Chapter = 15

Current Electricity

Q1.What is a Current

Current

A current is motion of any charge moving from one point to another point.

Representation:

Current is represented by I.

Unit

The SI unit of current is ampere.

Nature

Current is a tensor quantity.

Mathematically

Current can be calculated by

$$I = \frac{q}{t}$$

Q2.Define Electronic current and Conventional current

Electronic current

When current flows from the negative terminal to the positive terminal of battery.

Conventional current

When current flows from the positive terminal to the negative terminal of battery.

Q3.Name and discus the Types of current

Types of current

There are two types of electric current.

1. Direct current (DC)
2. Alternating current (AC)

Direct current (DC)

A current that always flows in one direction only is called direct current.

Example The current we get from a battery is a direct current.

Alternating current (AC)

A current that reverses its direction periodically is called alternating current.

Example Most power stations in our country produce alternating current.

Q4.Differentiate between A.C and D.C.

Alternating Current	Direct Current

Safe to transfer over longer city distances and can provide more power.	Voltage of DC cannot travel very far until it begins to lose energy.
Rotating magnet along the wire.	Steady magnetism along the wire.
The frequency of alternating current is 50Hz or 60Hz depending upon the country.	The frequency of direct current is zero
It reverses its direction while flowing in a circuit.	It flows in one direction in the circuit.
Electrons keep switching directions - forward and backward.	Electrons move steadily in one direction or 'forward'.
A.C Generator and mains.	Cell or Battery

Q5.What are Advantage of AC over DC.

Advantage of AC over DC

One advantage of AC over DC is that it can be transmitted over long distances without much loss of energy.

Q6.DEFINE Potential difference. Give its formula and unit.

Potential difference The potential difference is the difference in the amount of energy that charge carriers have between two points in a field.

Mathematically

Equation of electric potential difference is

$$\Delta V = \frac{w}{q}$$

$$\Delta V = V_B - V_A$$

$$V_B - V_A = \frac{W}{q}$$

Unit

The unit of potential differences volt(V).

Define Electromotive force. Also write its formula and unit.

Electromotive force

The amount of energy required to move the charge from lower potential to higher potential of the battery is called electromotive force (EMF).

Mathematically:

$$\boldsymbol{EMF(\varepsilon) = \frac{Energysupplies(w)}{Unitcharge(q)}}$$

SI unit of EMF

The SI unit of EMF is volt(V).

CGS unit of EMF

The CGS unit of EMF: Stat volt or one erg per electrostatic unit of charge.

Q7.State Ohm's law. Also derive V = IR.

Ohm's law

Statement

The current flowing through the conductor is directly proportional to the potential difference across the two ends of a conductor, provided the physical state (Dimension, Temperature, etc) of the conductor remains same.

Mathematically:

According to ohm's law

$$I \propto V$$

$$I = KV$$

Where K is constant of proportionality called conductance or physical state of conductor. Conductance is opposite to resistance. Thus, K = 1/R

$$I = V/R$$

$$V = I R$$

Where R is the constant called resistance.

Q8.What are the limitation of Ohm's law

Ohm's law limitations

There are some limitations to ohm's law. They are as follows:

- Ohm's law is an empirical law which is found true for maximum experiments but not for all.
- Some materials are non-ohmic under a weak electric field.
- Ohm's law holds true only for a conductor at a constant temperature because resistivity changes with temperature.
- As long as the current flows, greater will be the temperature of the conductor.
- Heat produced in a conductor can be calculated by Joule's heat law $H= I^2Rt$ where I is current, R is resistance and t is time.
- Ohm's law is not applicable to in-network circuits.
- Ohm's law does not apply directly to capacitor circuits and inductor circuits.
- The V-I graph of ohmic conductors is not really a straight graph. It does show some variation.
- The V-I characteristics of diodes are much different from ohmic conductors V-I graph.

Q9.What do you know about Non-ohmic device? Also give example of it.

Non-ohmic device

The device that does not follow ohm's law is known as a non-ohmic device.

Example

The examples of non-ohmic devices are thermistors, crystal rectifiers, vacuum tube and diode etc.

Q10. What is resistance?

Resistance

The electrical resistance measures how much the flow of this electric charge is restricted within the circuit.

Mathematically:

$$R = \frac{V}{I}$$

Unit

The SI unit of electrical resistance is ohm(Ω).

Q11. What are the Factors affecting the resistance?

Factor affecting the resistance

- Electrical resistance is directly proportional to the length (L) of the conductor and inversely proportional to the cross-sectional area (A). It is given by the following relation.

$$R = \frac{\rho L}{A}$$

Where ρ is the resistivity of the material measured in Ω-m.

- Electrical resistance is inversely proportional to the temperature of metallic conductors.

Q12. Define Resistivity. State its uses.

Resistivity

Resistivity is a qualitative measurement of a material's ability to resist flowing electric current.

Uses of resistance

Resistance is also useful in things like transistor radios and TV sets.

The volume knob is actually part of an electronic component called a variable resistor. If you turn the volume down, you are actually turning up the resistance in an electrical circuit that drives the TV's loudspeaker. When you turn up the resistance, the electric current flowing through the circuit is reduced. With less current, there is less energy to power the loudspeaker - so it sounds much quieter.

Q13. What is a Circuit? Name the types of Circuit.

Circuit

The method of connecting the electric components is called circuit.

Types of circuits:

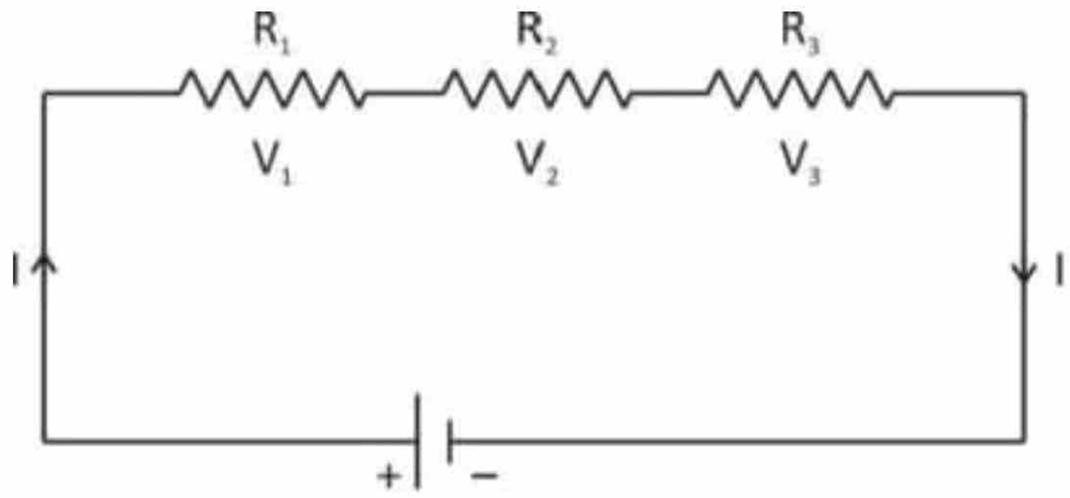
There are two types of circuits

1. Series combination circuit
2. Parallel combination circuit

Q14. Derive an expression of equivalent resistance the resistance connected in series

Series combination circuit

When resistors are connected end to end such that there is only one path for the current to flow then the combination is called series combination.



Derivation for Equivalent resistance

Let suppose three resistors R_1, R_2 and R_3 are connected in series, when this combination is connected to a battery of V volts, it draws current I from the battery. R_e is called equivalent resistor and its resistance is called equivalent resistance.

Then, for series combination

$$V = V_1 + V_2 + V_3 \qquad \text{.....(i)}$$

By applying Ohm's Law to each resistor. We have:

$$V_1 = IR_1,\ V_2 = IR_2,\ V_3 = IR_3$$

Using them in equation (i) we get:

$$IR = IR_1 + IR_2 + IR_3$$
$$IR = I(R_1 + R_2 + R_3)$$
$$R = R_1 + R_2 + R_3$$

Thus, equivalent resistance is equal to the sum of individual resistance.

Q15. List some Advantages and disadvantages of series resistance.

Advantages

1. It's employed when a large number of bulbs or lights need to be used at the same time.
2. Because the circuit receives less current, it is safer.
3. Because all the bulbs, lights and appliances are connected together, it's easier to turn them on or off.

Disadvantages:

1. Because all electrical appliances have only one switch, no single appliance may be turned off separately.
2. The second component of the circuit will not function if one component is used or quits operating.
3. Because the voltage is distributed in series or combination, not all of the components receive the same voltage.

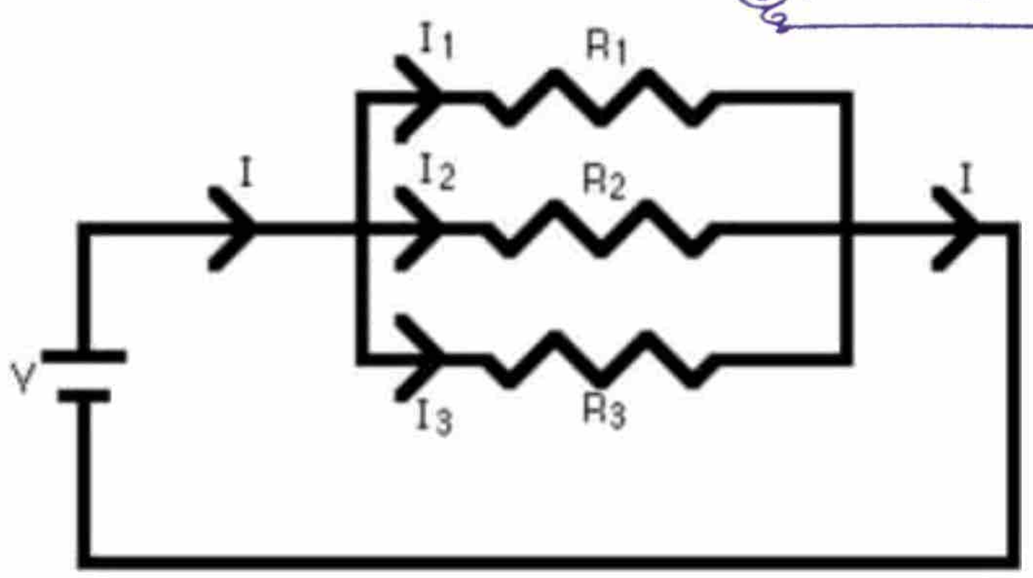
Q16. Derive an expression of equivalent resistance the resistance connected in series

Parallel combination circuits

When there are multiple paths for current flow in a circuit, the combination of resistance is referred to as parallel combination.

Derivation for Equivalent resistance

Let suppose three resistors R_1,R_2 and R_3 are connected in parallel. When the combination is connected to a battery of V volts, it draws a current I from the battery. R_e is called equivalent resistor and its resistance is called equivalent resistance.



Then, for parallel combinations

$$I = I_1 + I_2 + I_3$$

By applying Ohm's law to each register. We have:

$$V = IR \quad \text{or} \quad I = \frac{V}{R}$$

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

Using them in equation (i). We get:

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

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

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Thus the reciprocal of equivalent resistance is equal to the sum of reciprocals of individual resistances.

Q17. List some Advantages and disadvantages of parellel resistance.

Advantages:

1. Each appliance can be turned on or off independently.
2. The voltage of each electrical appliance is the same as the power supply line.
3. If one electrical appliance stops working due to a problem, the other appliances will continue to function.

Disadvantages:

1. Because the circuit can carry higher current, it is less safe.
2. If hundreds of appliances or lamps need to be turned on or off at the same time, this method is difficult to apply.

Q18. Define Electric power.

Electric power

The rate at which the work is being done in an electrical circuit is called an electric power.

Q19. What is Power dissipation

Power dissipation

The rate at which the heat is dissipated is called power dissipation.

Representation

It is represented by P.

Unit

The SI unit of power dissipation is Watts(W).

Mathematically:

$$P = IV$$

Or

$$P = I^2R$$

Or

$$P = \frac{V^2}{R}$$

Q20. Define the term Energy in resistors

Energy in resistors or components or circuits

Energy is dissipated when a particular amount of power is dissipated over a period of time.

Unit

The SI unit of energy dissipated is Joules (J).

Mathematically

The energy dissipated by a component or circuit can be estimated by including time(t) in the power formulas.

Energy dissipated = Pt Or

Energy dissipated = IVt Or

Energy dissipated = I^2Rt Or

Energy dissipated = $\frac{V_2 t}{R}$

Q21. What is Kilowatt hour

Kilowatt hour(kWh): The commercial unit of energy is kilowatt hour.

To calculate the kWh for a specific appliance, multiply the power rating (watts) of the appliance by the amount of time (hrs) you use the appliance and divide by 1000.

$$\text{Khw} = \frac{\text{watt} \times \text{time}}{1000}$$

Q22. State and explain Joule's law

Statement

When an electric current passes through a conductor, heat H is produced, which is directly proportional to the resistance R of the conductor, the time t for which the current flows, and to the square of the magnitude of current I.

Mathematically:

$$H \propto I^2Rt$$
$$H = I^2Rt$$

- The amount of generated heat is proportional to the wire's electrical resistance when the current in the circuit and time of flow are not changed.
- The amount of generated heat in a conductor carrying current is proportional to the square of the current flow through the circuit when the electrical resistance and time of flow are constant.
- The amount of heat produced because of the current flow is proportional to the time of flow when the resistance and current flow is kept constant.

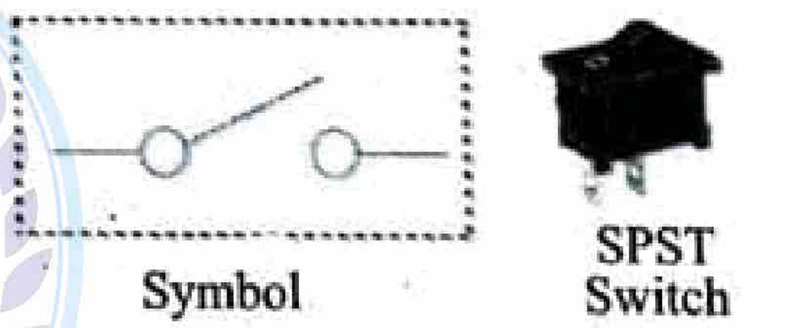
Q23. Discus some Electrical components or circuit components and their uses.

Electrical components or circuit components and their uses

The devices that make up an electric circuit are known as electrical components. Different components are used for different purposes.

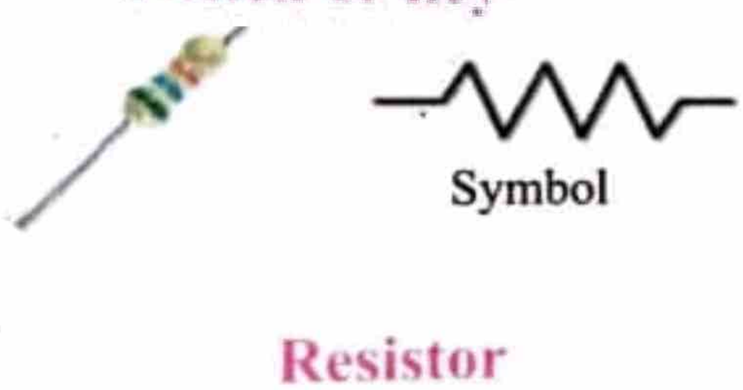
Switches or key:

It is one of the most fundamental electrical components.
it is used to turn electric circuits ON and OFF. This simply implies that when you press or flick a switch, current is allowed to pass through to the rest of the circuit.



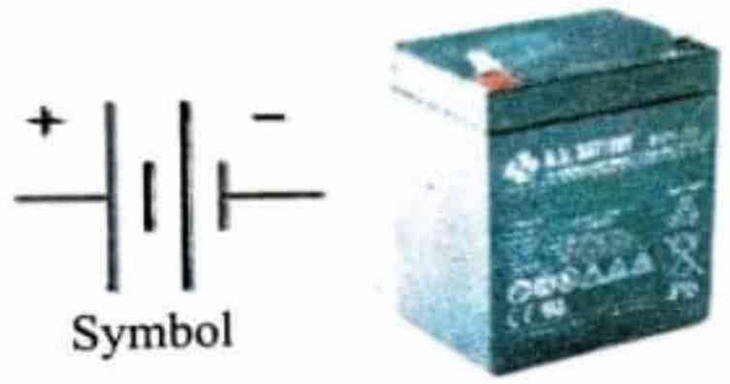
Resistor

It is a two-terminal electrical component that implements electrical resistance as a circuit element.



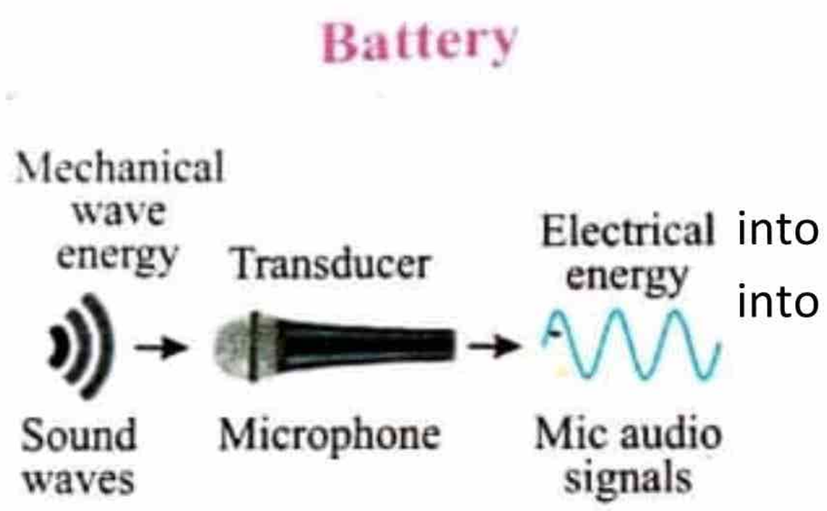
Battery

It is electrical source that store the chemical energy and converts the chemical energy into electrical energy.



Transducer

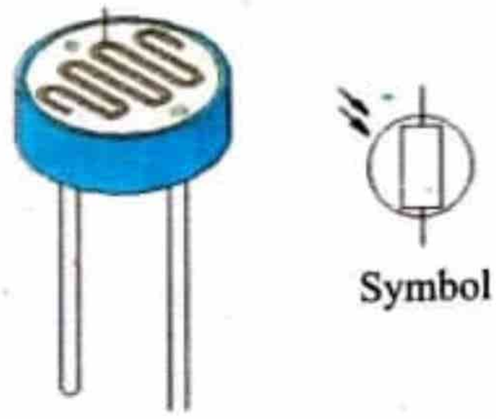
It is an electrical component that converts one form of energy into another form of energy like microphone converts sound energy into electrical energy/signal.



LDRs (Light Dependent Resistors)

A photoresistor or light dependent resistor is an electronic component that is sensitive to light. It is used in automatic security lights.

- In low light levels, the resistance of an LDR is high and little current can flow through it.
- In bright light, the resistance of an LDR is low and more current can flow through it.



Thermistors

It is thermally sensitive resistors whose resistance is strongly dependent on temperature. It is used to measure the temperature very accurately.

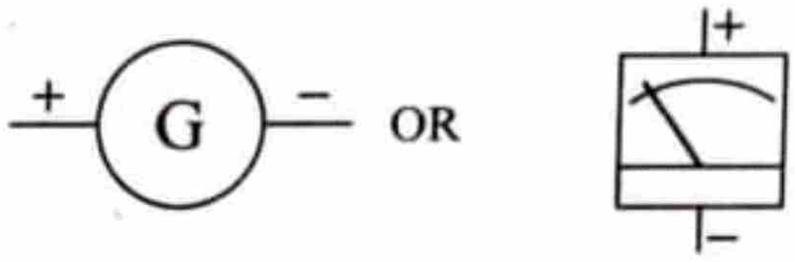
Relay

It switches which aim at OFF and ON the circuits electronically as well as electromechanically.

Q24. **what is Moving coil galvanometer?**

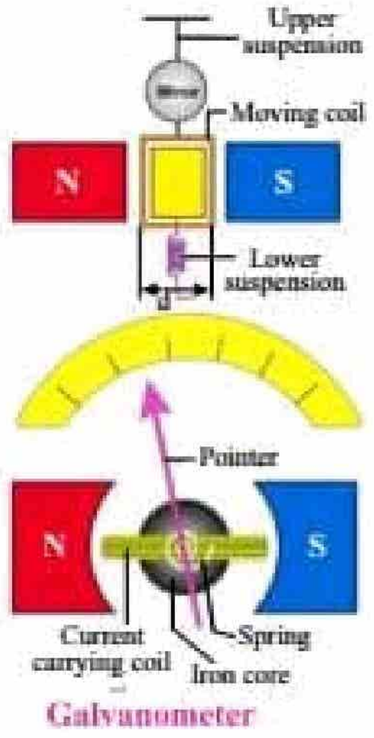
Moving coil galvanometer

It is an electromechanical instrument used to detect and measure small amount of current which is in the range between milliamperes or microamperes.



Working principle

This is a current detecting meter based on magnetic dipole torque.



Galvanometer

Q25. What is an ammeter? How galvanometer is converted in ammeter?

Ammeter

An ammeter is an electromechanical instrument used to measure electric current.

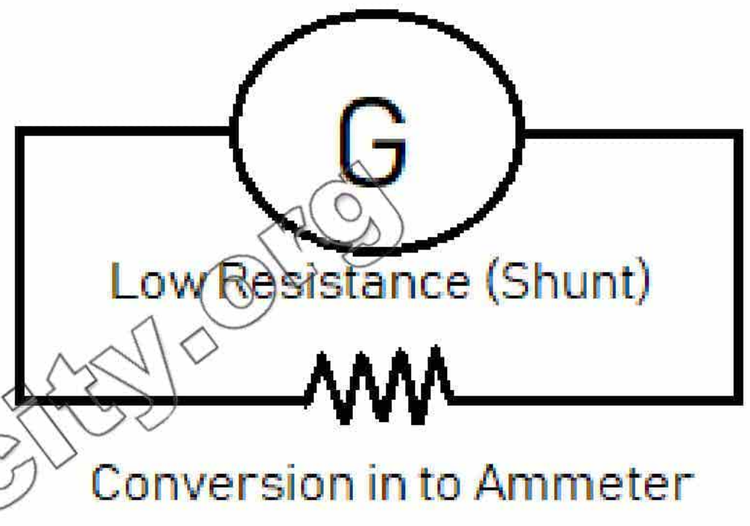
Conversion of galvanometer into ammeter

A galvanometer can be converted into an ammeter by connecting a low shunt resistance in parallel to the galvanometer.

Connection

An ammeter is used in a circuit always in 'series'.

Circuit diagram of ammeter



Conversion in to Ammeter

Symbol

Its symbol is (A).

Q26. What is an voltmeter? How galvanometer is converted in voltmeter?

Voltmeter

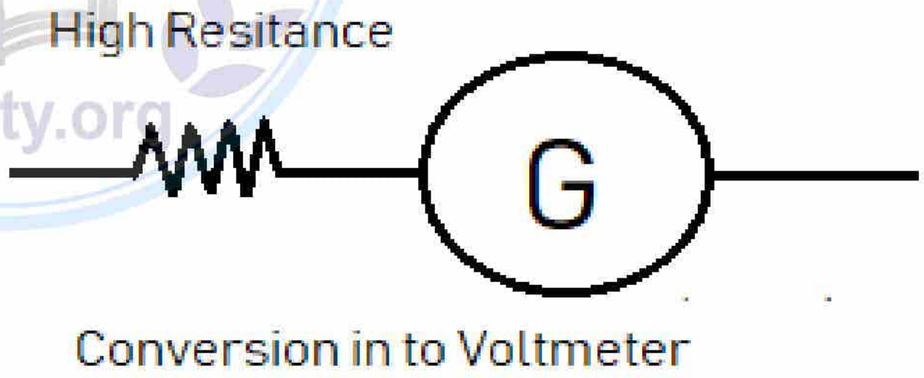
Voltmeter is an electromechanical instrument used to measure potential difference.

Conversion of galvanometer into voltmeter

A galvanometer can be converted into a voltmeter if a high resistance is connected in series with galvanometer.

Connection

A voltmeter is used in a circuit always in parallel.



Conversion in to Voltmeter

Symbol

Its symbol is (V).

Q27. What is Shunt resistor

Shunt resistor

A resistor having a very low value of resistance, such type of resistor is called shunt resistor.

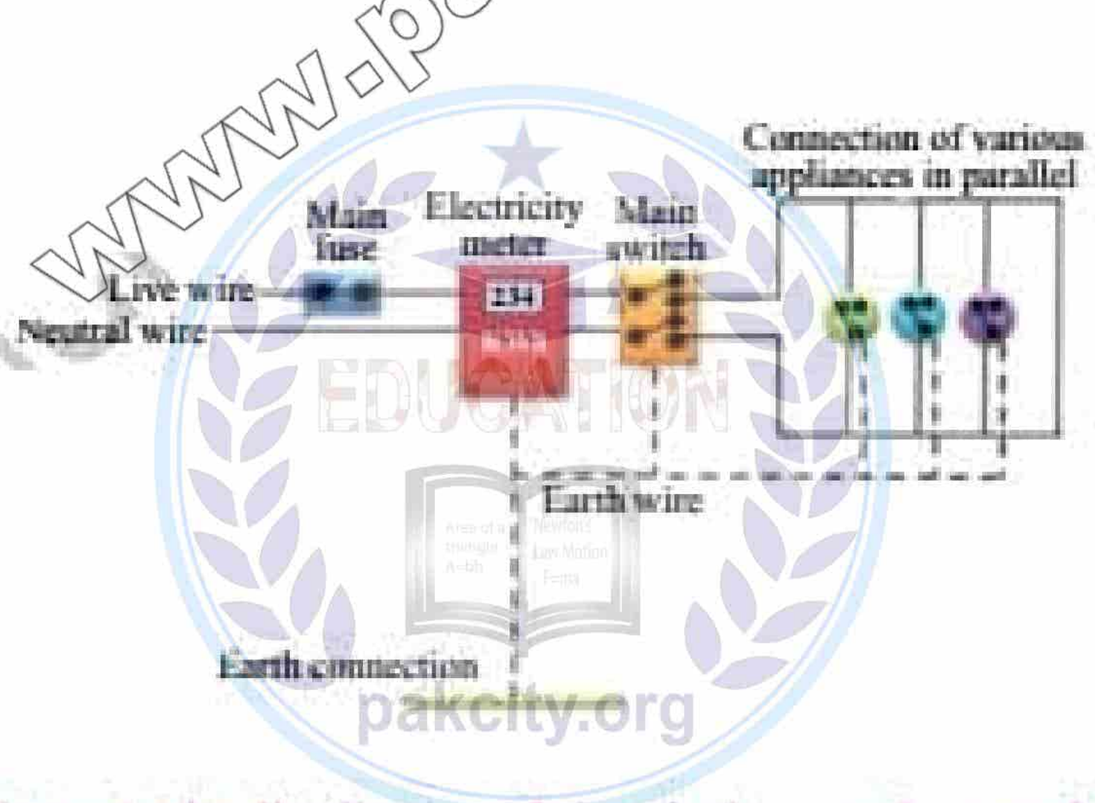
Q28. Write short note on Electrical Power transmission to a house

Electrical Power transmission to a house

There are three cables that provide electricity into the building. One is referred to as a **ground wire** or **earth wire(E)**. There is no current through this. The house's earth wire is connected to a buried metal plate.
The other cable, known as **neutral wire**, is grounded to the earth within the power plant itself to keep its voltage constant (N). The current flows back through this wire. The third wire, which has a high potential and is called the **livewire**, is connected to the battery (L). Difference in voltage between the live and neutral wires is 220 V.

The human body is a good conductor of electricity. If a person holds livewire, current will flow to the ground through his body, which could be dangerous. The live and neutral wires are used to connect all of the equipment in a home. All have the same potential difference; thus they are joined in parallel to the power source.

A connection has been made between the cables coming from the mains and the electricity meter that has been installed in the residence is shown in the figure. The electric meter's output goes to the main distribution board and subsequently the home electric circuit.
The main box has uses with ratings of about 30 A. Each appliance has its own connection made directly to the live wire. A fuse and a switch are used to connect the appliance terminal to the live wire. In the event that the fuse of one appliance blows, it will not have any impact on the functioning of the other appliances.



Illustrate the distribution of electrical power from main to the home appliances

Q29. What are the Hazards of electricity?

Hazards of electricity

Electrical shock, fire, and arc flashes are the primary hazards that are present in working with electricity. When the human body comes into contact with either or both of the wires in an electrical circuit or with one wire of an energized circuit and the ground, or with a metallic part that has become energized by contact with an electrical conductor, the result is an electric shock.

Electrical shock depends on the pathway through the body, the amount of current, the length of exposure, and whether the skin is wet or dry. Wet skin and wet conditions are good conductors of electricity.

Damaged Insulation

Insulation refers to the sheath made of plastic that is wrapped around wires in a circuit. If the insulation on a cable is damaged, the metal conductors inside will be exposed.

It is possible for a person to receive an electric shock if he comes into contact with the exposed wires, which could result in his death. Before replacing any damaged insulation, attempt to cover any damaged insulation with electrical tape, make sure that all power sources have been turned off and then replace that damaged insulation.

Overheating of cables

When a very high current is passed through a cable, there is a possibility that the wire will overheat as a result of the excessive amount of energy.

Because of the overheating, there is a risk of electrical fires.

Damp conditions

People who are in close proximity to an electrical appliance that is being used in a damp environment, such as a bathroom, have an increased risk of being electrocuted by the electricity that is being conducted through the water because water is a conductor. If a person touches a socket while their skin is wet in any way, they run the risk of being electrocuted.

Q30. Discus some of devices use for Safety measures in household electricity.

Safety measures in household electricity

To avoid any unwanted incident few measures must be taken which are given below:

Fuses: Fuses prevent damage to electronic components caused by overheating. When there is a significant amount of current running through the circuit, the wires that are contained within the circuit will begin to overheat. A metal wire fuse with a low melting point will become molten, breaking the circuit.

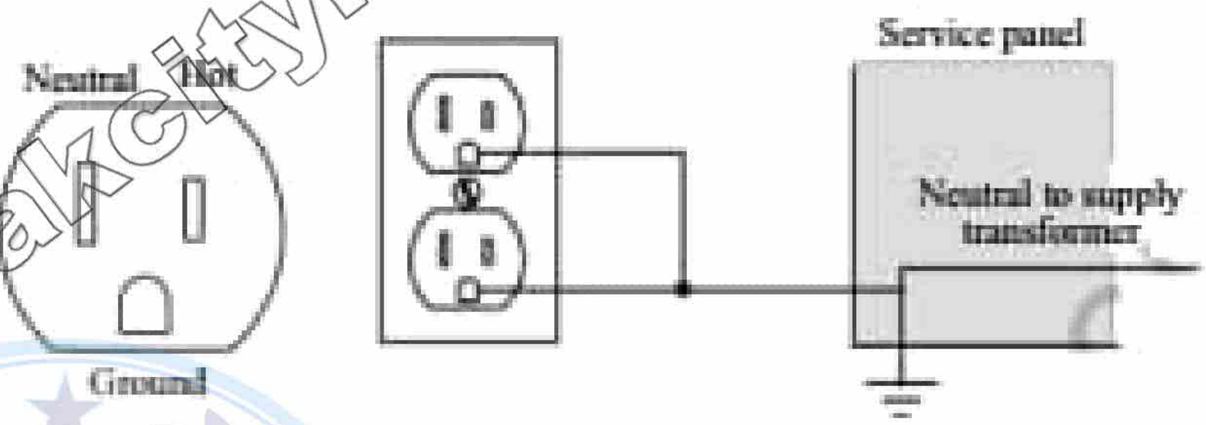
Different type of fuse used in electronic components

The Circuit-Breaker

Breakers prevent damage to electronic components caused by overheating. In the majority of applications found in the home, circuit breakers are used to restrict the amount of current flowing through a single circuit. Although the circuit breakers are available in a wide range of sizes, the maximum current that can flow through a single circuit is typically 20 amps. 20 amps of current will heat the bimetallic strip, bending it download and releasing the trip-lever. In the case of a high-current spike, the bimetallic strip will be rapidly retracted by a small electromagnet made from wire loops wrapped around a piece of iron.

The ground wires

The word 'ground' means that something is connected to the Earth, which stores charge. A ground wire gives an electrical appliance a path to the earth that is separate from the normal path that current takes. As a practical matter, it is connected to the electrical neutral at the service panel so that if there is an electrical fault, there is a path with low enough resistance to trip the circuit breaker as illustrated in figure.



Attached to an appliance's case, it keeps the case's voltage at ground potential (usually taken as the zero of voltage). In this way, electric shock is prevented.

Standard electric circuits

Standard electric circuits have a ground wire and either a fuse or a circuit breaker for safety.

Q31. List some Effects of electric shock on human body

Effects of electric shock on human body

- Electric current of 0.001 A can be felt.
- Electric current of 0.005 A can be painful for human body.
- If electric current is of 0.01 A, resulting in the contraction of muscles in an uncontrollable manner (spasms).
- Electric shock of 0.015 A can lead to a lack of control over the muscles.

- The electric current of 0.070 A passes through the heart; creates a significant disturbance; and is almost certainly fatal if the current continues for more than one second.

Chapter = 15

Multiple Choice Questions (MCQs)

1. In an electric circuit when electrons move from low to high potential they will:

(a) Gain energy (b) Lose their identity

(c) Lose energy (d) Gain potential

2. In an electric circuit an ammeter is always connected in

(a) series (b) parallel (c) mixed (d) none of the above

3. Resistance of a conductor does not depend on

(a) Length of the conductor (b) area of cross section

(c) Density (d) Resistivity

4. Ohm's law states that:

(a) Resistance increases as current increases

(b) Resistance decreases as current increases

(c) Resistance increases as voltage increases

(d) Current increases as voltage increases

5. The condition when the resistance of a circuit is zero is known as

(a) Closed-circuit (b) Open circuit (c) Short circuit (d) Zero circuit

6. The condition for the validity of Ohm's law is that the

(a) Temperature should remain constant (b) Current should be proportional to voltage

(c) Resistance must be wire wound type (d) All of the above

7. Ohm's law is not applicable to

(a) Semiconductors (b) D.C. circuits (c) Small resistors (d) High currents

8. Two resistances of 6Ω and 12 Ω are connected in parallel their net resistance is —--.

(a) 7Ω (b) 6Ω (c) 4Ω (d) 5Ω

9. The property of a body to oppose the flow of electric resistance through it is called electric —--.

(a) Capacitance (b) potential (c) resistance (d) conductance

10. Which of the following is the purpose of connecting a battery in an electric circuit?

(a) To maintain resistance across the conductor.

(b) To vary resistance across the conductors.

(c) To maintain constant potential difference across the conductor.

(d) To maintain varying potential difference across the conductor.

Ans:

1.Lose energy	2.series	3.Density	4.Current increases as voltage increases	5.Short circuit
6.All of the above	7.Semiconductor s	8. 4Ω	9.resistance	10.To maintain constant potential difference across the conductor.

Numerical

1. When the current in a pocket calculator is 0.0002 A, how much charge flows every minute? (12mC)
2. Calculate the amount of current that an electric heater uses to heat a room in 5 minutes if the charge is 2100 C. (7 A)
3. A potential difference of 90 V exists between two points. The amount of work done when an unknown charge is moved between the points is 450J. Determine the charge amount (5 C)
4. Calculate the potential difference between two points A and B if it takes $9x10^4$J of external work to move a charge of +9 HC from A to B. (100 V)
5. The potential difference applied to a portable radio terminal is 6.0 Volts. Determine the resistance of the radio when a current of 20 mA flows through it. (300 Ω)
6. Resistances of 4 Ω, 6 Ω, and 12 Ω are connected in parallel and then connected to a 6V emf source. Determine the value of
    1. The circuit's equivalent resistance. (2 2)
    2. The total current flowing through the circuit. (3 A)
    3. The current that flows through each resistance. (1.5 A, 1 A, 0.5 A)
7. A 220 V circuit is used to power two 120 watt and 80 watt light bulbs. Which bulb has the greater resistance and which one has the higher current? (80 W bulb, 120 W bulb)

Worked Example 1 How much voltage will be dropped across a 50 kΩ resistance whose current is 300 μA?

Worked Example 2 Find the current passing through circuit and the voltage across each of the resistors. 100Ω, 400Ω and 200Ω Resistors in series.

Worked Example 3 100J of heat is produced each second in a 4 Ω resistance, Find the potential difference across the resistor.