms of other elements and form more than one product. Thus, they are said to have different combining capacity. These atoms have more than one valency. Some cations exhibit more than one valency. For example, copper combines with oxygen and forms two products namely cuprous oxide (Cu_2O) and cupric oxide (CuO). In Cu_2O, valency of copper is one and in CuO valency of copper is two. For lower valency a suffix –ous is attached at the end of the name of the metal. For higher valency a suffix –ic is attached at the end of the name of the metal. Sometimes Roman numeral such as I, II, III, IV etc. indicated in parenthesis followed by the name of the metal can also be used.

Table 4.3 Metals with variable valencies

Element	Cation	Names
Copper	Cu^{+}	Cuprous (or) Copper (I)
	Cu^{2+}	Cupric (or) Copper (II)
Iron	Fe^{2+}	Ferrous (or) Iron (II)
	Fe^{3+}	Ferric (or) Iron (III)
Mercury	Hg^{+}	Mercurous (or) Mercury (I)
	Hg^{2+}	Mercuric (or) Mercury (II)
Tin	Sn^{2+}	Stannous (or) Tin (II)
	Sn^{4+}	Stannic (or) Tin (IV)

4.5 Ions

In an atom, the number of protons is equal to the number of electrons and so the atom is electrically neutral. But, during chemical reactions unstable atoms try to attain stable electronic configuration (duplet or octet) either by gaining or losing one or more electrons. When an atom gains an electron it has more number of electrons and thus it carries negative charge. At the same time when an atom loses an electron it has more number of protons and thus it carries positive charge. These atoms which carry positive or negative charges are called ions. The number of electrons gained or lost by an atom is shown as a superscript to the right of its symbol. When an atom loses an electron, '+' sign is shown in the superscript and '–' sign is shown if an electron is gained by an atom. Some times, two or more atoms of different elements collectively lose or gain electrons to acquire positive or negative charge. Thus we can say, an atom or a group of atoms when they either lose or gain electrons, get converted into ions or radicals

4.5.1 Types of Ions

Ions are classified into two types. They are: cations and anions.

Cations

If an atom loses one or more electrons during a chemical reaction, it will have more number of positive charge on it. These are called cations (or) positive radicals. Sodium atom loses one electron to attain stability and it becomes cation. Sodium ion is represented as Na^{+}.

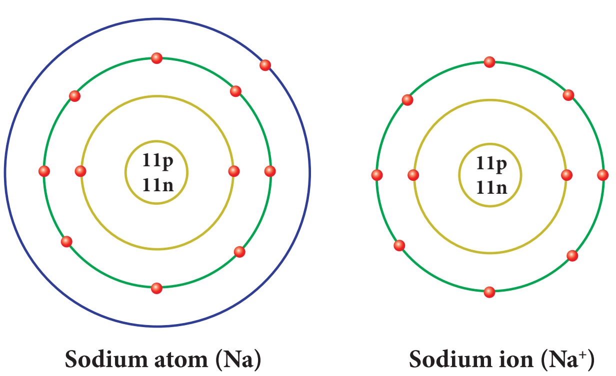
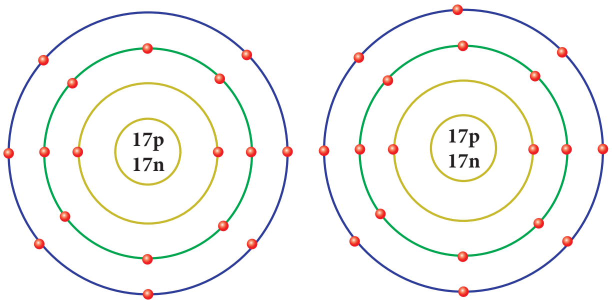


Figure 4.6 Electronic configuration of Sodium

Anions

If an atom gains one or more electrons during a chemical reaction, it will have more number of negative charge on it. These are called anions or negative radicals. Chlorine atom attains stable electronic configuration by gaining an electron. Thus, it becomes anion. Chlorine ion is represented as Cl^-.



Chlorine atom (Cl) **Chlorine ion (Cl^-)**

Figure 4.7 Electronic configuration of Chlorine

4.5.2 Different valent ions

During a chemical reaction, an atom may gain or lose more than one electron. An ion or radical is classified as monovalent, divalent, trivalent or tetravalent when the number of charges over it is 1,2,3 or 4 respectively. Based on the charges carried by the ions, they will have different valencies.

Valency of Anions (negative radicals) and Cations (positive radicals)

The valency of an anion or cation is a number which expresses the number of hydrogen atoms or any other monovalent atoms (Na,K,Cl….) which combine with them to give an appropriate compound. For example, two hydrogen atoms combine with one sulphate ions (SO_4^{2-}) to form sulphuric acid (H_2SO_4). So, the valency of SO_4^{2-} is 2. One chlorine atom (Cl) combines with one ammonium ion (NH_4^+) to form NH_4Cl. So, the valency of NH_4^+ is 1. Valencies of some anions and cations and their corresponding compounds are given below.

Activity 2

Classify the following ions into monovalent, divalent and trivalent.

Ni^{2+}, Fe^{3+}, Cu^{2+}, Ba^{2+}, Cs^+, Zn^{2+}, Cd^{2+}, Hg^{2+} Pb^{2+}, Mn^{2+}, Fe^{2+}, Co^{2+}, Sr^{2+}, Cr^{3+}, Li^+, Ca^{2+}, Al^{3+}

Table 4.4 Valencies of some anions.

Compound	Name of the anion	Formula of anion	Valency of anion
HCl	Chloride	Cl^-	1
H_2SO_4	Sulphate	SO_4^{2-}	2
HNO_3	Nitrate	NO_3^-	1
H_2CO_3	Carbonate	CO_3^{2-}	2
H_3PO_4	Phosphate	PO_4^{3-}	3
H_2O	Oxide	O^{2-}	2
H_2S	Sulphide	S^{2-}	2
NaOH	hydroxide	OH^-	1

Table 4.5 Valencies of some cations.

Compound	Name of cation	Formula of cation	Valency of cation
NaCl	Sodium	Na^+	1
KCl	Potassium	K^+	1
NH_4Cl	Ammonium	NH_4^+	1
$Mg\,Cl_2$	Magesium	Mg^{2+}	2
$CaCl_2$	Calcium	Ca^{2+}	2
$Al\,Cl_3$	Aluminium	Al^{3+}	3

4.6 Chemical formula or Molecular formula

Chemical formula is the shorthand notation of a molecule of a substance (compound). It shows the actual number of atoms of each element present in a molecule of a substance. Certain steps are followed to write down the chemical formula of a substance. They are given below.

Step1: Write down the symbols of elements/ ions side by side so that the positive

8th_Science_Term_II_Unit-4_CHM.indd 43 30-07-2019 14:26:55

radical is on the left and the negative radical is on the right hand side.

Step2: Write the valencies of the two radicals above their symbols to the right in superscript (Signs '+' and '-' of the ions are omitted).

Step3: Reduce the valencies to simplest ratio if needed. Otherwise interchange the valencies of the elements/ions. Write these numbers as subscripts. However, '1' appearing on the superscript of the symbol is omitted.

Thus, we arrive the chemical formula of the compound.

Let us derive the chemical formula for calcium chloride.

Step 1: Write the symbols of calcium and chlorine side by side.

Ca Cl

Step 2: Write the valencies of calcium and chlorine above their symbols to the right.

$Ca^2\ Cl^1$

Step 3: Interchange the valencies of elements.

$Ca\ Cl^2$

Thus the chemical formula for calcium chloride is **$CaCl_2$**

Activity 3

Write the chemical formula of the compounds.

Compound	Symbols with valencies	Simplest ratio if any	Chemical formula
Magnesium chlorinde			
Sodium hydroxide			
Calcium oxide			
Aluminium sulphate			
Calcium phosphate			

4.7 Naming chemical compounds

A chemical compound is a substance formed out of more than one element joined together by chemical bond. Such compounds have properties that are unique from that of the elements that formed them. While naming these compounds specific ways are followed. They are given below.

1. In naming a compound containing a metal and a non-metal, the name of the metal is written first and the name of the non-metal is written next after adding the suffix-ide to its name.

Examples:

NaCl - Sodium chloride

Ag Br - Silver bromide

2. In naming a compound containing a metal, a non-metal and oxygen, name of the metal is written first and name of the non-metal with oxygen is written next after adding the suffix- ate (for more atoms of oxygen) or –ite (for less atoms of oxygen) to its name.

Examples:

$Na_2\ SO_4$ - Sodium sulphate

$Na\ NO_2$ - Sodium nitrite

3. In naming a compound containing two non-metals only, the prefix mono, di, tri, tetra, penta etc. is written before the name of non- metals.

Examples:

SO_2 - Sulphur dioxide

N_2O_5 - Dinitrogen pentoxide

Activity 4

Write the names of the chemical compounds.

Chemical Compound	Name
SO_3	
$Na_2\ SO_3$	
PCl_5	
$CaCl_2$	
$Na\ NO_3$	
BaO	

8th_Science_Term_II_Unit-4_CHM.indd 44 30-07-2019 14:26:55

4.8 Chemical Equation

A chemical equation is a short hand representation of a chemical reaction with the help of chemical symbols and formulae. Every chemical equation has two components: reactants and products. Reactants are the substances that take part in a chemical reaction and the products are the substances that are formed in a chemical reaction.

4.8.1 Steps in writing the skeleton equation

Before writing the balanced equation of a chemical reaction, skeletal equation is written. The following are the steps involved in writing the skeletal equation.

1. Write the symbols and formulae of each of the reactants on the left hand side (LHS) and join them by plus (+) sign.
2. Follow them by an arrow ($\rightarrow$) which is interpreted as gives or forms.
3. Write on the right hand side (RHS) of arrow the symbols and formulae for each of the products.
4. The equation thus written is called as skeleton equation (unbalanced equation).
5. If the product is a gas it should be represented by upward arrow ($\uparrow$) and if it is a precipitate it should be represented by downward arrow($\downarrow$).

   Example: $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2\uparrow$

4.8.2 Balancing chemical equation

According to law of conservation of mass, the total mass of all the atoms forming the reactants should be equal to that of all the atoms forming the products. This law will hold good only when the number of atoms of all types of elements on both sides is equal. A balanced chemical equation is one in which the total number of atoms of any element on the reactant side is equal to the total number of atoms of that element on the product side.

There are many methods of balancing a chemical equation. Trial and error method (direct inspection), fractional method and odd number-even number method are some of them. While balancing a chemical equation following points are to be borne in mind.

1. Initially the number of times an element occurs on both sides of the skeleton equation should be counted.
2. An element which occurs least number of times in reactant and product side must be balanced first. Then, elements occuring two times, elements occuring three times and so on in an increasing order must be balanced.
3. When two or more elements occur same number of times, the metallic element is balanced first in preference to non-metallic element. If more than one metal or non-metal is present then a metal or non-metal with higher atomic mass (refer periodic table to find the atomic mass) is balanced first.
4. The number of molecules of reactants and products are written as coefficient.
5. The formula should not be changed to make the elements equal.
6. Fractional method of balancing must be employed only for molecule of an element (O_2,H_2,O_3,P_4,…) not for compound (H_2O, NH_3,…)

Now let us balance the equation for the reaction of hydrogen and oxygen which gives water. Write the word equation and balance it.

Step1: Write the word equation.

Hydrogen + Oxygen $\rightarrow$ Water

Step2: Write the skeleton equation.

$H_2 + O_2 \rightarrow H_2O$

Step3: Select the element which is to be balanced first based on the number of times an element occurs on both sides of the skeleton equation.

Element	H	O
Number of times particular element occurs on both sides	2	2

8th_Science_Term_II_Unit-4_CHM.indd 45 30-07-2019 14:26:55

Step4: In the above case, both elements occur one time each. Here, preference must be given to oxygen because it has higher atomic mass (refer periodic table).

Step5: To balance oxygen, put 2 before H_2O on the right hand side (RHS).

$$H_2 + O_2 \rightarrow 2H_2O$$

Step6: To balance hydrogen, put 2 near hydrogen (H_2) on the left hand side (LHS).

$$2H_2 + O_2 \rightarrow 2H_2O$$

$$(H = 4 \quad O = 2) \qquad (H = 4 \quad O = 2)$$

Now, on both sides number of hydrogen atoms is four and oxygen atoms is two. Thus, the chemical equation is balanced.

4.8.3 Information conveyed by a balanced chemical equation

A balanced chemical equation gives us both qualitative and quantitative information. It gives us qualitative informations such as the names, symbols and formulae of the reactant molecules taking part in the reaction and those of the product molecules formed in the reaction. We also can get quantitative information like the number of molecules/ atoms of the reactants and products that are taking part in the reaction. However, a chemical equation does not convey the following.

i. Physical state of the reactants and the products.
ii. Heat changes (heat liberated or heat absorbed) accompanying the chemical reaction.
iii. Conditions such as temperature, pressure, catalyst etc., under which the reaction takes place.
iv. Concentration (dilute or concentrated) of the reactants and products.
v. Speed of the reaction.

4.9 Laws of chemical combinations

By studying quantitative measurements of many reactions, it was observed that the reactions taking place between various substances are governed by certain laws. They are called as the 'Laws of chemical combinations'. They are given below.

1. Law of conservation of mass
2. Law of constant proportion
3. Law of multiple proportions
4. Gay Lussac's law of gaseous volumes

In this lesson, we will study about the first two laws. You will study about Law of multiple proportions and Gay Lussac's Law of gaseous volumes in standard IX.

4.9.1 Law of conservation of mass

The law of conservation of mass which relates the mass of the reactants and products during the chemical change was stated by a French chemist **Lavoisier** in 1774. It states that **during any chemical change, the total mass of the products is equal to the total mass of the reactants**. In other words the law of conservation of mass means that mass can neither be created nor be destroyed during any chemical reaction. This law is also known as **Law of indestructibility of mass**.

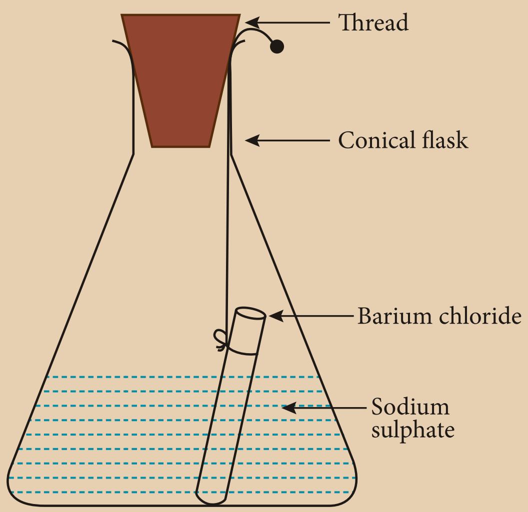
Activity 5

Take some ice cubes in an air tight container and note the weight of the container with ice cubes. Wait for a while for the ice cubes to become water. It is a physical change ie., ice cubes melt and they are converted into liquid. Now weigh the container and compare the weight before and after the melting of ice cubes. It remains the same. Hence it is proved that during a physical change, the total mass of matter remains the same.

8th_Science_Term_II_Unit-4_CHM.indd 46 30-07-2019 14:26:55

Activity 6

Prepare 5% of barium chloride (5g of $BaCl_2$ in 100 ml of water) and sodium sulphate solutions separately. Take some solution of sodium sulphate in a conical flask and some solution of barium chloride in a test tube. Hang the test tube in the conical flask. Weigh the flask with its contents. Now mix the two solutions by tilting and swirling the flask. Weigh the flask after the chemical reaction is occurred. Record your observation. It can be seen that the weight of the flask and the contents remains the same before and after the chemical change. Hence, it is proved that during a chemical change, the total mass of matter remains the same.



Consider the formation of ammonia (Haber's process) from the reaction between nitrogen and hydrogen

N_2	+	$3H_2$	$\rightarrow$	$2NH_3$
28g		6g		34g

During Haber's process the total mass of the reactant and the product are exactly same throughout the reaction.

Now, it is clear that mass is neither created not destroyed during physical or chemical change. Thus, law of conservation of mass is proved.

4.8.2 Law of constant proportions

Law of constant proportions was proposed by the scientist **Joseph Proust** in 1779. He states that **in a pure chemical compound the elements are always present in definite proportions by mass**. He observed all the compounds with two or more elements and noticed that each of such compounds had the same elements in same proportions, irrespective of where the compound came from or who prepared it. For example, water obtained from different sources like rain, well, sea, and river will always consist of the same two elements hydrogen and oxygen, in the ratio 1:8 by mass. Similarly, the mode of preparation of compounds may be different but their composition will never change. It will be in a fixed ratio. Hence, this law is also known as 'Law of definite proportions'.

Points to Remember

- An atom consists of elementary particles like proton, electron and neutron.
- The discharge tube used in the experiment is now referred as Crookes tube or Cathode Ray Tube **(CRT)**. It is a long glass tube filled with gas and sealed at both the ends.
- Different atoms have different combining capacities. The combining capacity of an atom is known as its **valency**.
- Chemical formula is the shorthand notation of a molecule of a substance (compound). It shows the actual number of atoms of each element in a molecule of a substance.
- In naming a compound containing a metal and a non-metal, the name of the metal is written first and the name of the non-metal is obtained by adding the suffix-ide to its name.
- Balancing chemical equation is necessary, so that law of conservation of mass may be obeyed.
- The law of conservation of mass states that during any chemical change, the total mass of the products is equal to the total mass of the reactants.

8th_Science_Term_II_Unit-4_CHM.indd 47 30-07-2019 14:26:56

A-Z GLOSSARY

Anode	The positively charged electrode or an electron acceptor.
Cathode	The negatively charged electrode or an electron donor.
Chemical formula	It is a representation of a substance using symbols for its constituent elements.
Discharge tube	A tube containing charged electrodes and filled with a gas in which ionisation is induced by an electric field.
Ion	An atom or molecule with a net electric charge due to the loss or gain of one or more electrons.
Molecular formula	It is a formula giving the number of atoms of each of the elements present in one molecule of a specific compound.
Precipitate	An insoluble solid that emerges from a liquid solution.
Product	A substance that is formed as the result of a chemical reaction.
Reactant	A substance that takes part in and undergoes change during a reaction.
Valency	The combining power of an element, especially as measured by the number of hydrogen atoms it can displace or combine with.

TEXT BOOK EXERCISES

J1D1C7

1. Choose the best answer.

1. The same proportion of carbon and oxygen in the carbon dioxide obtained from different sources proves the law of ________
   a) reciprocal proportion
   b) definite proportion
   c) multiple proportion
   d) conservation of mass

2. Cathode rays are made up of
   a) neutral particles
   b) positively charged particles
   c) negatively charged particles
   d) None of the above

3. In water, hydrogen and oxygen are combined in the ratio of ________by mass.
   a) 1:8 b) 8:1 c) 2:3 d) 1:3

4. Which of the following statements made by Dalton has not undergone any change?
   a) Atoms cannot be broken.
   b) Atoms combine in small, whole numbers to form compounds.
   c) Elements are made up of atoms.
   d) All atoms of an elements are alike

5. In all atoms of an element
   a) the atomic and the mass number are same.
   b) the mass number is same and the atomic number is different.
   c) the atomic number is same and the mass number is different
   d) both atomic and mass numbers may vary.

II. Fill in the blanks.

1. ____________ is the smallest particle of an element.

8th_Science_Term_II_Unit-4_CHM.indd 48 30-07-2019 14:26:56

2. An element is composed of ____________ atoms.
3. An atom is made up of ____________, ____________ and ____________.
4. A negatively charged ion is called ____________, while positively charged ion is called ____________
5. ____________ is a negatively charged particle (Electron/Proton).
6. Proton is deflected towards the _________ charged plate (positively, negatively).

III. Match the following.

1.	Law of conservation of mass	-	Sir William Crookes
2.	Law of constant proportion	-	James Chadwick
3.	Cathode rays	-	Joseph Proust
4.	Anode rays	-	Lavoisier
5.	Neutrons	-	Goldstein

IV. Answer briefly.

1. State the law of conservation of mass.
2. State the law of constant proportions.
3. Write the properties of anode rays.
4. Define valency of an element with respect to hydrogen.
5. Define the term ions or radicals.
6. What is a chemical equation?
7. Write the names of the following compounds.

   a) CO b) N_2O c) NO_2 d) PCl_5

V. Answer the following.

1. Find the valency of the element which is underlined in the following formula.

   a) $\underline{Na}Cl$ b) $\underline{C}O_2$ c) $\underline{Al}\,(PO_4)$
   d) $\underline{Ba}\,(NO_3)_2$ e) $\underline{Ca}Cl_2$

2. Write the chemical formula for the following compounds

   a) Aluminium sulphate b) Silver nitrate
   c) Magnesium oxide d) Barium chloride

3. Write the skeleton equation for the following word equation and then balance them.

a) Carbon + Oxygen → Carbon dioxide
b) Phosphorus + Chlorine → Phosphorus pentachloride.
c) Sulphur + Oxygen → Sulphur dioxide
d) Magnesium + hydrogen chloride → Magnesium chloride + Hydrogen

4. Balance the following chemical equation.

   a) $Na + O_2 \rightarrow Na_2O$
   b) $Ca + N_2 \rightarrow Ca_3N_2$
   c) $N_2 + H_2 \rightarrow NH_3$
   d) $CaCO_3 + HCl \rightarrow CaCl_2 + CO_2 + H_2O$
   e) $Pb(NO_3)_2 \rightarrow PbO + NO_2 + O_2$

VI. Higher Order Thinking Questions.

1. Why does a light paddle wheel placed in the path of cathode rays begin to rotate, when cathode rays fall on it?
2. How can we prove that the electrons carry negative charge?
3. Ruthresh, Hari, Kanishka and Thahera collected different samples of water from a well, a pond, a river and underground water. All these samples were sent to a testing laboratory. The test result showed the ratio of hydrogen to oxygen as 1:8.

   a) What conclusion would you draw from the above experiment?
   b) Which law of chemical combination does it obey?

REFERENCE BOOKS

1. Petrucci, Ralph H et.al. General Chemistry: Principles & Modern Applications (9th Edition). Upper Saddle River, NJ: Pearson Prentice Hall, 2007. Print.

2. P.L.Soni, Text book of Inorganic Chemistry, S. Chand publication, New Delhi
3. Complete Chemistry (IGCSE), Oxford university press, New York
4. Raymond Chang. (2010). Chemistry. New York, NY: The Tata McGraw Hill Companies. Inc.
5. Frank New Certificate Chemistry. McMillan Publishers

INTERNET RESOURCES

1. https://www.chem4kids.com
2. https://courses.lumenlearning.com/boundless-chemistry/chapter/the-structure-of-the-atom/
3. https://www.khanacademy.org/science/biology/chemistry--of-life/elements-and-atoms/e/atomic-structure

Concept Map

Atomic Structure

- **Dalton's Atomic theory**
  - Thomson's Atom model
- **Fundamental Particles**
  - Electrons
  - Protons
  - Neutrons
- **Valency**
  - Types
  - Valency of ions
  - Variable valency
- **Chemical formula**
  - Chemical Equation
- Law of conservation of mass.
- Law of constant proportion.

ICT CORNER — ATOMIC STRUCTURE

Through this activity you will learn the atomic structure through Interactive games

Step 1

- Open the Browser and type the URL given below.
- You can see Protons Neutrons and Electrons Atom games.
- Click the first game, you will see the periodic table. Start the quiz and answer it.
- Likewise explore the next game and play it.

B359_8_SCIENCE_EM

URL: https://www.wartgames.com/themes/science/atomicstructure.html

8th_Science_Term_II_Unit-4_CHM.indd 50 30-07-2019 14:26:56

UNIT 1

Measurement and Measuring Instruments

EJC4ZT

Learning Objectives

To get exposed to:

- the rules to be followed while expressing physical quantities in SI units
- the derived units
- the usage of scientific notations
- the three characteristics of measuring instruments
- the usage of vernier caliper and screw gauge for small measurements
- to try and find the weight of an object using a spring balance
- the importance of accurate measurements

Introduction

Measurement is the basis of all important scientific study. It plays an important role in our daily life also. When finding your height, buying milk for your family, timing the race completed by your friend and so on, you need to be able to make measurements. Measurement answers questions like, how long, how heavy and how fast? Measurement is the assignment of a number to a characteristic of an object or event which can be compared with other objects or events. It is defined as the determination of the size or magnitude of something. In this lesson you will learn about units of measurements and the characteristics of measuring instruments.

1.1 Physical Quantities and Units

1.1.1 Physical quantities

Physical quantity is a quantity that can be measured. Physical quantities can be classified into two: fundamental quantities and derived quantities. Quantities which cannot be expressed in terms of any other physical quantities are called fundamental quantities. Example: Length, mass, time, temperature. Quantities like area, volume and density can be expressed in terms of some other quantities. They are called derived quantities.

Physical quantities have a numerical value (a number) and a unit of measurement (say, 3 kilogram). Suppose you are buying

IX_Science Unit-1.indd 1 02-04-2018 18:16:21

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3 kilograms of vegetable in a shop. Here, 3 is the numerical value and kilogram is the unit. Let us see about units now.

1.1.2 Unit

A unit is the standard quantity with which unknown quantities are compared. It is defined as a specific magnitude of a physical quantity that has been adopted by law or convention. For example, feet is the unit for measuring length. That means, 10 feet is equal to 10 times the definite predetermined length, called feet. Our forefathers used units like muzham, furlong (660 feet), mile (5280 feet) to measure length.

Many of the ancient systems of measurement were based on the dimensions of human body. As a result, unit of measurement varied from person to person and also from location to location. In earlier time, different unit systems were used by people from different countries. Some of the unit systems followed earlier are given below in Table 1.

Table - 1 Unit systems of earlier times

System	Length	Mass	Time
CGS	centimetre	gram	second
FPS	foot	pound	second
MKS	metre	kilogram	second

But, at the end of the Second World War there was a necessity to use worldwide system of measurement. Hence, SI (International System of Units) system of units was developed and recommended by General Conference on Weights and Measures in 1960 for international usage.

1.2 SI System of Units

SI system of units is the modernised and improved form of the previous system of units. It is accepted in almost all the countries of the world. It is based on a certain set of fundamental units from which derived units are obtained by multiplication or division. There are seven fundamental units in the SI system of units. They are also known as base units as in Table 2.

The units used to measure the fundamental quantities are called fundamental units and the units which are used to measure derived quantities are called derived units.

Table - 2 Fundamental physical quantities and their units

Fundamental quantities	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Temperature	kelvin	K
Electric current	ampere	A
Luminous intensity	candela	cd
Amount of substance	mole	mol

With the help of these seven fundamental units, units for other derived quantities are obtained and their units are given below in Table-3.

DO YOU KNOW?

Fortnight: A fortnight is two weeks or 14 days.

Moment: If you ask someone to wait for a moment, you know it is a short period of time. But, how short? It is 1/40 th of an hour or 1.5 minutes.

IX_Science Unit-1.indd 2 02-04-2018 18:16:21

Table - 3 Derived quantities and their units

S.No	Physical quantity	Expression	Unit
1	Area	length × breadth	m^2
2	Volume	area × height	m^3
3	Density	mass/volume	Kgm^{-3}
4	Velocity	displacement/time	ms^{-1}
5	Momentum	mass × velocity	$kgms^{-1}$
6	Acceleration	velocity/time	ms^{-2}
7	Force	mass × acceleration	$kgms^{-2}$ or N
8	Pressure	force/area	Nm^{-2} or Pa
9	Energy (work)	force × distance	Nm or J
10	Surface tension	force/length	Nm^{-1}

Atomus: The smallest amount of time imaginable to us is a twinkling of the eye. This is called atomus. Do you know the value of this? It is 1/6.25 seconds or 160 milliseconds.

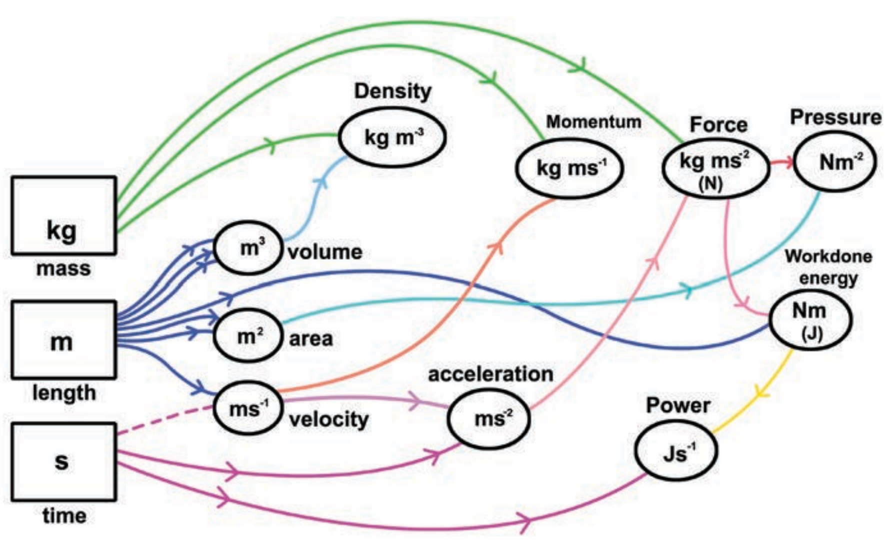
Donkey Power: You might have heard about horse power. But do you know donkey power? It is one third of a horse power. Its value is around 250 watt.

1.3 Fundamental Units of SI System

1.3.1 Length

Length is defined as the distance between two points. The SI unit of length is metre. One metre is the distance travelled by light through vacuum in 1/29,97,92,458 second.

In order to measure very large distance (distance of astronomical objects) we use the following units.



Flow chart for derived units

IX_Science Unit-1.indd 3 02-04-2018 18:16:22

- Light year
- Astronomical unit
- Parsec

Light year: It is the distance travelled by light in one year in vacuum and it is equal to 9.46×10^{15} m.

> **DO YOU KNOW?**
> Light travels 3×10^{8} m in one second or 3 lakhs kilometre in one second. In one year we have 365 days. The total number of seconds in one year is equal to $365 \times 24 \times 60 \times 60 = 3.153 \times 10^{7}$ second.
>
> 1 light year $= (3.153 \times 10^{7}) \times (3 \times 10^{8}) = 9.46 \times 10^{15}$ m.

Astronomical unit (AU): It is the mean distance of the centre of the Sun from the centre of the earth. 1 AU $= 1.496 \times 10^{11}$ m Figure 1.

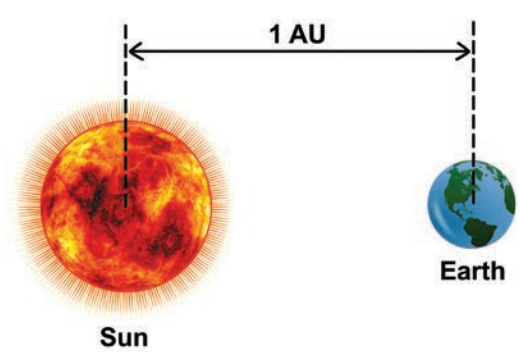


Figure 1 Astronomical unit

> **DO YOU KNOW?**
> 1 AU is equal to 14,95,97,871 km or approximately equal to 150 million km or 1,500 lakhs km.

Parsec: Parsec is the unit of distance used to measure astronomical objects outside the solar system.

1 parsec = 3.26 light year.

> **DO YOU KNOW?**
> The nearest star alpha centauri is about 1.34 parsec from the sun. Most of the stars visible to the unaided eye in the night sky are within 500 parsec distance from the sun.

To measure small distances such as distance between two atoms in a molecule, the size of the nucleus and the wavelength, we use submultiples of ten. These quantities are measured in Angstrom unit (Table 4).

> **DO YOU KNOW?**
> The total length of all the blood vessels in human body is 96,000 km.
>
> When born, a baby giraffe is 1.8 m (6ft) tall.
>
> A chameleons tongue is twice the length of its body.

Info bits

In Tamil Nadu, people still use some common length scales other than SI units. It is advisable to know the relationship between SI units with these length scales.

One feet = 30.4 cm, one meter =3.2 feet.

One inch = 2.54 cm, one meter is approximately equal to 40 inches.

These length scales are still used in hardware shops to measure house hold things like pipes, wood. Carpenters still use inch scale.

1.3.2 Mass

Mass is the quantity of matter contained in a body. The SI unit of mass is kilogram. One kilogram is the mass of a particular international

IX_Science Unit-1.indd 4 02-04-2018 18:16:23

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Table - 4 Smaller and larger units

Smaller units	In metre	Larger units	In metre
Fermi (f) *	10^{-15} m	Kilometre (km)	10^{3} m
Angstrom (Å)**	10^{-10} m	Astronomical unit (AU)	1.496×10^{11} m
Nanometre (nm)	10^{-9} m	Light year (ly)	9.46×10^{15} m
Micron (micrometre μ m)	10^{-6} m	Parsec (pc)	3.08×10^{16} m
Millimetre (mm)	10^{-3} m		
Centimetre (cm)	10^{-2} m		

* unit outside SI system and not accepted for use with it
** Non-SI unit accepted for use with it.

prototype cylinder made of platinum-iridium alloy, kept at the International Bureau of Weights and Measures at Sevres, France.

The related units in submultiples of 10 (1/10) are gram and milligram and in multiples of 10 are quintal and metric tonne.

1 quintal = 100 kg

1 metric tonne = 1000 kg = 10 quintal

1 solar mass = 2×10^{30} kg

Atomic mass unit (amu):

Mass of a proton, neutron and electron can be determined using atomic mass unit.

1 amu = 1/12th of the mass of carbon-12 atom.

More to Know

SI unit of volume is m^3 or cubic metre. Volume can also be measured in (l).

1 l = 1dm^3 = 1000 ml

1ml = 1cm^3

Mass of 1 ml of water = 1g

Mass of 1l of water = 1kg

Mass of the other liquids vary with their density.

DO YOU KNOW?

1 TMC is (thousand million cubic feet) hundred crore cubic feet.

1 TMC = 2.83×10^{10} litre.

1 TMC is approximately 3000 crore litres.

1.3.3 Time

Time is a measure of duration of events and the intervals between them. The SI unit of time is second. One second is the time required for the light to propagate 29,97,92,458 metres through vacuum. It is also defined as 1/86, 400th part of a mean solar day. Larger unit for measuring time is millennium. 1 millenium = 3.16×10^{9} s.

DO YOU KNOW?

In villages, people still use different time scales other than SI time units.

One hour = 2.5 Nazhikai (நாழிகை)

One day = 60 Nazhikai, Day time = 30 Nazhikai and Night time =30 Nazhikai.

In day time nazhikai starts at 6 am and ends at evening 6pm. Total nazhikai in

IX_Science Unit-1.indd 5 02-04-2018 18:16:23

daytime= 12 hours × 2.5 Nazhikai = 30 Nazhikai. Similiarly in the night time the Nazhikai starts at 6 pm and ends next day at 6 am. Total nazhikai in night time =12 hours × 2.5 Nazhikai = 30 Nazhikai. For example, night 12 pm is equivalent to 15 Nazhikai (6 hours × 2.5 Nazhikai=15 nazhikai).

1.3.4 Temperature

Temperature is the measure of hotness. SI unit of temperature is kelvin(K). One kelvin is the fraction of 1/273.16 of the thermodynamic temperature of the triple point of water (The temperature at which saturated water vapour, pure water and melting ice are in equilibrium). Zero kelvin (0 K) is commonly known as absolute zero. The other units for measuring temperature are degree Celsius and Fahrenheit (Table 5). To convert temperature from one scale to another we use

$$C/100 = (F - 32)/180 = (K-273)/100$$

Example:

Convert (a) 300 K in to Celsius scale, (b) 104°F in to Celsius scale.

Solution

(a) Celsius = K-273 = 300-273 = 27°C

(b) Celsius = (F – 32) × 5/9 = (104-32) × 5/9 =72 × 5/9 = 40°C

1.4 Unit Prefixes

Unit prefixes are the symbols placed before the symbol of a unit to specify the order of magnitude of a quantity. They are useful to express very large or very small quantities. k(kilo) is the unit prefix in the unit, kilogram. A unit prefix stands for a specific positive or negative power of 10. k stands for 1000 or 10^3. Some unit prefixes are given in Table-6.

The physical quantities vary in different proportion like from 10^{-15} m being the diameter of nucleus to 10^{26} m being the distance between two stars and 9.11×10^{-31} kg being the electron mass to 2.2×10^{41} kg being the mass of the milky way galaxy.

Table – 6 Unit prefixes

Power of 10	Prefix	Symbol
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m

Contd. on next page

Table - 5 Temperature conversion table

Units	Fahrenheit	Celsius	Kelvin
Fahrenheit (°F)	F	(F – 32) × 5/9	(F – 32) × 5/9 + 273
Celsius (°C)	(C × 9/5) + 32	C	C + 273
Kelvin (K)	(K – 273) × 9/5 + 32	K-273	K

Table – 6 Unit prefixes (*Contd*)

Power of 10	Prefix	Symbol
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

1.5 Rules and Conventions for Writing SI Units and their Symbols

1. The units named after scientists are not written with a capital initial letter. E.g. newton, henry, ampere and watt.
2. The symbols of the units named after scientists should be written by the initial capital letter. E.g. N for newton, H for henry, A for ampere and W for watt.
3. Small letters are used as symbols for units not derived from a proper noun. E.g. m for metre, kg for kilogram.
4. No full stop or other punctuation marks should be used within or at the end of symbols. E.g. 50 m and not as 50 m.
5. The symbols of the units are not expressed in plural form. E.g. 10 kg not as kgs.
6. When temperature is expressed in kelvin, the degree sign is omitted. E.g. 283 K not as 283° K (If expressed in Celsius scale, degree sign should be included e.g. 100° C not as 100 C, 108° F not as 108 F).
7. Use of solidus is recommended for indicating a division of one unit symbol by another unit symbol. Not more than one solidus is used. E.g. ms^{-1} or m/s. J/K/mol should be JK^{-1} mol^{-1}.
8. The number and units should be separated by a space. E.g. 15 $kgms^{-1}$ not as 15$kgms^{-1}$.
9. Accepted symbols alone should be used. E.g. ampere should not be written as amp and second should not be written as sec.
10. The numerical values of physical quantities should be written in scientific form. E.g. the density of mercury should be written as 1.36×10^4 kg m^{-3} not as 13600 kg m^{-3}.

1.6 Vernier Caliper and Screw Gauge

In our daily life, we use metre scale for measuring lengths. They are calibrated in cm and mm scales. The smallest length which can be measured by metre scale is called least count. Usually the least count of a scale is 1 mm. We can measure the length of objects up to mm accuracy using this scale. But this scale is not sufficient for measuring the size of small spherical objects. So, Vernier caliper and screw gauge are used.

Can you ask for milligram measures of groceries or gram measures of rice from the nearby shop? Can you ask for millimetre measure of cloth? What are the things that you could buy in smaller measures? Why?

1.6.1 Vernier scale

The diameters of spherical objects such as cricket ball and hollow objects such as a pen cap cannot be measured with a meter scale. For that we use an instrument named Vernier caliper which can measure the inner and outer diameters of objects.

Pierre Vernier (1580 – 1637) was a French government official. Vernier

IX_Science Unit-1.indd 7 02-04-2018 18:16:23

was taught mathematics and science by his father who was a lawyer and engineer. He worked much of the time as an engineer, working on the fortifications of various cities. Like many other mathematicians and scientists of that period, Vernier worked on cartography and on surveying. His interest in surveying led him to develop instruments for surveying and this prompted the invention of a precise instrument called Vernier caliper.

1.6.2 Description of Vernier caliper

The Vernier caliper consists of a thin long steel bar graduated in cm and mm. This is the main scale. To the left end of the steel bar an upper and a lower jaw are fixed perpendicular to the bar. These are named as fixed jaws. To the right of the fixed jaws, a slider with an upper and a lower moveable jaw is fixed. The slider can be moved or fixed to any position using a screw. The Vernier scale is marked on the slider and moves along with the movable jaws and the slider. The lower jaws are used to measure the external dimensions and the upper jaws are used to measure the internal dimensions of objects. The thin bar attached to the right side of the Vernier scale is used to measure the depth of hollow objects.

1.6.3 Usage of Vernier caliper

The first step in using the Vernier caliper is to find out its least count, range and zero error.

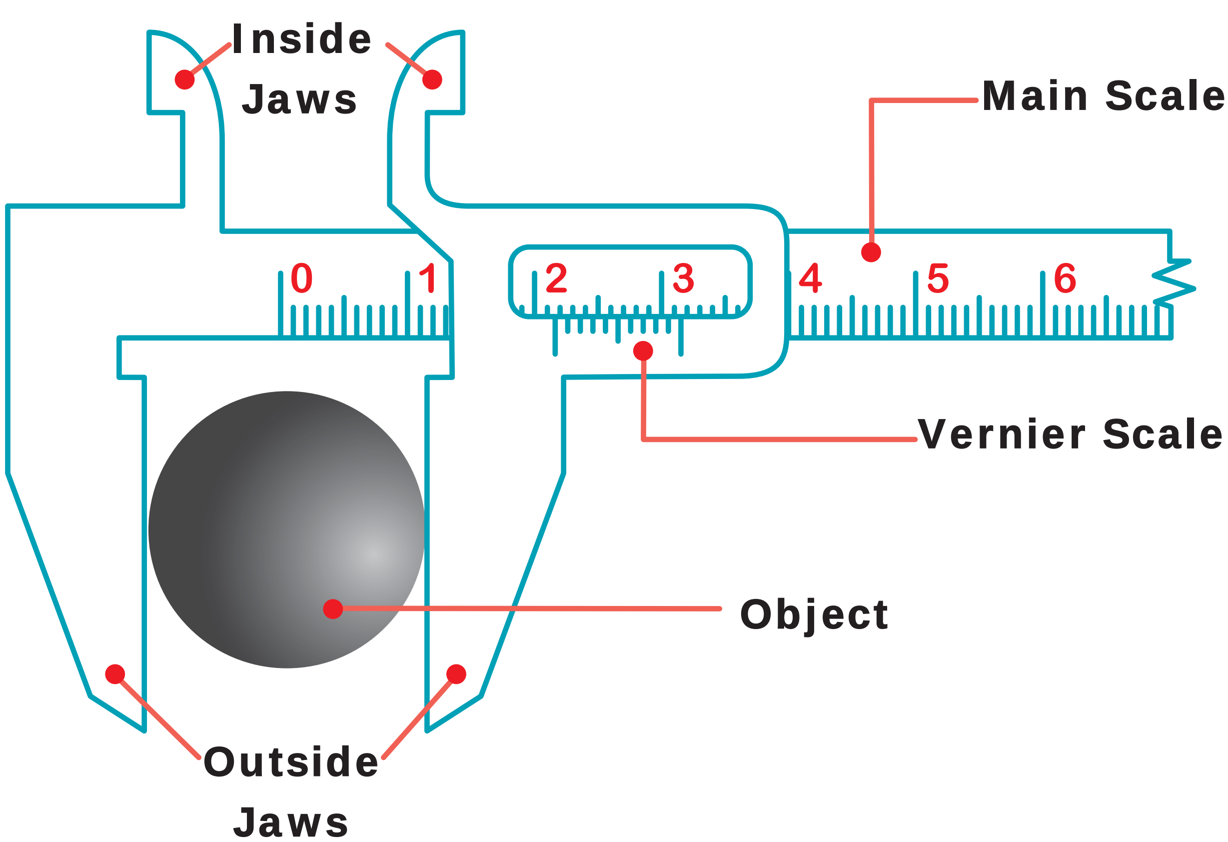


Figure 2 Vernier Caliper

Least count

$$\text{Least count of the instrument (L.C)} = \frac{\text{Value of one smallest main scale division}}{\text{Total number of vernier scale division}}$$

The main scale division can easily be obtained by inspecting the main scale. It will be in centimeter, further divided into millimetre. The value of the smallest main scale division is 1 mm. The Vernier scale division is obtained by counting number of division in it. In the Vernier scale there will be 10 divisions.

$$L.C = \frac{1mm}{10} = 0.1mm = 0.01cm$$

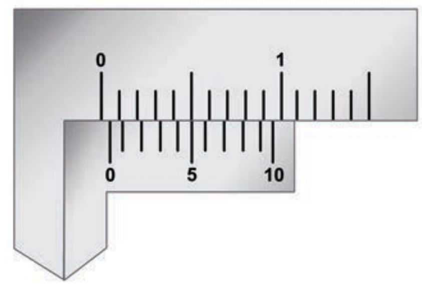
Zero error

Unscrew the slider and move it to the left, such that both the jaws touch each other. Check whether the zero marking of the main scale coincides with that of the Vernier scale. If they are not coinciding with each other, the instrument is said to posses zero error. Zero error may be positive or negative. If the zero mark of the Vernier is shifted to the right, it is called positive error. On the other hand, if the Vernier zero is shifted to the left of the main scale zero marking, then the error is negative.

Positive zero error

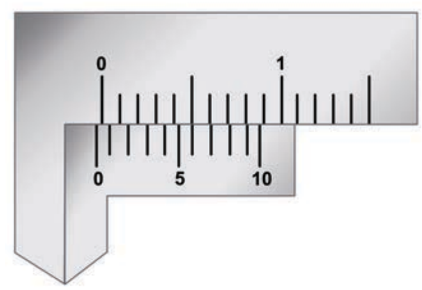
Figure 3(a) shows the positive zero error. From the figure you can see that zero of the vernier scale is shifted to the right of zero of the main scale. In this case the reading will be more than the actual reading. Hence, this error should be corrected. In order to correct this error, find out which vernier division is coinciding with any of the main scale divisions. Here, fifth vernier division is coinciding with a main scale division. So, positive zero error = +5 x LC = +5 x 0.01 = 0.05 cm.

(a)



Positive zero error

(b)



Negative zero error

Figure 3 Positive zero error
Negative zero error

Negative zero error

Now look at the Figure 3(b). You can see that zero of the vernier scale is shifted to the left of the zero of the main scale. So, the obtained reading will be less than the actual reading. To correct this error we should first find which vernier division is coinciding with any of the main scale divisions, as we found in the previous case. In this case, you can see that sixth line is coinciding. But, to find the negative error, we can count backward (from 10). So, the fourth line is coinciding. Therefore, negative zero error = $-4 \times LC = -4 \times 0.01 = -0.04$ cm.

Example:

Calculate the positive and negative error from the given Figure 4.

IX_Science Unit-1.indd 9 02-04-2018 18:16:23

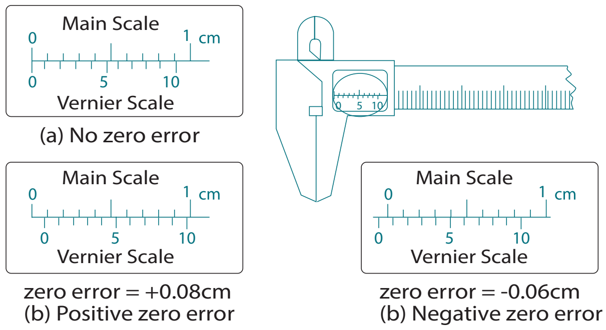


Figure 4 Zero error

Solution:

Case (a): Zero of the vernier scale and zero of the main scale are coinciding with each other. So there is no zero error.

Case (b): The zero of veriner scale is shifted to the right from the zero of the main scale. It is positive error. The 8th division of vernier scale coincides with one of the main scale divisions. So the positive error = (8×0.01cm) = 0.08 cm.

Case (c): The zero of veriner scale is shifted to the left from the zero of main scale. It is negative error. The 4th division of vernier scale (6^{th} from backward) coincides with one of the main scale divisions. So the negative zero error = -(6×0.01cm)= -0.06 cm.

Once you are able to calculate the zero error, you can get the correct reading using the formula:

The correct reading = Main scale reading + (VC × LC) ± (Zero correction)

Zero Correction:

If error is positive the we should subtract that error value. If error is negative, we should add that error value.

For example, let us calculate the correct reading, if the main scale reading is 8 cm, vernier coincidence is 4 and positive zero error is 0.05 cm,

The correct reading = 8 cm + (4 × 0.01cm) – 0.05 cm = 8 + 0.04 – 0.05 = 8 – 0.01 = 7.99 cm

Let us try another one. The main scale reading is 8 cm and vernier coincidence is 4 and negative zero error is 0.02 cm, then the correct reading:

= 8 cm+(4×0.01 cm)+(0.02 cm)

= 8+0.04+0.02 = 8.06 cm.

We can use Vernier caliper to find different dimensions of any familiar object. If the length, width and height of the object can be measured, volume can be calculated. For example, if we could measure the inner diameter of a beaker (using appropriate jaws) as well as its depth (using the depth probe) we can calculate its inner volume.

Example:

Calculate the diameter of the sphere which is shown in the Figure 5. Assume the scale has no zero error.

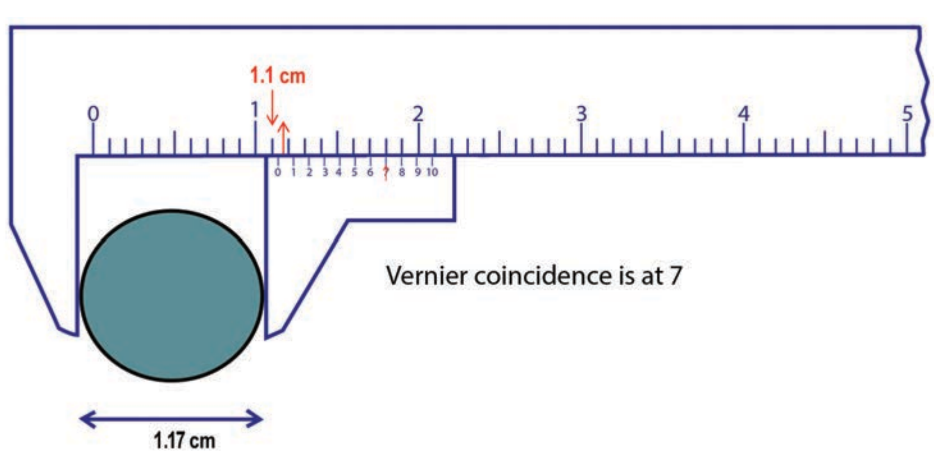


Figure 5 Measuring the diameter of a sphere

IX_Science Unit-1.indd 10 02-04-2018 18:16:24

The diameter (D) of the sphere = Main scale reading (MSR) + (Vernier scale coincidence (VC) × least count (LC))± ZE. In this case the zero of the vernier scale is right after the main scale reading 1.1. So the main scale reading is 1.1 cm. The vernier scale coincidence is 7. The least count is 0.01 cm. The diameter of the sphere = 1.1 cm + (7 × 0.01cm)-0 = 1.1 + 0.07 = 1.17 cm.

1.6.4 Digital Vernier caliper

Today, we are living in a digital world and the digital version of the vernier callipers are available now. Digital Vernier caliper (Figure 6) has a digital display on the slider, which calculates and displays the measured value. The user need not manually calculate the least count, zero error etc.

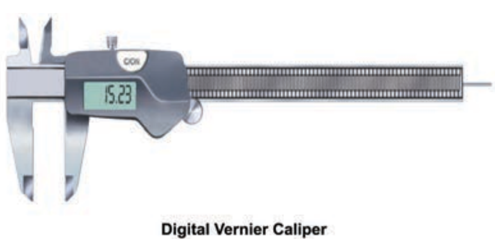


Figure 6 Digital Vernier caliper

1.7 Screw Gauge

Measurements made with a Vernier caliper can be made in centimetre only. Hence to measure the length and thickness of very small objects we use a screw gauge. This instrument can measure the dimensions upto 1/100th of a millimetre or 0.01 mm. With the screw gauge it is possible to measure the diameter of a thin wire and the thickness of thin metallic plates.

1.7.1 Description of screw gauge

The screw gauge consists of a U shaped metal frame. A hollow cylinder is attached to one end of the frame. Grooves are cut on the inner surface of the cylinder through which a screw passes (Figure 7).

Activity 1

Find the inner diameter and the depth of a tea cup with Vernier caliper. Record the observation in the table given below.

S.NO		Main Scale Reading MSR × 10^{-2} m	Vernier Scale coincidence	Observed reading OR = MSR + (LC × VC)	Corrected reading = OR ± ZC
Inner diameter	1				
	2				
	3				
	4				
				Average (D)	
depth	1				
r = D/2	2	$V = \pi r^2 h$			
	3				
	4				
				Average (h)	

On the cylinder parallel to the axis of the screw there is a scale which is graduated in millimetre called Pitch Scale (PS). One end of the screw is attached to a sleeve. The head of the sleeve (Thimble) is divided into 100 divisions called the Head scale.

The end of the screw has a plane surface (Spindle). A stud (Anvil) is attached to the other end of the frame, just opposite to the tip of the screw. The screw head is provided with a ratchat arrangement (safety device) to prevent the user from exerting undue pressure.

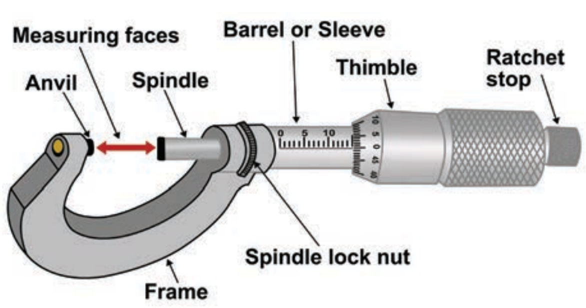


Figure 7 Screw gauge

1.7.2 Using the screw gauge

The screw gauge works on the principal that when a screw is rotated in a nut, the distance moved by the tip of the screw is directly proportional to the number of rotations.

Pitch of the screw

The pitch of the screw is the distance between two successive screw threads. It is also equal to the distance travelled by the tip of the screw for one complete rotation of the head. It is equal to 1 mm in typical screw gauges.

EJL12G

$$\text{Pitch of the screw} = \frac{\text{Distance moved by the Pitch}}{\text{No. of rotations by Head scale}}$$

Least count of a screw gauge

The distance moved by the tip of the screw for a rotation of one division on the head scale is called the least count of the screw gauge.

$$\text{Least count of the instrument (L.C.)} = \frac{\text{Value of one smallest pitch scale reading}}{\text{Total number of Head scale division}}$$

$$LC = \frac{1}{100} = 0.01 \text{ mm}$$

Zero Error of a screw gauge

When the plane surface of the screw and the opposite plane stud on the frame area brought into contact, if the zero of the head scale coincides with the pitch scale axis there is no zero error (Figure 8).

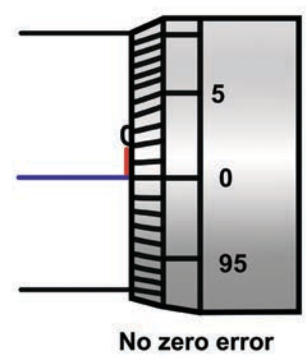


Figure 8 No Zero Error

Positive zero error

When the plane surface of the screw and the opposite plane stud on the frame are brought into contact, if the zero of the head scale lies below the pitch scale axis, the zero error is positive (Figure 9). For example, the 5th division of the head scale coincides with the pitch scale axis, then the zero error is positive and is given by

Z.E = + (n × LC) where 'n' is the head scale coincidence. In this case, Zero error = + (5 × 0.01) = 0.05mm. So the zero correction is – 0.05 mm.

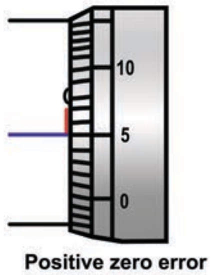


Figure 9 Positive Zero Error

Negative zero error

When the plane surface of the screw and the opposite plane stud on the frame are brought into contact, if the zero of the head scale lies above the pitch scale axis, the zero error is negative (Figure 10). For example, the 95th division coincides with the pitch scale axis, then the zero error is negative and is given by

$$ZE = -(100 - n) \times LC$$
$$ZE = -(100 - 95) \times LC$$
$$= -5 \times 0.01$$
$$= -0.05 \text{ mm}$$

The zero correction is + 0.05mm.

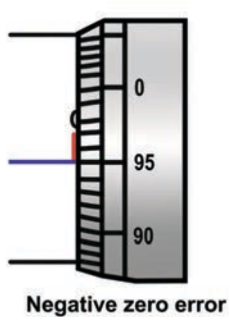


Figure 10 Negative Zero Error

1.7.3 To measure the thickness of a thin coin using a screw gauge

- Determine the pitch, the least count and the zero error of the screw gauge
- Place the coin between the two studs
- Rotate the head until the coin is held firmly but not tightly, with the help of the ratchat
- Note the reading of the pitch scale crossed by the head scale (PSR) and the head scale division that coincides with the pitch scale axis (HSC)
- The width of the coin is given by PSR + CHSR (Corrected HSR). Repeat the experiment for different positions of the coin
- Tabulate the readings
- The average of the last column readings gives the width of the coin

Activity 2

Using screw gauge or Vernier caliper find the outer diameter of your pen cap.

Activity-2

S.No	P.S.R (mm)	H.S.C (division)	CHSC = HSC ± ZC (Division)	CHSR = CHSC × LC (mm)	Total reading = PSR + CHSR (mm)
1					
2					
3					
					mean = mm

Width of the coin = mm

IX_Science Unit-1.indd 13 02-04-2018 18:16:26

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Activity 3

Can you determine the thickness of a single sheet of your science textbook? Justify the answer.

DO YOU KNOW?

The shell of an egg is 12% of its mass. A blue whale can weigh as much as 30 elephants and it is as long as 3 large tour buses.

1.8 Measuring Mass

We commonly use the term 'weight' which is actually the 'mass'. Many things are measured in terms of 'mass' in the commercial world. The SI unit of mass is kilogram. In any case, the units are based on the items purchased. For example, we buy gold in gram or milligram, medicines in milligram, provisions in gram and kilogram and express cargo in tonnes.

Can we use the same instrument for measuring the above listed items? Different measuring devices have to be used for items of smaller and larger masses. In this section we will study about some of the instruments used for measuring mass.

Common (beam) balance

A beam balance compares the sample mass with a standard reference mass. (Standard reference masses are 5g, 10g, 20g, 50g, 100g, 200g, 500g, 1kg, 2kg, 5kg). This balance can measure mass accurately up to 5g (Figure 11).

Figure 11 Common beam balance

Two pan balance

This type of balance is commonly used in provision and grocery shops (Figure 12). This balance compares the sample mass with the standard reference mass. The pans rest on top of the beam and can be conveniently placed on a table top. This balance can measure mass accurately upto 5 g.

Figure 12 Two pan balance

Physical balance

This balance is used in labs and is similar to the beam balance but it is a lot more sensitive and can measure mass of an object correct to a milligram (Figure 13).

The standard reference masses used in this physical balance are 10 mg, 20 mg, 50 mg, 100 mg, 200 mg, 500 mg, 1 g, 2g, 5 g, 10 g, 20 g, 50 g, 100g, and 200 g.

Figure 13 Physical balance

Activity 4

Visit a provision shop, grocery shop, jewellery shop, timber mart and a heavy vehicle weighing bridge with the guidance of your teacher. Observe the different devices used for measuring the accurate mass and the operating range of the device used in each case.

IX_Science Unit-1.indd 14 02-04-2018 18:16:26

Digital balance

Nowadays for accurate measurements digital balances are used, which measures mass accurately even up to a few milligrams, the least value being 10 mg (Figure 14). This electrical device is easy to handle and commonly used in jewellery shops and labs.

Figure 14 Digital balance

Activity 5

With the resources available at home such as paper plates, tea cups, thread and sticks make a model of an ordinary balance. Using standard masses find the mass of some objects.

Spring balance

This balance helps us to find the weight of an object. It consists of a spring fixed at one end and a hook attached to a rod at the other end. It works by 'Hooke's law' which explains that the addition of weight produces a proportional increase in the length of the spring (Figure 15). A pointer is attached to the rod which slides over a graduated scale on the right. The spring extends according to the weight attached to the hook and the pointer reads the weight of the object on the scale.

Figure 15 Spring balance

Solve – The mass of 40 apples in a box is 10 kg. (i) Find the mass of a dozen of them (ii) Express the mass of one apple in gram.

1.8.1 Difference between mass and weight

Mass (m) is the quantity of matter contained in a body. Weight (w) is the normal force (N) exerted by the surface on the body to balance against gravitational pull on the object. In the case of spring scale the tension in the spring balances the gravitational pull on the object. When the man is standing on the surface of the earth or floor, the surface exerts a normal force on the body which is equivalent to gravitational force. The gravitational force acting on the object is given by 'mg'. Here m is mass of the object and 'g' is acceleration due to gravity.

If a man has a mass 50 kg on the earth, then what is his weight?

Weight (w) = mg
Mass of a man = 50 kg
His weight = 50×9.8
w = 490 newton

Mass	Weight
1. Fundamental quantity	Derived quantity
2. Has magnitude alone – scalar quantity	Has magnitude and direction – vector quantity
3. It is the amount of matter contained in a body	It is the normal force exerted by the surface on the object against gravitational pull
4. Remains the same	Varies from place to place

IX_Science Unit-1.indd 15 02-04-2018 18:16:27

Mass	Weight
5. It is measured using physical balance	It is measured using spring balance
6. Its unit is kilogram	Its unit is newton

The pull of gravity on the Moon is 1/6 times weaker than that on the Earth. This causes the weight of the object on the Moon to be less than that on the Earth.

Acceleration due to gravity on the Moon = $1.63 m/s^2$

If the mass of a man is 70 kg then his weight on the Earth is 686 N and on the Moon is 114 N. But his mass is still 70 kg on the Moon.

1.9 Accuracy in Measurements

When measuring physical quantities, accuracy is important. Accuracy represents how close a measurement comes to a true value. Accuracy in measurement is center in engineering, physics and all branches of science. It is also important in our daily life. You might have seen in jewellery shops how accurately they measure gold. What will happen if little more salt is added to food while cooking? So, it is important to be accurate when taking measurements.

Faulty instruments and human error can lead to inaccurate values. In order to get accurate values of measurement, it is always important to check the correctness of the measuring instruments. Also, repeating the measurement and getting the average value can correct the errors and give us accurate value of the measured quantity.

Points to remember

- Length, mass, time, temperature, electric current, intensity and mole are the fundamental units in SI system
- To find the length or thickness of smaller dimensions Vernier caliper or screw gauge are used
- Austronomical unit is the mean distance of the sun from center of the earth 1AU=1.496×10^{11}m
- Light year is the distance travelled by light in one year in vacuum. 1 Light year = 9.46×10^{15}m
- Parsec is the unit distance used to measure astronomical objects outside the solar system
- 1 Angstrom (Å) = 10^{-10} m
- SI Unit of volume is cubic metre or m^3. Generally volume is represented in litre (l). 1m*l*=1cm^3
- C/100 = (F −32)/180 = (K −273)/100
- Least count of screw gauge is 0.01 mm. Lease count of Vernier caliper is 0.01 cm
- Common balance can measure mass accurately upto 5 g
- Accuracy of physical balance is 10 mg

A-Z GLOSSARY

1. **Metre [m]** The metre is the basic unit of length. It is the distance light travels, in a vacuum, in 1/299792458th of a second.
2. **Kilogram [kg]** The kilogram is the basic unit of mass. It is the mass of an international prototype in the form of a platinum-iridium cylinder kept at Sevres in France. It is now the only basic unit still defined in terms of a material object, and also the only one with a prefix [kilo] already in place.

IX_Science Unit-1.indd 16 02-04-2018 18:16:27

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3. **Second [s]** The second is the basic unit of time. It is the length of time taken for 9192631770 periods of vibration of the Caesium-133 atom to occur.
4. **Ampere [A]** The ampere is the basic unit of electric current. It is that current which produces a specified force between two parallel wires which are 1 metre apart in a vacuum.
5. **Kelvin [K]** The kelvin is the basic unit of temperature. It is $1/273.16^{th}$ of the thermodynamic temperature of the triple point of water.
6. **Mole [mol]** The mole is the basic unit of a substance. It is the amount of the substance that contains as many elementary units as there are atoms in 0.012 kg of carbon-12.
7. **Candela [cd]** The candela is the basic unit of luminous intensity. It is the intensity of a source of light of a specified frequency, which gives a specified amount of power in a given direction.
8. **Farad [F]** The farad is the SI unit of the capacitance of an electrical system, that is, its capacity to store electricity. It is rather a large unit as defined and is more often used as a microfarad.
9. **Joule [J]** The joule is the SI unit of work or energy. One joule is the amount of work done when an applied force of 1 newton moves through a distance of 1 metre in the direction of the force.
10. **Newton [N]** The newton is the SI unit of force. One newton is the force required to give a mass of 1 kilogram an acceleration of 1 metre per second^2.
11. **Ohm [Ω]** The ohm is the SI unit of resistance of an electrical conductor. Its symbol is the capital Greek letter 'omega'.
12. **Pascal [Pa]** The pascal is the SI unit of pressure. One pascal is the pressure generated by a force of 1 newton acting on an area of 1 square metre. It is rather a small unit as defined and is more often used as a kilopascal [kPa].
13. **Volt [V]** The volt is the SI unit of electric potential. One volt is the difference of potential between two points of an electical conductor when a current of 1 ampere flowing between those points dissipates a power of 1 watt.
14. **Watt [W]** The watt is used to measure power or the rate of doing work. One watt is a power of 1 joule per second. Electrical power $V \times I = W$.

ICT CORNER

MEASUREMENT - VERNIER CALIPER

Vernier is a visual aid that helps the user to measure the internal and external diameter of the object.

This activity helps the students to understand the usage better

Step 1. Type the following URL in the browser or scan the QR code from your mobile. Youcan see"Vernier caliper" on the screen.

Step 2. The yellow colour scale is movable. Now you can drag and keep the blue colour cylinder in between. Now you can measure the dimension of the cylinder. Use the + symbol to drag cylinder and scale.

Step 3. Now go to the place where you can enter your answer. An audio gives you the feedback and you can see the answer on the screen also

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https://play.google.com/store/apps/details?id=com.ionicframework.vernierapp777926

IX_Science Unit-1.indd 17 02-04-2018 18:16:27

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EXERCISE

I. Multiple Choice Questions

1. Choose the correct one
   a. mm< cm < m < km
   b. mm > cm > m > km
   c. km < m < cm < mm
   d. mm > m> cm> km
2. Rulers, measuring tapes and metre scales are used to measure
   a. Mass
   b. Weight
   c. Time
   d. Length
3. 1 metric ton is equal to
   a. 100 quintals   b. 10 quintals
   c. 1/10 quintals   d. 1/100 quintals
4. Distance between Chennai and Kanyakumari can be found in
   a. Kilometres   b. Metres
   c. Centimetres   d. Millimetres
5. Which among the following is not a device to measure mass?
   a. Spring balance
   b. Beam balance
   c. Physical balance
   d. Digital balance

II. Fill in the blanks

1. Metre is the unit of _________
2. 1 kg of rice is weighed by ______
3. The thickness of a cricket ball is measured by ________
4. The radius of a thin wire is measured by _________
5. A physical balance measures small differences in mass up to ______

III. True or False

1. The SI unit of electric current is kilogram
2. Kilometre is one of the SI units of measurement
3. In everyday life, we use the term weight instead of mass.
4. A physical balance is more sensitive than a beam balance as it can accurately measure even a very small mass, even milligram
5. One Celsius degree is an interval of 1K and zero degree Celsius is 273.15 K.

IV. Match the following

1.

Column I	Column II
Length	Kelvin
Mass	metre
Time	kilogram
Temperature	second

2.

Column I	Column II
Screw gauge	Vegetables
Vernier caliper	Coins
Beam balance	Gold ornaments
Digital balance	Cricket ball

3.

Column I	Column II
Temperature	Beam balance
Mass	Ruler
Length	Digital clock
Time	Thermometre

IX_Science Unit-1.indd 18 02-04-2018 18:16:27

V. Assertion and reason type

1. Assertion (A): The SI systems of units is the improved system of units for measurement.

   Reason (R): The SI unit of mass is kilogram

   a. Both A and R are true but R is not the correct reason
   b. Both A and R are true and R is the correct reason
   c. A is true but R is false
   d. A is false but R is true

2. Assertion (A): The skill of estimation is important for all of us in our daily life.

   Reason (R): The skill of estimation reduces our consumption of time

   a. Both A and R are true but R is not the correct reason
   b. Both A and R are true and R is the correct reason
   c. A is true but R is false
   d. A is false but R is true

3. Assertion(A): The scientifically correct expression is " The mass of the bag is 10 kg"

   Reason (R): In everyday life, we use the term weight instead of mass

   a. Both A and R are true but R is not the correct reason
   b. Both A and R are true and R is the correct reason
   c. A is true but R is false
   d. A is false but R is true

4. Assertion (A): 0 °C = 273.16 K. For our convenience we take it as 273 K after rounding off the decimal

   Reason (R): To convert a temperature on the Celsius scale you have to add 273 to the given temperature

   a. Both A and R are true but R is not the correct reason
   b. Both A and R are true and R is the correct reason
   c. A is true but R is false
   d. A is false but R is true

5. Assertion (A): The distance between two celestial bodies is measured in the unit of light year

   Reason (R): The distance travelled by the light in one year is one light year

   a. Both A and R are true but R is not the correct reason
   b. Both A and R are true and R is the correct reason
   c. A is true but R is false
   d. A is false but R is true

VI. Comprehensive type

Read the passage and answer the questions given below.

Mass is the amount of matter contained in an object. Measurement of mass helps us to distinguish between a lighter and a heavier body. Beam balance, spring balance and electronic balance are used to measure mass of different objects. The SI unit of mass is the kilogram (kg). But different units are used to measure the mass of different objects. E.g. weight (mass) of a tablet is measured in milligrams (mg), weight of a student is measured in kilogram (kg) and weight of a truck with goods is measured in metric tons. 1 metric ton is equal to 10 quintals and 1 quintal is equal to 100 kg. 1 gram is equal to 1000 mg.

1. The value of 1 metric ton is equal to

   a. 1000 kg   b. 10 quintals
   c. 10,00,000 g   d. 100 kg

2. How will you measure the weight of a tablet?

   a. kg   b. g
   c. mg   d. None of these

VII. Very short answer type

1. Define measurement.
2. Define standard unit.
3. What is the full form of SI system?
4. Define least count of any device.

5. What do you know about pitch of screw gauge?
6. Can you find the diameter of a thin wire of length 2 m using the ruler from your instrument box?

VIII. Short answer type

1. Write the rules that are followed in writing the symbols of units in SI system.
2. Write the need of a standard unit
3. Differentiate mass and weight
4. What is the measuring unit of the thickness of a plastic carry bag?
5. How will you measure the least count of vernier caliper?

IX. Numerical Problem

1. Inian and Ezhilan argue about the light year. Inian tells that it is 9.46×10^{15} m and Ezhilan argues that it is 9.46×10^{12} km. Who is right? Justify your answer.
2. The main scale reading while measuring the thickness of a rubber ball using Vernier caliper is 7 cm and the Vernier scale coincidence is 6. Find the radius of the ball.
3. Find the thickness of a five rupee coin with the screw gauge, if the pitch scale reading is 1 mm and its head scale coincidence is 68.
4. Find the mass of an object weighing 98 N.

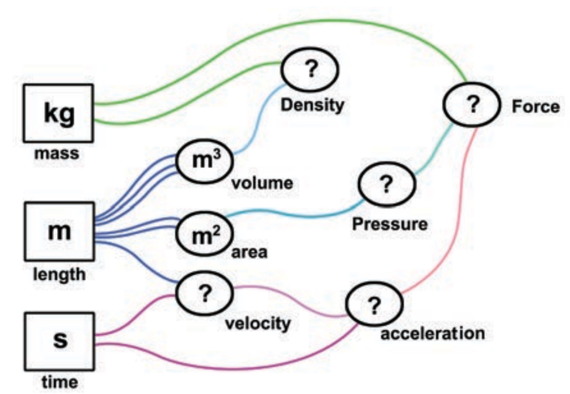
X. Long answer type

1. Explain a method to find the thickness of a hollow tea cup.
2. How will you find the thickness of a one rupee coin?
3. Find out any 'ten words' related to measurement from the grid.

A	C	C	U	R	A	T	E	V	B
N	U	O	P	I	E	R	R	E	E
A	B	N	I	S	N	I	R	R	A
L	I	S	T	C	D	A	O	N	M
O	T	T	C	R	F	L	R	I	B
G	Z	A	H	E	H	S	M	E	A
U	Y	N	E	W	T	O	N	R	L
E	G	T	R	A	I	L	E	R	L
L	E	A	S	T	C	O	U	N	T
K	E	L	V	I	N	O	T	E	C
X	B	E	A	M	B	A	N	C	E

XII. Activity - 6

Complete the flow chart



REFERENCE BOOKS

1. Units and measurements – John Richards, S. Chand publishing, Ram nagar, New Delhi.
2. Units of Measurement - Past, Present and Future. International System of Units - Gupta, S. V. eBook ISBN 978-3-642-00738-5 DOI 10.1007/978-3-642-00738-5
3. Complete physics(IGCSE) - Oxford University press, New York
4. Practical physics – Jerry. D. Wilson – Saunders college publishing, USA

INTERNET RESOURCES

http://www.npl.co.uk/reference/measurement-units/

http://www.splung.com/content/sid/1/page/units

http://www.edinformatics.com/math_science/units.htm

https://www.unc.edu/~rowlett/units/dictA.html

https://study.com/academy/lesson/standard-units-of-measure.html

IX_Science Unit-1.indd 20 02-04-2018 18:16:28

UNIT 2

Motion

EK4S5R

Learning Objectives

Students will be able to

- list the objects which are at rest and which are in motion around them
- understand distance and displacement
- determine the displacement and distance covered by an object describing a circular path
- classify the motion of vehicles as uniform motion and non-uniform motion
- distinguish between speed and velocity
- relate accelerated and unaccelerated motion
- deduce the equations of motion of an object from velocity – time graph
- write the equations of motion for a freely falling body
- understand the nature of circular motion
- identify centripetal force and centrifugal force in day to day life

Introduction

Every object undergoes motion, even stationary objects move along with the speed of earth.

Hence it becomes necessary to study the state of an object at any instant of time. An object under the influence of forces may either be at rest or in motion.

2.1 State of Rest and Motion

Activity 1

Look around you! What do you see? Many things, a row of houses, large trees, small plants, flying birds, running cars and buses and many more

- List the objects which remain fixed at their position, and do not change their position and
- List the objects which keep on changing their position

In physics, the objects which do not change their position are said to be at rest, while those which change their position are said to be in motion. Example: A book lying on a table, the walls of a room (at rest) Cars and buses running on the road, birds and aeroplanes flying in air (in motion). Motion is a relative phenomenon. This means that an object appearing to be in motion to one person can appear to be at rest as viewed

IX_Science Unit-2.indd 21 02-04-2018 18:18:37

by another person. For example, trees on roadside would appear to move backward for a person travelling in a car while the same tree would appear to be at rest for a person standing on road side.

2.2 Types of Motion

Activity 2

Have you ever gone to an amusement park? Have you seen the motion of a giant wheel? List various types of motion of the play machines like children train, dragula ride, etc.

In physics, motion can be classified under the following types for ease of understanding.

Linear motion – where the object moves along a straight line.

Circular motion – where the object moves along a circular path.

Oscillatory motion – where an object describes a repetitive to and fro movement retracing its original path.

Uniform motion – where an object travels equal distance in equal intervals of time.

Random motion – where the motion of the object does not fall in any of the above categories.

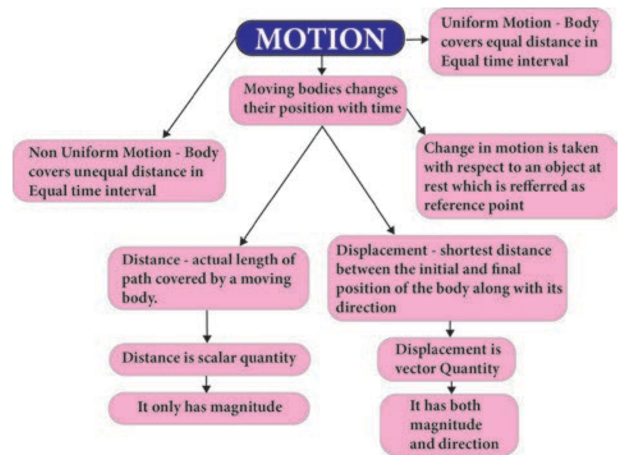
2.3 Distance and Displacement

2.3.1 Distance

The actual length of the path travelled by a moving body irrespective of the direction is called the distance travelled by the body. It is measured in metre in SI system. It is a scalar quantity having magnitude only.

2.3.2 Displacement

It is defined as the change in position of a moving body in a particular direction. It is vector quantity having both magnitude and direction. It is also measured in metre in SI system.



Activity 3

Observe the motion of a car as shown in the Figure 1.

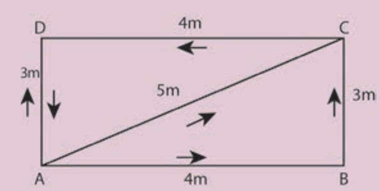


Figure 1 Motion of a car

Now answer the following questions:

1. How much distance is covered by the car through the path ABC and AC and compare the values? From this what do you observe?
2. Which path gives the shortest distance to reach D from A? Either the path ABCD or the path ACD or the path AD. Think!
3. What is the total distance covered by the car when it travels the path ABCDA and where does it finally reach? From this what do you understand? How much distance it covers? What is its displacement?

Activity 4

Tabulate the differences between distance and displacement.

IX_Science Unit-2.indd 22 02-04-2018 18:18:38

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2.4 Uniform and Non Uniform Motion

Activity 5

Tabulate the distance covered by a bus in a heavy traffic road in equal intervals of time and do the same for a train which is not in an accelerated motion. From this table what do you understand?

The bus covers unequal distance in equal intervals of time but the train covers equal distances in equal intervals of time.

2.4.1 Uniform motion

An object is said to be in uniform motion if it covers equal distances in equal intervals of time how so ever big or small these time intervals may be.

For example, suppose a car covers 60 km in first hour, another 60 km in second hour, and again 60 km in the third hour and so on. The motion of the car is uniform. Let us now understand the meaning of the words "how so ever small the time interval may be" used in the definition. In this example, the car travels a distance of 60 km in each hour. In the striker sense, the car should travel 30 km in each half an hour, 15 km in every 15 minutes, 10 km in every 10 minutes, 5 km in every 5 minutes and 1 km in every 1 minute. Only then the motion of the car can be said to be uniform.

2.4.2 Non uniform motion

An object is said to be in non uniform motion if it covers unequal distances in equal intervals of time.

EKDN7E

Consider a bus starting from one stop. It proceeds slowly when it passes crowded area of the road. Suppose, it manages to travel merely 100 m in 5 minutes due to heavy traffic, when it gets out and the road is clear, it speeds up and is able to travel about 2 km in 5 minutes.

We say, the motion of the bus is non uniform i.e. it travels unequal distances in equal intervals of time.

2.5 Speed, Velocity and Acceleration

2.5.1 Speed

Speed is the rate of change of distance or the distance travelled in unit time. It is a scalar quantity. The SI unit of speed is ms^{-1}. Thus,

Speed = Distance travelled / time taken

2.5.2 Velocity

Velocity is the rate of change of displacement. It is the displacement in unit time. It is a vector quantity. The SI unit of velocity is ms^{-1}. Thus,

EKHJ92

Velocity = Displacement / time taken

2.5.3 Acceleration

Acceleration is the rate of change of velocity or it is the change of velocity in unit time. It is a vector quantity. The SI unit of acceleration is ms^{-2}.

Acceleration = Change in velocity/time
= (Final velocity – initial velocity)/time
$a = (v-u)/t$

Consider a situation in which a body moves in a straight line without reversing its direction.

Case 1: From the above equation if $v > u$, i.e. if final velocity is greater than

IX_Science Unit-2.indd 23 02-04-2018 18:18:38

Compare speed and velocity

Speed	Velocity
It is the rate of change of distance	It is the rate of change of displacement
It is a scalar quantity having magnitude only	It is a vector quantity having both magnitude and direction
It is measured in ms^{-1} in SI system	It is also measured in ms^{-1} in SI system
Speed in any direction would be a positive quantity, since the distance in any direction is a positive quantity.	Velocity can have both positive and negative values. If velocity in one direction is assumed to be positive then the velocity in the opposite direction would be a negative quantity. Velocity can have zero value also, even for an object under motion.

initial velocity, the velocity increases with time and the value of acceleration is positive.

Case 2: If v < u, i.e. if final velocity is less than initial velocity, the velocity decreases with time and the value of acceleration is negative. It is called negative acceleration.

Note

Negative acceleration is called retardation or deceleration.

If the acceleration has a value of -2 ms^{-2} when we say that the retardation is 2 ms^{-2} or deceleration is 2 ms^{-2}.

Case 3: If v = u, then a = 0. This means that the acceleration is zero when the final velocity is equal to initial velocity

2.6 Graphical Representation of Motion along a Straight Line

Plotting the distance/displacement or speed/velocity on a graph helps us visually understand certain things about time and position.

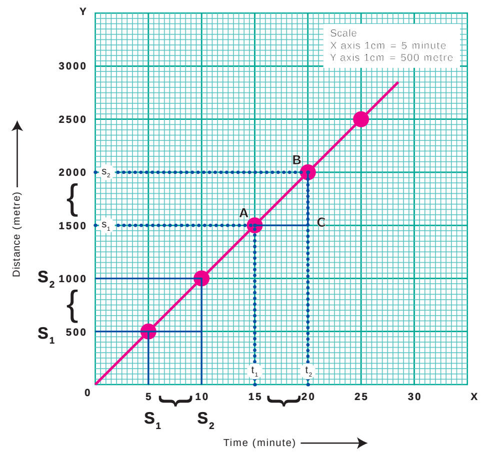
2.6.1 The distance – time graph for uniform motion

The following Table shows the distance walked by Surya at different times.

Time (minute)	Distance (metre)
0	0
5	500
10	1000
15	1500
20	2000
25	2500

A graph is drawn by taking time along X-axis and distance along Y-axis. The graph is known as distance – time graph. When we look at the distance – time graph of Surya's walk, we notice certain things. First, it is a straight line. We also notice that Surya covers equal distances in

IX_Science Unit-2.indd 24 02-04-2018 18:18:38



equal intervals of time. We can therefore conclude that Surya walked at a constant speed. Can you find the speed at which Surya walked, from the graph? Yes, you can. The parameter is referred to as the slope of the line.

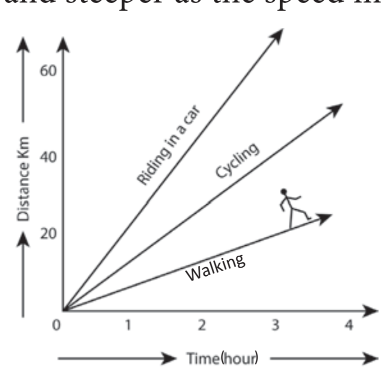
Speed at which Surya walked = distance covered / time taken = BC/AC (From the graph)

= slope of the straight line

= 500 / 5 = 100 ms^{-1}

Steeper the slope (in other words the larger value) the greater is the speed.

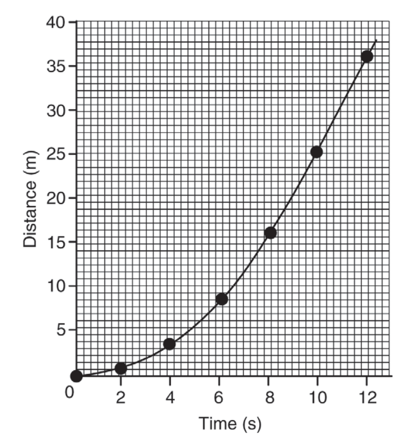
Let us take a look at the distance – time graphs of three different people – Surya walking, Monica cycling and Hari going in a car, along the same path. We know that cycling can be faster than walking and a car can go faster than a cycle. The distance – time graph of the three would be as given in the following graph. The slope of the line on the distance – time graph becomes steeper and steeper as the speed increases.



2.6.2 The distance time graph for non uniform motion

We can also plot the distance – time graph for accelerated motion (non uniform motion). Table given below shows the distance travelled by a car in a time interval of two second.

Time (second)	Distance (metre)
0	0
2	1
4	4
6	9
8	16
10	25
12	36

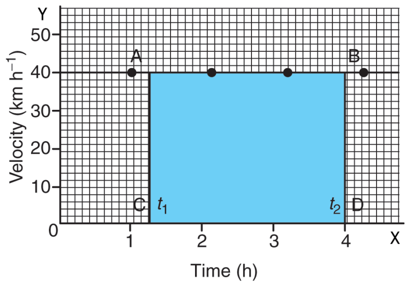


Note that the graph is not a straight line as we got in the case of uniform motion. This nature of the graph shows non – linear variation of the distance travelled by the car with time. Thus, the graph represents motion with non uniform speed.

2.6.3 Velocity – Time graph

The variation in velocity of an object with time can be represented by velocity – time graph. In the graph, time is represented along the X – axis and the velocity is represented along the Y – axis. If the object moves at uniform velocity, a straight line parallel to

X-axis is obtained. This Graph shows the velocity – time graph for a car moving with uniform velocity of 40 km/hour.



We know that the product of velocity and time gives displacement of an object moving with uniform velocity.

The area under the velocity – time graph is equal to the magnitude of the displacement.

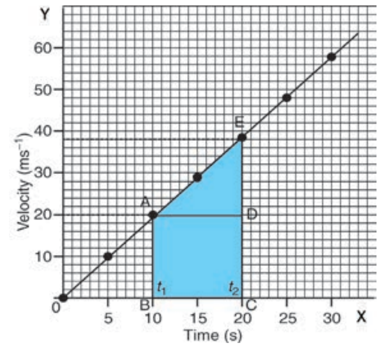
So the distance (displacement) S covered by the car in a time interval of t can be expressed as

S = AC × CD

S = Area of the rectangle ABCD (shaded portion in the graph)

We can also study about uniformly accelerated motion by plotting its velocity – time graph. Consider a car being driven along a straight road for testing its engine. Suppose a person sitting next to the driver records its velocity for every 5 seconds from the speedometer of the car. The velocity of the car in ms^{-1} at different instants of time is shown in the Table below.

Time (Second)	Velocity of the Car (ms^{-1})
0	0
5	9
10	18
15	27
20	36
25	45
30	54



In this case, the velocity – time graph for the motion of the car is shown in graph (straight line). The nature of the graph shows that the velocity changes by equal amounts in equal intervals of time. Thus, for all uniformly accelerated motion, the velocity – time graph is a straight line.

One can also determine the distance moved by the car from its velocity – time graph. The area under the velocity – time graph gives the distance (magnitude of displacement) moved by the car in a given interval of time.

Since the magnitude of the velocity of the car is changing due to acceleration, the distance S travelled by the car will be given by the area ABCDE under the velocity – time graph. That is

S = area ABCDE

= area of the rectangle ABCD + area of the triangle ADE

S = (AB × BC) + ½ (AD × DE)

The area ABCDE can also be calculated by considering the shape as trapezium. Area of the quadrangle ABCDE can also be calculated by calculating the area of trapezium ABCDE. It means

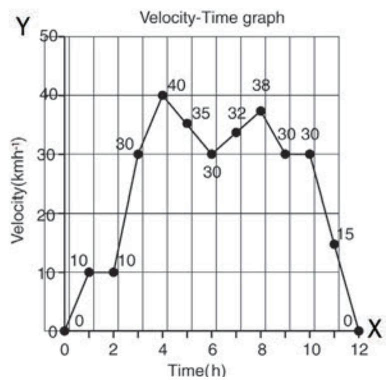
S = area of trapezium ABCDE

= ½ × sum of length of parallel sides × distance between parallel sides

S = ½ × (AB + CE) × BC

IX_Science Unit-2.indd 26 02-04-2018 18:18:38

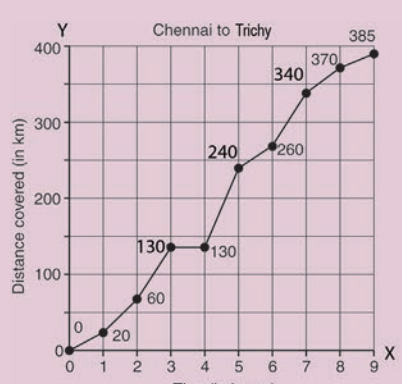
In the case of non uniformly accelerated motion, distance – time graph, velocity – time graphs can have any shape as shown in Figure below:



Study the velocity – time graph of the car and answer the following questions:

- *What was the maximum value of velocity during the journey?*
- *Was the velocity constant during any part of the journey? If so, when was it?*
- *What was the maximum value of acceleration during the journey? When did it occur?*
- *When did the car slow down?*
- *What was the value of acceleration during the period between 10^{th} and 12^{th} hour?*

Activity 6



The whole class can divide themselves into small groups, study the distance-time graph of the bus travelling from Chennai to Trichy and discuss the questions given below:

- *What is the total distance between Chennai and Trichy?*
- *How long did the bus take for the full journey?*
- *Was the speed of the bus constant?*
- *Did the bus halt for a while during the journey?*
- *If it halted, how long was the halt?*
- *Simply, by looking at the inclination of the graph line, can you tell when the speed was the greatest?*
- *What was the maximum speed that the bus attained during the journey?*

DO YOU KNOW?

The magnitude of instantaneous velocity is equal to the instantaneous speed at the given instant. The speedometer of an automobile measures the instantaneous speed of the automobile. In a uniform motion in one dimension, the average velocity = instantaneous velocity. Instantaneous velocity is also called velocity and instantaneous speed also called simply speed.

2.7 Equations of Motion

Newton studied the motion of an object and gave a set of three equations of motion. These equations relate the displacement, velocity, acceleration and time of an object under motion. An object is in motion with initial velocity u attains a final velocity v in time t due to acceleration a, with displacement s.

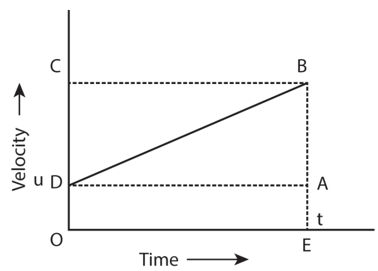
The three equations of motion can be written as,

IX_Science Unit-2.indd 27 02-04-2018 18:18:39

$$v = u + at$$
$$s = ut + \frac{1}{2} a t^2$$
$$v^2 = u^2 + 2as$$

Let us try to derive these equations by graphical method.

Equations of motion from velocity – time graph:



Graph shows the change in velocity with time for an uniformly accelerated object. The object starts from the point D in the graph with velocity u. Its velocity keeps increasing and after time t it reaches the point B on the graph.

The initial velocity of the object = u = OD = EA

The final velocity of the object = v = OC = EB

Time = t = OE = DA

Also from the graph we know that, AB = DC

2.7.1 First equation of motion

By definition, acceleration = change in velocity / time

= (final velocity – initial velocity)/ time

= (OC – OD) / OE

= DC / OE

a = DC / t

DC = AB = at

From the graph EB = EA + AB

$$\boxed{v = u + at} \qquad (1)$$

This is first equation of motion.

2.7.2 Second equation of motion

From the graph the distance covered by the object during time t is given by the area of quadrangle DOEB

s = area of the quadrangle DOEB

= area of the rectangle DOEA + area of the triangle DAB

= (AE × OE) + (1/2 × AB × DA)

$$\boxed{s = ut + \frac{1}{2} at^2} \qquad (2)$$

This is second equation of motion.

2.7.3 Third equation of motion

From the graph the distance covered by the object during time t is given by the area of the quadrangle DOEB. Here DOEB is a trapezium. Then

S = area of trapezium DOEB

= ½ × sum of length of parallel side × distance between parallel sides

= ½ × (OD + BE) × OE

S = ½ × (u + v) × t

since a = (v – u) / t or t = (v – u)/a

Therefore s = ½ × (v + u) × (v – u)/a

$$2as = v^2 - u^2$$

$$\boxed{v^2 = u^2 + 2as} \qquad (3)$$

This is third equation of motion.

Motion of objects under the influence of gravitational force of the earth – Freely falling body:

Activity 7

Take a large stone and a small eraser. Stand on the top of a table and drop them simultaneously from the same height? What do you observe?

Activity 8

Take a small eraser and a sheet of paper. Stand on the top of a table and drop them simultaneously from the same height? What do you observe?

Activity 9

Take two sheets of paper having same mass. Now, crumple one of the sheets into a ball and drop the sheet and the ball from the same height. What do you observe?

In activity 7, both the stone and the eraser have reached the surface of the earth almost at the same time but in activity 8, the eraser reaches first, the sheet of paper reaches later. In activity 9, the paper crumpled into a ball reaches ground first and plain sheet of paper reaches later, although they have equal mass. Do you know the reason? When all these objects are dropped in the absence of air medium (vacuum), all would have reached the ground at the same time. In air medium, due to friction, air offers resistance to the motion of free falling objects. The resistance offered by air is negligibly small when compared to the gravitational pull acting on the stone and rubber (in activity 7). Hence, they reach the ground at the same time. But, in activity 8, the air resistance exerted on the sheet of paper is much higher than that on the eraser. Again in activity 9, the air resistance offered to the plain sheet of paper is much higher than that offered to the paper ball. This is because the magnitude of air resistance depends on the area of objects exposed to air. If we do experiment in a tall glass jar from which air has been sucked out, both the paper and the eraser would fall at the same rate. Galileo dropped different objects from the top of the Leaning Tower of Pisa in Italy to prove the same. We know that an object experiences acceleration during free fall. This acceleration experienced by an object is independent of mass. This means that all objects hollow or solid, big or small, should fall at the same rate.

DO YOU KNOW?

Can a body have zero velocity and finite acceleration?

Yes, when a body is thrown vertically upwards in space, then at the highest point, the body has zero velocity and acceleration equal to the acceleration due to the gravity.

The equation of motion for a freely falling body can be obtained by replacing 'a' in equations 1 to 3 with g, the acceleration due to gravity. For an object falling freely, its initial velocity u = 0. Thus we get the following equations

$$v = gt,\ s = \tfrac{1}{2} gt^2,\ v^2 = 2gh$$

when we through an object vertically upwards, it moves against the acceleration due to gravity. Hence g is taken to be –g in such cases.

Uniform circular motion

Activity 10

1. Draw a square path as shown in following Figure.
2. Place the tip of your pencil on the middle of any side of the square path.
3. Note how many times you have to change the direction while tracing the complete path.

IX_Science Unit-2.indd 29 02-04-2018 18:18:39

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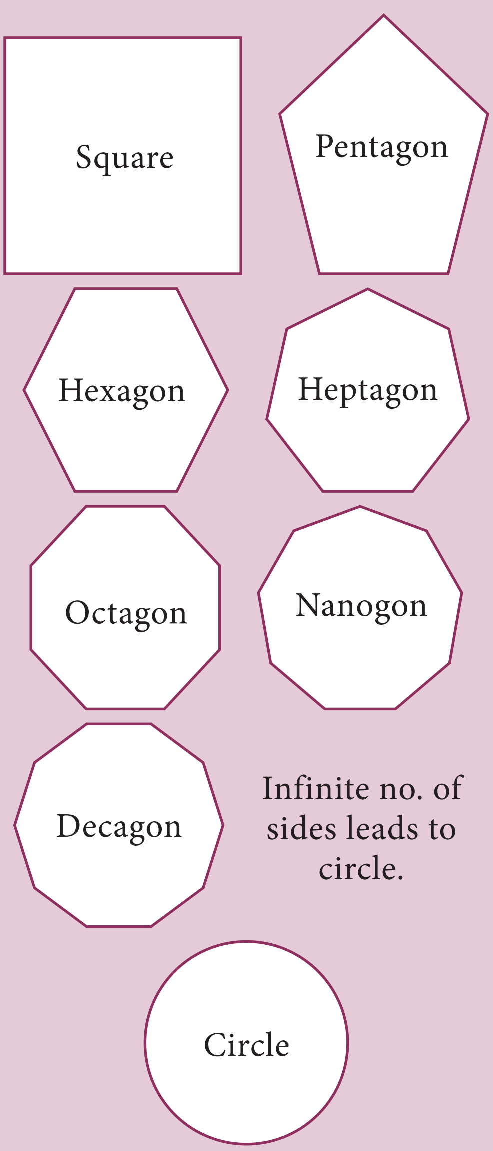
4. Now repeat this action for a pentagon, hexagon, octagon and note the number of times one changes the direction to complete the path.

   This shows that as we increase the number of sides, we have to keep changing direction more and more times.

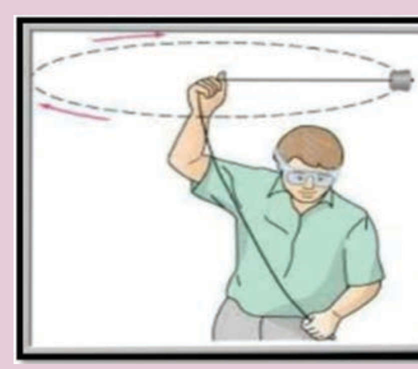
5. If you increase the number of sides of the polygon and make it infinite, how many times will you have to change the direction? What will be the shape of the path?

   And when we increase the number of sides to infinity, the polygon becomes a circle.



Activity 11

1. Take a piece of thread and tie a small piece of stone at one of its ends. Rotate the stone to describe a circular path with constant speed by holding the thread at the other end as shown in Figure below.
2. Now, release the thread and let the stone go.
3. Can you tell the direction in which the stone moves after it is released?
4. Repeat the activity for a few times, and releasing the stone at different positions of the circular path. Check whether the direction in which the stone moves remains the same or not.



If you carefully observe, on being released the stone moves along a straight line tangential to the circular path. This is because once the stone is released, it continues to move along the direction it has been moving at that instant. This shows that the direction of motion changed at every point when the stone was moving along the circular path. When an object moves with constant speed along a circular path, the motion is called uniform circular motion. When an object is moving with a constant speed along a circular path, the velocity changes due to the change in direction. Hence it is an accelerated motion.

IX_Science Unit-2.indd 30 02-04-2018 18:18:39

Examples of uniform circular motion.

1. Revolution of earth around the sun.
2. Revolution of moon around the earth.
3. The tip of the second's hand of a clock.

If an object, moving along a circular path of radius r, takes time T to come back to its starting position, the speed v is given by,

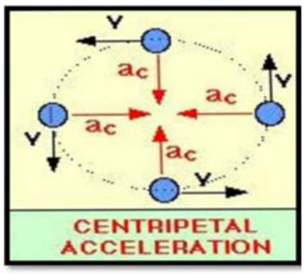
Speed = circumference/time taken

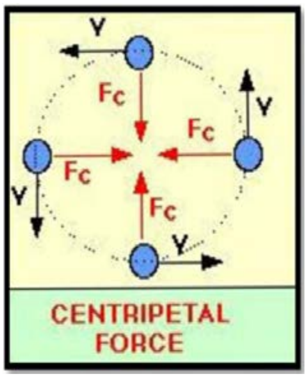
$V = 2\pi r/T$

Giant Wheel moves in a vertical circular path.

2.8 Centripetal Acceleration and Centripetal Force

A body is said to be accelerated, if the velocity of the body changes either in magnitude or in direction. Hence the motion of a stone in circular path with constant speed and continious changes of direction is an accelerated motion. There must be an acceleration acting along the string directed inwards, which makes the stone to move in circular path.





This acceleration is known as centripetal acceleration and the force is known as centripetal force. Since the centripetal acceleration is directed radially towards the centre of the circle, the centripetal force must act on the object radially towards the centre.

Let us consider an object of mass m, moving along a circular path of radius r, with a velocity v, its centripetal acceleration is given by

$$a = v^2/r$$

Hence, the magnitude of centripetal force is given by,

F = mass × centripetal acceleration

$F = mv^2/r$

Note

Any force like gravitational force, frictional force, magnetic force, electrostatic force etc., may act as a centripetal force.

Activity 12

Take a piece of rope and tie a small stone at one end. Hold the other end of the rope and rotate it such that the stone follows a circular path. Will you experience any pull or push in your hand? What do you infer?

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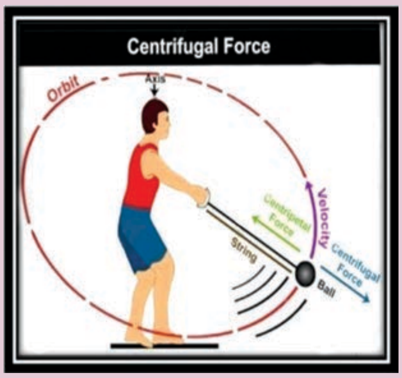


In this activity, a pulling force that acts away from the centre is experienced. This is called as centrifugal force.

2.9 Centrifugal Force

Force acting on a body away from the centre of circular path is called centrifugal force. Thus centrifugal force is in a direction opposite to the direction of centripetal force. Its magnitude is same as that of centripetal force. The dryer in a washing machine is an example for the application of centrifugal force.

DO YOU KNOW?

How do we separate cream from milk?

A separator is a high speed spinner. It acts on the same principle of centrifuge machines. The bowl spins at very high speed causing the heavier contents of milk to move outward in the bowl pushing the lighter contents inward towards the spinning axis. Cream is lighter than other components in milk. Therefore, skimmed milk which is denser than cream is collected at outer wall of the bowl. The lighter part of cream is pushed towards the centre from where it is collected through pipe.

Spin dryer – centrifugal force

1-rotating metal drum

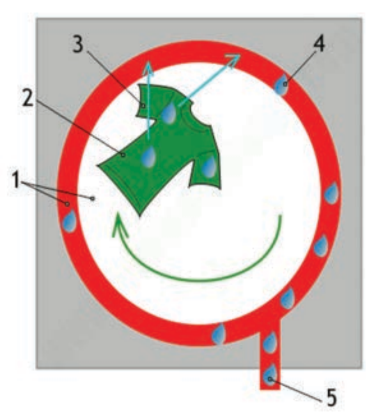
2&3 - wet cloth

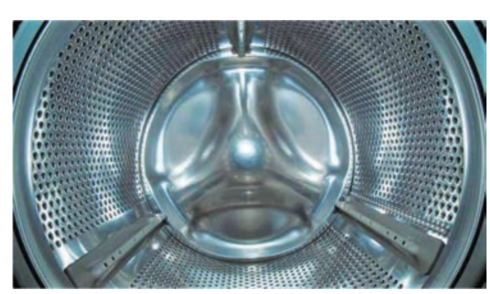
4-water droplet

5-let out of droplets

DO YOU KNOW?

When you go for a ride in a merry-go-round in amusement parks, what force do you experience? We experience an outward pull as merry-go round rotates about vertical axis. This is due to centrifugal force.





A spin dryer removes excess water from clothing by rotating a perforated drum at high speed. The water is thrown out through the holes. The clothes keep moving in a circle because the contact force of the drum provides centrifugal force.

IX_Science Unit-2.indd 32 02-04-2018 18:18:39

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2.10 Summary

- Motion is a change of position, which can be described in terms of the distance moved or the displacement.
- The motion of an object could be uniform or non-uniform depending on its velocity.
- The speed of an object is the distance covered per unit time and velocity is the displacement per unit time.
- The acceleration of an object is the change in velocity per unit time.
- Uniform and non-uniform motion of object can be shown through graphs.

The motion of an object at uniform acceleration can be described with the help of three equations, namely

$$v = u + at$$
$$s = ut + \tfrac{1}{2} at^2$$
$$v^2 = u^2 + 2as$$

where u is initial velocity of the object, v is its final velocity, s is the distance travelled in time t, a is the acceleration.

For a freely falling body the acceleration a is replaced by g.

An object under uniform circular motion experiences centripetal force.

A-Z GLOSSARY

1. **Motion** an object's change in position
2. **Distance** is a scalar quantity that refers to "how much length an object has covered" during its motion
3. **Displacement** is an object's change in position, only measuring from its starting position to the final position
4. **Speed** the rate of motion at which the object moves (distance/time)
5. **Velocity** the speed of an object in a particular direction
6. **Acceleration** change in velocity either magnitude or direction
7. **Circular motion** circular motion is a movement of an object along the circumference of a circle or rotation along a circular path
8. **Centripetal force** a force which acts on a body moving in a circular path and is directed towards the centre
9. **Centrifugal force** a force, arising from the body's inertia, which appears to act on a body moving in a circular path and is directed away from the centre
10. **Gravity** a force of attraction between object and the centre of Earth, due to their masses

ICT CORNER

FORCE AND MOTION

Newton's second law says a force acting on the object either change it's direction or acceleration or both. F=ma

This activity proves that:

Step 1. Type the following URL in the browser or scan the QR code from your mobile.Youcan see a wheel barrow full of load on the screen. Below that you can see two sets of people also.

Step 2. Place different number of peoples on both the side of the rope. Click go. According to the force given by the people the wheel barrow moves to anyone of the side. If the number of people is equal on both the sides the load will not move.

Step 3. By changing the number of people you can see the force and motion.

https://phet.colorado.edu/en/simulation/forces-and-motion-basics

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IX_Science Unit-2.indd 33 02-04-2018 18:18:39

EKWFAP

EXERCISE

I. Solved Examples

1. An object travels 16m in 4s and then another 16m in 2 s. What is the average speed of the object?

Sol: Total distance travelled by the object = 16 m + 16 m = 32m

Total time taken = 4s + 2s = 6s

Average speed =

$$\frac{\text{Total distance travelled}}{\text{total time taken}} = \frac{32m}{6s} = \frac{32}{6} = 5.33 ms^{-1}$$

Therefore, the average speed of the object is $5.33 ms^{-1}$

2. The brakes applied to a car produce an acceleration of $6\ ms^{-2}$ in the opposite direction to the motion. If the car takes 2s to stop after the application of brakes. Calculate the distance it travels during this time.

Sol: We have been given $a = -6\ ms^{-2}$, $t = 2s$ and $v = 0$

From the equation of motion $v = u + at$

$0 = u + (-6 \times 2)$

$0 = u - 12$

$u = 12\ ms^{-1}$

$s = ut + \frac{1}{2} at^2$

$= (12 \times 2) + \frac{1}{2}(-6 \times 2 \times 2)$

$= 24 - 12$

$s = 12m$

Thus, the car will move 12m before it stops after the application of brakes.

3. Surya swims in a 90 m long pool. He covers 180 m in 60 s by swimming from one end to the other and back along the same straight path. Find the average speed and the average velocity of Surya.

Sol: Average speed $= \frac{\text{Distance covered}}{\text{time taken}} = \frac{180m}{60s} = 3 ms^{-1}$

Average velocity $= \frac{\text{Displacement}}{\text{time taken}} = \frac{0m}{60s} = 0$

The average speed of Surya is $3\ ms^{-1}$ and his average velocity is 0

4. A 100 m long train crossed a bridge of length 200 m in 50 s with constant velocity. Find the velocity of the train.

Sol: Distance travelled by the train = length of the train + length of the bridge

= 100 m + 200 m

= 300 m

Velocity of the train =

$$\frac{\text{Distance travelled by the train}}{\text{time taken}} = \frac{300}{50}$$

$= 6\ ms^{-1}$

5. A sound is heard 5 s later than the lightning is seen in the sky on a rainy day. Find the distance of location of lightning? Given the speed of sound = $346\ ms^{-1}$

$$\text{Speed} = \frac{\text{Distance}}{\text{time}}$$

Distance = speed × time = 346 × 5 = 1730m

Thus, the distance of location of lightning = 1730 m

6. A 900 kg car moving at $10\ m\ s^{-1}$ takes a turn around a circle with a radius of 25 m. Determine the acceleration

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and the net force acting upon the car.

When the car turns around circle, it experiences centripetal acceleration

$$a = \frac{\upsilon^2}{r}$$

The solution is as follows: $a = \frac{(10)^2}{25}$

$$a = \frac{100}{25}$$

$a = 4\ m\ s^{-2}$

To determine the net force acting upon the car, use the equation F = m a.

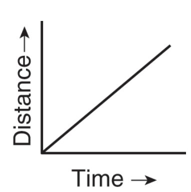
F = m a F = 900 × 4 F = 3600 N

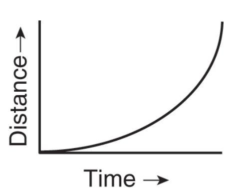
II. Multiple Choice Questions

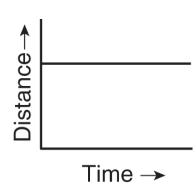
1. Slope of the velocity - time graph gives
   a) speed b) displacement
   c) distance d) acceleration

2. Which of the following graph represents uniform motion of a moving particle?

a)


b)


c)


d)


3. A body moving with an initial velocity $5ms^{-1}$ and accelerates at $2ms^{-2}$. Its velocity after 10s is
   a) $20ms^{-1}$ b) $25ms^{-1}$
   c) $5ms^{-1}$ d) $22.55ms^{-1}$

4. In a 100 m race, the winner takes 10s to reach the finishing point. The average speed of the winner is
   a) $5ms^{-1}$ b) $20ms^{-1}$
   c) $40\ ms^{-1}$ d) $10\ ms^{-1}$

5. The area under velocity – time graph represents
   a) velocity of the moving object
   b) displacement covered by the moving object
   c) speed of the moving object
   d) acceleration of the moving object

6. A car is being driven at a speed of 20 ms^{-1} when brakes are applied to bring it to rest in 5 s. The deceleration produced in this case will be
   a) $+4\ ms^{-2}$ b) $-4\ ms^{-2}$
   c) $-0.25\ ms^{-2}$ d) $+0.25\ ms^{-2}$

7. Unit of acceleration is
   a) ms^{-1} b) ms^{-2}
   c) ms d) ms^2

8. Which one of the following is most likely not a case of uniform circular motion?
   a) Motion of the Earth around the Sun.
   b) Motion of a toy train on a circular track.
   c) Motion of a racing car on a circular track.
   d) Motion of hours' hand on the dial of the clock.

9. The force responsible for drying of clothes in a washing machine is ....
   a) Centripetal force
   b) Centrifugal force
   c) Gravitational force
   d) Electro static force

10. The centrifugal force is ....
    a) Real force
    b) The force of reaction of centripetal force
    c) Virtual force
    d) Directed towards the centre of the circular path.

IX_Science Unit-2.indd 35 02-04-2018 18:18:41

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III. Fill in the Blanks

1. Speed is a _____________ quantity whereas velocity is a _____________ quantity
2. The slope of the distance – time graph at any point gives ___________
3. Consider an object is rest at position x = 20m. Then its displacement – time graph will be straight line to ______________ the axis.
4. Negative acceleration is called _____________
5. Area under velocity – time graph shows _____________

IV. True or False

1. The motion of a city bus in a heavy traffic road is an example for uniform motion.
2. Acceleration can get negative value also.
3. Distance covered by a particle never becomes zero between any interval of time but displacement becomes zero.
4. The velocity – time graph of a particle falling freely under gravity would be straight line parallel to the x axis.
5. If the velocity – time graph of a particle is a straight line inclined to time axis then its displacement – time graph will be a straight line?

V. Assertion and Reason Type Question

Mark the correct choice as:

a. If both assertion and reason are true and reason is the correct explanation of assertion.
b. If both assertion and reason are true but reason is not the correct explanation of assertion.
c. If assertion is true but reason is false.
d. If assertion is false but reason is true.

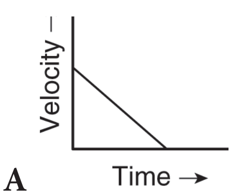
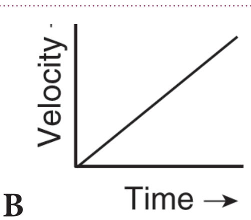
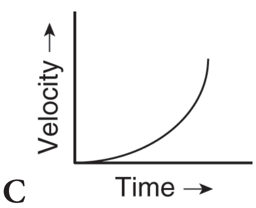
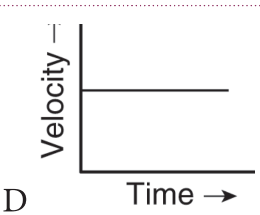
1. Assertion: The accelerated motion of an object may be due to change in magnitude of velocity or direction or both of them.

   Reason: Acceleration can be produced only by change in magnitude of the velocity it does not depend the direction.
2. Assertion: The Speedometer of a car or a motor-cycle measures the average speed of it.

   Reason: Average velocity is equal to total displacement divided by total time taken.
3. Assertion: Displacement of a body may be zero when distance travelled by it is not zero.

   Reason: The displacement is the shortest distance between initial and final position.

VI. Match the Following

List I	List II
Motion of a body covering equal distances in equal interval of time	 A
Motion with non uniform acceleration	 B
Constant retardation	 C
Uniform acceleration	 D

IX_Science Unit-2.indd 36 02-04-2018 18:18:41

VII. Short Answer Questions

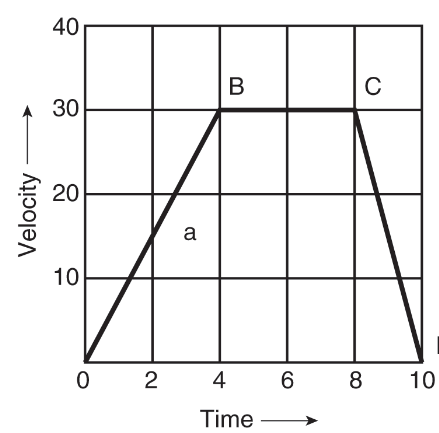
1. Define velocity?
2. Distinguish distance and displacement?
3. What do you mean by uniform motion?
4. Compare speed and velocity?
5. What do you understand about negative acceleration?
6. What remains constant in uniform circular motion? And What Changes continuously in uniform circular motion?
7. Is the uniform circular motion accelerated? Give reasons for your answer?
8. What is meant by uniform circular motion? Give two examples of uniform circular motion.

VIII. Paragraph Questions

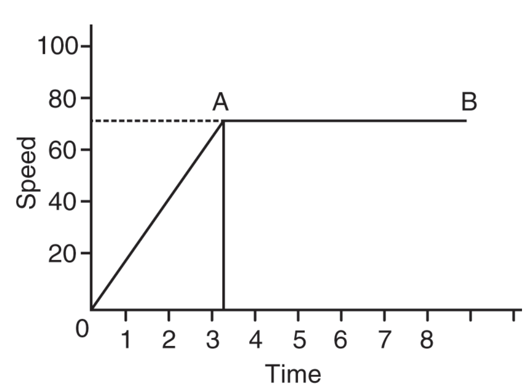
1. Derive equations of motion by graphical method.

IX. Exercise Problems

1. During an experiment, a signal from a spaceship reached the ground station in five seconds. What was the distance of the spaceship from the ground station? The signal travels at the speed of light that is 3×10^8 ms^{-1}
2. A ball is gently dropped from a height of 20m. If its velocity increases uniformly at the rate of 10 ms^{-2} with what velocity will it strike the ground? After what time will it strike the ground?
3. An Athlete completes one round of a circular track of diameter 200 m in 40 s. What will be the distance covered and the displacement at the end of 2 m and 20 s?
4. A racing car has a uniform acceleration of 4 ms^{-2}. What distance it covers in 10 s after start?
5. A train travelling at a speed of 90 kmph. Brakes are applied so as to produce a uniform acceleration of −0.5 ms^{-2}. Find how far the train will go before it is brought to rest?
6. The adjacent diagram shows the velocity time graph of a body. During what time interval is the motion of the body accelerated. Find the acceleration in the time interval mentioned in part 'a'. What is the distance travelled by the body in the time interval mentioned in part a?



7. The following graph shows the motion of a car. What do you infer from the graph along OA and AB? What is the speed of the car along AB and what time it reached this speed



8. From the following Table, check the shape of the graph

Time (s)	0	2	4	6	8	10	12
Velocity(ms^{-1})	0	20	40	40	40	20	0

QUESTION PAPER - I

I. Choose the best answer

1. The area under velocity time graph represents
   a. Velocity of the moving object
   b. Displacement covered by the moving object
   c. Speed of the moving object

2. Unit of acceleration is
   a. Ms^{-1} b. ms^{-2}
   c. ms d. ms^2

3. When a body starts from rest, the acceleration of the body after 2second in ______________ of its displacement
   a. Half b. Twice
   c. Four times d. One fourth

II. Short answer Questions

1. A bus travel, a distance of 20km from Chennai central airport in 45 minutes. What is the average speed?
2. Why did the actual speed differ from average speed!
3. Mention the uses of velocity–time graph
4. The speed of a particle is constant. Will it have acceleration? Justify with an example
5. Distinguish distance and displacement of a moving object

III. Answer the following Question briefly

Derive the three equations of motion by graphical method.

QUESTION PAPER - II

I. Choose the best answer

1. In a 100 m race, the winner takes 10s to reach the finishing point. The average speed of the winner is ___________ ms^{-1}
   a) 5 b) 10
   c) 20 d) 40

2. Force involved in uniform circular motion is given by________________
   a) $f = \frac{mv^2}{r}$ b) f = mvr
   c) $f = \frac{mr^2}{v}$ d) $f = \frac{v^2}{r}$

II. Choose correct statement

1. Action and reaction forces act on same object

   Action and reaction forces act on different objects

   Both (a) and (b) are possible

   Neither (a) nor (b) is correct

III. Short answer Questions

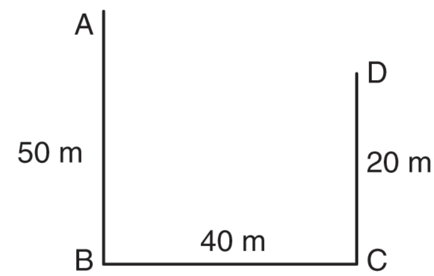
1. A motorcycle travelling at $20ms^{-1}$ has an acceleration of $4ms^{-2}$. What does it explains about the velocity of the motorcycle.

IX_Science Unit-2.indd 38 02-04-2018 18:18:43

2. Complete of following sentences
   a. The acceleration of the body that moves with a uniform velocity will be _________
   b. A train travels from A to station B with a velocity of 100 km/h and returns from station B to station A with a velocity of 80km/h. Its average velocity during the whole journey in _______________ and its average speed is _____________
3. Distinguish speed and velocity.
4. What is meant by negative acceleration?

IV. Answer the following Question

A boy moves along the path ABCD. What is the total distance Covered by the boy? What is his net displacement?



REFERENCE BOOKS

1. Advanced Physics by: M. Nelkon and P. Parker, C.B.S publications, Chennai
2. College Physics by: R.L.Weber, K.V. Manning, Tata McGraw Hill, New Delhi.
3. Principles of Physics (Extended) - Halliday, Resnick & Walker, Wiley publication, New Delhi.

INTERNET RESOURCES

http://www.ducksters.com/science/physics/motion_glossary_and_terms.php

http://www.physicsclassroom.com/mmedia/circmot/ucm.cfm

http://www.physicsclassroom.com/Class/1DKin/U1L1d.cfm

http://www.physicsclassroom.com/Class/1DKin/U1L1e.cfm

https://brilliant.org/wiki/uniform-circular-motion-easy/

Centrifugal force

https://www.youtube.com/watch?v=Rv4pnUlf0PQ

IX_Science Unit-2.indd 39 02-04-2018 18:18:43

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UNIT 3

Light

EL6BCC

Learning Objectives

At the end of this unit the students will be able to

- describe the nature of images formed by plane mirrors
- explain why lateral inversion takes place
- apply the laws of reflection for plane mirrors and spherical mirrors
- draw ray diagrams to find the position and size of the image for spherical mirrors
- distinguish between real and virtual images
- apply the mirror equation to calculate position, size and nature of images and focal lengths for spherical mirrors
- identify situations in which refraction will occur
- identify the direction of bending when light passes from one medium to another
- solve problems using Snell's law
- predict whether light will be refracted or undergo total internal reflection
- recognize atmospheric conditions that cause refraction

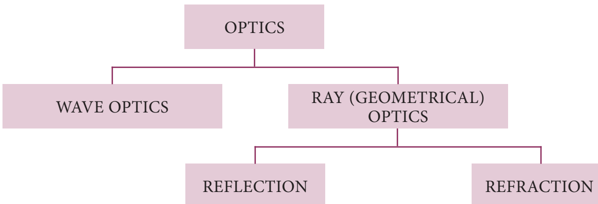
Introduction

In our day to day life we use number of optical instruments. Microscopes are inevitable in physics laboratory, biology laboratory and in medical laboratories. Also telescopes, binoculars, cameras and projectors are used in educational, scientific and entertainment fields. Do you know the basic components or parts used in these instruments? Mirrors and lenses! You can name some more optical instruments you have seen. Also, in our daily life we come across many optical illusions like mirage, rainbow, apparent bending of objects placed in liquids.

In this chapter, you will learn about the properties of plane mirror and spherical mirrors (concave and convex). Also you will learn about the properties of light, namely reflection and refraction and their applications.

Light is a form of energy and it travels in the form of electromagnetic waves. The branch of physics that deals with the properties and applications of light is called *optics*. The branch of optics that treats light as rays is named *ray optics* or *geometrical optics* and the branch of optics where the wave nature of light is considered is called *wave optics*.

IX_Science Unit-3.indd 40 27-03-2018 12:27:51



3.1 Reflection of Light

You know that light is a form of energy. This energy travels from a source in all direction and the direction along which it travels is called a ray of light. Observe a bulb in your house, slightly closing your eye lids. You can see the light in the form of yellow lines. One such a line is called a ray. A bundle of such rays constitute a beam of light.

Light falling on any polished surface such as a mirror, is reflected. This reflection of light on polished surfaces follows certain laws and you might have studied about them in your lower classes. Let us study about them little elaborately.

3.1.1 Laws of reflection

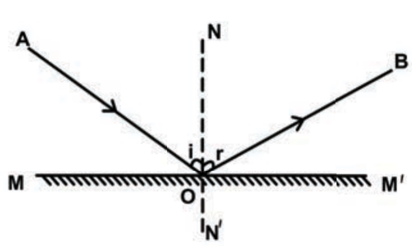


Figure 1 Plane mirror

Consider a plane mirror MM′ as shown in Figure 1. Let AO be the light ray incident on the plane mirror at O. The ray AO is called incident ray. The plane mirror reflects the incident ray along OB. The ray OB is called reflected ray. Draw a line ON at O perpendicular to MM′. This line ON is called **normal.**

The angle made by the incident ray with the normal (i = *angle* AON) is called angle of incidence. The reflected ray OB makes an angle (r = angle NOB) with the normal and this is called angle of reflection. From the figure you can observe that the angle of incidence is equal to the angle of reflection. (i.e) $\angle i = \angle r$. Also, the incident ray, the reflected ray and the normal at the point of incidence all lie in the same plane. These are called the laws of reflection.

Laws of reflection:

- The incident ray, the reflected ray and the normal at the point of incidence, all lie in the same plane.
- The angle of incidence is equal to angle of reflection.

Activity 1

The most common modern usage of mirror writing can be found on the front of ambulances, where the word "AMBULANCE" is often written in very large mirrored text, find out why it is written in such a way?

Reflection of light has many interesting facts. Let us look at some of them here.

How tall does a mirror have to be to fit your entire body?

Can you see your entire body in a make-up mirror? Now, stand before the mirror in your dressing table or the mirror fixed in a steel almirah. Do you see your whole body now? What do you know from this? To see your entire body in a mirror, the

IX_Science Unit-3.indd 41 27-03-2018 12:27:51

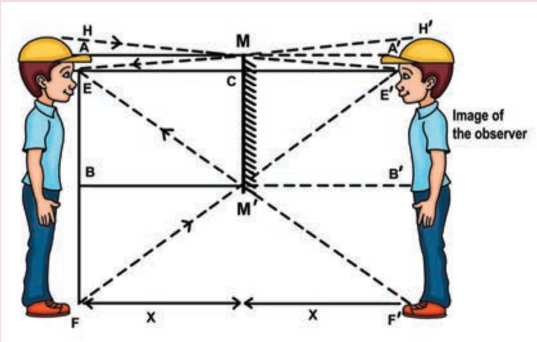
mirror should be atleast half of your height. Height of the mirror= Your height/2

Find out

Using a metre scale, measure your height in centimetre. Now find out the height of the mirror to see your entire body.

More to Know

Let an observer *HF* stand at a distance '*x*' in front of a plane mirror *MM'*. The image *H'F'* of the observer is formed at the same distance '*x*' behind the plane mirror. The image *H'F'* of this observer will be of the same size as that of the observer.



A ray from the person's feet FM', gets reflected as M'E. He observes this as virtual image at F'. Based on Law of reflection (2) and on the geometry of the triangles Δ FM'B and Δ BM'E,

the height of the person from feet to eye = FE
this is double that of EB (or) EB = $\frac{FE}{2}$.

Also EB = CM' (1)

Similarly, a ray from the person's head HM, gets reflected as ME. He observes this as virtual image at H'. Based on the same law and geometry of the triangles Δ HMA and Δ H'MA',

the height of the person from head to eye = HE
this is double that of AE (or) AE = $\frac{HE}{2}$.

Also AE = MC (2)

From the above figure,

total height of the person = HF = HE + EF (3)

total height of his image = H'F' = H'E' + E'F' (4)

These two heights are the *same*. (Can you prove it?)

Moreover, from (1) and (2),

Height of mirror = CM' + CM = $\frac{FE}{2} + \frac{EH}{2} = \frac{HF}{2}$. i.e., half of his height

Note: The requirement remains the same regardless of the distance *x* of the observer from the mirror.

3.1.2 Lateral inversion

You might have heard about inversion. But what is lateral inversion?The word lateral comes from the Latin word *latus* which means side. Lateral inversion means sidewise inversion; it is the apparent inversion of left and right that occurs in a plane mirror.

Why do plane mirrors reverse left and right, but they do not reverse up and down?

Well the answer is surprising. Mirrors do not actually reverse left and right and they do not reverse up and down also. What actually mirrors do is reverse inside out.

Look at the image below and observe the arrows, which indicate the light ray from the object falling on the mirror. The arrow from object's head is directed towards the top of the mirror and the arrow from the feet is directed towards the bottom. The arrow from left hand goes to the left side of the mirror and the arrow from the right hand goes to the right side of the mirror. Here, you can see that there is no switching. It is an optical illusion.

IX_Science Unit-3.indd 42 27-03-2018 12:27:51

Lateral Inversion

The apparent lateral inversion we observe is not caused by the mirror but the result of our perception.

Note: You can try this activity with pencil or pen. What do you observe?

3.2 Curved Mirrors

We studied about laws of reflection. These laws are applicable to all types of reflecting surfaces including curved surfaces. Let us learn about image formation in curved surfaces in this part.

In your earlier classes, you have studied that there are many types of curved mirrors, such as spherical and parabolic mirrors. The most commonly used type of curved mirror is spherical mirror. The curved surfaces of a shining spoon could also be considered as a curved mirror.

Take a hemispherical spoon. It has an inner and outer surface like the inside and outside of the ball. See your face on these surfaces? How do they look?

Move the spoon slowly away from your face. Observe the image. How does it change? Reverse the spoon and repeat the activity. How does the image look like now?

3.2.1 Spherical mirrors

In curved mirrors, the reflecting surface can be considered to form a part of the surface of a sphere. Such mirrors whose reflecting surfaces are spherical are called spherical mirrors.

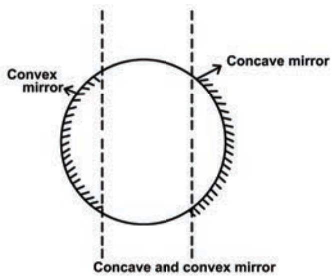


Figure 2 Concave and Convex mirror

In some spherical mirrors the reflecting surface is curved inwards, that is, it faces towards the centre of the sphere. It is called concave mirror. In some other mirrors, the reflecting surface is curved outward. It is called convex mirror and are shown in Figure 2.

In order to understand reflection of light at curved surfaces, we need to know the following.

Centre of curvature (C): The centre of the hollow sphere of which the spherical mirror forms a part.

Pole (P): The geometrical centre of the spherical mirror.

Principal axis (PC): The perpendicular line joining the pole and the centre of curvature of the mirror.

Radius of curvature(R): The distance between the pole and the centre of curvature of the spherical mirror.

Principal focus (F): The point on the principal axis of the spherical mirror where the rays of light parallel to the principal axis meet or appear to meet after reflection from the spherical mirror.

Focal length(f): The distance between the pole and the principal focus.

IX_Science Unit-3.indd 43 27-03-2018 12:27:52

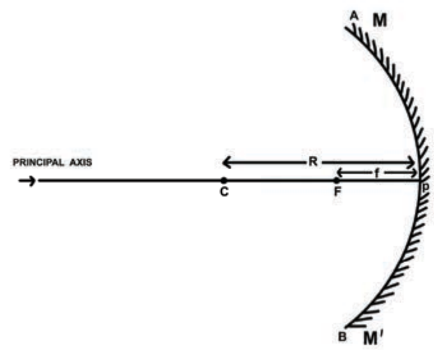


Figure 3 Concave mirror

Radius of curvature and focal length are related to each other by the formula: R=2f. All these are depicted in Figure 3.

Check yourself:

ELF7DZ

1. Focal length of a concave mirror is 5 cm. Find its radius of curvature.
2. For a concave mirror the distance between P and C is 10 cm. Calculate it's the focal length.
3. A concave mirror has radius of curvature 20 cm. Find the focal length of the mirror.

3.3 Image Formed by Curved Mirrors

Activity 2

Hold a concave mirror in your hand (or placed in a stand). Direct its reflecting surface towards the sun. Direct the light reflected by the mirror onto a sheet of paper held not very far from the mirror. Move the sheet of paper back and forth gradually until you find a bright, sharp spot of light on the paper. **[Do this activity only under adult supervision].** Position the mirror and the paper at the same location for few moments. What do you observe? Why does the paper catches fire?

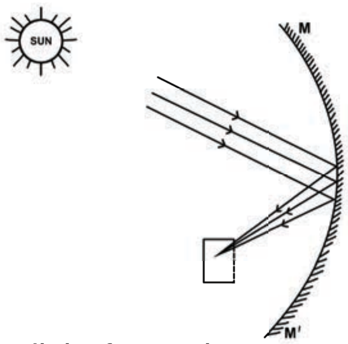


Figure 4 Sunlight focused on a concave mirror

We have seen that the parallel rays of sun light (Figure 4) could be focused at a point using a concave mirror. Now let us place a lighted candle and a white screen in front of the concave mirror. Adjust the position of the screen. Move the screen front and back. Note the size of the image and its shape. Is it inverted? Is it small?

Next, slowly bring the candle closer to the mirror. What do you observe? As you bring the object closer to the mirror the image becomes bigger. Try to locate the image when you bring the candle very close to the mirror. Are you able to see an image on the screen? Now look inside the mirror. What do you see? An erect magnified image of the candle is seen. In some positions of the object an image is obtained on the screen. However at some position of the object no image is obtained. It is clear that the behaviour of the concave mirror is much more complicated than the plane mirror.

However, with the use of geometrical technique we can simplify and understand the behaviour of the image formed by a concave mirror. In the earlier case of plane mirror, we used only two rays to understand how to get full image of a person. But for understanding the nature of image formed

IX_Science Unit-3.indd 44 27-03-2018 12:27:53

by a concave mirror we need to look at four specific rules.

3.3.1 Rules for the construction of image formed by spherical mirrors

From each point of an object, number of rays travel in all directions. To find the position and nature of the image formed by a concave mirror, we need to know the following rules.

Rule 1: A ray passing through the centre of curvature is reflected back along its own path (Figure 5).

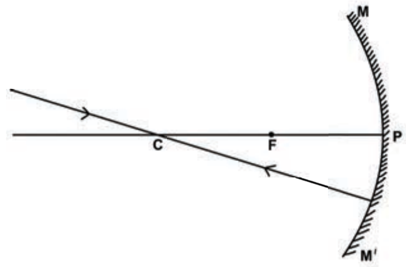


Figure 5 Ray passing centre of curvature

Rule 2: A ray parallel to the principal axis passes through the principal focus after reflection (Figure 6).

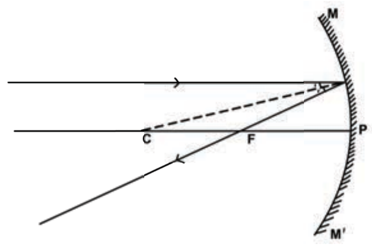


Figure 6 Ray parallel to prinicpal axis

Rule 3: A ray passing through the focus gets reflected and travels parallel to the principal axis (Figure 7).

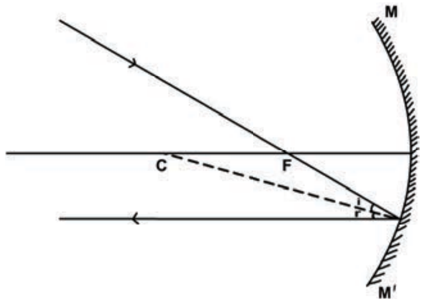


Figure 7 Ray travelling through the principal focus

Rule 4: A ray incident at the pole of the mirror gets reflected along a path such that the angle of incidence (APC) is equal to the angle of reflection (BPC) (Figure 8).

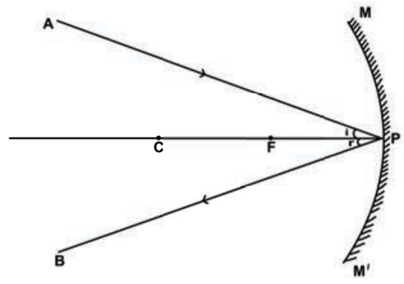


Figure 8 Angle of incidence equal to angle of reflection

3.4 Real and Virtual Image

If the light rays coming from an object actually meet, after reflection, the image formed will be a real image and it is always inverted. A real image can be produced on a screen. When the light rays coming from an object do not actually meet, but appear to meet when produced backwards,that image will be virtual image. The virtual image is always erect and cannot be caught on a screen (Figure 9).

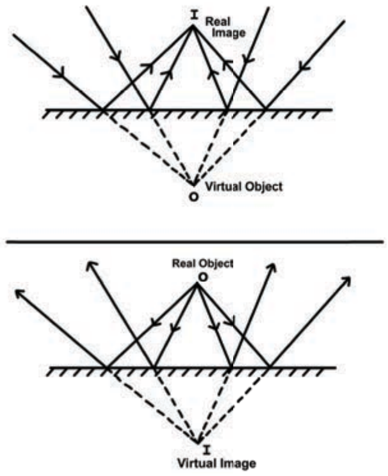


Figure 9 Real and virtual image

Activity 3

Keep a lighted candle between the principal focus (F) and pole (P) of a concave mirror. Can you see an enlarged image of the candle on the mirror? Now keep the candle away from P, beyond C. You can obtain an image of the candle on a screen.

What is the type of image formed by a plane mirror? Can you catch that image on a screen?

3.5 Concave Mirror

3.5.1 Ray diagrams for the formation of images

We shall now find the position, size and nature of image by drawing the ray diagram for a small linear object placed on the principal axis of a concave mirror at different positions.

Case–I: When the object is far away (at infinity), the rays of light reaching the concave mirror are parallel to each other (Figure 10).

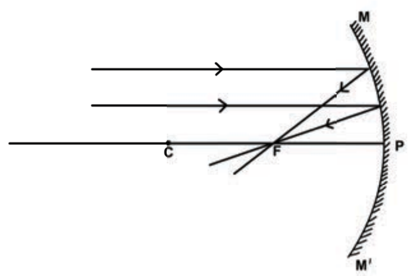


Figure 10 Object at inifinity

Position of the Image: The image is at the principal focus F.

Nature of the Image: It is (i) real, (ii) inverted and (iii) highly diminished in size.

Case–II: When the object is beyond the centre of curvature (Figure 11).

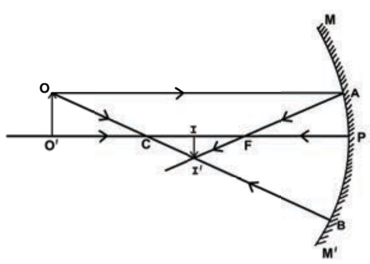


Figure 11 Object beyond the centre of curvature

Position of the image: Between the principal focus F and centre of curvature C.

Nature of the image: Real, inverted and smaller than object.

Case – III: When the object is at the centre of curvature (Figure 12).

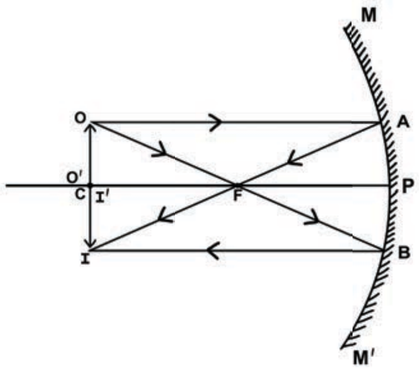


Figure 12 Object at the centre of curvature

Position of the image: The image is at the centre of curvature itself.

Nature of the image: It is i) Real, ii) inverted and iii) same size as the object.

Case – IV: When the object is in between the centre of curvature C and principal focus F (Figure 13).

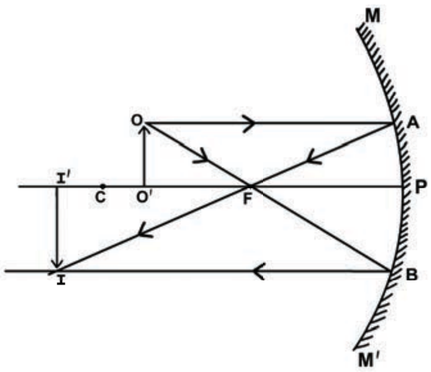


Figure 13 Object in between centre of curvature and principal focus

Position of the image: The image is beyond C

Nature of the image: It is i)Real ii) inverted and iii) magnified.

IX_Science Unit-3.indd 46 27-03-2018 12:27:56

Case – V: When the object is at the principal focus F (Figure 14).

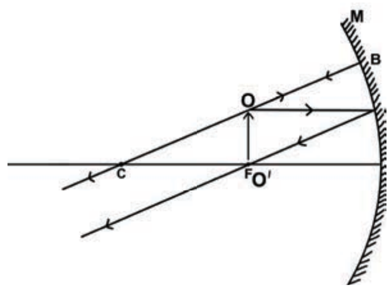


Figure 14 Object at principal focus

Position of the image: Theoretically, the image is at infinity.

Nature of the image: No image can be captured on a screen nor any virtual image can be seen.

Case – VI: When the object is in between the focus F and the pole P (Figure 15).

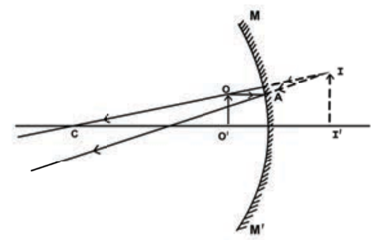
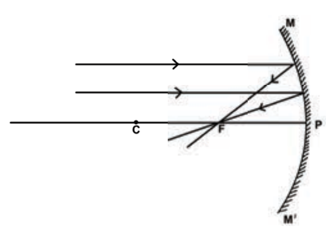
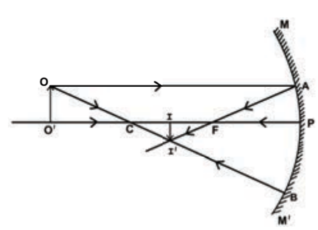
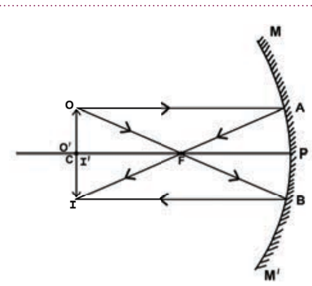
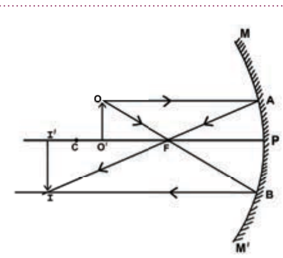


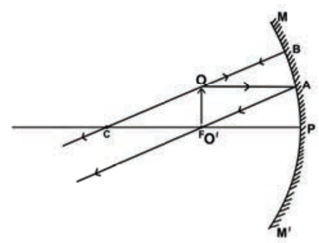
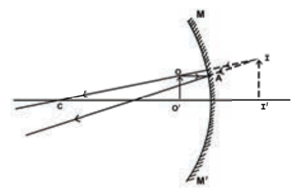
Figure 15 Object in between principal focus and pole

Position of the image: The image is behind the mirror.

Nature of the image: It is virtual,erect and magnified.

Sl. No.	Position of Object	Ray Diagram	Position of Image	Size of Image	Nature of Image
1.	At infinity		At the principal focus	Point size	Real and Inverted
2.	Beyond the Centre of Curvature C		Between F and C	Smaller than the object	Real and Inverted
3.	At the Centre of Curvature C		At C	Same size	Real and Inverted
4.	Between C and F		Beyond C	Magnified	Real and inverted

IX_Science Unit-3.indd 47 27-03-2018 12:27:57

Sl. No.	Position of Object	Ray Diagram	Position of Image	Size of Image	Nature of Image
5.	At the principal focus F		At infinity	infinitely large	Real and Inverted
6.	Between the principal focus F and the pole P of the mirror		Behind the mirror	Magnified	Virtual and Erect

3.5.2 Sign convention for measurement of distances

We follow a set of sign conventions called the cartesian sign convention. In this convention the pole (P) of the mirror is taken as the origin. The principal axis is taken as the x axis of the coordinate system (Figure 16).

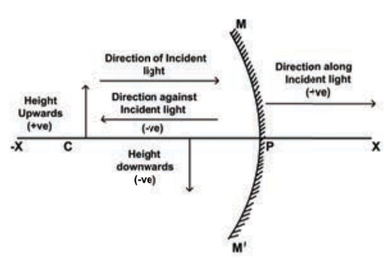


Figure 16 Sign convention for spherical mirrors

- The object is always placed on the left side of the mirror.
- All distances are measured from the pole of the mirror.
- Distances measured in the direction of incident light are taken as positive and those measured in the opposite direction are taken as negative.
- All distances measured perpendicular to and above the principal axis are considered to be positive.
- All distances measured perpendicular to and below the principal axis are considered to be negative.

3.5.3 Mirror equation

The expression relating the distance of the object u, distance of image v and focal length f of a spherical mirror is called the mirror equation. It is given as:

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

Type of mirror	u	v		f	R	Height of the Object	Height of the Image	
		real	virtual				real	virtual
Concave mirror	-	-	+	-	-	+	-	+
Convex mirror	-	No real image	+	+	+	+	No real image	+

Sign convention for measurement of distances

IX_Science Unit-3.indd 48 27-03-2018 12:27:58

3.5.4 Linear magnification (m)

Magnification produced by a spherical mirror gives the how many times the image of an object is magnified with respect to the object size.

It can be defined as the ratio of the height of the image (h_i) to the height of the object (h_o).

$$m = \frac{h_i}{h_o}$$

The magnification can be related to object distance (u) and the image distance (v)

$$m = -\frac{v}{u}$$

$$\therefore m = \frac{h_i}{h_o} = -\frac{v}{u}$$

Note: A negative sign in the value of magnification indicates that the image is real. A positive sign in the value of magnification indicates that the virtual image.

Sample Problem 1

Find the size, nature and position of image formed when an object of size 1 cm is placed at a distance of 15 cm from a concave mirror of focal length 10 cm.

1. Position of image

Object distance u = – 15 cm (to the left of mirror)

Image distance v =?

Focal length f = – 10 cm (concave mirror)

Using mirror formula

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{v} + \frac{1}{-15} = \frac{1}{-10}$$

$$\frac{1}{v} - \frac{1}{15} = \frac{-1}{10}$$

$$\frac{1}{v} = \frac{-1}{10} + \frac{1}{15}$$

$$= \frac{-3+2}{30}$$

$$\frac{1}{v} = \frac{-1}{30}$$

∴ Image distance v = −30cm (negative sign indicates that the image is on the left side of the mirror)

∴ Position of image is 30 cm in front of the mirror

2. Nature of image: Since the image is in front of the mirror it is real and inverted.
3. Size of image: To find the size of the image, we have to calculate the magnification.

$$m = \frac{-v}{u}$$

Object distance u = – 15cm

Image distance v = – 30 cm

$$m = \frac{-(-30)}{(-15)}$$

$$m = -2$$

We know that, $m = \frac{h_2}{h_1}$

Here, height of the object h_1 = 1 cm

$$-2 = \frac{h_2}{1}$$

$$h_2 = -2 \times 1$$

$$= -2 \text{ cm}$$

The height of image is 2 cm (negative sign shows that the image is formed below the principal axis).

Sample Problem 2

An object 2 cm high is placed at a distance of 16 cm from a concave mirror which produces a real image 3 cm high. Find the position of the image.

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Calculation of position of image

Height of object $h_1 = 2$ cm

Height of real image $h_2 = -3$ cm

Magnification $m = \frac{h_2}{h_1}$

$$= \frac{-3}{2}$$

$$= -1.5$$

We know that, $m = \frac{-v}{u}$

here, object distance u = – 16 cm

Substituting the value, we get

$$-1.5 = -\frac{v}{(-16)}$$

$$-1.5 = \frac{v}{16}$$

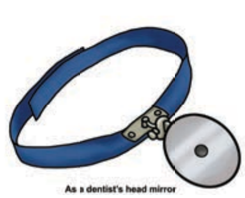
$$v = 16 \times (-1.5)$$

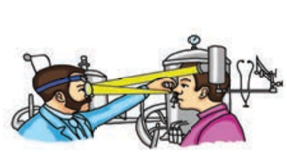
$$v = -24 \text{ cm}$$

The position of image is 24 cm in front of the mirror (negative sign indicates that the image is on the left side of the mirror).

3.5.5 Uses of concave mirror

As a dentist's head mirror: You would have seen a circular mirror attached to a band tied to the forehead of the dentist/ENT specialist. A parallel beam of light is made to fall on the concave mirror;this mirror focuses the light beam on a small area of the body (such as teeth, throat etc.).





As a make-up mirror: When a concave mirror is held near the face (between the pole and principal focus of the mirror), an upright and magnified image is seen. Here, our face will be seen magnified.

Other applications: Concave mirrors are also used as reflectors in torches, head lights in vehicles and search lights to get powerful beams of light. Concave reflectors are also used in room heaters. Large concave mirrors are used in solar heaters.

Think

Stellar objects are at an infinite distance; therefore the image formed by a concave mirror would be diminished, and inverted. Yet, why do astronomical telescopes use concave mirror?

3.6 Convex Mirror

3.6.1 Rules for the construction of image formed by spherical mirrors

We have studied the image formation by a concave mirror. Similarly, we can trace the path of light rays reflected by the convex mirrors using four 'rules'.

Rule 1: A ray of light which is parallel to the principal axis of a convex mirror appears to be coming from its principal focus, after reflection from the mirror (Figure 17).

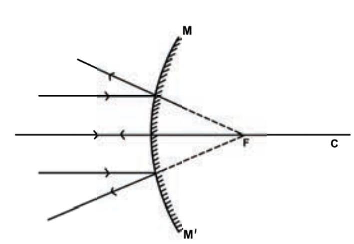


Figure 17 Rule 1

Rule 2: A ray of light going towards the centre of curvature is reflected back along the same path (Figure 18).

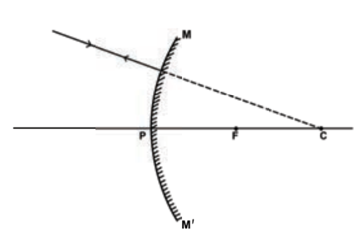


Figure 18 Rule 2

IX_Science Unit-3.indd 50 27-03-2018 12:28:00

Rule 3: A ray of light going towards the principal focus of a convex mirror becomes parallel to the principal axis after reflection (Figure 19).

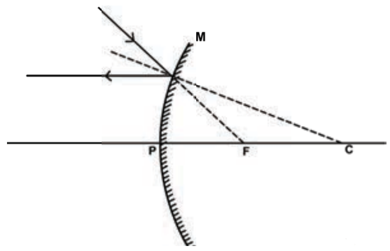


Figure 19 Rule 3

Rule 4: A ray of light which is incident at the pole of a convex mirror is reflected back making the same angle with the principal axis (Figure 20).

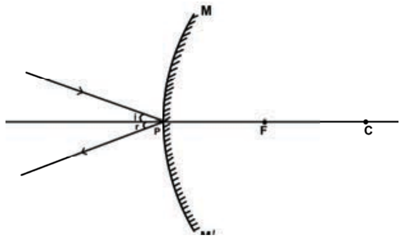


Figure 20 Rule 4

3.6.2 Image formation in a convex mirror

Any two rays can be chosen to draw the position of the image in a convex mirror (Figure 21).

1st ray: the ray that is parallel to the principal axis (rule 1) and

2nd ray : the ray that appears to pass through the centre of curvature (rule 2).

Note: All rays behind the convex mirror shall be shown with dotted lines.

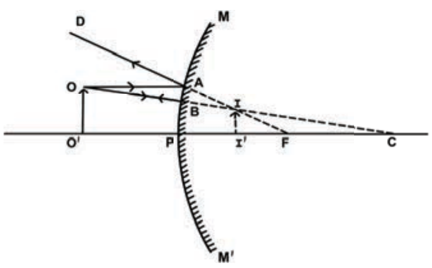


Figure 21 Image formation in a convex mirror

The ray OA parallel to the principal axis is reflected along AD. The ray OB retraces its path. The two reflected rays diverge but they appear to intersect at I when produced backwards. Thus II′ is the virtual image of the object OO′. It is virtual, erect and smaller than the object.

Activity 4

Draw a ray diagram with the object at different positions in front of the convex mirror. Observe the size, nature and positions of image in each case. What do you conclude?

Activity 5

Take a convex mirror. Hold it in one hand. Hold a pencil close to the mirror in the upright position in the other hand. Observe the image of the pencil in the mirror. Is the image erect or inverted? Is it diminished or enlarged? Move the pencil slowly away from the mirror. Does the image become smaller or larger? What do you observe?

ELP3FH

Sample Problem 3

A car is fitted with a convex mirror of focal length 20 cm. Another car is 6 m away from the first car.

a) Find the position of the second car as seen in the mirror of the first

b) What is the size of the image if the second car is 2 m broad and 1.6 m high?

Focal length = 20 cm (convex mirror)

Object distance = –6m

= –600 cm

Image distance v =?

IX_Science Unit-3.indd 51 27-03-2018 12:28:00

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Calculation for position of image using mirror equation

$$\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$$
$$\frac{1}{20}=\frac{1}{-600}+\frac{1}{v}$$
$$\frac{1}{v}=\frac{1}{20}-\frac{1}{-600}$$
$$=\frac{1}{20}+\frac{1}{600}$$
$$\frac{1}{v}=\frac{30+1}{600}=\frac{31}{600}$$
$$v=\frac{600}{31}$$
$$= 19.35 \text{ cm}$$

b) Size of the image

$$\text{m} = \frac{-v}{u}$$
$$= -\frac{v}{(-u)} = \frac{-600}{31} \text{ x } \frac{1}{-600}$$
$$\text{m} = \frac{1}{31}$$
$$\text{Breadth of image} = \frac{1}{31} \text{ x } 200 \text{ cm} = 6.45 \text{ cm}$$
$$\text{Height of image} = \frac{1}{31} \text{ x } 160 \text{ cm} = 5.16 \text{ cm}$$

3.6.3 Uses of convex mirrors

Convex mirrors are used as rear-view mirrors in vehicles. It always forms a virtual, erect, small-sized image of the object. As the vehicles approach the driver from behind the size of the image increases. When the vehicles are moving away from the driver, then image size decreases. A convex mirror provides a much wider field of view* compared to plane mirror.

(* field of view – it is the observable area as seen through eye / any optical device such as mirror)

DO YOU KNOW?

Convex mirrors are installed on public roads as traffic safety device. They are used in acute bends of narrow roads such as hairpin bends in mountain passes where direct view of oncoming vehicles is restricted. It is also used in blind spots in shops.

More to know by observation

1) Have you ever seen the dish antenna used at your home? What is the shape of the antenna? Is it convex or concave? Why?
2) Look around your environment. Observe all the spherical objects (having reflecting surfaces) and record your observation (for example soap bubble).

IX_Science Unit-3.indd 52 27-03-2018 12:28:02

DO YOU KNOW?

In the rear view mirror, the following sentence is written."Objects in the mirror are closer than they appear" Why?

Crossword puzzle

		1												
					2						12			
				3										
4							5							
							11							
				6			7		8					
							9				10			

Across

3. Kind of image formed when rays from the mirror converge.
4. Rays from an object at infinity.
6. Converging mirror.
9. Line perpendicular to the surface at the point of incidence.
11. Diameter of circular rim of spherical mirror.

Down

1. Reflection of light into many directions by rough objects.
2. The turning back of light at the shining surface of substance.
5. _______ of reflection: angle of incidence (i) = angle of reflection (r).
7. Centre of curvature is on the side opposite to the reflecting surface of mirror.
8. Image of an object in a plane mirror.
10. _______ of reflection angle between the reflected ray and the normal at thepoint of contact.
12. Nature of image formed by convex mirror.

3.7 Speed of light

In early seventeenth century, the Italian scientist Galileo Galilee (1564-1642) tried to measure the speed of light as it travelled from a lantern on a hill top about a mile (1.6 km) away from where he stood. His attempt was bound to fail, because he had no accurate clocks or timing instruments.

In 1665 the Danish astronomer Ole Roemer first estimated the speed of light by observing one of the twelve moons of the planet Jupiter. As these moons travel around the planet, at a set speed, it would take 42 hours to revolve around Jupiter. Roemer made a time schedule of the eclipses for the whole year. He made first observation in June and second observation in December. Roemer estimated the speed of light to be about 220,000 km per second.

In 1849 the first land based estimate was made by Armand Fizeau. Today the speed of light in vacuum is known to be almost exactly 300,000 km per second.

IX_Science Unit-3.indd 53 27-03-2018 12:28:02

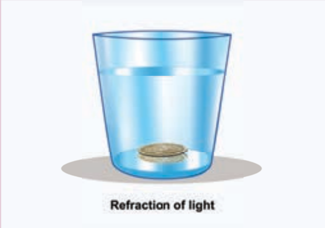
3.7.1 Refraction of light

Activity 6

Refraction of light at air – water interface

a) Coin in a cup

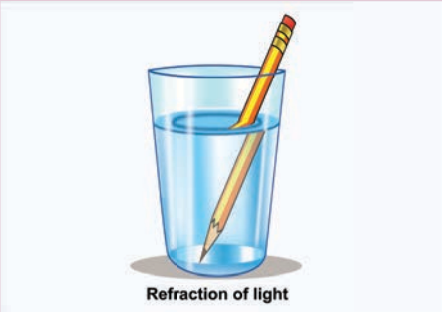
Put a small coin, for example a five-rupee coin at the nearside of the cup and keep it at a distance so you/or your friend cannot see the coin; now gently pour water in the cup (without disturbing the coin). At some point, the coin comes in sight.



Refraction of light

b) The bent pencil

Put a straight pencil into a tank of water or beaker of water at an angle of 45° and look at it from one side and above. How does the pencil look now? The pencil appears to be bent at the surface of water.



Refraction of light

Both the above activities are the result of refraction of light. The bending of light rays when they pass obliquely from one medium to another medium is called refraction of light.

3.7.2 Cause of refraction

Light rays get deviated from their original path while entering from one transparent medium to another medium of different optical density. This deviation (change in direction) in the path of light is due to the change in velocity of light in the different medium. The velocity of light depends on the nature of the medium in which it travels. Velocity of light in a rarer medium (low optical density) is more than in a denser medium (high optical density).

3.7.3 Refraction of light from a plane transparent surface

When a ray of light travels from optically rarer medium to optically denser medium, it bends towards the normal. (Figure 22)

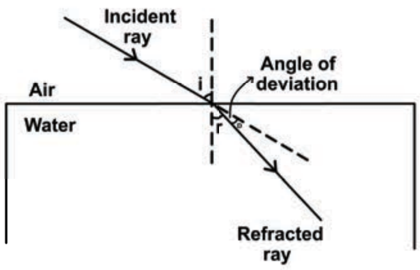


Figure 22 Light ray travelling from rarer to denser medium

When a ray of light travels from an optically denser medium to an optically rarer medium it bends away from the normal. (Figure 23)

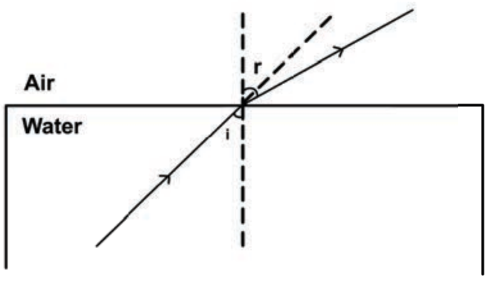


Figure 23 Light ray travelling from denser to rarer medium

A ray of light incident normally on a denser medium, goes without any deviation. (Figure 24).

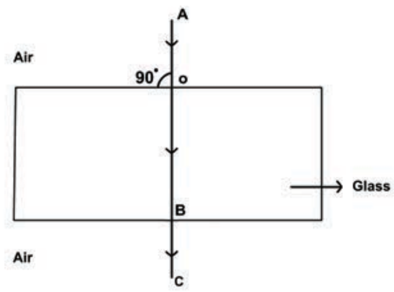


Figure 24 Incident of light ray in denser medium

3.7.4 The laws of refraction of light

The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.

The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant for a light of a given colour and for the given pair of media. This law is also known as Snell's law of refraction.

If i is the angle of incidence and r is the angle of refraction, then

$$\frac{\sin i}{\sin r} = \text{constant}$$

This constant is called the refractive index of the second medium with respect to the first medium. It is generally represented by the Greek letter, ${}_1\mu_2$ (mew)

Note: The refractive index has no unit as it is the ratio of two similar quantities

3.7.5 Verification of laws of refraction

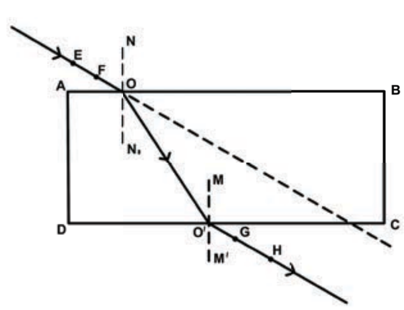


Figure 25 Verification of laws of refraction

Activity 7

Fix a sheet of white paper on a drawing board using drawing pins.

Place a rectangular glass slab over the sheet in the middle

Draw the outline of the slab with a pencil. Let us name the outline as ABCD

Take four identical pins.

Fix two pins. Say E and F, vertically such that the line joining the pins is inclined to the edge AB.

Look for the images of the pins E and F through the opposite edge. Fix two other pins, say G and H, such that these pins and the images of E and F lie on a straight line.

Remove the pins and the slab.

Join the prints of the pins E and F and let it meet AB at O. Let EF meet AB at O. Similarly, join the prints of the pins G and H and Let it meet HG at O′. Join O and O′. Also produce EF as shown by a dotted line in Figure 25.

Draw a perpendicular NN′ to AB at O and another perpendicular MM′ to CD at O′. In this activity, you will note that, the light ray has changed its direction at points O and O′. Note that both the points O and O′ lie on surfaces separating two transparent media. The light ray has entered from air to glass and has bent towards the normal that is from a rarer to denser medium.

The light ray has emerged from glass to air that is from a denser medium to a rarer medium. The light here has bent away from the normal. Compare the angle of incidence with the angle of refraction at both refracting surfaces AB and CD.

In Figure 25 EO is the incident ray OO′ the refracted ray and O′H the

IX_Science Unit-3.indd 55 27-03-2018 12:28:04

emergent ray. You may observe that the emergent ray is parallel to the direction of the incident ray. Why does it happen so? The extent of bending of the ray of light at the opposite parallel faces AB (air-glass interface) and CD (glass-air-interface) of the rectangular glass slab is equal and opposite. This is why the ray emerges parallel to the incident ray. However, the light ray is shifted sideward slightly. What happens when a light ray is incident normally to the interface of two media? Try and find out.

Refraction through Rectangular glass slab:

http://www.freezeray.com/flashFiles/Refraction2.htm

3.7.6 Speed of light in different media

Light has the maximum speed in vacuum and it travels with different speeds in different media. The speed of light in some media is given below.

Substance	Speed of light(ms^{-1})	Refractive index(μ)
Water	2.25×10^8	1.33
glass	2×10^8	1.5
diamond	1.25×10^8	2.41
Air	3×10^8	1.00

Note: The refractive index of a medium is also defined in terms of speed of light in different media

$$\mu = \frac{\text{speed of light in vacuum or air } (c)}{\text{speed of light in the medium } (v)}$$

In general $_1\mu_2 = \dfrac{\text{Speed of light in medium 1}}{\text{Speed of light in medium 2}}$

Sample problem 4

The speed of light in air is $3 \times 10^8 ms^{-1}$ and in glass it is $2 \times 10^8 ms^{-1}$ what is the refractive index of glass.

$$_a\mu_g = \frac{3 \times 10^8}{2 \times 10^8} = \frac{3}{2} = 1.5$$

Sample problem 5

Light travels from a rarer medium to a denser medium. The angles of incidence and refraction are respectively 45° and 30°. Calculate the refractive index of the second medium with respect to the first medium.

Angle of incidence i = 45°

Angle of refraction r = 30°

$$_1\mu_2 = \frac{\sin i}{\sin r}$$

$$_1\mu_2 = \frac{\sin 45^\circ}{\sin 30^\circ}$$

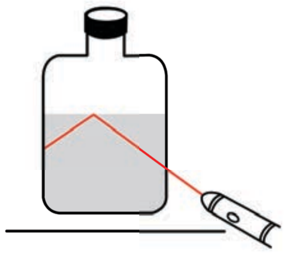
$$= \frac{1/\sqrt{2}}{1/2} = \sqrt{2}$$

$$_1\mu_2 = 1.414$$

3.8 Total Internal Reflection

A demonstration for total internal reflection

Apparatus: Small transparent bottle, Few drops of Dettol (or some salt); Pointer laser



- Take some water in a bottle; add a few drops of Dettol or some salt.

IX_Science Unit-3.indd 56 27-03-2018 12:28:04

- Point the laser pointer at different angles and note its path
- At some angle, you will see that the light gets reflected within the water itself. This is called total internal reflection.

Total internal reflection: https://www.youtube.com/watch?v=axwDkA9PrgI

3.8.1 When does total internal reflection takes place?

When light travels from denser medium into a rarer medium, it gets refracted away from the normal. We know this. While the angle of incidence in the denser medium increases the angle of refraction also increases and it reaches a maximum value of r = 90° for a particular angle of incidence value. This angle of incidence is called critical angle (Figure 26). Now the refracted ray grazes the surface of separation between the two media.

The angle of incidence at which the angle of refraction is 90° is called the critical angle.

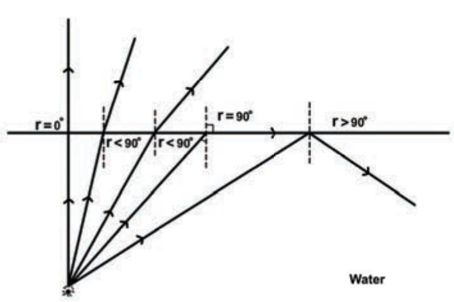


Figure 26 Critical angle

When the angle of incidence exceeds the value of critical angle, the refracted ray is not possible, since r > 90° the ray is totally reflected back to the same medium. This is called as total internal reflection.

3.8.2 Conditions to achieve total internal reflection

- Light must travel from denser medium to rarer medium. Example from water to air.
- The angle of incidence inside the denser medium must be greater than that of the critical angle.

Recall

1. Write the relation between the angle of incidence and the angle of refraction.
2. What is the unit of refractive index?
3. Which has higher refractive index: water or glass?
4. When does refraction take place?
5. When does total internal reflection take place?

3.8.3 Total internal reflection in nature

Mirage: On hot summer days, when you are travelling on a straight road have you seen the patch of water on the road which keeps moving ahead as you approach it? This is an illusion sometimes in the desert or over hot roads. Especially in summer, the air near the ground becomes hotter than the air at higher levels. The refractive index of air increases with its density. Hotter air is less dense, and has smaller refractive index than the cooler air. If the air currents are small, that is, the air is still, the optical density of different layers of air increases with height. As a result, light from an object such as a car (See Photo), passes through a medium whose refractive index decreases towards the ground. Thus, a ray of light from such an object successively bends away from the normal and undergoes total internal reflection, if the angle of incidence for the air near the ground exceeds the critical angle.

IX_Science Unit-3.indd 57 27-03-2018 12:28:05

Diamond: Diamonds are known for their spectacular brilliance. Do you know the reason for their brilliance? It is mainly due to the total internal reflection of light inside them. The critical angle for diamond – air interface (θ_C =24.4°) is very small; therefore once light enters a diamond, it is very likely to undergo total internal reflection inside it. Diamonds faces in nature rarely exhibit the brilliance for which they are known. It is the technical skill of a diamond cutter which makes diamonds to sparkle so brilliantly. By cutting the diamond suitably, multiple total internal reflections can be made to occur.

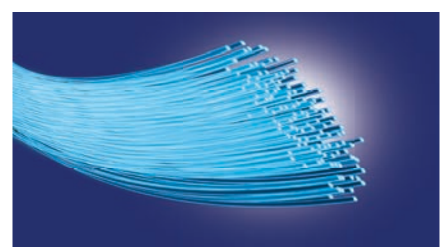
Why do stars twinkle?

Stars are very far away from us (so appear as point-like objects); light from the star passes through our atmosphere before it reaches our eyes. This light bends (refracts) due to the varying densities and temperature of atmosphere. Moreover, the atmosphere is not stable; it is very turbulent. Therefore, the light which reaches us appears to come from different points. This gives the impression that stars are twinkling. If you go above the atmosphere and see(!), stars do not twinkle. Can you find why do planets not twinkle?

Optical fibres

Optical fibres are bundles of high-quality composite glass/quartz fibres. Each fibre consists of a core and cladding. The refractive index of the material of the core is higher than that of the cladding. Optical fibres work on the phenomenon of total internal reflection. When a signal in the form of light is directed at one end of the fibre at a suitable angle, it undergoes repeated total internal reflection along the length of the fibre and finally comes out at the other end.

Optical fibres are extensively used for transmitting audio and video signals through long distances. Moreover, due to their flexible nature, optical fibers enable physicians to look and work inside the body through tiny incisions without having to perform surgery.



DO YOU KNOW?

We must be proud that an Indian-born physicist **Narinder Kapany** is regarded as the *Father of Fibre Optics*. Kapany used optical fibres to transmit and get back good images. In addition, Kapany's work is now used in lasers, biomedical instrumentation, solar energy and pollution monitoring. He is the one to have coined the name Fibre Optics.

Optical Fiber You tube Video: https://www.youtube.com/watch?v=llI8Mf_faVo

Recall

1. What are the examples of total internal reflection in nature?
2. What are the uses of total internal reflection?

IX_Science Unit-3.indd 58 27-03-2018 12:28:06

Key words

Spherical mirror
Concave mirror
Convex mirror
Centre of curvature
Radius of curvature
Pole
Principal axis
Principal focus
Focal length
Magnification
Refraction of light
Laws of refraction
Total internal reflection

A-Z GLOSSARY

1. **Light** Light is a form of energy which produces the sensation of sight
2. **Ray of Light** Line drawn in the direction of propagation of light
3. **Laws of reflection**
   i) Angle of incidence is equal to the angle of reflection
   ii) The incident ray, the normal to the point of incidence and the reflected ray, all lie in the same plane
4. **Plane Mirror** Mirror with a flat (planar) reflective surface
5. **Spherical Mirror** A reflecting surface which is a part of a sphere whose inner or outer surface is reflecting
6. **Concave Mirror** Part of a hollow sphere whose outer part is silvered and/or inner part is the reflecting surface
7. **Convex Mirror** Part of the hollow sphere whose inner part is silvered and/or outer part is the reflecting surface
8. **Centre of curvature** The centre of the hollow sphere of which the spherical mirror forms a part is called centre of curvature
9. **Radius of curvature** The radius of the hollow sphere of which the spherical mirror forms a part is called radius of curvature
10. **Pole** The midpoint of the spherical mirror is called the pole
11. **Aperture** The diameter of the circular rim of the mirror is called the aperture of the mirror
12. **Principal axis** The normal to the centre of the mirror is called the principal axis
13. **Principal focus** The point on the principal axis of the spherical mirror where the rays of light parallel to the principal axis meet or appear to meet after reflection from the spherical mirror
14. **Focal length** The distance between the pole and the principal focus of the spherical mirror is called focal length. $f = \frac{R}{2}$; Where R is the radius of curvature of the mirror

IX_Science Unit-3.indd 59 27-03-2018 12:28:06

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15. **Mirror equation** The relation between u, v and f of a spherical mirror is known as mirror formula $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$

16. **Magnification** $m = \frac{\text{height of the image } h_2}{\text{height of the object } h_1}$

$$= \frac{-\text{image distance } v}{\text{object distance } u}$$

$$\text{so } m = \frac{h_2}{h_1} = \frac{-v}{u}$$

17. **Refraction of light** the bending of light when it passes obliquely from transparent medium to another is called refraction

18. **Laws of refraction**

The incident ray, the refracted ray and the normal to the surface separating two medium lie in the same plane

The ratio of the sine of the incident angle ($\angle$i) to the sine of the refracted angle ($\angle$r) is constant

i.e. $\mu = \frac{\sin i}{\sin r}$ = constant

19. **Total internal reflection** When the angle of incidence exceeds the value of critical angle the refracted ray is impossible, since r > 90° refraction is impossible the ray is totally reflected back to the same medium (denser medium). This is called as total internal reflection

ICT CORNER

LIGHT - REFRACTION

Refraction is bending of light when travel from one medium to another

This activity enable the students to learn about the different mediums and its role in refraction of light

B121_9_SCI_EM

Step 1. Type the following URL in the browser or scan the QR code from your mobile. Youcan see"**Bending light**" on the screen. Click intro

Step 2. Now you can see light beam from the torch. Options are there in the four corners. Select options of your choice and then press the button in the torch. You can see the phenomeno of refraction. The angles of refraction differ for different medium. You can check it with the protractor

Step 3. Next select prism. Now explore with given tools and different mediums and come out with different results

https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html

IX_Science Unit-3.indd 60 27-03-2018 12:28:06

EXERCISE

I. Multiple Choice Questions

1. The field of view * is maximum for _______________
   a) plane mirror
   b) concave mirror
   c) convex mirror
   (*FOV is the extent of the observable area that is seen at any given instant)
2. When a ray of light passes from one medium to another medium, refraction takes place when angle of incidence is
   a) 0° b) 45° c) 90°
3. ___________ is used as reflectors in torchlight
   a) concave mirror
   b) convex mirror
   c) plane mirror
4. We can create enlarged, virtual images with
   a) concave mirror
   b) convex mirror
   c) plane mirror
5. When the reflecting surface is curved outwards the mirror formed will be
   a) concave mirror
   b) convex mirror
   c) plane mirror
6. The focal length of a concave mirror is 5cm. Its radius of curvature is
   a) 5 cm b) 10 cm c) 2.5 cm
7. When a beam of white light passes through a prism it gets
   a) Reflected
   b) deviated and dispersed
   c) only deviated
8. The speed of light is maximum in
   a) vacuum
   b) glass
   c) diamond
9. A real and enlarged image can be obtained by using a
   a) convex mirror
   b) plane mirror
   c) concave mirror
10. Which of the following statements about total internal reflection is true?
    a) angle of incidence should be greater than critical angle
    b) light must travel from a medium of higher refractive index to a medium of lower refractive index
    c) both (a) and (b)

II. True or False – If false give the correct answer

1. The angle of deviation depends on the refractive index of the glass.
2. If a ray of light passes obliquely from one medium to another, it does not suffer any deviation.
3. If the object is at infinity in front of a convex mirror the image is formed at infinity.
4. An object is placed at distance of 3 cm from a plane mirror. The distance of the object and image is 3 cm.

IX_Science Unit-3.indd 61 27-03-2018 12:28:06

5. The convex mirror always produces a virtual, diminished and erect image of the object.
6. The distance from centre of curvature of the mirror to the pole is called the focal length of the mirror.
7. When an object is at the centre of curvature of concave mirror the image formed will be virtual and erect.
8. Light is one of the slowest travelling energy with a speed of 3×10^{-8} ms^{-1}
9. The angle of incidence at which the angle of refraction is 0^o is called the critical angle.
10. The reason for brilliance of diamonds is mainly due to total internal reflection of light.

III. Fill in the blanks / complete the Sentence

1. In going from a rarer to denser medium, the ray of light bends ______________.
2. The ratio of sine of the angle of incidence to the sine of ____________ is a constant.
3. The mirror used in search light is ____________.
4. The angle of deviation of light ray in a prism depends on the angle of ____________.
5. The radius of curvature of a concave mirror whose focal length is 5cm is ________________.
6. A spherical mirror whose reflecting surface is curved outwards is called ____________ mirror
7. Large __________ mirrors are used to concentrate sunlight to produce heat in solar furnaces
8. All distances parallel to the principal axis are measured from the ____________ of the mirror
9. A negative sign in the value of magnification indicates that the image is _____________
10. Light is refracted or bent while going from one medium to another because its ___________ changes.

IV. Match the following

i) List I	List II
1. Ratio of height of image to height of object.	1. concave mirror
2. Used in hairpin bends in mountains	2. total internal reflection
3. Coin inside water appearing slightly raised	3. magnification
4. Mirage	4. convex mirror
5. Used as Dentist's mirror	5. refraction

ii) Position of object	Position of image	Size and nature of image
1. Within focus	a) Between F and C	A) Magnified , Real, inverted
2. At focus F	b) At C	B) Magnified, virtual, erect
3. Between F and C	c) Behind the mirror	C) Diminished, Real, inverted
4. At C	d) Infinity	D) Highly Diminished, Real, inverted
5. Beyond C	e) At F	E) Highly Magnified , Real, inverted
6. At infinity	f) Beyond C	F) Same size, Real, inverted

V. Assertion & Reason

In the following questions, the statement of assertion is followed by a reason. Mark the correct choice as:

a) If both assertion and reason are true and reason is the correct explanation

b) If assertion is true but reason is false.

c) If assertion is false but reason is true.

1. Assertion: For observing the traffic at a hairpin bend in mountain paths a plane mirror is preferred over convex mirror and concave mirror.

   Reason: A convex mirror has a much larger field of view than a plane mirror or a concave mirror.

2. Assertion: Incident ray is directed towards the centre of curvature of spherical mirror. After reflection it retraces its path.

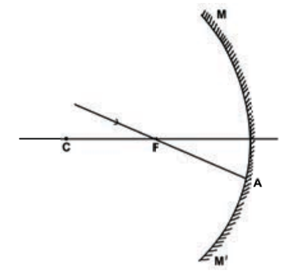
   Reason: Angle of incidence i = Angle of reflection $r = 0^o$.

VI. Very short answer type

1. Give two examples of transparent medium that are denser than air.
2. According to cartesion sign convention, which mirror and which lens has negative focal length?
3. A coin in a glass beaker appears to rise as the beaker is slowly filled with water, why?
4. Name the mirror(s) that can give (i) an erect and enlarged image, (ii) same sized, inverted image
5. Name the spherical mirror(s) that has/have

   i) Virtual principal focus

   ii) Real principal focus
6. If an object is placed at the focus of a concave mirror, where is the image formed?
7. Copy this figure in your answer book and show the direction of the light ray after reflection

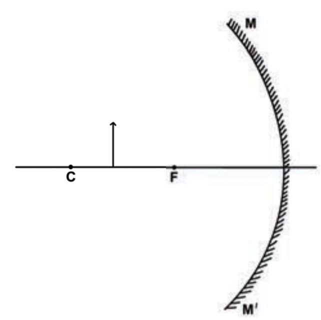


8. Why does a ray of light bend when it travels from one medium to another?
9. What is speed of light in vacuum? Who first measured the speed of light?
10. Concave mirrors are used by dentists to examine teeth. Why?

VII. Short answer type

1. a) Complete the diagram to show how a concave mirror forms the image of the object.

   b) What is the nature of the image?



2. Pick out the concave and convex mirrors from the following and tabulate them

   Rear-view mirror, Dentist's mirror, Torch-light mirror, Mirrors in shopping malls, Make-up mirror.
3. State the direction of incident ray which after reflection from a spherical mirror retraces its path. Give reason for your answer.

IX_Science Unit-3.indd 63 27-03-2018 12:28:07

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4. What is meant by magnification? Write its expression. What is its sign for the

   a) real image b) virtual image

5. Write the spherical mirror formula and explain the meaning of each symbol used in it.

VIII. Long answer type

1. a) Draw ray diagrams to show how the image is formed, using a concave mirror when the position of object is i) at C ii) between C and F iii) between F and P of the mirror.

   b) Mention in the diagram the position and nature of image in each case.

2. Explain with diagrams how refraction of incident light takes place from

   a) rarer to denser medium b) denser to rarer medium c) normal to the surface separating the two media.

3. State and verify laws of refraction using a glass slab.

4. Draw a ray diagram to show the formation of image by a concave mirror for an object placed between its pole and Principal focus and state three characteristics of the image.

IX. Numerical problems

1. The radius of curvature of a convex mirror is 40 cm. Find its focal length (Ans: 20 cm)

2. An object of height 2 cm is placed at a distance 20 cm in front of a concave mirror of focal length 12 cm. Find the position, size and nature of the image.

   (Ans: 30 cm in front of the mirror 3 cm high, real, inverted and magnified)

3. A concave mirror produces three times magnified real image of an object placed at 7 cm in front of it. Where is the image located?

   (Ans: 21 cm in front of the mirror)

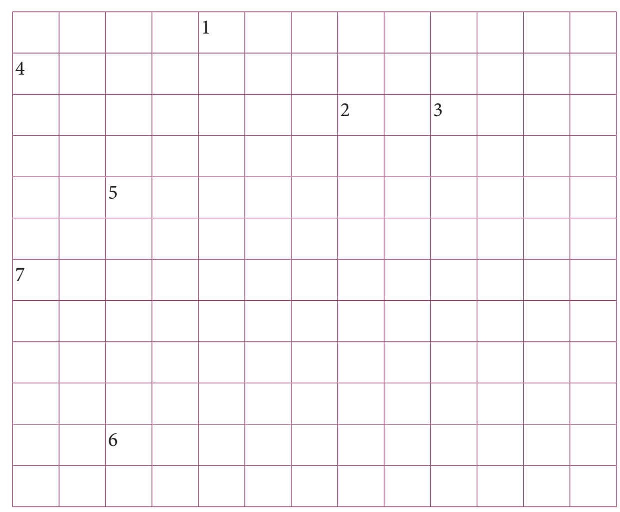
4. Light enters from air into a glass plate having refractive index 1.5. What is the speed of light in glass?(Speed of light in vacuum is 3×10^8 ms^{-1})

   (Ans: 2×10^8 ms^{-1})

5. The speed of light in water is 2.25×10^8 ms^{-1}. If the speed of light in vacuum is 3×10^8 ms^{-1}, calculate the refractive index of water.

   (Ans:1.33)

X. Cross word puzzle



Across

2. Optical illusion due to refraction
4. A type of mirror that diverge the light rays
6. The nature of image formed when object is near the pole of concave mirror
7. Electromagnetic radiation visible to us

Down

1. The light ray sent back from a surface into the same medium
3. When magnification is negative, the nature of the image is ________
5. For concave mirror u and f are always __________

IX_Science Unit-3.indd 64 27-03-2018 12:28:07

HOTS

1. Light ray emerges from water into air. Draw a ray diagram indicating the change in its path in water.
2. When a ray of light passes from air into glass, is the angle of refraction greater than or less than the angle of incidence?
3. What do you conclude about the speed of light in diamond if you are told that the refractive index of diamond is 2.41?

Amazing fact

Did you know that some organisms can make their own light too? This ability is called bioluminescence. Worms, fish, squid, starfish and some other organisms that live in the dark sea habitat glow or flash light to scare off predators.

REFERENCE

1. Optics – Brijlal and Subramaniam (1999) Sultan chand Publishers
2. Optics – Ajay GhotakDharyaganj Publishing circle, New Delhi
3. Physics for entertainment – book 2 Yakov Perelman, Mir Publishers

INTERNET RESOURCES

I. www.Physics.org
II. https://elearning.cpp.edu/learning-objects/optics/spherical-mirrors/
III. https://www.geogebra.org/m/aJuUDA9Z
IV. https://www.edumedia-sciences.com/en/media/362-concave-mirror
V. http://www.animations.physics.unsw.edu.au/light/geometrical-optics/
VI. https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html
VII. http://www.splung.com/content/sid/4/page/snellslaw
VIII. http://interactagram.com/physics/optics/refraction/
IX. https://faraday.physics.utoronto.ca/PVB/Harrison/Flash/Optics/Refraction/Refraction.html

IX_Science Unit-3.indd 65 27-03-2018 12:28:07

UNIT 5

Atomic Structure

Learning Objectives

At the end of this unit you will be able to

- state and illustrate the laws of multiple proportion, reciprocal proportion and law of combining volumes
- solve simple numerical problems based on the above laws
- to understand Rutherford's gold foil experiment
- conclude the presence of nucleus in an atom.
- to identify the limitations of Rutherford's model
- compare the charge and mass of sub-atomic particles
- calculate number of protons, neutrons and electrons in a given atomic number and mass number of an element
- differentiate isotopes, isobars and isotones
- explain the main postulates of Bohr's atomic model
- draw the atomic structure of first 20 elements
- recognize the significance of quantum numbers.
- assign valency of various elements based on the number of valence electrons

EVZ9I1

Introduction

We already know that anything that has definite mass and occupies space is known as matter.

Let us quickly recall
What is matter?
What are the different states of matter?
Is matter continuous or particulate in nature?

If somehow we could go on dividing any piece of matter we will get smaller and smaller particles until we reach the smallest particle of it which cannot be divided further. These smallest particles can be atoms, molecules or ions.

Atoms are the building blocks of matter. Every substance is made up of atoms in one form or other. Different kinds of atoms have different properties (both physical and chemical).

You already know that atoms combine together to form molecules. This combination is called a chemical reaction which can be represented symbolically by balanced chemical equations.

Now look at the following equation. What do you understand?

We can say that Sodium and Chlorine combine to form Sodium Chloride.

IX_Science Unit-5.indd 104 27-03-2018 12:30:55

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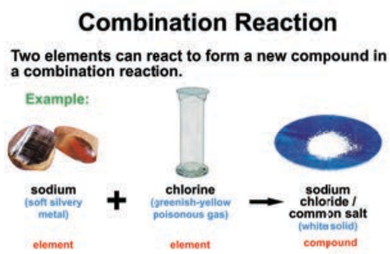
$$2Na + Cl_2 \longrightarrow 2NaCl$$



What is a combination reaction?

Combination reaction is a reaction where two or more substances combine to form a single substance. The combination of different elements to form a compound is governed by certain basic rules. These rules are known as Laws of chemical combination.

5.1 Laws of Chemical combination

Out of these five laws you already know the first two laws. Let us see the next three laws in detail in this chapter.

More to Know

- Kanada, the Indian philosopher of 6th century put forward the theory that everything in the universe was made of minute particles called "Paramanu"
- In fourth century BC, the Greek philosophers Leucippus and Democritus suggested that the universe was formed by very tiny particles named atoms.
- Ancient Indian philosophers said that Universe is formed from five basic elements, air, water, fire, soil, and space. Greek philosopher Plato argued that the Universe is formed of four elements soil, air, water & fire.

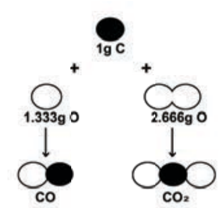
5.1.1 Law of multiple proportions

This law was proposed by **John Dalton in 1804**.

When two elements A and B combine together to form more than one compound, then masses of A which separately combines with a fixed mass of B are in simple ratio.

To illustrate the law let us consider the following example.

Carbon combines with oxygen to form two different oxides, carbon monoxide(CO) and carbon dioxide (CO_2).



The ratio of masses of oxygen in CO and CO_2 for fixed mass of carbon is 1: 2. Isn't this a simple ratio? Let us take one more example. Sulphur combines with oxygen to form sulphur dioxide and sulphur trioxide. The ratio of masses of oxygen in SO_2 and SO_3 for fixed mass of Sulphur is 2:3.

Test Yourself

Tabulate the composition by mass of oxides of nitrogen with the fixed weight of nitrogen in the following table

What do you conclude?

Compound	N_2O	NO_2	N_2O_4	N_2O_5
Ratio of the molar masses N : O				

IX_Science Unit-5.indd 105 27-03-2018 12:30:56

Law of Chemical Combination

- Law of Conservation of Mass
- Law of constant Proportions
- Law of Multiple Proportions
- Law of Reciprocal Proportions
- Gay Lussac's Law of Gaseous volumes

S. No	Compound	No. of atoms/g of carbon	No atoms/g of Oxygen	Ratio of masses C : O
1.	CO	One -12g	One-16g	12:16 or 1: 1.333g
2.	CO_2	One-12g	Two- 32g	12:32 or 1: 2.666g

Compound	N_2O	NO_2	N_2O_4	N_2O_5
Grams of oxygen combining with 1 gm of Nitrogen				
Simple O : N ratio				

Sample Problem (Solved)

Iron forms two different chlorides, namely ferrous and ferric chlorides. Each of these chlorides was prepared from 2 gram of iron. It was found that 4.538 gram ferrous chloride and 5.804 gram ferric chloride were produced. Show that these observations are according to the law of multiple proportions.

Solution:

Here iron is forms different chlorides. The weight of iron taken in both cases is the same. i.e. 2.0 g. Therefore, we have

	Ferrous chloride (A)	Ferric chloride (B)
Weight of chloride	4.538 g	5.804 g

	Ferrous chloride (A)	Ferric chloride (B)
Weight of iron	2.000 g	2.000 g
Weight of chlorine	2.538 g	3.804 g

The proportion of chlorine in this compound is

Ferrous chloride	:	Ferric chloride
2.538	:	3.804
1	:	1.5 or 2: 3

The proportion by weight of chlorine is indicated by a simple ratio. Thus Law of multiple proportions is verified

Activity 1

Lead forms three oxides A, B and C. The quantity of oxygen in each of the oxides A, B and C is 7.143%, 10.345% and 13.133% respectively. Show that the law of multiple proportions is obeyed.

5.2 Law of Reciprocal Proportions

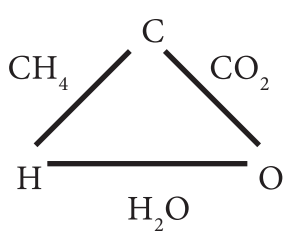
The **law of reciprocal proportions** was proposed by Jeremias Ritcher in 1792.

IX_Science Unit-5.indd 106 27-03-2018 12:30:56

Jeremias Ritcher

It states that, "If two different elements combine separately with the same weight of a third element, the ratios of the masses in which they do so are either the same or a simple multiple of the mass ratio in which they combine."

Let us study the following example Here carbon combines with hydrogen and oxygen to form Methane (CH_4) and CO_2 (carbon dioxide) respectively. Hydrogen and oxygen combine to form water.



Sr. No	Compounds	Combining elements		Combining weights	
1	CH_4	C	H	12	4
2	CO_2	C	O	12	32

It is seen that in CH_4 the ratio of masses C : H = 3:1

In CO_2 the ratio of masses of C : O = 3:8

Here hydrogen and oxygen combine with the same mass of carbon. They also combine with each other to form water (H_2O)

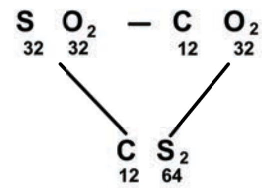
What is the ratio of masses of H and O in H_2O?

It is 2: 16 or 1:8 which is same as 4:32, which is the ratio of the different masses of hydrogen and oxygen combining with the same mass of carbon.

This illustrates the law of reciprocal proportions.

Let us consider one more example.

Sulphur combines with oxygen to form sulphur dioxide, carbon combines with oxygen to form carbon dioxide and carbon combines with sulphur to form carbon disulphide



The ratio of masses of carbon and sulphur which combine with fixed mass (32 parts) of oxygen is

12:32 or 3:8 ...(1)

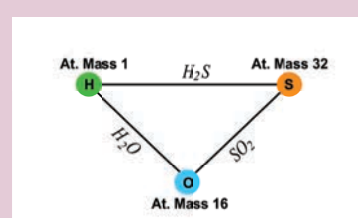
In CS_2 ratio of masses of carbon and sulphur is in the ratio

12:64 or 3:16 ...(2)

The two ratios (1) and (2) are related to each other by $\frac{3}{8}:\frac{3}{16}$ or **2:1**

Activity 2

Illustrate the given diagram of law of reciprocal proportion



Solved problem

Hydrogen sulphide (H_2S) contains 94.11% sulphur, water (H_2O) contains 11.11% hydrogen and sulphur dioxide (SO_2) contains 50% of oxygen. Show that the results are in agreement with the law of reciprocal proportions.

IX_Science Unit-5.indd 107 27-03-2018 12:30:57