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Contents

Unit 6

Electricity in Everyday Life

After studying this chapter the students will be able to:

- Describe the characteristics and effects of static charges.
- Explain static charges in terms of electron transfer.
- Explain practical applications of static and current electricity (e.g., household appliances)
- Identify problems related to electrostatic charge in everyday situations and evaluate solutions (e.g., use of an electrostatic paint sprayer for uniform paint; use of static straps to reduce charge build-up in automobiles; use of electrostatic precipitators to decrease pollution; use of lightning rods to protect buildings.
- Describe household wiring and its typical components (e.g., parallel circuits with switches, fuses, circuit breakers, outlets)
- Develop a solution to a practical problem related to the use of electricity in home, school, or community (e.g., choose an appropriate fuse or circuit breaker for a specific circuit).
- Propose a plan for a self-contained system to generate energy, using renewable energy resources, to meet the energy requirements of a dwelling, farm, or community in Pakistan.
- Identify the safety measures to avoid and handle electric hazards.
- Describe careers that involve electrical technologies, and use print and electronic media to identify the knowledge and skill requirements of such careers.

INTRODUCTION

In the previous classes you have already learnt that charge is produced when an ebonite rod is rubbed with a woolen cloth or glass rod with a silk. Similarly when a plastic comb is charged by moving it through dry hair, it remains charged until it is touched by something else. When objects are charged in such a way, we say that they have built up static charges. The buildup of static charges on objects is called static electricity. This phenomenon belongs to the branch of Physics called electrostatics. However if a conducting path is provided to the static charges they will flow and remain no more static charges. The study of flowing charges is called current electricity. In this chapter you will learn about the nature and applications of Static and Current electricity in your daily life.

6.1 Static Charges

Everything in nature is made up of atoms which in turn composed of protons, electrons and neutrons. The protons are positively charged, the electrons are negatively charged and neutrons are neutral. It means that every physical object has charges. You have learnt in previous classes that like charges repel each other and unlike charges attract each other. All the physical objects will be in a neutral state if the amount of positive charge is equal to the amount of negative charge present in them. However, if in an object there is an imbalance between negative and positive charges, there will be either net negative or net positive charge on the object. An object becomes negatively charged if it gains electrons and positively charged if it loses the electrons. The charges produced on objects by rubbing them together or by pressing and pulling them apart, are called static charges. As these charges are confined to the rubbed areas of objects and unable to move to other areas of the same objects so that is why they are called static charges.

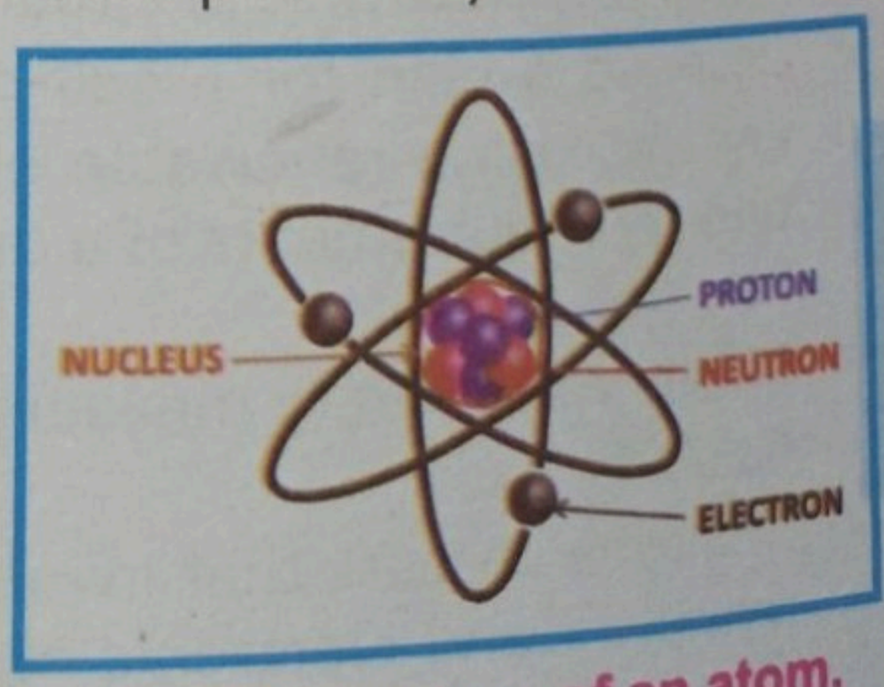

Fig:6.1 structure of an atom.

Static charges can also be produced on a conducting object by putting it in the vicinity of a charged object. The phenomenon of building up static charges on objects is called static electricity. The phenomenon of producing static charges on objects is called static electricity.

a. Building up Static Charges in Terms of Electrons Transfer

When certain materials (especially insulating) are rubbed together or when they are pressed and pulled apart, the electrons are transferred from one object to other. For example, when you rub your shoes vigorously on a wool rug, electrons are transferred from wool rug to your body, giving your body a net negative charge and the rug a net positive charge. The negative charge on your body can be sensed and removed by lightly touching a friend who can startle by feeling a light shock. Similarly, when you pull apart the cap from your hair, electrons are transferred from the cap to the hair. As all the hairs acquire the same charge so they repel each other and tend to get away from each other as much as possible. This is the reason you experience the "hair raising" phenomenon.

DO YOU KNOW?

When you rub a inflated balloon against your clothes; electrons are transferred from your clothes to the surface of the balloon. When this balloon is released it sticks to the wall or the ceiling of a room.

Charged balloon stuck with the wall.

b. Production of Static Charges in Terms of Electrostatic

Electrostatic induction is the mechanism of charging a conductor without any physical contact with a charged body. When a charged body is brought near an uncharged conducting body, the side of uncharged body close to charged body, becomes oppositely charged while its other side gains similarly charge as that of the charged body.

Let a negatively charged ebonite rod be brought near a small metallic rod mounted on an insulated stand as shown in figures 6.2. Experiences show that near the ebonite rod positive charge accumulates at the end A while negative charge accumulates at end B of the metallic rod (that is electrons in the part of the metallic rod near to the ebonite rod shift to the opposite side of the metallic rod).

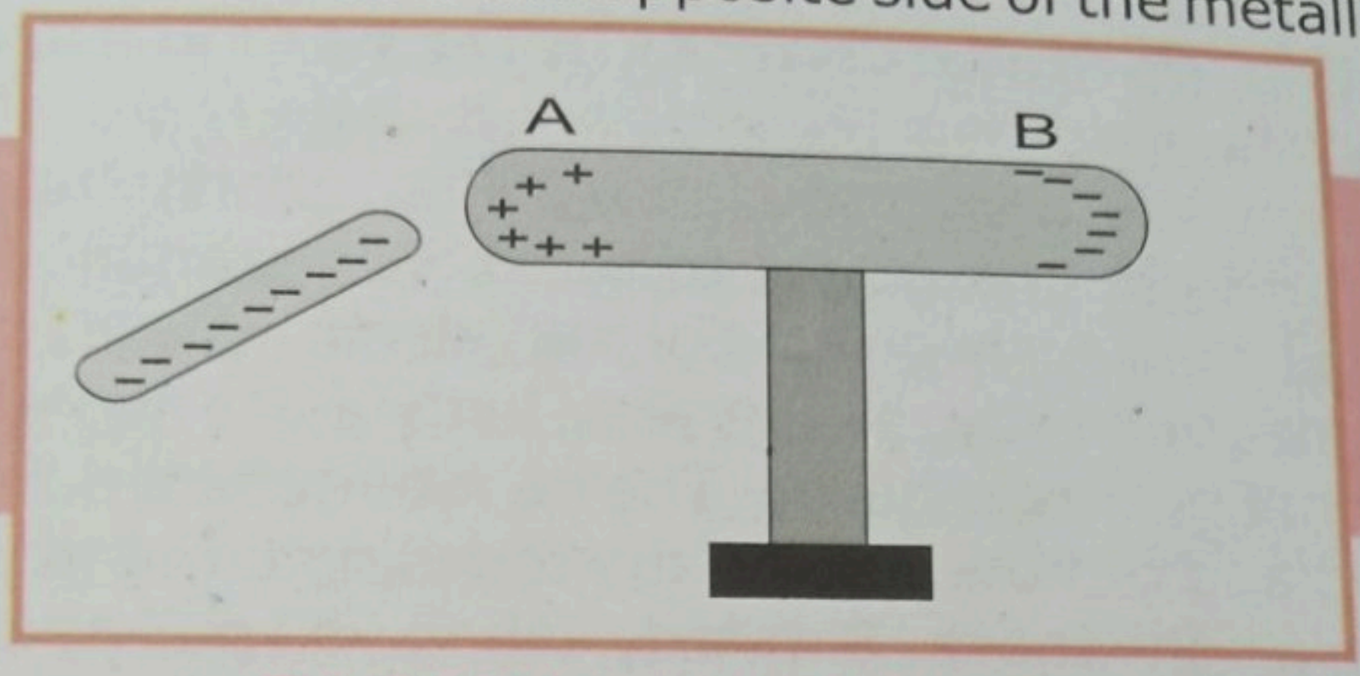

Fig. 6.2 Electrostatic induction.

This phenomenon of redistribution of charges on the surface or inside a neutral conducting body due to the presence of a charged body in its proximity is called electrostatic induction. In the neutral body the redistribution of charge persists till the charged body is kept in its proximity. When the charged body is moved away from the neutral body, it attains its original charge distribution.

TIDBIT

A spark of static electricity can measure thousands of volts, but has very little current and lasts for a short period of time. This means it has little power or energy.

6.2 CHARACTERISTICS AND EFFECTS OF STATIC CHARGES

You will learn more about static charges by studying the followin characteristics and effects of static charges.

Characteristics of Static Charges

Some of the basic characteristics of static charges are given below:

i. Conservation of charges

Ordinarily objects are electrically neutral and contain equal number of negative charge particles (electrons) and positive charge particles (protons). When one body rubbed against another, charge is not created in the process. The electrified state is due to transfer of charge (electrons) from one body to the other. Therefore, one body gains some amount of negative charge while the other gains an equal amount of positive charge. In other words electric charge is always conserved. For example, when a glass rod is rubbed with silk, the silk obtains a negative charge that is equal in magnitude to the positive charge on the glass rod.

ii. Attraction

One of the characteristics of static charges is that they make certain materials to attract each other. For example, when you rub a glass rod with silk cloth or an ebonite rod with a woolen cloth, static charge is developed and these rods are able to attract small particles. Similarly another every day example of attraction due to static charges is that of a plastic comb which when moved in dry hair, gathers static charges and starts attracting small pieces of paper.

Fig:63 Using static charge to pick up pieces of paper with a comb.

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iii. Repulsion

Static charges also produce the ability of repulsion in objects. For example, when you comb your hair on a dry day or after using hair drier, negative charges builds up on the comb while positive charge on the hair. You know that like charges repel each other. As all the hair acquire the same charge so they repel each other. As a result the phenomenon of "flyaway of hair" occurs.

iv. The force of attraction or repulsion between charged bodies is inversely proportional to the square of distance between them.

Fig. 6.4 Repulsion of charges

Effects of Static Charges

Some of the effects of static charges are given below.

i. Electrostatic Sparks

The production of electrostatic spark is a common effect of static charges. A spark is produced due to heating up of air present between two highly charged bodies. If there are more positive charges on one object and equally negative charges on the surface of another object, then the attraction between the charges may be great enough. This condition can lead the electrons to jump the gap between these highly charged objects.

Once a few electrons start to move across the gap, they heat up the air and more electrons will jump across the gap quickly.

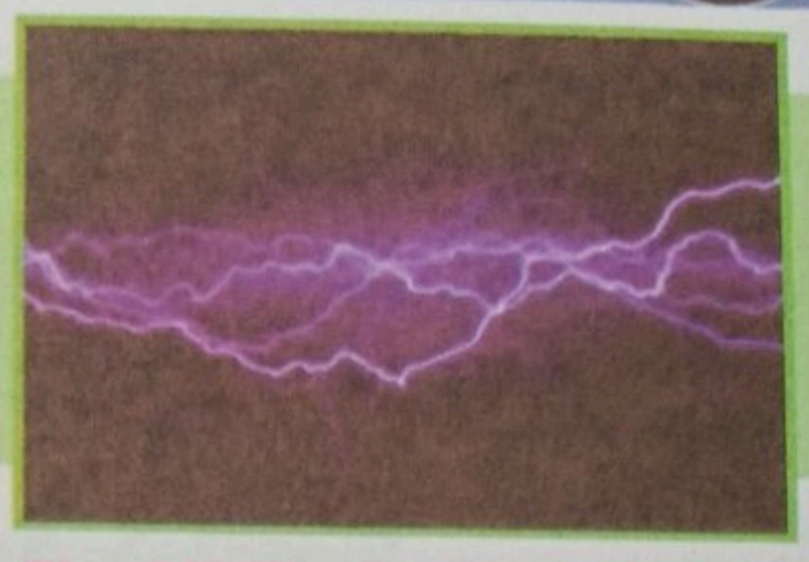

Fig. 6.5 Electrostatic Sparks

This heats up the air even more. The air gets so hot that for a very short period of time it glows and produces a spark which is known as an electrostatic spark. The same phenomenon is seen during thunderstorms when electrostatic sparks are produced on a much larger scale resulting in lightning.

ii. Polarization charges

In most neutral atoms or molecules, the center of positive charge coincides with the center of negative charge. However, in the presence of a charged object, these centers may shift slightly, resulting in positive charge on one side of the molecule and negative charge on the other side. This effect is known as polarization. Polarization of charges within individual molecules produces an induced charge on the surface of the insulator as shown in the figure 6.2. This effect explains why a comb that has been moved through hair, attracts bits of neutral paper.

6.3 Practical Applications of Static Electricity

Static electricity has many applications, e.g. photocopiers, inkjet printers, laser printers, high voltage generators, electrostatic painting, electrostatic precipitators etc. However, electrostatic painting and electrostatic precipitators are discussed here in detail.

i. Electrostatic or Electro painting

The principle of electrostatic is applied to paint uniformly the surfaces of metallic bodies such as refrigerator, metallic furniture, metallic boxes, automobiles etc.

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The surface of metallic body is earthed. The paint particles when emerge out of the nozzle of the spray machine, they acquire positive charge due to fraction. When these positively charged particles reach near the metallic body, induce negative charge on it. Thus due force of attraction between opposite charges a uniform coat of paint is formed on the surface of metallic body.

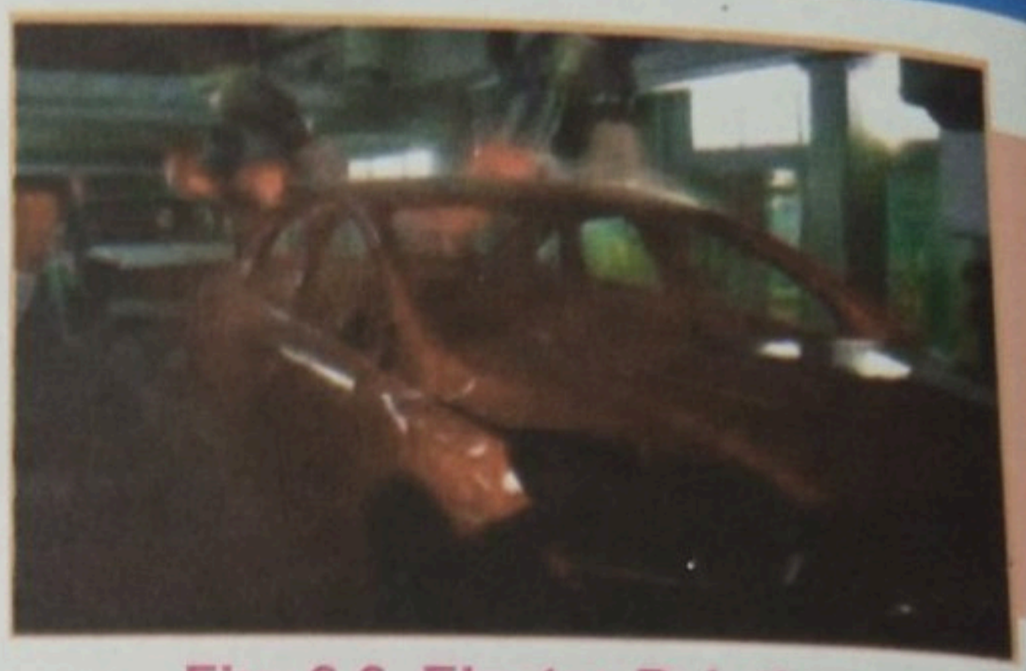


Fig: 6.6 Electro Painting.

FOR YOUR INFORMATION

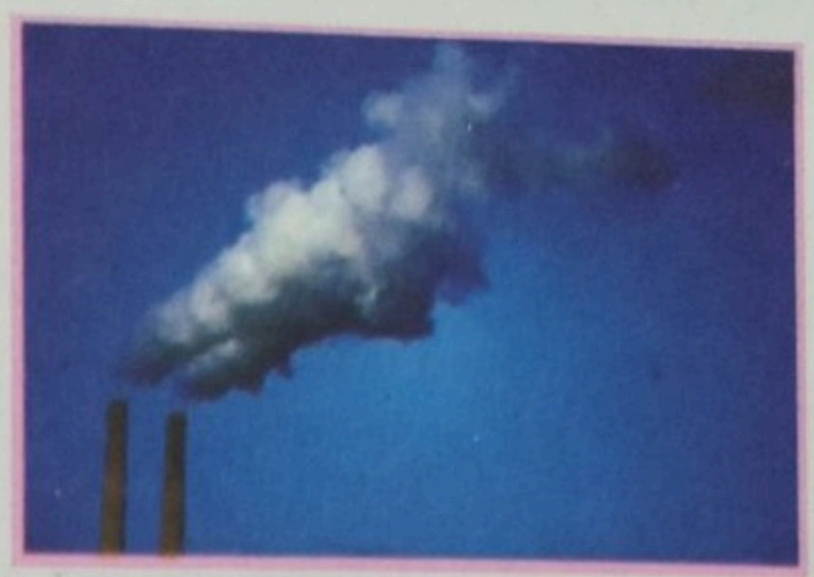
The van de Graff generator is a very useful static charge generator. It can produce a potential difference or voltage up to 14 million volts. It is used in nuclear research to accelerate sub-atomic particles.

ii. Electrostatic Precipitators for Pollution Control

A device which is used for removing unwanted solid or liquid particles from gases by the application of principle of electrostatics, is called electrostatic precipitator. Large electrostatic precipitators are used in coal-burning power plants and in industrial plants that generate large quantities of smoke. They eliminate ash and dust particles from the smoke thereby reducing air pollution. Small electrostatic precipitators are used in homes in conjunction with heating and cooling systems for elimination of unwanted particles from the atmosphere. In this process static charge (usually positive) is produced on smoke dust and other unwanted particles passing through electrostatic precipitator. These charged particles are attracted by a plate having opposite charge thereby collected and are finally removed away.

DO YOU KNOW?

a. Smokestacks



Principle of static electricity is applied in the extraction of smoke and dust particles from the gases coming out of the smoke-stacks of factories. When the smoky and dusty gases pass through smoke-stack, positive charge is induced on smoke and dust particles due to positively charged wire gauze fitted in the smoke-stack. Then negatively charged plates of the smoke-stack attract and deposit these positively charged particles, from where they are removed away. In this way, the outgoing gases from factories are cleaned from smoke and dust particles with the help of smoke-stack.

b. Air fresheners

Air freshener, also known as air ionizer, is a device, used to freshens and purify air in the homes. It works on the principle of static electricity. Usually, it strip off electrons from smoke, dust and pollen particles present in the air. Due to which these particles gain positive charge. These positively charged particles are attracted and deposited by negatively charged plate of the air freshener. In this way, air freshener freshens and purify the air.

6.4 Current Electricity

Electricity which is produced due to flow of charges (electrons or ions) through conducting material is called current electricity or electric current. Current electricity is of two types i.e. direct current and alternating current.

The electric current which flows in one direction only, is called direct current (DC). While the electric current that regularly changes its direction, is called alternating current (AC). Alternating current supplied to our homes, changes its direction 100 times in one second.

a. Application of Current Electricity in Household Appliances

Most of practical applications of electricity deal with the current electricity. A variety of home appliances operate on it. We utilize electric current for different purposes e.g., lighting, heating, cooling, washing etc. at home. In all these situations electric current is converted into other forms of energies according to the need.

When an electric current passes through the filament of a bulb, it heats up as much as that it emits light. Here electric current is converted into heat and light energies. Electric room heater, electric iron, immersion rod, electric kettle etc. are such appliances which contain a high resistance metallic heating coils. When these appliances are switched on, the electric current is converted into heat energy in these coils. Similarly in clothes drier machine, hair drier, toaster, oven etc. electric current is converted into heat and mechanical energy.

In summer season we use electric fan, air cooler and air conditioner for cooling purpose. When electric current flows, their blades start rotating hence electric current is converted into mechanical energy. Similarly, in washing machine and electric motor, electric current is converted into mechanical energy. Other household appliances like refrigerator, television, computer etc. need electric current for their operation. In other words, current electricity has become necessity of our life.

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6.5 Problems Related to Electrostatic Charge and their Solutions

There are many problems related to electrostatic charge; here we discuss only two of them and their solutions.

i. Lightning and use of Lightning Rods

Lightning is a natural phenomenon which happens when electrons travel between two objects having different and large amount of static charges. Lightning can occur between or within clouds or between clouds and the earth. Electrons heat the air present between the charges so much that causes lightning. The heat also makes the air move away from the charge very fast. The air expands. When this occurs, a very loud sound, called the thunder, is produced. Lightning can be dangerous. It can strike trees, buildings, people and animals.

Lightning rods are used to protect the buildings from the hazard of lightning. Lightning rod is a metal rod attached to the roof of a house or a building. Its lower end is connected to a copper or aluminum wire which goes down to the earth and is grounded.

As lightning always follows the shortest way to the ground. So if it strikes a lightning rod on a building, it goes down along the wire to the earth. Thus in this way lightning rod protects the building from the hazard of lightning.

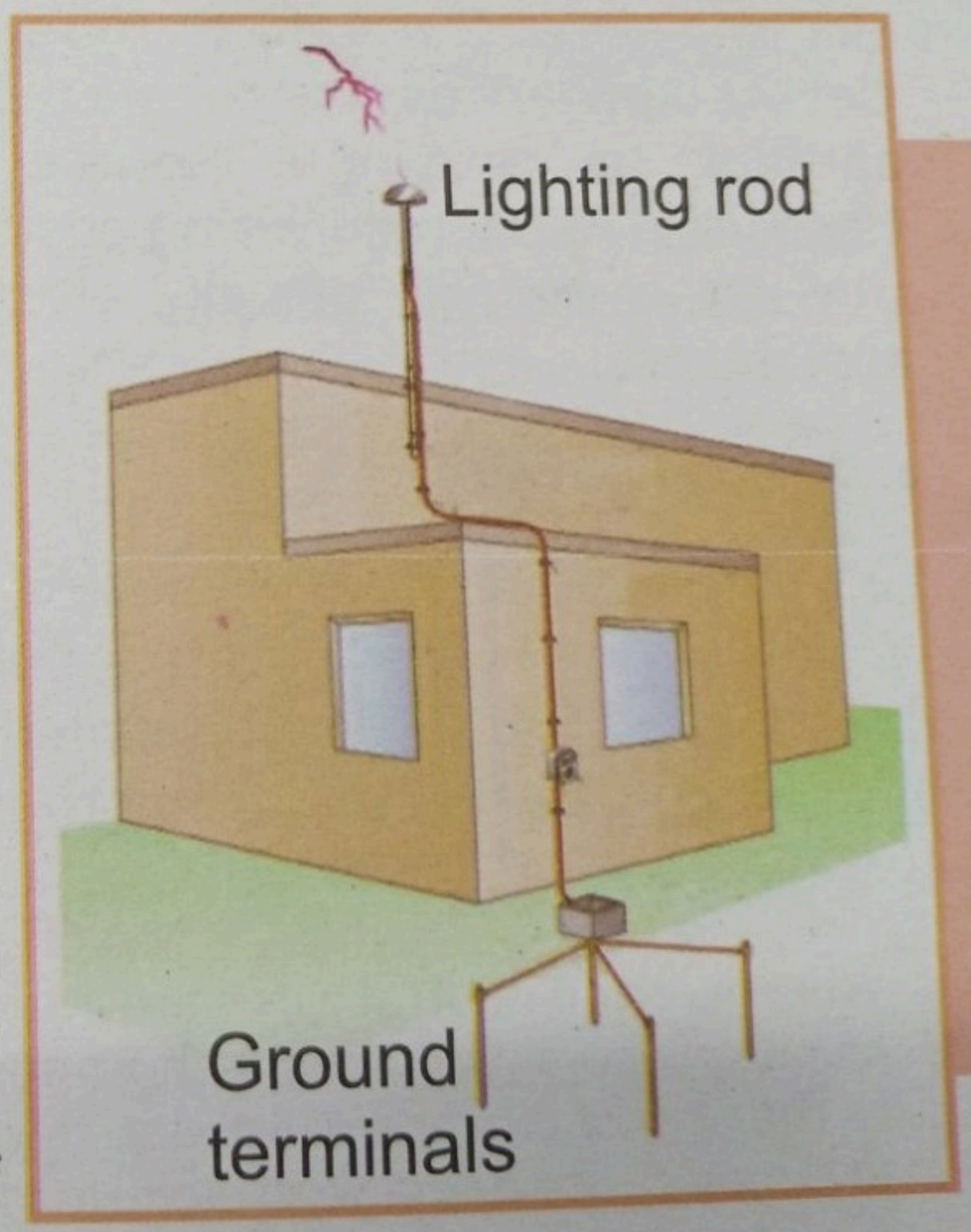

Fig: 6.7 Lightning Rod

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ii. Building up Electrostatic Charge on Vehicles & Use Static Straps

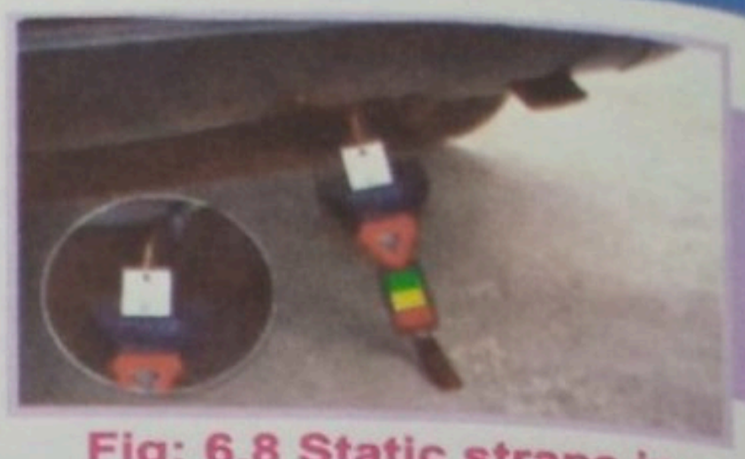


Fig: 6.8 Static straps in automobiles

In large vehicles which transport inflammable chemicals, fire and explosion may occur in them due to building up of very large static charges on their bodies. These charges are built up due to friction. To avoid these hazards, hanging metallic straps, called static straps are connected to the rear sides of vehicles. These straps touch the ground thereby providing a conducting path for the flow of static charges towards the ground. In this way Static straps prevent the accumulation of static charges on the bodies of the vehicles. These also help in reducing radio interference and electric shocks.

6.5 Household Wiring

Basically household wiring is an electric circuit in which different electric appliances are connected in parallel to a single source of electricity. Household wiring ensures smooth running of all electric appliances.

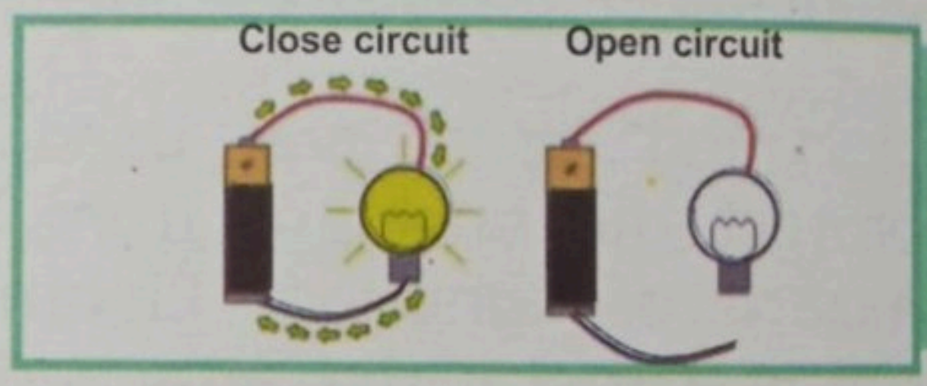


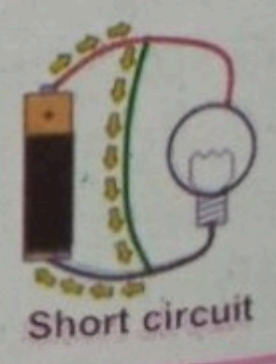
Fig: 6.9 Different types of circuits.

a. Electric Circuit

The path for the flow of electric current is called electric circuit. When switch is off or power supply is disconnected and no current flows in the circuit, then it is called open circuit. While if switch is on and current flows in the circuit then it is called closed circuit.

FOR YOUR INFORMATION

When live and neutral wires are interconnected accidently or otherwise, it provides a short and low resistance path to the flow of current. This condition is called short circuit and may cause damage to electric meter.



b. Components of Household Wiring

Following are the typical components of household wiring:

I. Resistors

The opposition offered by a conductor to the flow of electric current is called its resistance while the conductor is called a resistor. The electrical appliances which are connected in a circuit, act as resistors. The basic function of a resistor is to control the magnitude of current flowing in a circuit. Resistors in a circuit can be connected in a series or in parallel.

a. Resistors in Series

In a series circuit, there is only one path for the flow of current and same amount of current flows through all the resistors. The total voltage across the circuit is equal to the sum of voltages across all the resistors. The total resistance is equal to the sum of resistances of all the resistors. An example of series circuit is a string of decoration lights. If any one of the bulb is missing or burnt out, no current will flow and none of lights will work.

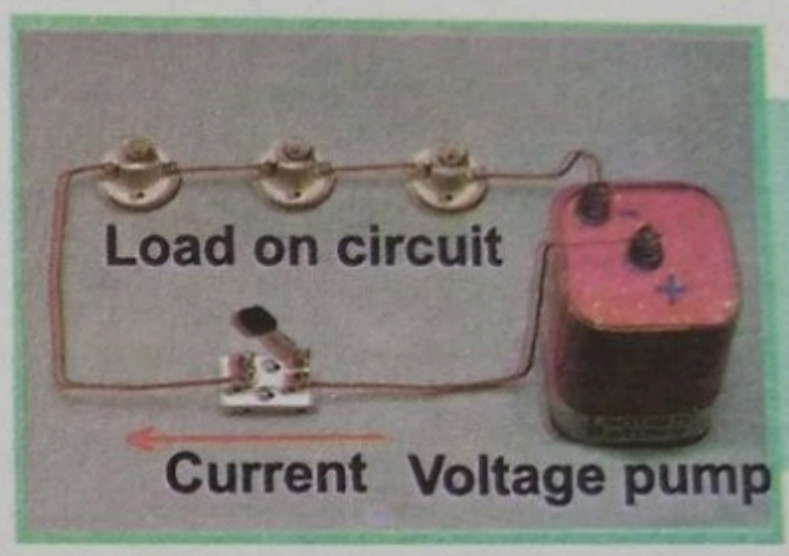


Fig: 6.10 Series circuit

b. Resistors in Parallel

In a parallel circuit, there is two or more paths for the flow of current and different amounts of current flows through each resistor. The voltage of the circuit is equal to the voltage across each resistor.

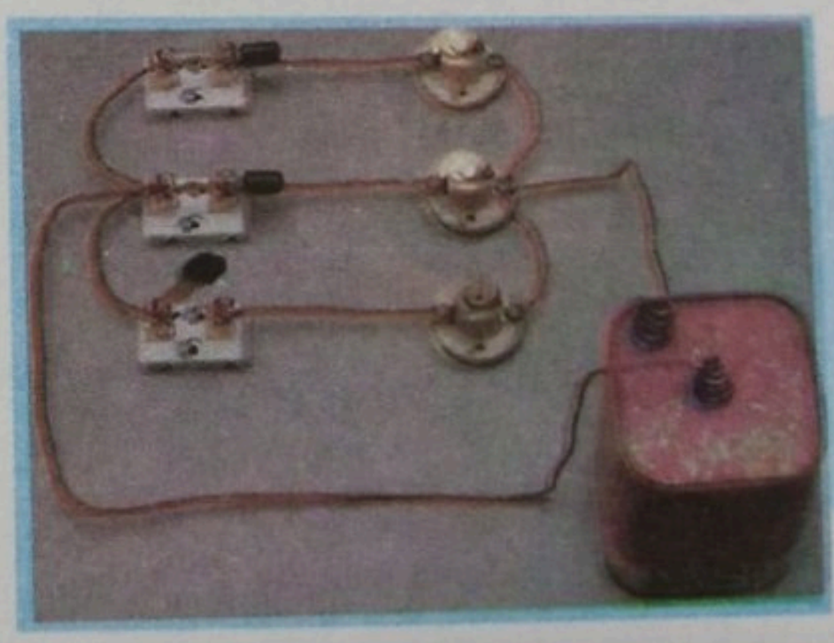


Fig: 6.11 Parallel circuit.

An example of parallel circuit is wiring system of a house. If one of the appliances stops working, current still flows through other appliances. However, in case of short circuit, the voltage drops almost to zero and the circuit stops working.

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II. Switch

Switch is commonly used to close or open the circuit and to turn on or off an electric appliance. Switch is fitted in the live wire. According to construction there are many types of switches e.g. single pole, main switch, push button etc.

i. Fuse

Fig: 6.12 Electrical fuse.

Fuse is a thin and small piece of metallic wire of low melting point. It is connected in the live wire, often as a cartridge. If a fault develops and current exceeds the limits, then fuse overheats and melts thereby breaks the circuit before the circuit catches fire. Fuse is connected in series along the main supply line so that entire current passes through the fuse.

ii. Circuit Breaker

A circuit breaker is modified form of fuse. It is in the form of a switch that automatically turns off circuit when the current exceeds the specified value. It can be reset by turning the switch on or by pressing a button.

Fig: 6.13 Circuit breaker.

iii. Outlets

An outlet or socket is an electrical device that connects other electrical appliances to electric supply. It is a point along the circuit where an electrical device or portable appliances can be connected to the circuit. Modern outlets consists of three pins and a fuse. The fuse protects the appliance from any electrical fault.

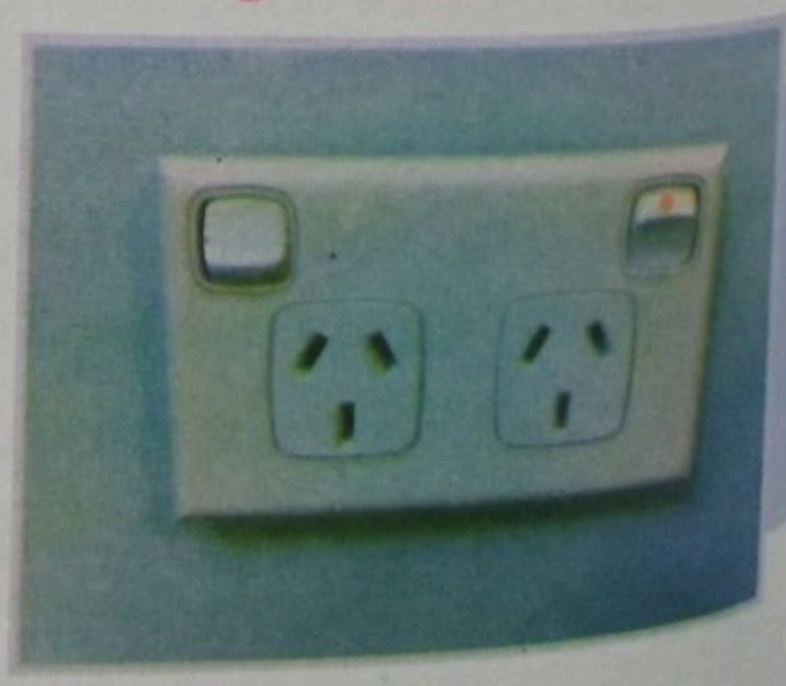

Fig: 6.14 Outlets.

6.6 Electric Safety Measures

To avoid the hazards of electricity in homes and in your surroundings, the following safety measures should be adopted.

- Don't touch switches unnecessarily.
- Never use electrical equipment in or close to water.
- Never play near broken plugs or in areas with many electrical wires and appliances.
- Never pull out a plug by pulling its cable.
- Never touch any torn or taped cables or switches. keep them away from heat and water.
- Avoid touching electrical appliances with any metallic object.
- Never go near a declined power line.
- Avoid climbing electric poles, transmission towers or fences around power stations.
- Avoid climbing trees or poles that are near power lines.
- Always contact an electrician or relevant expert in case of any fault in circuit or in an electrical appliance.

6.7 Careers in Electrical Technology

Following are some of the careers one can choose in electrical technology.

Electrician

An electrician is responsible for the overall installation, maintenance and repair of electrical connections in a home, industry or any other building. An electrician connects wires to circuits and their components.

Line Worker

A line worker installs and maintains lines and cables that carry electricity from the distribution point to the homes, industries and other setups. Apart from this they also work in power grid stations.

Electrical Installers

These persons are expert in installing various electrical appliances used in domestic as well as industrial setups. They also install and maintain main switch boards and power grids.

Power Plant Operators

Power plant operators work in electricity producing companies where they are responsible for operating and maintenance of power plants.

6.8 ENERGY GENERATION FROM RENEWABLE ENERGY RESOURCES

Energy is the basic need of our life. We utilize energy for different purposes e.g. for operating industries, running automobiles, stoves, heating, lighting, cooling etc. For these purposes one form of energy is converted into other form according to the need. In this regard, different sources are utilized e.g. coal, petroleum products, natural gas, electricity etc. Today a large amount of energy in the world, is obtained from coal , petroleum products and natural gas. However, these resources are gradually decreasing and ultimately will be depleted because these are not renewable. Moreover, these resources are not environment friendly, cause global warming and ozone layer depletion. This is the reason that today man is struggling to utilize maximum renewable energy resources like sunlight, flowing water, wind etc. These resources do not deplete on consumption. Such energy resources which do not deplete on consumption are called renewable energy resources.

There are a number of renewable energy resources such as sunlight, wind, flowing water, rain, tides, waves, biomass, geothermal heat etc. However, a few of them are described below.

1. Sunlight

The major renewable energy resource is sunlight. Large amount of energy in the form of light and heat receiving from sunlight is called

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solar energy. This energy is vital for human beings, animals and plants on the earth. In past, large spherical mirrors and lenses were used to concentrate sunlight and convert into heat energy. However, today solar cells are used to convert solar energy into heat and electrical energy.

Solar cell is a device that directly converts solar energy into electric energy. A single solar cell produces a small voltage. A number of solar cells are connected in series to generate large amount of voltage. This connection of solar cells is called a solar panel. Solar panels are installed according to need of electric energy.

Today, due to load shedding the use of solar panels has been started in offices and homes for lighting and other needs. Similarly solar panels are used in artificial satellites to meet their electrical need. Solar energy is utilized in different fields of agriculture. Moreover, today where conventional electric facility is not available, tube wells are operated by solar panels to irrigate agricultural lands.

2. Flowing Water

Flowing water is a very useful renewable energy resource of hydro energy. In ancient times, man used water mills to convert hydro energy into mechanical energy for milling grains and crushing sugar cane. Today, in most of the countries of the world hydro energy is utilized for generation of electricity. For this purpose water is stored in dams, from where it is passed through tunnels where it turns huge turbines whose rotating shafts connected to generators that generate electricity. It is then supplied to homes, offices, industries and other areas through cables.

3. Wind

Man has been using wind as a source of energy for centuries. In past people were utilizing wind energy for navigation of sail boats and sail ships. Similarly they used wind mills for milling grains and drawing water from wells.

Winds blow from regions of high pressure towards regions of low pressure. Sea winds are stronger than land winds. In windy regions, wind mills convert wind energy into mechanical energy for operating tube wells and flour mills. In Pakistan, wind energy can be utilized in coastal areas and high mountainous areas like Chitral, Gilgit and swat. Now a days, wind energy is used for operating turbines which generate electricity.

4. Biomass

Biomass is a renewable energy source. It consists of organic materials like animal manure, sawdust of timber mills, plants and trees residues, crop residue and used tires. Energy from biomass can be obtained by using all these materials as a fuel either by direct burning or fermentation. In direct burning the solid waste are fed into a furnace producing heat which is used to boil the water and run the turbines and generators for generating electric energy. While in fermentation, biomass is enclosed in a tank and decomposes it by bacterial action. As a result methane gas is produced which is then utilized for different energy purposes.

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KEY POINTS

- Static charges are build up due to transfer of electrons in the process of rubbing two objects or due to electrostatic induction
- All things are composed of charges (protons and electrons). Electric charge on them is built up due to imbalance between positive (protons) and negative (electrons) charges.
- Opposite charges attract each other while like charges repel each other.
- Principle of static electricity is used in pollution control by applying a static charge to dirt particles in the air and then collecting those charged particles on a plate having opposite electrical charge.
- Electricity is a type of energy that can build up in one place or due to flow of charges from one place to other. In first case it is called static electricity while in second case it is called current electricity.
- An electric circuit is a path of flow of current. A closed circuit has a complete path for current flow while an open circuit does not have a complete path for current flow.
- The opposition offered by a conductor to the flow of current is called its resistance while the conductor is called a resistor.
- Lightning rods are used to protect the buildings from lightning.
- Static straps are used to the rear sides of vehicles to prevent building up static charge on their bodies due to friction.
- Renewable energy resources do not deplete on consumption.

EXERCISE

A. Select the correct answers for the following questions.

1. **Opposite charges _____ each other.**
   a. Attract b. Repel c. Cancel d. None of them
2. **An object that is negatively charged has:**
   a. gained protons b. lost protons
   c. gained electrons d. lost electrons
3. **The term "electricity" in referring to static electricity, Means:**
   a. An imbalance of protons b. An equal number of atoms
   c. An imbalance of electrons d. An imbalance of neutrons
4. **Which one rod will become positively charged when rubbed with silk:**
   a. Glass rod b. Carbon rod c. Silver rod d. Ebonite rod
5. **If an ebonite rod and a glass rod are brought together after being rubbed with fur, which of the following will happen?**
   a. They will remain stationery b. They will attract each other
   c. They will repel each other d. None of them
6. **You are walking on a carpet and gain a positive charge. When you touch a neutral doorknob:**
   a. The electrons flow from the doorknob to your hand and you feel a shock.
   b. The electrons flow from your hand to the doorknob and you feel a shock
   c. The electrons do not flow and you feel no shock.
   d. The electrons do not flow but you still feel a shock.
7. **Why does lightning hit buildings and homes?**
   a. They are the closest point to thunder clouds.
   b. They are good insulators.
   c. Lightning clouds tend to form over buildings.
   d. None of these.
8. **Electrostatic precipitator is used.**
   a. In pollution control b. In electro painting
   c. In automobiles d. To protect from lightening

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9. **Which one phenomenon is not related to static electricity?**
   a. Both unlike and like charges attract
   b. Like charges repel
   c. Opposite charges attract
   d. Neutral objects are attracted to charged objects
10. **The path on which current flow is called _____.**
   a. Resistance b. Resistor c. Circuit d. none of these.

B. Write short answers of the following questions.

1. Why a metallic chain is hanging from the rear side of a petrol supply tanker.
2. Define electrostatic induction.
3. Describe fuse and its importance.
4. What is meant by circuit, closed circuit and open circuit?
5. What is a circuit breaker? Describe its importance.
6. What is meant by current electricity? Describe its types.
7. Why do your hair stand on ends when you pull apart your cap?
8. How does a lightning rod protect a building from a lightning strike?
9. Define static charges. Why are they called static?
10. What is meant by polarization of charge?

C. Write detail answers of the following questions.

1. What are the basic characteristics of static charges?
2. Describe the effects of static charges.
3. What is meant by resistance? How resistors are connected in a circuit?
4. Describe the practical applications of static electricity.
5. Write about practical uses of current electricity in household appliances?
6. What safety measures should be adopted to avoid hazards of electricity?
7. Write a note on energy generation from renewable resources.