

Unit 14

CURRENT ELECTRICITY

After studying this unit, the students will be able to:

- a. Define electric current.
- b. Describe the concept of conventional current.
- c. Understand the potential difference across a circuit component and name its unit.
- d. Describe ohm's law and its limitations.
- e. Define resistance and its unit.
- f. Calculate the effective resistance of a number of resistances connected in series and also in parallel.
- g. Describe the factors affecting the resistances of a metallic conductor.
- h. Distinguish between conductors and insulators.
- i. Sketch and interpret the v - i characteristics graph for a metallic conductor, a filament lamp and thermistor.
- j. Describe how energy is dissipated in a resistance and explain joule's law.
- k. Apply the equation $E = I, Vt = I^2, Rt = V^2t / R$ to solve numerical problem.
- l. Calculate the cost of energy when given the cost per kwh.
- m. Distinguish between d.c and a.c.
- n. Identify circuit components such as switches, resistors, batteries etc..
- o. Describe the use of electrical measuring devices like galvanometer, ammeter and voltmeter (construction and working principles not required).
- p. Construct simple series (single path) and parallel circuits (multiple paths)
- q. Predict the behavior of light bulbs in series and parallel circuit such as for celebration lights.
- r. State the function of the live, neutral and earth wires in the domestic main supply.

- s. State reason why domestic supplies are connected in parallel.
- t. Describe hazards of electricity (damage insulation, overheating of cables, damp conditions).
- u. Explain the use of safety measures in household electricity, (fuse, circuit breaker).

Q.1 Define the term electric current? What is conventional current?

Answer

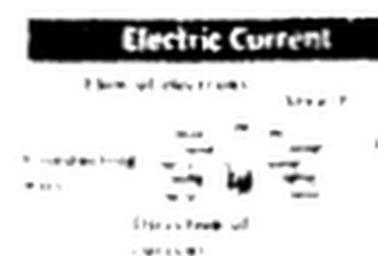
" The rate of flow of electric charge through any cross-sectional area is called current."

Explanation

If the charge 'Q' is passing through any area in time then current 'I' flowing through it will be given by:

$$\text{Current} = \frac{\text{charge}}{\text{time}}$$

Or
$$I = \frac{Q}{t}$$



SI unit of current is ampere (A).

- 1) In metals, the current is produced only due to flow of free electrons i.e. negative charges.
- 2) In case of electrolyte, its molecules in aqueous solution dissociate among positive and negative ions.
- 3) Electric current is produced due to the flow of either positive charge or negative charge or both of charges at the same time.

Conventional current

Before the idea of free electrons which constitute current in metals, it was thought that current in conductors flows due to the motion of positive charges.

Definitions

Current flowing from positive to negative terminal of a battery due to the flow of positive charges is called conventional current.

Explanation

- 1) We know that when the ends of a copper wire are at different temperatures: heat energy flows from the end of higher temperature to the end of lower temperature.
- 2) Water in pipe also flows from higher level to lower level.
- 3) Similarly, when a conductor is connected to a battery, it pushes positive charges to flow current from higher potential to the lower potential as shown in figure 13.2.

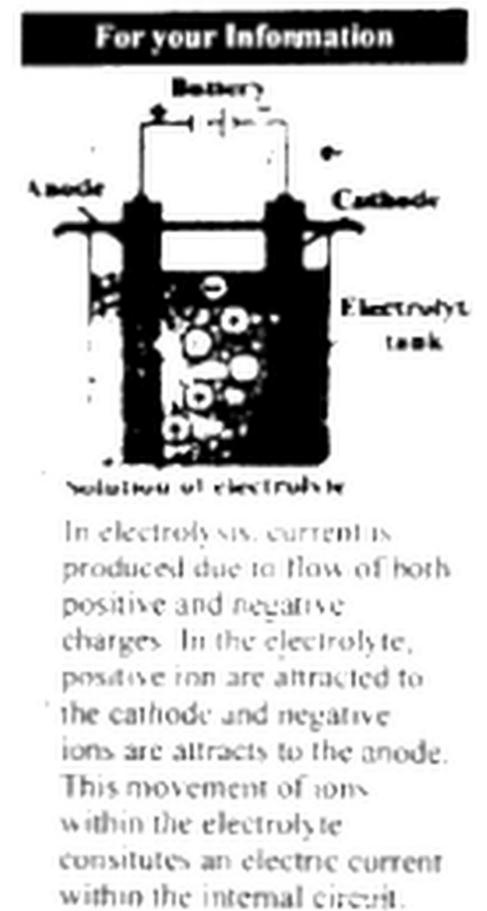




Fig 14.2: Current flows in a conductor when it is connected to a battery

- 4) The flow of current continues as long as there is a potential difference.
- 5) Conventional current produces the same effect as the current flowing from negative terminal to the positive terminal due to the flow of negative charges.

Q.2 What is meant by the electric potential of the battery?

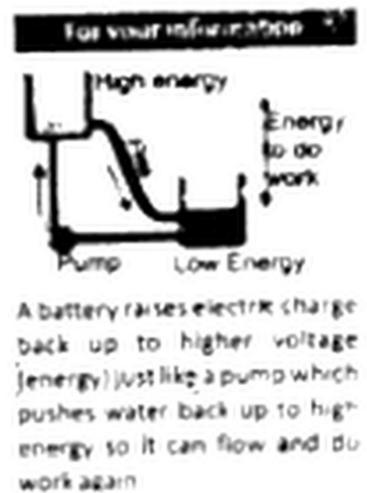
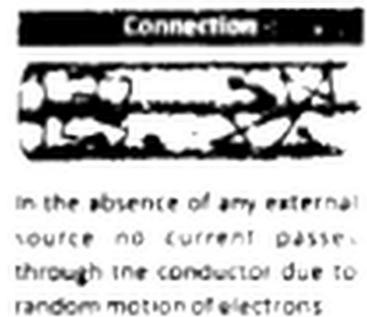
Answer

Electric potential of a battery:

Energy is one of the sources of current. The electromechanical reaction inside a battery separates positive and negative electric charges as shown in the figure 14.1. This separation of charges sets up potential difference between the terminals of the battery.

When we connect a conducting wire across the terminals of the battery, the charges can move from one terminal to the other due to the potential different. The chemical energy of the battery changes to electric potential energy.

The electrical potential energy decreases as the charges move around the circuit. This electrical potential energy can be converted to other useful forms of energy such as heat, light, sound etc.. It is only the energy which changes form but the number of



charge carriers and the charge on each carrier always remains the same (i.e. charge carriers are not used up).

Instead of electrical potential energy we use the term electric potential, which is potential energy per unit charge."

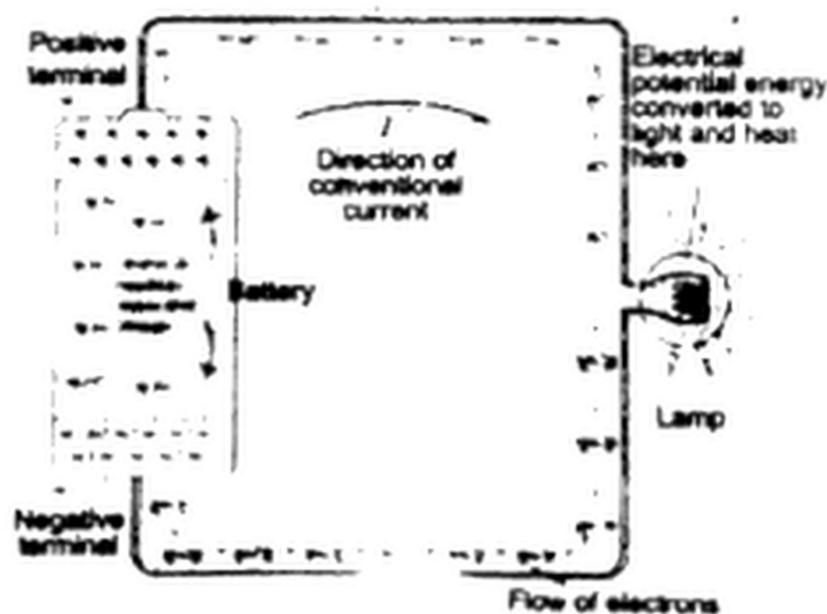


Fig. 14.1: Schematic diagram of battery as a current source

Q.3 What do you mean by the term "electric potential difference"?

Answer

(Electric) potential difference

Definition

" potential difference across the two ends of a conductor causes the dissipation of electrical energy into other forms of energy as charges flow through the circuit."

Explanation

When one end 'A' of conductor is connected to the positive terminal and its other end 'B' is connected to the negative terminal of the battery then the potential 'A' becomes higher than the potential of 'B' as shown in the figure 14.6.

This causes a potential difference between the two ends of the conductor. The flow of current continues as long as there is a potential difference.

The agency which provides the potential difference for the steady flow of current in the copper wire is the battery.

As the current flows from higher potential to a lower potential through the conductor, the electrical energy (due to current) is converted into other forms, such as heat and light etc.

When current flows through the conductor, it experiences a resistance in the conductor. The energy supplied by the battery is utilized in overcoming this resistance and is dissipated as heat and other forms of energy.

The dissipation of this energy is accounted for by the potential difference across the two ends of the light bulb.

Unit

SI unit of potential difference is Volt.

Physics insight



The flow of charge in a circuit is like the flow of water in a pipe except that a return wire is needed in order to have a complete conducting path.

Do you know?

The volt is named after the Italian physicist Alessandro Volta (1745-1827), who developed the first practical electric battery, known as a voltaic pile. Because potential difference is measured in units of volts, it is sometimes referred to as voltage.

Volt

"A potential difference of 1 V across a bulb means that each coulomb of charge or 1 ampere of current that passes through the bulb consumes 1 joule of energy."

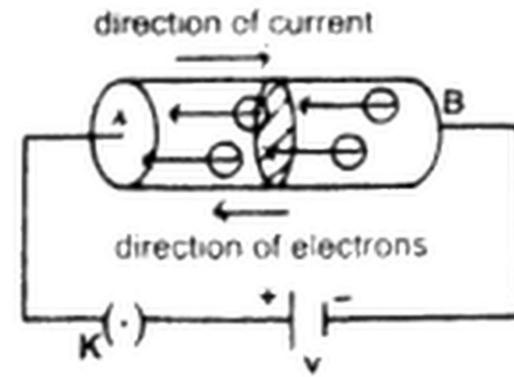


Fig 14.6

Q.4 What do you mean by the term e.m.f? Is it really a force?

Answer

Electromotive force (e.m.f)

Definition

"It is the energy supplied by a battery to a unit charge when it flows through the closed circuit. OR The energy converted from nonelectrical forms to electrical form when one coulomb of positive charge passes through the battery."

Explanation

A source of electromotive force (e.m.f). converts nonelectrical (chemical, thermal, mechanical etc.) into electrical energy. Examples of sources of e.m.f are batteries, thermocouples and generators. When a conductor is connected to a battery, current flows through it due to potential difference.

For the continuous flow of current through a wire, battery supplies energy to the charges. The positive charges leave the positive terminal of the battery, pass through the conductor and reach the negative terminal of the battery. As a positive charge enters the battery at its lower potential point (negative terminal), the battery must supply energy, 'W' say to the positive

Do you know?



A battery raises electric current back up to higher voltage (energy); similarly to how a pump pushes water back up to high energy so it can flow and do work.

For your information



In a dry cell chemical energy changes into electric energy

charge to drive it to a point of higher (positive terminal). Such energy supplied 'W' per unit charge is called electromotive force (e.m.f) of the battery.

$$\text{Thus, } e.m.f = \frac{\text{Energy}}{\text{Charge}}$$

$$E = \frac{W}{Q}$$

Unit:

The unit of e.m.f is joule/coulomb (JC^{-1}), which is volt (V) in SI system.

e.m.f is a force or not:

Electromotive force (emf) is not a force but is an electrical energy supplied by the battery per unit charge.

Q.5 How the current and the potential difference are measured in an electric circuit.

Answer

Measurement of current

To measure the current, we use different electrical instruments. Galvanometer and Ammeter are some examples of current measuring instruments.

Galvanometer

Galvanometer is very sensitive instrument and can detect small current in the circuit as shown in the fig. 14.3. A current of few, milliamperes is sufficient to cause full scale deflection in it. While making the connections polarity of the terminals of the galvanometer should be taken into consideration. Generally, the terminal of the galvanometer with red colour



Fig. 14.4 A ammeter



Fig. 14.3 A galvanometer

shows the positive polarity while that of with black colour shows negative polarity. An ideal Galvano meter should have very small resistance to pass the maximum current in the circuit.

Ammeter

After suitable modification galvanometer can be converted into an ammeter. A large current of the range such as 1 A to 10 A can be measured by means of an ammeter. Ammeter is also connected in series so the current flowing in the circuit also passes through the ammeter as shown in fig. 14.5:

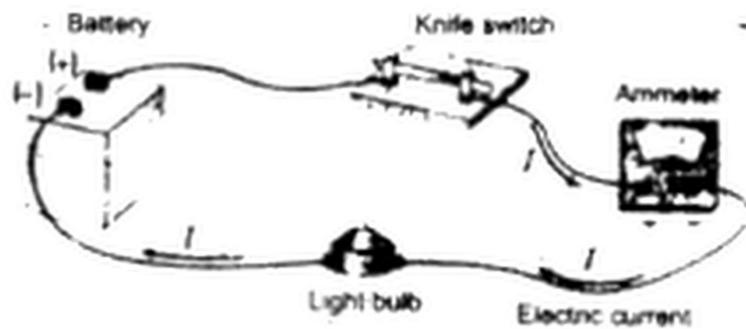


Fig 14.5 Schematic diagram showing the measurement of current

Measurement of potential difference

The potential difference across a circuit component (e.g. light bulb) can be measured by a voltmeter as shown in the figure 14.7. connected, directly across the terminals of the component. The positive terminal of the cell is connected to the positive terminal of the voltmeter and the negative terminal of the cell is connected the negative terminal of the voltmeter. An ideal voltmeter should have very large value of resistance so at noncurrent passes through it.



Fig 14.3 A voltmeter



Fig 14.8 Schematic diagram for measuring potential difference in a circuit

Voltmeter is always connected in parallel with the device across which the potential difference is to be measured.

Q.6 Write briefly about the measurement of e.m.f?

Answer

Measurement of e.m.f

In general, e.m.f refers, to the potential difference across the terminals of the battery when it is not driving current in the external circuit. So, in order to measure e.m.f of the battery we connect voltmeter

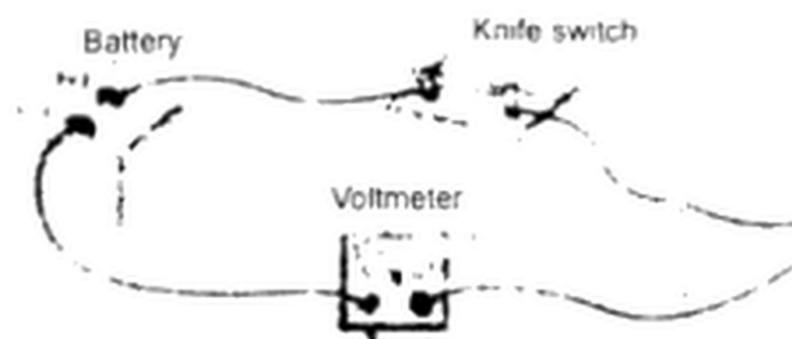


Fig. 14.9 Schematic diagram for measuring e.m.f of the battery

directly with the terminals of the battery as shown in the figure. 14.9.

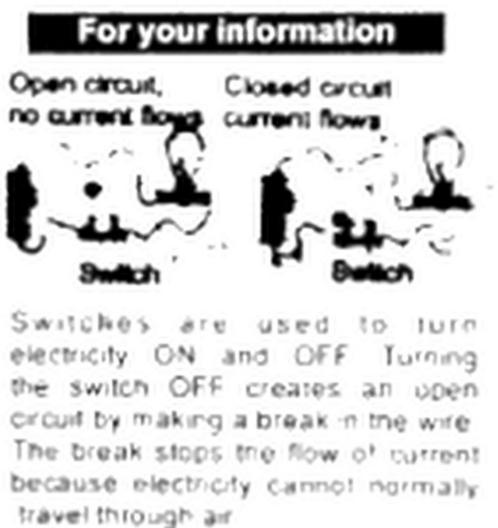
Q.7 Explain ohm's law?

Answer

Ohm's law (statement)

The amount of current 'I' passing through a conductor is directly proportional to the potential difference V applied across its ends, provided the temperature and the physical state of the conductor does not change, i.e.

$$V \propto I$$



Or $V = IR$

Explanation

Take a copper wire of about 50 cm in length and apply a potential difference of 1.5 V from a battery. Measure the current flowing through the wire using an ammeter connected to it in series. Also measure the potential difference across the resistance using a voltmeter connected across it.

Obtain a set of readings for I and V, by increasing the number of cells. Plot a graph drawn between I and V which is a straight line.

This straight line indicates that voltage V and current I are directly proportional to each other provided the resistance R remains constant.

For your understanding

1. In order to measure current through resistance, ammeter is always connected in series with the resistance.
2. In order to measure potential difference across the resistance, voltmeter is always connected in parallel with the resistance.

Resistance

The property of a substance which offers opposition to the flow of current through it is called its resistance.

The SI unit of resistance is ohm.

For your understanding

1. In order to measure current through resistance, ammeter is always connected in series with the resistance.
2. In order to measure potential difference across the resistance, voltmeter is always connected in parallel with the resistance.

Unit of resistance (Ohm)

When a potential difference of one volt is applied across the ends of a conductor and one ampere of current passes through it, then its resistance will be one ohm:"



Q.8 Differentiate between ohmic and nonohmic substances?**Answer****Ohmic**

Materials that obey ohm's law, and hence have a constant resistance over a wide range of voltages, are said to be ohmic.

Nonohmic

Materials having resistance that changes with voltage or current are nonohmic.

V-I characteristics of ohmic and non ohmic conductors

1) Ohmic conductors have linear current voltage relationship over a large range of applied voltages as shown in the figure 14.10 (a). The straight line shows a constant ratio between voltage and current. Ohm's law is obeyed. For example, most metals show ohmic behavior.

2) Nonohmic materials have a nonlinear current voltage relationship.

For example, filament lamp, and thermistor, the resistance of filament rises (current decreases) as it gets hotter, which is shown by the gradient getting steeper as shown in the fig. 14.10 (b).

3) A thermistor (a heat sensitive resistor) behaves in the opposite way. Its resistance decreases (current increases) as it gets hotter as shown in the figure 14.10(c).

This is because on heating, more free electrons become available for conduction of current.

Q.9 Explain the term specific resistance (resistivity)?**Answer**

- i) Thick wires have less resistance than thin wires.
- ii) Longer wires have more resistance than short wires.
- iii) Copper wire has less resistance than steel wire of the same size.
- iv) Electrical resistance also depends on temperature.



At a certain temperature and for a particular substance:

1) The resistance 'R' of the wire is directly proportional to the length of the wire i.e.

$$R \propto L \dots\dots\dots(1)$$

2) The resistance 'R' of the wire is inversely proportional to the area of cross section 'A' of the wire i.e.:

$$R \propto L/A \dots\dots\dots(2)$$

Combining equations (1) and (2), we get,

$$R \propto L/A$$

Or $R = \rho \frac{L}{A} \dots\dots\dots(3)$

Where 'p' is the constant of proportionality, known as "specific resistance."

Its value depends upon the nature of conductor, i.e. copper, iron, tin and silver would each have different values of 'ρ'.

Unit:

The unit of 'ρ' is ohmmeter (Ωm).

If we put L = 1 m, A = 1 m² in equ. (3), we get. R= ρ

Interesting Information
 Diamond does not conduct electricity, because it has no free electrons. However, it is very good at conducting heat because its particles are very firmly bonded together. Jewellers can tell if a diamond is a real diamond or a fake one made from glass, by holding it to their lips. A real diamond feels very cold due to good ability of transferring heat four or five times better than copper.

Q.10 What is the difference between conductors and insulators?**Answer****Conductors**

"The substances that have majority of free electrons due to which more electric current can flow are called conductors or electric conductor."

Metals, like silver and copper have excess of free electrons which are not held strongly with any particular atom of metals. When we apply external electric field, these electrons can easily move in a specific direction.

This movement of free electrons in a particular direction under the influence of an external field causes the flow of current in metal wires. This resistance of conductors increases with increase in temperature. This is due to increase in the number of collisions of electrons with themselves and with the atoms of the metals.

Do you know?

We use heating effect of an electric current for different purposes. For example, when a current flows through the filament of a bulb, it glows white hot and gives out light. Electric heaters have very thin wires that glow red hot when a current flows.

Insulators

"The substance that has rare free electrons and may cause none or negligible flow of current is called insulator."

The electrons in insulators, like rubber, however are not free to move. They are tightly bound inside atoms. Hence current cannot flow through an insulator because there are no free electrons for the flow of current.

Insulators have very large value of resistance. Insulators can be easily charged by friction and the induced charge remains static on this surface. Other examples of insulators are glass, wood plastic, fur, silk etc..

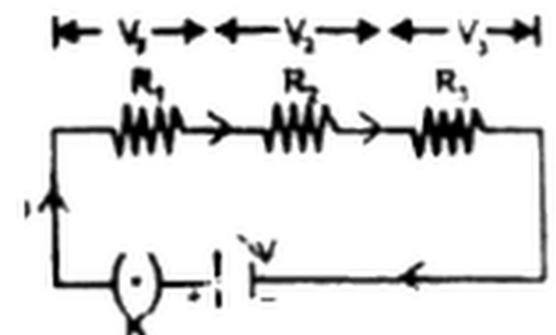


Fig. 14.11 Three resistors in series combination

Q.11 Determine the equivalent resistance of series combination of resistors?

Answer

Series combination of resistors

In series combination resistors are connected end to end and electric current has a single path through the circuit. This means that the current passing through each resistor is the same.

Equivalent resistance of series circuit

The total voltage in a series circuit divides among the individual resistors so the sum of the voltage across the resistance of each individual resistor is equal to the total voltage supplied by the source.

Thus, we can write as,

$$V = V_1 + V_2 + V_3 \dots\dots\dots(1)$$

Where 'V' is the voltage across battery and V_1, V_2, V_3 are the voltages across resistors R_1, R_2 and R_3 respectively.

If I is the current passing through each resistor, then from Ohm's Law,

$$V = IR_1 + IR_2 + IR_3$$

Or $V = I(R_1 + R_2 + R_3) \dots\dots\dots(2)$

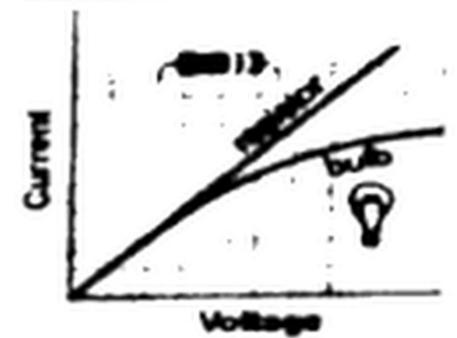
We can replace the combination of resistors with a single resistor called the equivalent resistance R_{eq} such that the same current passes through the circuit. From ohm's law:

$$V = I R_{eq}$$

Thus, from equ. (2), we have,

$$I R_{eq} = I(R_1 + R_2 + R_3)$$

Point to consider



The current versus voltage graph of a resistor is a straight line with a constant slope. The graph for light bulb is curved with a decreasing slope. What can you infer from this?

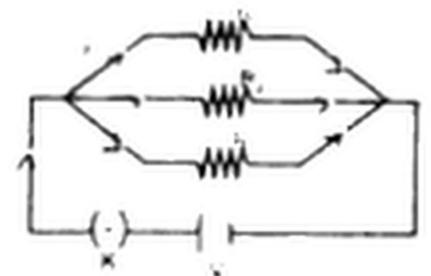
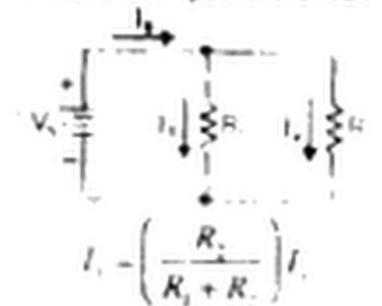


Fig 14.12 Three resistors in parallel combination

Parallel circuit and current divider only

In parallel circuit current divides into different paths. We can use following current divider formula to know value of current through resistor R_1 in the following parallel circuit.



Or $R_{eq} = R_1 + R_2 + R_3$

Thus, the equivalent resistance of a series combination is equal to the sum of the individual resistances of the combination.

If resistances $R_1, R_2, R_3, \dots, R_n$, are connected in series, then the equivalent resistance of the combination will be given by:

$$R_{eq} = R_1 + R_2 + R_3 + \dots + R_n$$

Q.12 Determine the equivalent resistance of parallel combination of resistors?

Answer

In parallel combination one end of each resistor is connected with positive terminal of battery while the other end of each resistor is connected with the negative terminal of battery as shown in the figure 14.12. Therefore, the voltage is same across each resistor which is equal to the voltage of the battery i.e.,

$$V = V_1 = V_2 = V_3$$

Effective resistance of parallel circuit

In parallel circuit, the total current equals the sum of the currents in various resistances i.e.:

$$I = I_1 + I_2 + I_3 \dots \dots \dots (1)$$

Since the voltage across each resistance, 'V' so by ohm's law,

$$I_1 = \frac{V}{R_1}, I_2 = \frac{V}{R_2}, I_3 = \frac{V}{R_3}$$

Thus, equ. (1) becomes,

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

For good information
 If the values of all the resistors in a parallel circuit are the same, the equivalent resistance can be determined by

$$\frac{1}{R_p} = \frac{N}{R}$$

$$\therefore R_p = \frac{R}{N}$$

where N is the total number of resistors and R is the resistance of each individual resistor.

Watch the picture



Or
$$I = V \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right) \dots\dots\dots(2)$$

We can replace the combination of resistors with a single resistor called the equivalent resistance R_{eq} such that the same current passes through the circuit.

From ohm's law, $I = V/R_{eq}$, thus equ. (2) becomes.

$$\frac{V}{R_{eq}} = V \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right)$$

Or
$$\frac{1}{R_{eq}} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right)$$

Thus, the equivalent resistance of a parallel combination is sum of the reciprocal of the individual resistances. Which is less than the resistance of a one of the combinations.

If resistance $R_1, R_2, R_3, \dots, R_n$ are connected in parallel than the equivalent resistance of the combination will be given by

$$\frac{1}{R_{eq}} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n} \right)$$

Q.13 Explain the energy dissipation in a resistance. What is Joule's law?

Answer

Energy dissipation in a resistance

Turbine runs generator to produce electrical 'energy when water falls on it from higher gravitational potential to lower gravitational 'potential.

Similarly, when charge moves from a higher electric to a lower potential, it delivers electric current. Thus, the electric

For your information
Energy saver light bulbs transform much more of the electrical energy into light and much less into wasted heat energy. An energy saver light bulb that uses 11 j of electrical energy each second gives the same amount of light as an "ordinary" incandescent bulb that uses 60 j of electrical energy each second.

current, during which charges continuously move from a higher potential to a lower potential, becomes a continuous source of electric energy.

Consider two points with a potential difference of V volts. If one coulomb of charge passes between these points; the amount of energy delivered by the charge would be V Joule.

Hence, when ' Q ' coulomb of charge flows between these two points, then we will get QV joule of energy.

If we represent this energy by W , then, electrical energy supplied by Q charge, $W = QV$ joule. Now current, when charges Q flow in time T is defined as:

$$I = Q / t$$

or $Q = It$

So, the energy supplied by Q charge in t second $= W = V \times I \times t$.

This electrical energy can be converted into heat and other forms in the circuit.

From ohm's law, we have $V = IR$.

So, the energy supplied by the Q charge is

$$W = I^2 R t$$

Or $W = V^2 t / R$

This equation is called Joule's law.

Joule's law

The amount of heat generated in a resistance due to flow of charges is equal to the product of square of current I , resistance ' R ' and the time duration ' t '.

For your information

All electrical appliances have power rating, given in watts or kilowatts. An appliance with a power rating of $1W$ transfers 1 joule of electrical energy each second. So a $60W$ light bulb converts $60J$ of electrical energy each second into light energy and heat energy. To find out the total energy an appliance transfers from the mains, we need to know the number of joules transferred each second and the number of seconds for which the appliance is ON.

Q.14 What is electrical power? Discuss the unit Kilowatt-hour?**Answer****Electric power**

"The amount of energy supplied by current in unit time is known as electric power."

Hence power 'p' can be determined by the formula:

electric power $P = \text{Electrical energy} / \text{time}$

Or $P = W / t$

Where 'W' is the electrical energy given by:

$$W = QV$$

Therefore, above equation becomes:

$$\text{electric power } P = \frac{QV}{t}$$

Or $P = VI = I^2R$

When current 'I' is passing through a resistor 'R'; the electric power that generates heat in the resistance is given by I^2R .

Unit

The unit of electric power is Watt, which is equal to one joule per second 1 Js^{-1} written on 'W'.

Electric bulbs commonly used in houses consume 25W, 40W, 60W, 75W, and 100W of electric power.

Kilowatt-hour

"The amount of energy delivered by a power of Kilowatt in one hour is called Kilowatt-hour.

**Remember**

- To work out the energy transferred, the time must be in seconds and the power in watts.
- To work out the cost, the power must be in kilowatts and the time must be in hours.

Do you know?

Although the light intensity from a 60 W incandescent light bulb appears to be constant, the current in the bulb fluctuates 50 times each second between -0.71 A and 0.71 A. The light appears to be steady because the fluctuations are too rapid for our eyes to perceive.

One Kilowatt-hour,

$$1 \text{ KWh} = 1000 \text{ W} \times 1 \text{ hour}$$

$$= 1000 \text{ W} \times (3600 \text{ s})$$

$$= 36 \times 10^5 \text{ J}$$

$$= 3.6 \text{ MJ.}$$

The energy in Kilowatt-hour can be obtained by the following formula:

The amount of energy is Kilowatt-hour:

$$= (\text{Watt} \times \text{time of use in hours}) / 1000$$

If the cost of one kilowatt-hour i.e. one unit is known, we can calculate the amount of electricity bill by the following formula:

$$= (\text{Watt} \times \text{time of use in hours}) / 1000$$

Q.15 What is the difference between D.C and A.C? Discuss the supply to a house and house wiring?

Answer

Direct Current (D.C)

The current derived from a cell or a battery is direct current D.C Since it is unidirectional. The positive and negative terminals of D.C. sources have fixed polarity, therefore, level of D.C remains constant with time as shown in the figure 14.13.

Alternating Current (A.C)

There is also a current which changes its polarity again and again. Such a current that changes direction after equal intervals of time is called alternating current A.C, as shown in the figure 14.14

Time period

The time interval after which the A.C. voltage or current repeats its value is known as its time period. In Pakistan, alternating current oscillates 50 times every second.

Supply to a house

1) The electric power enters our house through three wires. One is called earth wire or ground wire. (E).

This carries no electricity. The earth wire is connected to a large metal plate buried deep in the ground near the house.

2) The other wire is maintained at zero potential by connecting it to the earth at the power station itself and is called neutral wire (N). This wire provides the return path for the current.

3) The third wire is at a high potential and is called live wire (L). The potential difference between the live wire and the neutral wire is 220 V.

All electrical appliances are connected across the neutral and the live wires. The same potential difference is therefore applied to all of them and hence these are connected in parallel to the power source.

House wiring

Figure 14:15 shows the system of house wiring. The wires coming from power station are connected to electricity meter installed in the house. The output power from the electric meter is taken to the main distribution board and then to the domestic electric circuit.

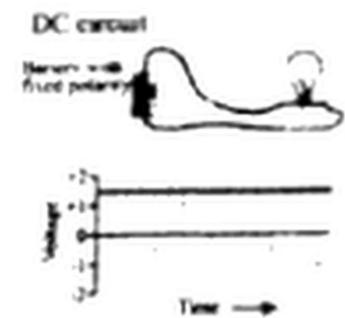


Fig 14 13 variation of D.C current with time

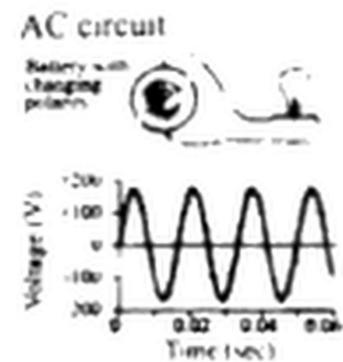


Fig 14 14 Variation of a.c. current with time

The main box contains fuses of rating about 30A. A separate connection is taken from the live wire of each appliance. The terminal of the appliance is connected to the live wire through a separate fuse and a switch.

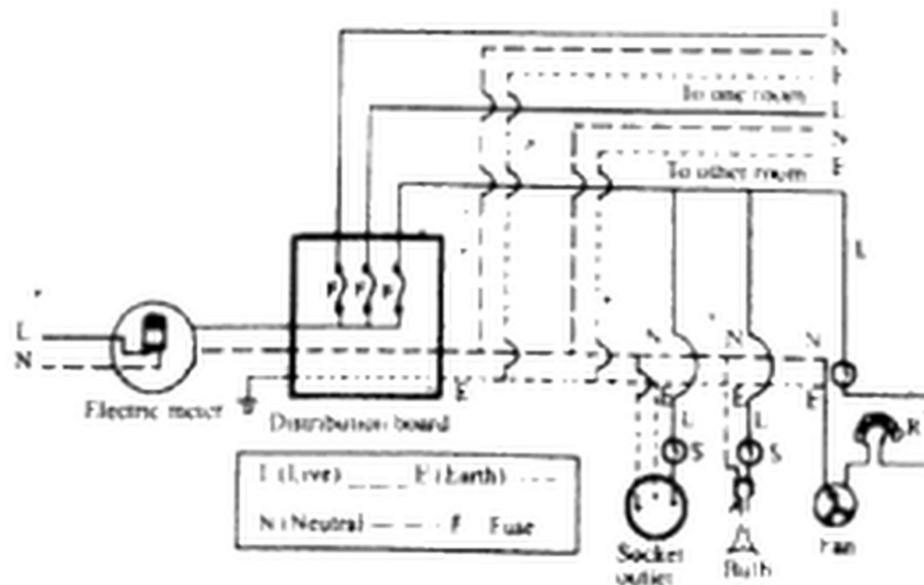


Fig 14.15 Wiring system of household electricity

If the fuse of one appliance burns out, it does not affect the other appliances. In house wiring, all appliances are connected in parallel with each other.

Q.16 Describe briefly the hazards of household electricity?

Answer

Electricity hazards

Major dangers of electricity are electric shock and fire. Some more faults in electrical circuits that may cause electricity hazards are given below.

Insulation damage

All electrical wires are insulated with some plastic cover for the purpose of safety. But when electrical current exceeds the rated current carrying capacity of the conductor, it can produce excess current that can damage insulation due to overheating of cables. This result into a short circuit which can severely damage electrical devices or persons. A short circuit occurs when a circuit with

a very low resistance is formed. The low resistance causes the current to be very large. When appliances are connected in parallel, each additional appliance placed in circuit reduces the equivalent resistance in the circuit and increases the current through the wires. This additional current might produce enough thermal energy to melt the wiring's insulation which causes a short circuit, or even starts a fire.

Short circuit can also occur when the live wire and the neutral wires come in direct contact as shown in fig. 14.16.

In order to avoid such situations, the wires carrying electricity should never be naked. Rather it should be covered with good insulator. Such an insulation covered wire is called cable. Constant friction may also remove the insulation from the wire whereas too much moisture also damages the insulation. In such a situation, it is advisable to use a cable with two layers of insulation.

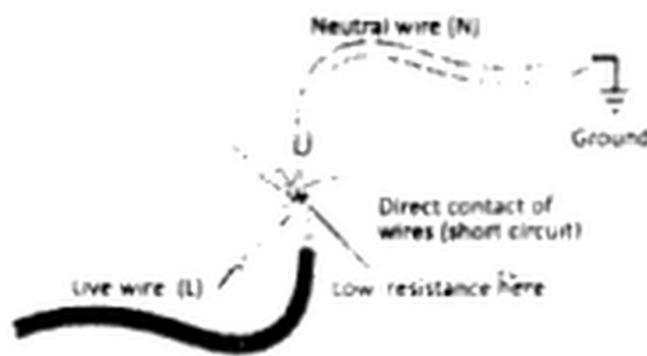


Fig. 14.16 Short circuit

Damp conditions

Dry human skin has a resistance of 105 ohms or more! But under damp conditions (wet environment) resistance of human skin is reduced



Warning sign: No fire



Do not fly kites near electricity lines. It may cause some fatal accident.

drastically to few hundred ohms. Therefore, never operate any electrical appliance with wet hands. Also keeps switches, plugs, sockets and wires dry.

Q.17 What is the use of a fuse in domestic electricity circuits?

Answer

Fuse

A fuse is a safety device that is connected in series with the live wire in the circuit to protect the equipment when excess current flows.

It is short and thin piece of metal wire that melts when large current passes through the circuit.

If a large, unsafe current passes through the circuit, the fuse melts and breaks the circuit, before the wires become very hot and cause fire.

Fuses are normally rated as 5A, 10A, 13A, 30A etc. Different types of fuses are shown in the figure 14.17.

The following safety measures should be taken while using fuses in household electrical circuits.

1) Fuses to be used should have slightly more rating than the current which the electrical appliance will draw under normal conditions. For example, for a lightening circuit choose a 5A fuse as the current drawn by each lamp is very small (about 0.4 A for a 100 W lamp).

In such circuit 10 lamps of 100 W can be safely used as the total current drawn is only 4A which can be calculated using the formula, $P = VI$

2) Fuses should be connected to the live wire so that the appliance will not become live alter the fuses has blown.



Think about: How do you find out if a fuse is blown? How do you replace a blown fuse?



Fig. 14.17 Different types of fuses

3) Switch off the main before changing any fuse.

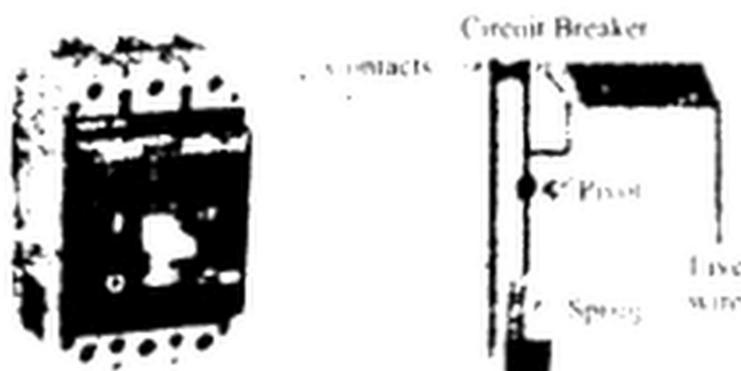
Q.18 What is the use of circuit breaker and earth wire in household circuits?

Answer

Circuit breaker

The circuit breaker as shown in the figure 14.18 acts as a safety device in the same way as a fuse. It disconnects the supply automatically if current exceeds the normal value. When the normal current passes through the live wire the electromagnet is not strong enough to separate the contacts.

If something goes wrong with the appliance and large current flows through the live wire, the electromagnet will attract the iron strip to separate the contacts and break the circuit as shown in the figure 14.19.



The spring then keeps the contact apart. After the fault is repaired, the contacts can then be pushed back together by pressing a button on the outside of the "circuit breaker box."

Earth wire

Sometimes, even the fuse cannot capture the high currents coming from the live wire into the household appliance.

Earthing further protects the user from electric shock by connecting the metal casing of the appliance to earth (a wired connection to the bare ground).

Many electrical appliances have metal cases, including cookers, washing machines and refrigerators. The earth wire provides a safe route for the current to flow through. If the live wire touches the casing as shown in the fig. 14.20, we will get an electric shock if the live wire inside an appliance comes loose and touches the metal casing.

However, the earth terminal is connected to the metal casing, so the current goes through the earth wire instead of passing through our body and causing an electric shock.

A strong current pass through the earth wire because it has a very low resistance. This breaks the fuse and disconnects the appliance.

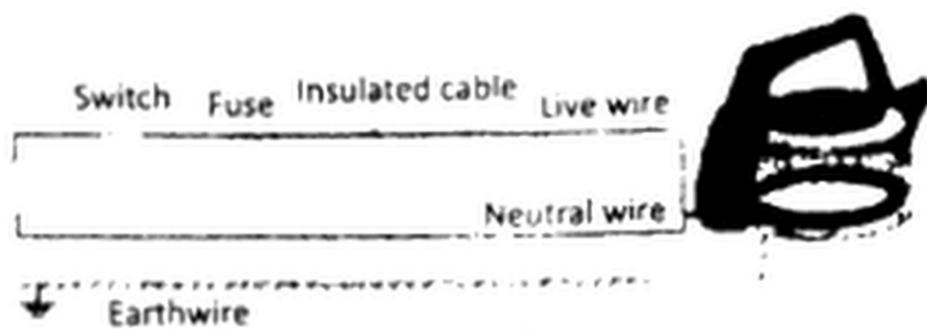


Fig. 14.20

