Students' Learning Outcomes

After completing this chapter, the students will be able to:

- Define current.
- Make parallel and series circuits.
- Investigate about types of circuits used for different purposes.
- Identify a disadvantage of a series circuit.
- Differentiate between current and energy.
- Explain the effects of electric current in daily use appliances.
- Describe voltage.
- Explain the resistance as an opposition to the flow of current.
- Describe the relationship between voltage and resistance.
- Measure current by using different devices.
- List the major uses of electricity in homes.
- List electrical hazards and precautionary measures to ensure the safe use of electricity at home.
- Describe why electricity is dangerous to humans.

Animation 11.2: Electric flow. Source & credit: sparkfun

We have learnt in class VI that electricity supplies energy. Electricity can produce light, heat, sound, etc. Electrical energy can help make our lives easier.
There are two kinds of electricity.
i. Static electricity
ii. Electric current
We have learnt about static electricity in the previous classes. Here we shall discuss electric current, its effects and measurement.

11.1: Flow of Current (Direction)

The flow of charges through a conductor is called **electric current**. Charges travel from one pole to the other pole of an electrical source (battery) as shown in the Fig.11.1.
It has been proved that only negatively charged electrons move from one place to the other. Positively charged protons do not move. In early days, before the discovery of electrons, scientists guessed wrongly that electric current was the flow of positive charges from the positive pole of the battery to the negative pole. Scientists still adopt this idea and they have called it as **conventional current.**
The unit for electric current is **ampere** (A). Other smaller units are milliampere (mA) and micro ampere (μ A). Electric current is measured by an **ammeter.**
An **electric circuit** is a complete path along which charges flow. A key (switch) can open or close a circuit. Electric current only flows through a closed circuit.

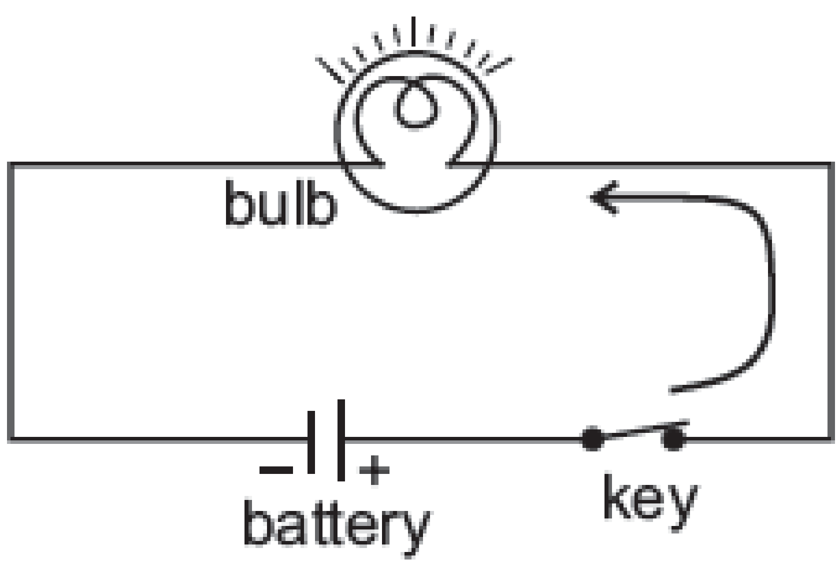


Fig. 11.1: Electric current flows from one pole to the other of an electrical source.

Animation 11.3: Current flow
Source & credit: etorgerson

Fig. 11.2: These and many other appliances in our homes use electric current.

Conductors and Insulators

The materials which allow electric current to pass through them are called conductors. Metals, such as copper, silver, iron and aluminium are good conductors.

The materials which do not conduct electricity are called insulators. Rubber, glass, sand, plastic and wood are insulators.

11.2: Types of Electric Circuits

There are several kinds of circuits. But here we shall discuss its two main types, i.e. **series circuits** and **parallel circuits.**

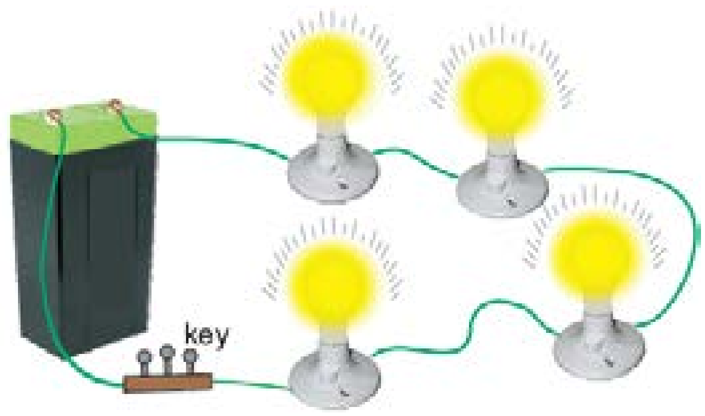
Series Circuits

If all the components are connected one after another in a single loop, then it is a **series circuit.** In a series circuit, there is only one path for the current to flow (Fig. 11.3). The amount of current which flows through each component (bulb) of the circuit is the same.

Disadvantages of the Series Circuits

There is a disadvantage of the series circuit:

- There is only one path for the current to flow. A break at any part of the circuit stops the flow of current in the whole circuit.



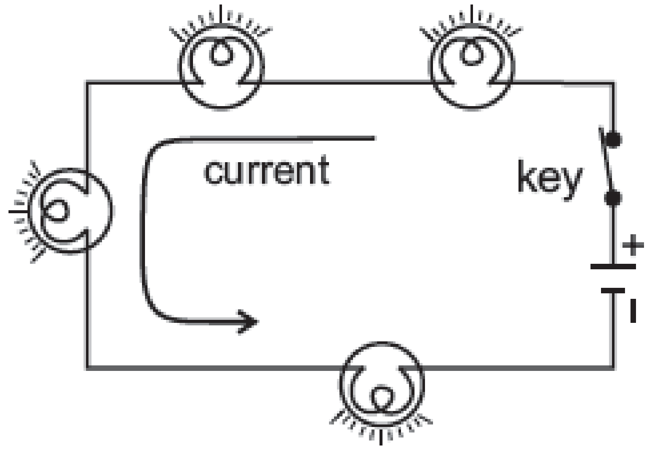
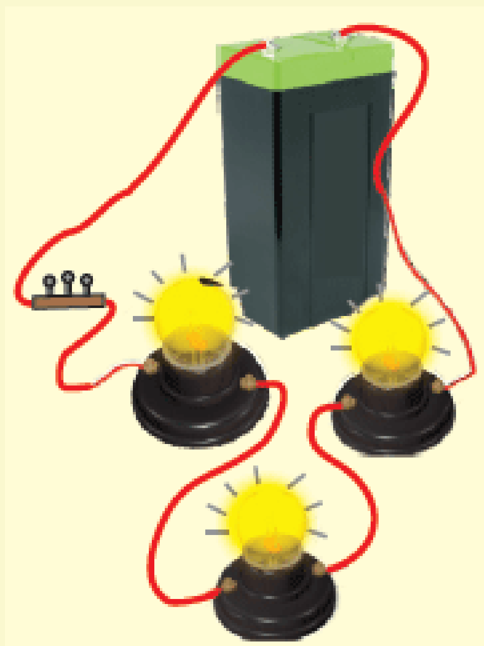


Fig. 11.3: A series circuit provides only one path for the flow of current.

Activity 11.1 Making a Series Circuit

You will need:

- A battery
- Three 1.5 volt bulbs with holders
- 1 burned-out bulb
- Connecting wires
- Key



Procedure

1. Connect a battery, a key and two 1.5V bulbs in a series circuit. Draw a picture of your circuit in your notebook.
2. Switch off the key. Add another bulb in the series with the other two bulbs. Switch on the key.
3. Replace one of the light bulbs with a burned-out light bulb.

Things to think

i. How does the brightness of the light bulbs change in step #2?
ii. What happens to the other lights in the circuit in step #3?

Parallel Circuits

If the components are connected in two or more loops, then it is a parallel circuit. In a **parallel circuit**, there are more than one paths for the current to flow (Fig. 11.4). The current flowing through different branches of a parallel circuit may be the same or different. But the current in each branch is less than the total current flowing out from the electrical source (battery).

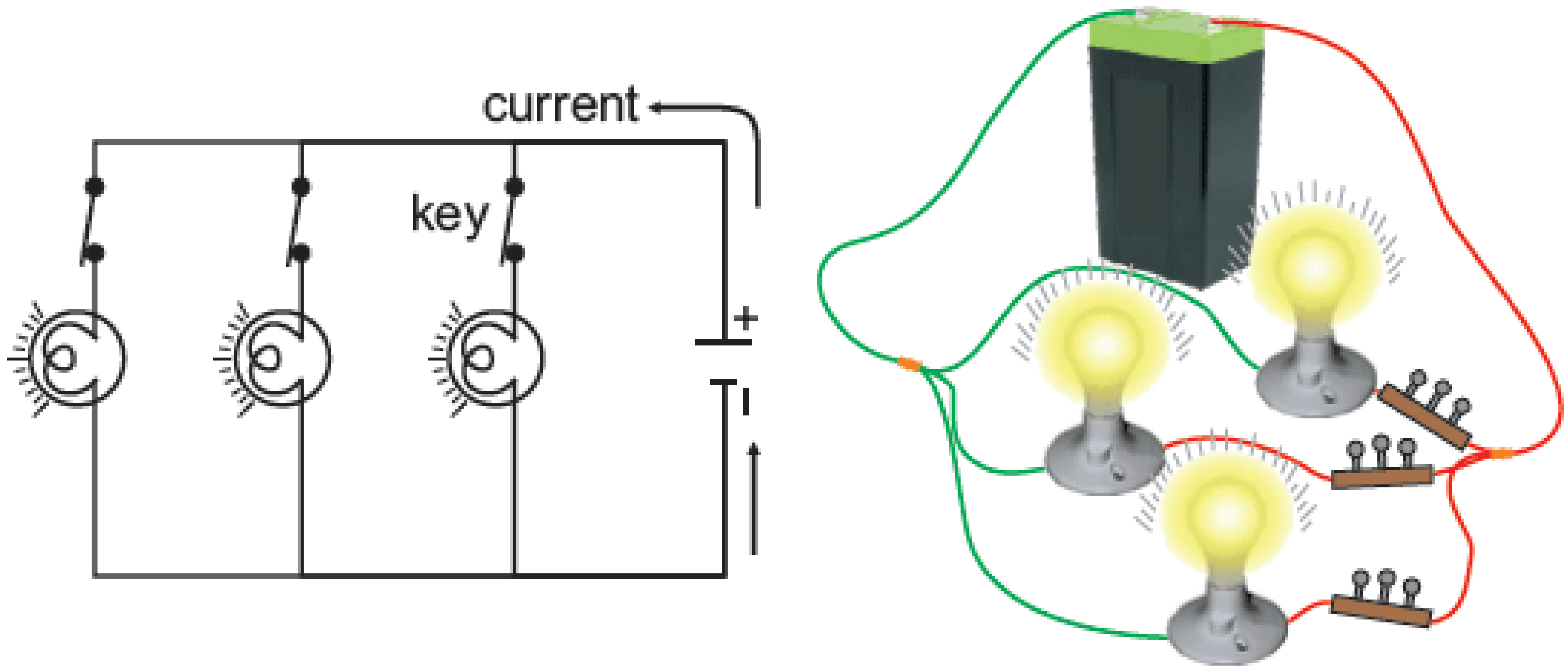


Fig. 11.4: In a parallel circuit, there are more than one path for the current to flow.

Advantage of a Parallel Circuit Over a Series Circuit

A parallel circuit has an advantage over a series circuit.

- There are more than one path for the current to flow. A break in any branch of the circuit stops the current flowing through that branch only.

Tidbit

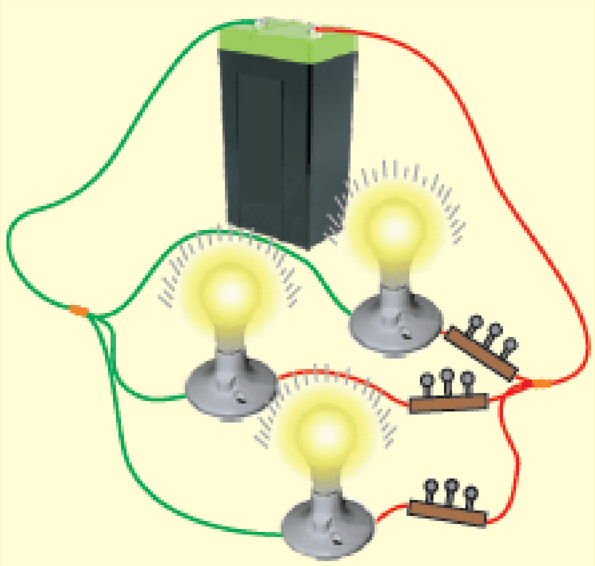
The lights of this ship are connected in a parallel circuit. If one light goes out, the rest keep glowing.

Extend Your Thinking

Why electrical wiring in our houses is parallel rather than in series circuits?

Activity 11.2 **Making a Parallel Circuit**

You will need:
- A battery
- Three 1.5 volt bulbs with holders
- 1 burned-out bulb
- Connecting wires
- 3 keys



Procedure
1. Connect a battery, keys and two 1.5V bulbs in a parallel circuit. Draw a picture of your circuit in your science notebook.
2. Switch off the keys. Add another bulb and key in parallel with the other two bulbs. Switch on the keys.
3. Replace one of the light bulbs with a burned-out light bulb.

Things to think

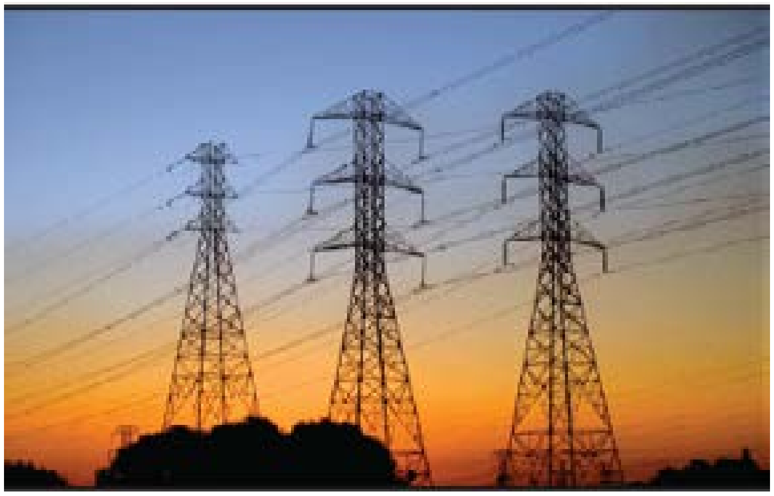
i. How does the brightness of the light bulbs change in step #2?

ii. What happens to the other lights in the circuit in step #3?

11.3: Energy Transfer in an Electrical Circuit

Electricity brings energy to our homes from a power station (Fig.11.5). The energy of moving electric charges within a circuit is called electrical energy. As charges flow in a circuit, some electrical energy always changes to heat energy.

A light bulb transforms electrical energy to light energy. Electric bells and stereo players transform electrical energy to sound energy. A heater gives us heat by using electrical energy. A fan converts electrical energy into mechanical energy (Fig.11.6).



Animation 11.4: Conductor
Source & credit: regentsprep

Fig. 11.5: Electrical energy comes from a power station through electric cables.

Fig. 11.6: A fan uses electrical energy to work.

11.3.1: How Do Charges Flow?

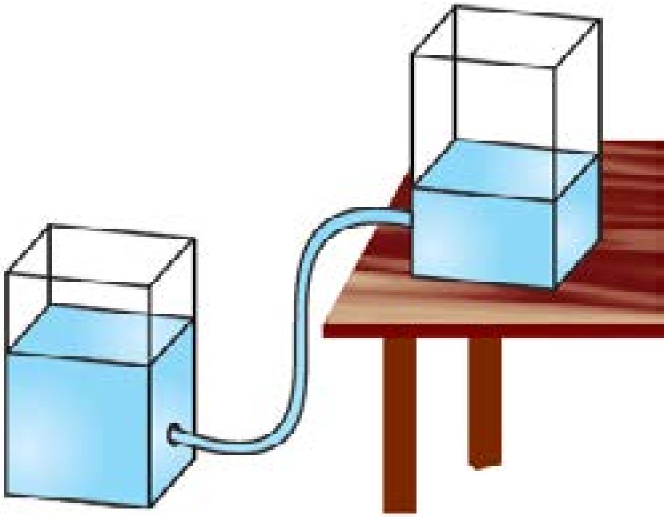


Fig. 11.7: The flow of current in a wire can be compared to the flow of water in a pipe.

The flow of electrons through a conductor (wire) can be compared to the flow of water in a pipe. Connect two cans of water, one on the floor and other on the table (Fig. 11.7). The water flows from higher level to the lower level. The potential energy of water in the can at a higher level causes the water to flow. Similarly, current flows from higher electric potential to lower electric potential.

The difference of potential between two points in a circuit or battery is called **potential difference** or **voltage.** Potential difference causes the charges to move through the conductor. Potential difference is measured in volts (V). Charges will flow as long as there is a potential difference between the two points. Every battery has its potential difference printed on it. For example, a dry cell carries 1.5V. Other units of volt are millivolts (mV) and kilovolts (kV). A **voltmeter** is used to measure potential difference.

11.3.2: Resistance

Electric current flows through some objects better than others . The measurement of how well something conducts electricity is its resistance.
Resistance is the hindrance to the flow of current. During its journey through an electric circuit, the charges collide countless times with atoms within the conductor (wire). These collisions result in the hindrance to the flow of the current (resistance).
The resistance of a wire depends on **length of the wire** and **thickness of the wire.**
Recall the flow of water in a pipe! A long pipe resists the flow of water more than a short pipe and a thin pipe resists the flow of water more than a wide pipe. Long wires have more resistance than short wires. Thin wires have more resistance than thick wires. The unit of resistance is ohm.

Fig.11.8: Water flows more easily through a short, wide pipe than through a long, narrow pipe. Similarly, electrons flow more easily through short and thick wires.

Extend Your Thinking
How is pressure of water created in a service station?

11.3.3: Relationship between Voltage and Resistance

A mathematical equation shows the relationship between voltage and resistance.

$$\text{Resistance} = \frac{\text{voltage}}{\text{current}}$$

The above equation shows that resistance is equal to the voltage divided by the current. It is called **Ohm's Law.**
In 1827, a German scientist George Simon Ohm discovered the relationship between the voltage and resistance in an electric circuit.

Tidbits

An electric eel can create a voltage of more than 600V.

Do You Know?
When electric current flows through the tungsten filament of a bulb, the resistance makes the filament very hot. It is because of the high resistance of tungsten filament that it glows.

11.4: Measuring Current, Voltage and Resistance

Following meters are used to measure current, voltage and resistance of an electric circuit:
An **ammeter** is the device to measure the amount of current in an electric circuit (Fig.11.9). It is connected to the circuit in series so that the full current passes through it. An ammeter does not change the amount of the current in a circuit because it has very low resistance.
A **voltmeter** is the device to measure the voltage (potential difference) in a circuit (Fig. 11.10). It is connected in parallel with the circuit. The current does not flow through a voltmeter because it has very high resistance.

A **multimeter** can measure resistance, voltage and small currents.

Fig.11.11: Multimeter

Fig. 11.10: Voltmeter

Fig. 11.9: Ammeter

11.4.1: Electrical Power

All electrical devices such as fans, blenders, computers, etc. convert electrical energy into other forms of energy. Electrical power is the rate at which a device converts electrical energy into another form of energy. Its unit is watt (W).

Kilowatt-hour (kWh)

Our electricity bill shows the amount of energy we Consume during one month. It is taken as kilowatt-hour. One kilowatt-hour is 1 unit on the electricity meter.

One **kilowatt-hour (kWh)** is the amount of energy used up when an electrical appliance of 1,000 watt works for 1 hour.

11.5: Effects of an Electric Current

We cannot see the electrical energy flowing in the circuit. But if any of the following three things happen, we say that electricity is flowing.

Fig. 11.12: A toaster and an electric iron convert electrical energy into heat.

Heating Effect of Current

When electric current flows through a metal wire, it makes it hot. Light is also produced when a wire becomes very hot. We use many appliances in our homes that convert electric current into heat.

Chemical Effect of Current

An electric current can chemically affect the materials particularly in molten or solution form. When a current flows through a solution, it can break up the solution into its components. This process is called **electrolysis.** Electricity is also used to coat a metal object with a thin layer of another metal. This process is called **electroplating.** The rims of bicycles are nickel-plated.

Fig. 11.13: Electricity is used to coat this rim with nickel.

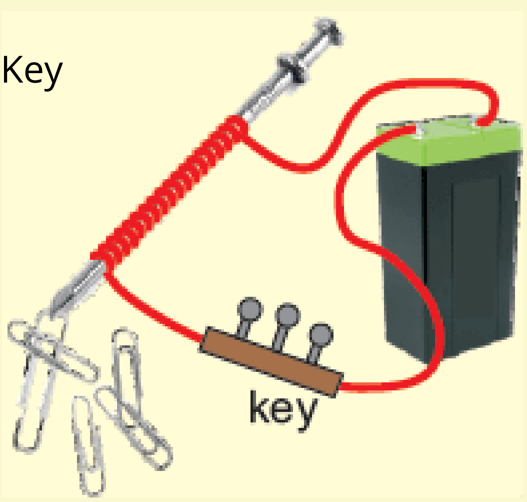
Magnetic Effect of Current

An electric current can also produce magnetic effect in a metal wire. A coil of wire around a piece of iron behaves like a bar magnet when an electric current is passed through it. Such magnets are called **electromagnets.** An electromagnet loses its magnetism when the current stops flowing through it. Electromagnets present in the earpieces of your telephone convert electric signals into sound. Electromagnets are also used in electric motors.

Activity 11.3	How to Make an Electromagnet

You will need:

- A battery • An iron nail •Insulated wire • Paper clips • Key



Procedure

1. Wrap the wire around a nail at least 15 turns as shown in the figure.
2. To make the electromagnet, connect the ends of the coiled wire to each end of the battery through key.
3. Try to pick paper clips with your electromagnet.
4. Switch off the key.
5. Can the electromagnet pick up paperclips when the current is off?

11.6: Why is Electricity Dangerous

Electricity is a part of our everyday life, but sometimes it can be dangerous. An electric shock is a lot painful and dangerous. If we follow these safety rules, we would be safe and sound:

- Don't touch an electric wire which has fallen from power lines.
- Never touch electrical appliances with wet hands.
- Don't enter any metal object into electric sockets.
- Don't overload power sockets. Overloaded sockets can cause fire (Fig. 11.14).
- If a person has been electrocuted, don't touch the body of that person. Use a non metallic object to move the victim away from the electric wire.

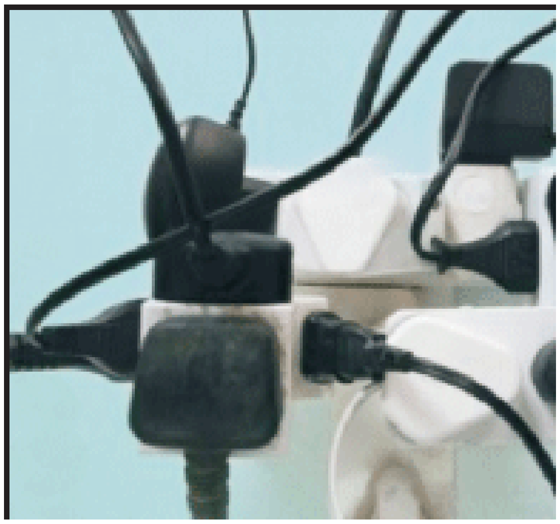


Fig. 11.14: An overloaded power socket

Short Circuit

Damaged insulation of wires may cause a short circuit. A large current passes through the wires which causes the wires to overheat quickly. A fire may start as a result of short circuit.

11.7: Electricity and Safety

By taking precautionary measures we can use electricity quite safely.

Fuses

A fuse is a piece of thin conducting wire connected in the path of a live wire. It gets heated up and melts on passing of a very large amount of current. Fuses are used to protect houses against short circuits and overloading.

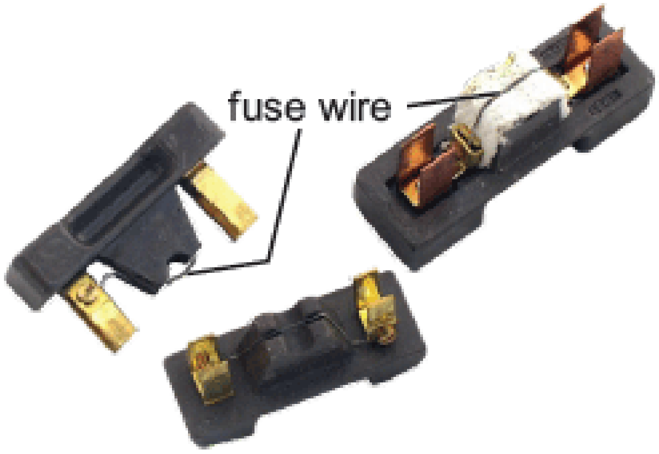


Fig. 11.15: Fuses

MCBs (Miniature Circuit Breakers)

Replacing the fuse again and again is not a pleasant experience. So, engineers have developed the alternatives of fuses,i.e. miniature circuit breakers (MCBs) (Fig.11.16).

An **MCB** is a small electromagnet switch that works like a fuse but it does not blow out. It just breaks the circuit by tripping when a current more than its rating passes through it .

Fig. 11.16: MCBs

Animation 11.5 : dangerous electricity
Source & credit: irysec.vic

Earth Wires

Additional earth wires protect us from electric shocks. If a short circuiting occurs in a device, current will flow directly into the earth through a low-resistance earth wire. In this way, a person who touches a faulty device will be protected. An earth wire is buried in the ground.

Three-pin Plug

In three pin plug, two pins connect the appliance to the main supply while the third pin connects the metal cover of an electric appliance to the Earth wire. In case of short circuiting, this third pin helps in sending the large amount of current into the ground.

Fig. 11.17: Three pin plug

ELCB (Earth Leakage Circuit Breaker)

An earth leakage circuit breaker (ELCB) is a safety device used in electrical installations to prevent a shock.

An ELCB is an electromagnetic switch. It quickly turns off the power when the current flowing through the earth wire exceeds the limit. If some one tries to use a faulty electric appliance, an ELCB breaks the circuit at once.

Fig. 11.18: ELCB

Extend Your Thinking

Why the third pin of a three-pin plug should not be removed?

Science, Technology and Society

Everyone in Pakistan is facing the widespread electricity loadshedding. People have to pass sleepless nights, and their daily routine is also disturbed. Besides many factors, the habits of consumers are also not good. Suggest some ways to stop the wastage of electricity in our homes.

Key Points

- The flow of charges through a conductor is called electric current.
- The path along which charges can flow is called an electric circuit.
- In a series circuit, all the components are connected one after the other in a single loop. In a parallel circuit, the components are connected in two or more loops.
- As there is only one path for the current to flow in a series circuit, a break at any part of the circuit stops the flow of current in the whole circuit.
- We use many appliances which use heating, chemical and magnetic effects of the electric current.
- Voltage is the difference of potential between two points in a circuit or battery.
- Resistance is the hindrance to the flow of current. The resistance of a wire depends on length of the wire and thickness of the wire.
- An ammeter is used to measure the amount of electric current in an electric circuit.
- Electricity is very important for us, but it can also be dangerous. An electric shock can be fatal for a person.
- We use fuses, MCBs, earth wires and ELCB's for the safe use of electricity.