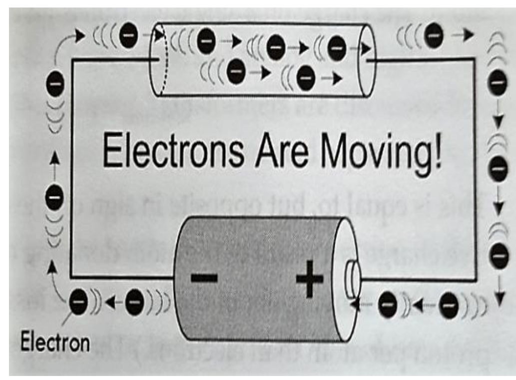
Chapter = 14

CURRENT ELECTRICITY

CURRENT ELECTRICITY

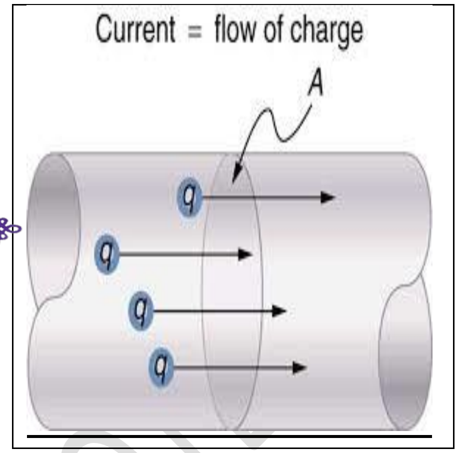
Definition: -

The scientific study of a moving electric charge is known as current electricity. OR
The branch of physics that deals with the charges in motion is known as current electricity.
Other Name:-The current electricity is also known as electrodynamics.



Electric Circuit:- The path followed by current is known as electric circuit

ELECTRIC CURRENT



Definition:-The rate of flow of electric charges through any cross – sectional area of a conductor is known as electric current. OR

The time rate of flow of charges is known as electric current.

Symbol: -It is denoted by **"I".**

Mathematical form:- Electric Current = $\frac{Electric\ charges}{time}$

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

Unit: - Its SI unit is ampere (A).

$$1A = \frac{1C}{1s} = 1CS^{-1}$$

Ampere: - "Current is said to be one ampere if one coulomb charge flow through any section of a wire in one second".

Submultiples of Ampere: -

- $1mA = 10^{-3}A$
- $1uA = 10^{-6}A$ etc.

Quantity: - It is a scalar quantity because it does not follow vector law of addition.

Nature: - It is a base quantity.

Cause of current:-It may be caused by

(i) Free electrons i-e negative charges in metals.

(ii) Positive charges i-e protons in Van de Graff accelerator.

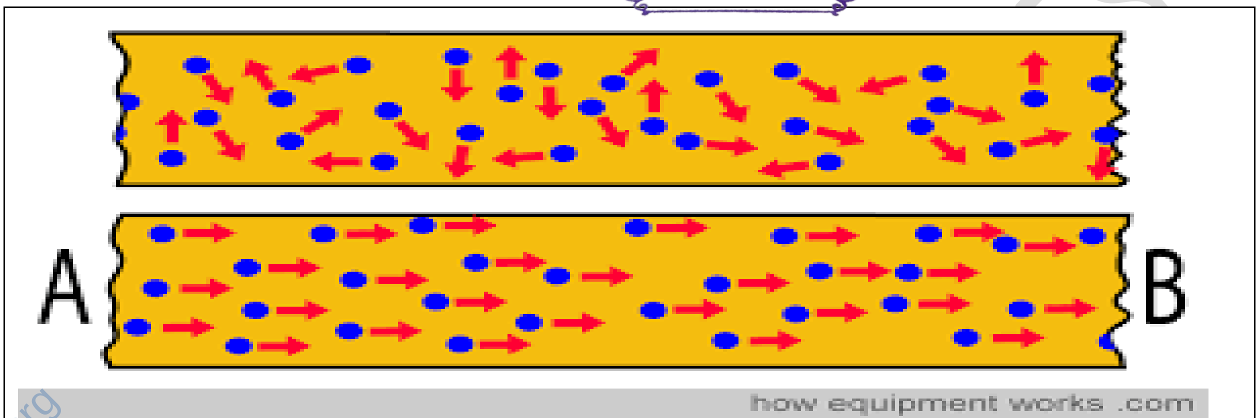
(iii) Both positive and negative charges in electrolytes etc.

Measurement: - It is measured with the help of

- Galvanometer
- Ammeter

THE MECHANISMS OF THE FLOW OF ELECTRIC CURRENT IN A CONDUCTOR

As we know that a conducting wire consists of large number of free electrons. In the absence of an external field, the resultant velocity of the randomly moving free electrons is zero. At any place of the wire the current is zero. The free electrons in the wire can be given a net resultant velocity along the wire by means of a battery which sets an electric field along the wire. In this way an electric current can be made to flow in a conducting wire as shown in figure.

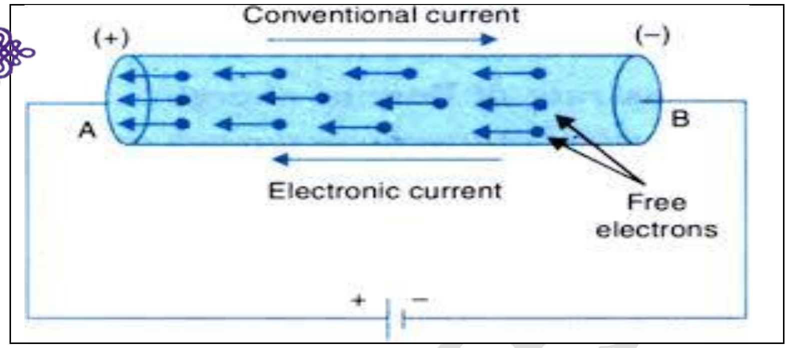


CONVENTIONAL CURRENT

Definition: -
The current due to the flow of positive charges is known as conventional current.
Symbol: - It is denoted by "I_+".
Mathematical: - $I_+ = \frac{+Q}{t}$
Unit: - Its SI unit is "Ampere".
Quantity: - It is a scalar quantity.
Nature: - It is a base quantity.
Direction: - It flow from higher (+ve plate) to lower (-ve plate) potential.

Example: - The current produced in nuclear accelerator due to the flow of positive charges (protons) etc.

Flow in Circuit:-



ELECTRONIC CURRENT

Definition: - "The current due to the flow of electrons or negative charges is known as electronic current".

Symbol: - It is denoted by "I_-" .

$$I_- = \frac{-Q}{t}$$

Unit: - Its SI unit is "ampere".

Quantity: - It is a base quantity.

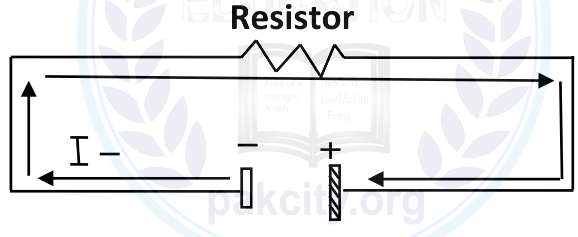
Measurement: - It is measured with the help of

- Ammeter
- Galvanometer

Direction: - It flows from lower (-ve plate) to higher (+ve plate) potential.

Example: - The flow of current in metallic conductors etc.

Flow in Circuit: -



NOTE:- **(i)**Both conventional and electronic currents equivalently affect the wire.
(ii) In liquids gases both conventional and electronic current flow.

DIFFERENCE BETWEEN ELECTRONIC CURRENT AND CONVENTIONAL CURRENT

ELECTRONIC CURRENT	CONVENTIONAL CURRENT
This current is produces due to the flow of electrons.	This current is produces due to the flow of electrons.
It is denoted by " I_- ".	It is denoted by " I_+ ".
It mathematical form: $I_- = \frac{-Q}{t}$	It mathematical form is $I_+ = \frac{+Q}{t}$
It flows from lower to higher potential.	It flows from higher to lower to potential.
It flows in direction against the direction of field.	It flows in direction along the direction of field.
Example: - The current flow in all metallic conductors etc.	Example:-The current produced in nuclear accelerator due to the flow of positive charges (protons) etc.

ELECTRO MOTIVE FORCE

Definition: - "The source of energy which brings the charge in motion in a conductor".

OR

"The energy needed to move a charge through the whole circuit including the battery".

Abbreviation: -It is abbreviated by "e m f ".

Symbol: -It is de denoted by "ε"(Epsilon).

Mathematical form: - Electro Motive Force = $\frac{\text{energy supplied}}{Charge}$

$$\varepsilon = \frac{E}{q} \quad \text{OR} \quad \varepsilon = \frac{W}{q}$$

Unit: - Its SI unit is volt.

Explanation: - As we know a current can be maimed in a closed circuit through the use of source of emf i-e source of energy. The emf source is the "charge pump" that forces charges to move around a circuit . The emf of a source describes the work done per unit charge.

Note: - e.m.f is a cause of potential difference.

Sources of e m f: -

Definition: - "Those sources which convert non-electrical energy into electrical energy are known as sources of emf ".

Example: -

- A generator converts mechanical energy into electrical energy.
- A thermo couple converts heat energy into electrical energy.
- A solar cell converts light energy into electrical energy etc.

POTENTIAL DIFFERENCE

Definition:- "The energy consumed by a charge in a circuit". OR "The energy used by a charge in a circuit".

Abbreviation: - It is abbreviated by "P.D".

Symbol: -It is denoted by "V".

Other Name: -It is also called "Voltage".

Mathematical form: - Potential Difference = $\frac{\text{Energy used}}{Charge}$

$$\text{P.D} = \frac{\text{E}}{q}$$

Unit: - Its SI unit is Volt.

Explanation: - when a conductor is connected across the terminals of the battery, the charge leaving the positive terminal of the battery has potential energy. It loses this potential energy in a device (resistor) as heat for instance and returns to negative terminal of the battery with negligible potential energy. That is there is a difference in potential energy per coulomb from one side of the resistor to the other. This difference is called potential difference.

NOTE:- Potential difference is the effect of emf.

VOLT:-

Definition: - The energy consumption of **one** joule per electric charge of **one** coulomb.
1V = 1J/C.
One volt is equal to current of **1** amp times resistance of **1** ohm: 1V = 1A · 1Ω

DEFFERENCE BETWEEN POTENTIAL DIFFERENCE AND ELECTROMOTIVE FORCE

POTENTIAL DIFFERENCE	ELECTROMOTIVE FORCE
The energy used by a charge in a circuit.	The energy needed to move a charge through the whole circuit including the battery
It is abbreviated by "P.D".	It is abbreviated by "e m f ".
It is denoted by "V".	It is denoted by " $\boldsymbol{\varepsilon}$ ".
Its mathematical form is P.D = $\frac{E}{q}$	Its mathematical form is $\boldsymbol{\varepsilon} = \frac{E}{q}$
It is the effect of emf.	It is a cause of potential difference.

OHM'S LAW

History: - This law was presented by a German Scientist G.S Ohm in 1826.
Purpose: - To show the relation between voltage and current.
Statement: -The current through an electrical conductor is directly proportional to the applied voltage, if the temperature and other physical conditions remains constant. OR The current in a conductor is directly proportional to the applied voltage as long as temperature and physical state of the conductor is kept constant.
Mathematical form: -

Current ∝ Voltage

$$I \propto V$$

$$I = \text{constant } (V)$$

$$I = k\,(V) \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

In equation (1) "k" is the constant of proportionality and is equal to 1/R, where "R" is called the resistance of the conductor. Then equation (1) becomes

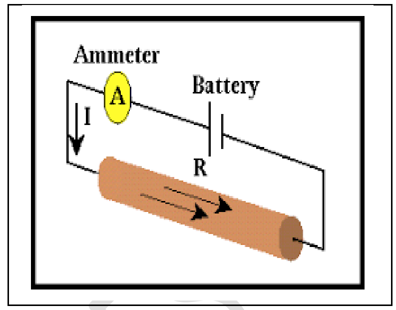
$$I = \frac{1}{R}(V)$$

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

OR V = IR ………………… (2)

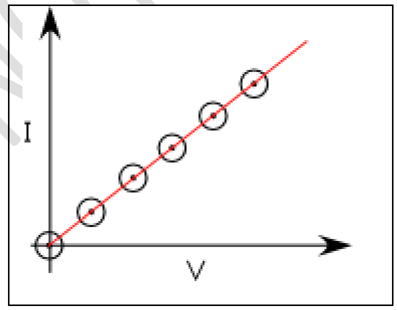
Equation (2) represents the mathematical form of **"OHM'S LAW".**

Circuit Diagram:-



Graphical Representation: - If we plot a graph between voltage and current, we get a straight line (graph).

Limitation: -This law is only applicable for metallic conductors.



ELECTRICAL RESISTANCE

Definition: -The property of a substance which offers opposition to the flow of current through it is known as resistance. OR

The opposition offered to the flow of charges is known as resistance. OR

It is a measure of opposition to the flow of current through a conductor.

Cause: - It is arises due to the collision of electrons with the atoms in the conductor.

Symbol: - It is denoted by "R".

Mathematical form: - Resistance = $\frac{\text{The voltage across the condutor}}{\text{The current through the conductor}}$

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

Unit: - The SI unit of resistance is "Ohm".

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

The resistance of a conductor will be one Ohm if a potential difference of one volt is across its ends causes one ampere current to flow through it.

Symbol: -It is denoted by "Ω" (Greek letter omega).

$$\Omega = \frac{1V}{1A}$$

Factors of resistance: - The resistance of a conducting wire depends upon the following factors.

i. Nature of the conducting wire.

ii. Length of the conducting wire.

iii. Area of cross-section of the conducting wire.

iv. Physical state of the conducting wire.

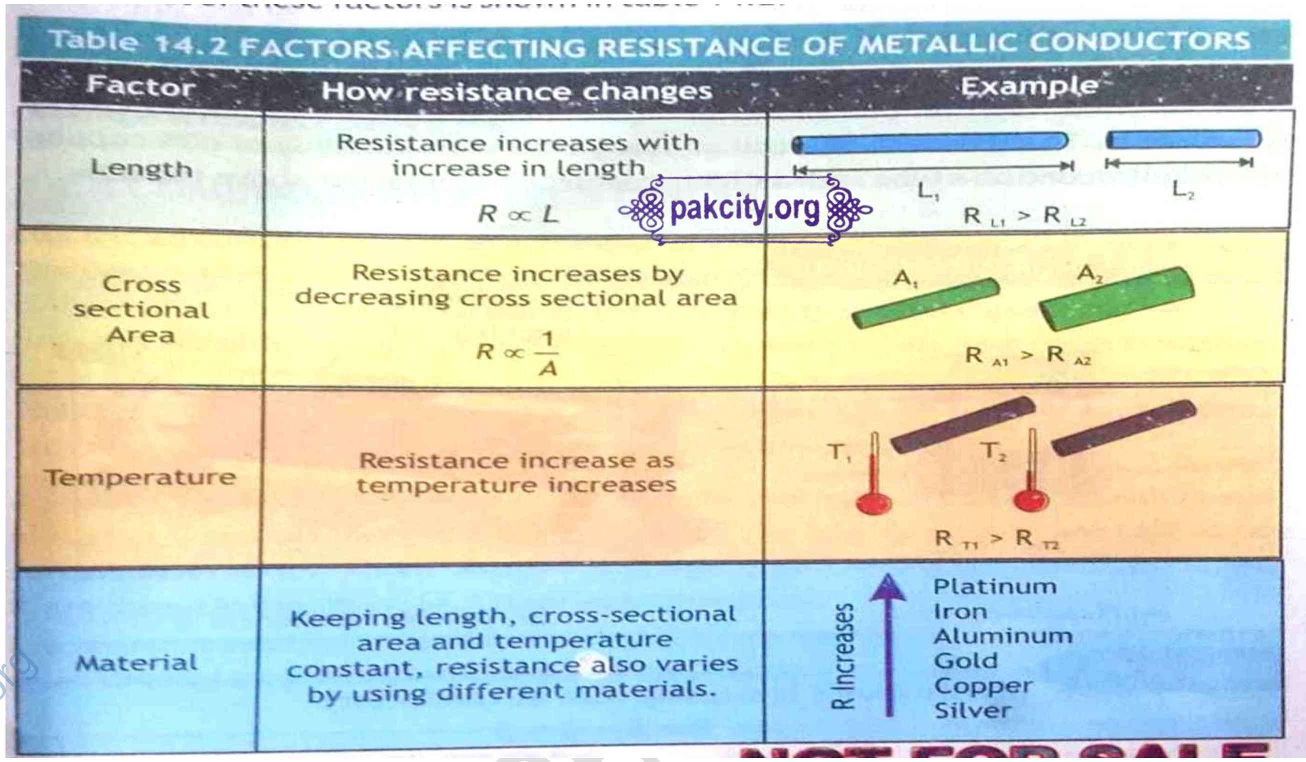


Table 14.2 FACTORS AFFECTING RESISTANCE OF METALLIC CONDUCTORS

Factor	How resistance changes	Example
Length	Resistance increases with increase in length $R \propto L$	L_1, L_2; $R_{L1} > R_{L2}$
Cross sectional Area	Resistance increases by decreasing cross sectional area $R \propto \frac{1}{A}$	A_1, A_2; $R_{A1} > R_{A2}$
Temperature	Resistance increase as temperature increases	T_1, T_2; $R_{T1} > R_{T2}$
Material	Keeping length, cross-sectional area and temperature constant, resistance also varies by using different materials.	R Increases: Platinum, Iron, Aluminum, Gold, Copper, Silver

RESISTIVITY

Definition: - "The resistance of a conductor of unit length and having unit area of cross-section".

Other name: - It is also called specific resistance.

Symbol: -It is denoted by "ρ" (Greek letter Rho).

Mathematical form: - $\rho = \frac{RA}{L}$

Explanation: - As we know that the resistance of a conducting wire depends upon its length, area of cross-section, nature and temperature.

Form experiments the resistance of a conducting wire is

(i) Directly proportional to its length i-e

$R \propto L$ ………………………… (C)

(ii) Inversely proportionally to its area of cross-section.

$R \propto \frac{I}{A}$ ……………………… (D)

- By combining equation(C) and (D) we get

$$R \propto (L)\left(\frac{I}{A}\right)$$

$$R = (\text{Constant})\,\frac{L}{A}$$

$$R = \rho\left(\frac{L}{A}\right)$$

$$\rho = \left(\frac{RA}{L}\right)$$

$$\rho = \frac{RA}{L} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (E)$$

❖ **In equation (E):-**

- "ρ" is the proportionality constant and is known as specific resistance.
- "ρ" is an intrinsic property of the conductor.

Unit: - Its SI unit is "Ω-m" (ohm-meter).

Note: - if L = 1m and A = 1m^2 then equation (E) becomes

$$\rho = \frac{RA}{L} = \frac{R \times 1}{1} = R \quad \text{Or} \quad \rho = R$$

Metal	Specific Resistance	Metal	Specific Resistance
Silver	1.5×10^{-8} Ωm	Lead	22×10^{-8} Ωm
Copper	1.7×10^{-8} Ωm	Quartz	75×10^{16} Ωm
Aluminum	2.82×10^{-8} Ωm	Carbon	3.5×10^{5} Ωm
Tungsten	503×10^{-8} Ωm	Platinum	10.6×10^{-8} Ωm

Why the resistance of a conductor increases with the rise in temperature?

Ans:- **Statement**:- The resistance of a wire increase with increase in temperature of wire.

Reason: - Due to the collision of electrons with the atoms in the conducting wire.

Explanation: - When a conducting wire is heated, the energy of its atoms is increases. Due to which the amplitude of vibration of atoms increase, so as a result the collisions of electrons with these atoms now offer greater resistance to the flow of electrons (current).

Conclusion: - As conclusion we find that the resistance of a wire increase with increase in temperature of the wire.

RESISTOR

Definition:- A device which is used in a circuit to reduce the current is known as resistor. OR

A wire or an electrical device that offers resistance to the flow of charges is known as resistor. OR

Devices intended to have a specific value of resistance are known as resistor. OR

A device which control current in a circuit to reduce the current is known as resistor.

Constructed Materials:- They are made either from wires of special alloys or carbon.

Symbol:- Its symbol in electrical circuit is zigzag line. "  "

Explanation:- The resistance can have a wide range of values. The copper wires in a television set, for instance, have a very small resistance. On the other hand, commercial resistors can have resistance up to many kilo-ohms (1 kΩ = $10^3\ \Omega$) or mega - ohms (1 MΩ = $10^6\ \Omega$).

Types of resistors: - There two types of resistors which are given below.

(1) Fixed Resistors **.**

(2) Variable Resistors.

COMBINATION OF RESISTORS

Definition: - The Combination of two or more than two resistors connected in any manner is known as combination of resistors.

Explanation:- Some time we required resistors of smaller or larger resistance which are not available in the market. Now in order to get the resistor of the required resistance we combine the resistor together. This required resistance is known as equivalent resistance. The arrangement of resistance in a circuit affects the current through each resistor and the voltage drop across each resistor.

Basic Ways of Combination of Resistors: -

1. Series Combination of resistors.
2. Parallel combination of resistors.

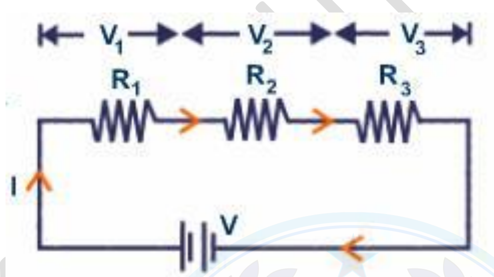
SERIES COMBINATION OF RESISTORS

Definition: - The end to end connection of two or more than two resistors with each other is known as series combination of resistors. OR

When the resistors are connected end to end in such a way that there is a single path for the flow of current are said to be connected in series.

Purpose: - To get high equivalent resistance.

Explanation: - Let us consider three resistors R_1, R_2 and R_3 are connected with a battery of voltage "V" in series as shown in figure.



CHARACTERISTICS OF SERIES COMBINATION OF RESISTORS

(i) It provides only one path for current flow.

(ii) The same current pass through each resistor. i-e

$I_1 = I_2 = I_2 = I$

(iii) The voltage is different across each resistor i-e. $V_1 \neq V_2 \neq V_3$

(iv) The voltage of the circuit will be equal to the sum of individual voltage across.

$V = V_1 + V_2 + V_3$ ………………. (A)

(v)From ohm's law: - $V = I R$ ……………………. (B)

Now for "V" from equation (B)

$V = I R_e$

$V_1 = I R_1$

$V_2 = IR_2$

$V_3 = IR_3$

(vi)For the equivalent resistance "Re" of the combination: -

By putting the values of V, V_1, V_2 and V_3 in equation (A) we get

$I R_e = IR_1 + R_2 + IR_3$

$I (R_e) = I (R_1 + R_2 + R_3)$

$I (R_e) = I (R_1 + R_2 + R_3)$

$R_e = R_1 + R_2 + R_3$ ……………………………………… (c)

vii. For N-resistors the equation (c) becomes

$R_e = R_1 + R_2 + R_3 + \text{-------------} + R_n$

Note: - Hence in this case "R_e" is equal to the sum of the individual resistance.

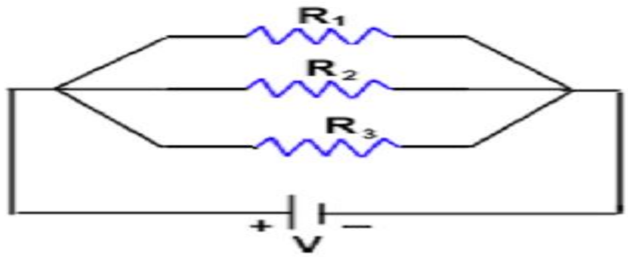
PARALLEL COMBINATION OF RESISTORS

<u>Definition</u>: - The combination of two or more than two resistors in which each and every resistor is parallel to each other known as parallel combination of resistors. OR

When the resistors are connected in different branches of the circuit in such a way that there is more than one path for the flow of current, resistors are said to be connected in parallel.

<u>Purpose</u>: - To get small equivalent resistance.

<u>Explanation</u>: - Let us consider three resistors R_1, R_2 and R_3 are connected with a battery of voltage "V" in parallel as shown in figure.



CHARACTERISTICS OF PARALLEL COMBINATION OF RESISTORS

(i) It provides more than one path for current flow.

(ii) The same voltage across each resistor i-e

$V_1 = V_2 = V_3 = V$

(iii) The different current pass through each resistor i-e $I_1 \neq I_2 \neq I_3$

(iv) The current of the circuit will be equal to the sum of individual current pass through each resistor i-e $I = I_1 + I_2 + I_3$

(v) From ohm's law: - $V = I R$ .... (K)

(vi) Now from equation (K) for

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

(vii)For equivalent resistance "R_e" of the combination:-

By putting the values of I, I_1, I_2, and I_3 in eq (K) we get

$$\frac{V}{Re} = \frac{V}{R1} + \frac{V}{R2} + \frac{V}{R3}$$

$$V\left(\frac{1}{Re}\right) = V\left(\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}\right)$$

For n-resistor:-

$$\frac{1}{Re} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \text{-----------} + \frac{1}{Rn}$$

<u>Note</u>: - Hence in this case the reciprocal of equivalence resistance is equal to the sum of the reciprocals of the individual resistance.

CONDUCTORS

<u>Definition</u>: - Those materials through which electric charges (electric current) flow easily are known as conductors.

Cause: - As we know that in conductors the valence electrons are not bound to the respective atom, but can move within the solids. These electrons are known as free electrons. The conductors having large number of free electrons often called electron gas.

Examples: -Iron, gold silver, copper, etc.

INSULATORS

Definition: - Those materials through which electric charges don't flow easily are known as insulators.

Other Name: - They are also called non-conductors.

Cause: - As we know that in insulators the valence electrons are tightly bound to the respective atoms, therefore electric current cannot flow easily through insulators.

Examples: - Dry wood, plastic, rubber, glass, paper, cloth etc.

THE I –V CHARACTERISTICS FOR OHMIC AND NON OHMIC CONDUCTORS

OHMIC CONDUCTORRS:-

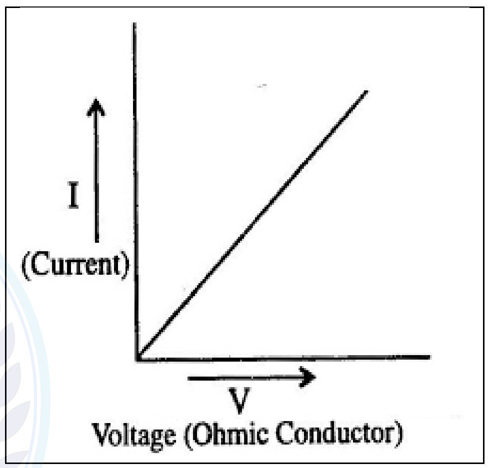
Definition:- Those conductors for which ohm's law is completely valid are known as Ohmic conductors.

Relation:- $V \propto I$ is valid

Resistance :- constant resistance

Examples :-

- Metals
- Some alloys .



Graph:-If we plot a graph for given values of current and voltage we get a straight line as shown in figure.

NON- OHIN CONDUCTORS :-

Definition: - Those conductors for which ohm's law is not valid are known as non-ohmic conductors.

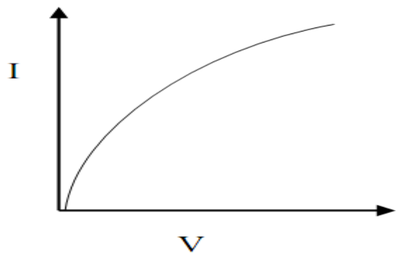
Relation :- $V \propto I$ is not valid

Resistance :-variable resistance

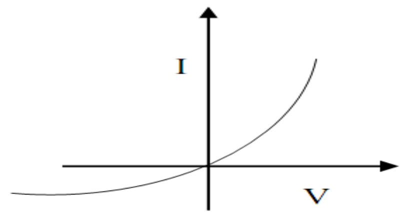
Examples :-

- Filament of an electric bulb.
- Thermistor etc

Graph :- If we plot a graph for given values of current and voltage we get a curve line as shown figure.



Filament of bulb



Thermistor

Electric Energy

Definition:-The energy which is caused by the moment of electrons from one place to another place is known as electrical energy. OR

The energy which is obtained from electric current is known as electrical energy.

Explanation:-

Let “V” be the potential difference between two points in a electric field, Let “Q” be the charge displaced between these two points by “W” amount of work done then by definition.

$$\text{Electrical potential} = \frac{Work\ done}{Cnarge}$$

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

OR $V = WQ$

Electrical energy = W = Q × V ………….. (1)

- This work is stored in the charges in the form of electrical energy.

As $I = \frac{Q}{t}$ OR Q = I x t then equation (1) becomes

Electrical energy = W = I x t × V ……………………….. (2)

As V = IR Then equation (2) becomes

Electrical energy = W = I x t × IR = I^2 R t ………………… (3)

As $I = \frac{V}{R}$ Then equation becomes (2)

Electrical energy = W = $\frac{V}{R}$ x t × V = $\frac{V^2 t}{R}$ ………………… (4)

This energy can be utilized for different function. For examples fans convert this energy into mechanical energy, bulb into light, and heaters into heat. This is the reason that we get heat when current passes through a heater.

JOULE'S LAW

History:-This law was presented by a British Physicist J. P joule in 1841.

Purpose: - To find the relationship between the current through resistance and the heat dissipated.

Statement:-The amount of heat (H) generated in a resistance due to the flow of charges is equal to the product of square of current (I^2), resistance (R) and the time duration (t).

Mathematical Form: - From the above statement

$H \propto I^2$ ……………………… (i)

$H \propto R$ ……………………… (ii)

$H \propto t$ ……………………… (iii)

By combining equations (i),(ii) and (iii) we get

$H \propto I^2 R t$

$H = \text{constant} (I^2 R t)$

$H = (\frac{1}{J}) I^2 R t$

Constant = $\frac{1}{J}$

$H = \frac{I^2 R t}{J}$ ………………… (iv)

(a) Equation (iv) represents the mathematical form of Joule's law of heating.

(b) "J" is called joule's mechanical equivalent of heat. Its value depends upon the choice of units of work and heat.

Verification:- This law can be verified in the laboratory by using **Joul,s Calorimeter**
.

ELECTRIC POWER

Definition:- The rate at which the work is done in an electric circuit is known as electric power.

Symbol:- It is denoted by "**P**".

Mathematical form:- Electric power = $\frac{Work\ done}{time}$

$$P = \frac{W}{t}$$

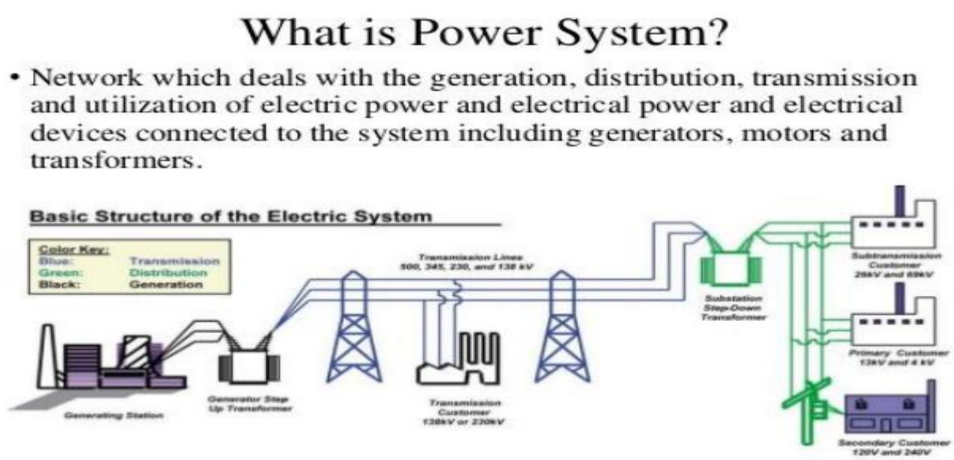
Unit:- Its SI unit is Watt (W) .

Watt :- A power of one watt is said to be consumed in a circuit if a potential difference of one volt causes a current of one ampere to flow through it.

1 watt = 1V X 1A

Other units:- Its bigger units are

- 1 kw =1000 watts = 10^3 watt
- 1 Mw= 10^6 watts
- Kilowatt- hours.



KILOWATT- HOURS

Definition:- The amount of energy obtained by a power of 1 kilowatt in one hour.

Explanation:- Electric energy is commonly consumed in very large quantity for the measurement of which joule is a very small unit . Hence a large unit of energy is required which is called Kilowatt- hour.

Symbol:- It is denoted by kWh.

1 kWh = 3.6×10^6 J.

Show that 1kwh = 3.6×10^6 J.

Proof:- As we that

- Kilo = k = 1000
- 1 hour = 3600 s then
- 1 kwh = 1000 W X 3600s
- 1 kWh =3600000 Ws
- 1kWh = 3.6×10^6Ws.

USE OF CIRCUIT COMPONENTS

Continuous current require complete conducting path or circuit in which copper wire is used to connect switches , batteries , resisters and so on.

WIRES AND CONNECTORS

They are used to direct current from one part of the circuit to another. A blob should be drawn where wires are connected. In complex diagrams, it is sometimes necessary to draw crossed wires even when they are not connected. In such cases a bridge, joined and not joined wires are in figure 14.13a.

POWER SUPPLY

Sources of electrical energy to the circuit , such as cells and batteries whose symbols are shown in figure 14.13 b.

FUSE

Definition: -It is a small wire connected in series with live wire. OR
It is a safety device used to protect equipment and wiring from excessive current flow.

Other Name:- It is also called fuse wire.

Construction:- It consists of a thin piece of metal wire which has a low melting temperature. As shown in figure 14.13c.

Use:- when too much of current flows through the fuse wire piece of metal gets hot and melt . This Opens the circuit. The fuse will melt before the copper wires in the circuit get hot enough to do any damage.

Earth (Ground)

Definition:- An additional wire which is used with live and neutral wire.

Purpose:- It is used for safety from electric shock.

Explanation:-This wire is either connected to power socket or directly with the appliance. In case of any fault this wire prevent the shock by blows the fuse. In case of touching a faulty appliance this wire allowed a huge current to flow to earth (through earth wire) thus blows the fuse as shown in figure 14.13 d.

LAMP

The device which converts electrical energy into light, its circuit symbol is shown in figure 14.13e.

SWITCH

Definition:-It is a device which is used for making and breaking the connection in an electric circuit.

Symbol in circuit: "  ".

Explanation:-

(i)It is an electrical control element.

(ii)It has two discrete state i- e ON and Off or closed and open .

(iii)Closed switch has zero resistance.

(iv)Open switch has infinite resistance.as shown in figure 14.13f.

HEATER

It is a device which converts electrical energy into heat. The circuit symbol is shown in figure 14.13g.

RESISTROS

Definition:- A device which are specifically designed to have a certain amount of resistance to the flow of current is known as resistor.

Purpose: - TO reduce the current to a desired value.

Symbol in circuit: -

- For fixed resistor :- 
- For variable resistor :- 

Explanation:-

i. They are made from coil wire of spherical alloys or carbon.
ii. They are of two types i-e variable and fixed resistor.

Uses:-

i. Variable resistors are used in electronics as volume and other control.
ii. Variable resistor as a restate for changing current in a circuit .
iii. Variable resistors is used as a potential divider for changing the potential difference applied to a device.

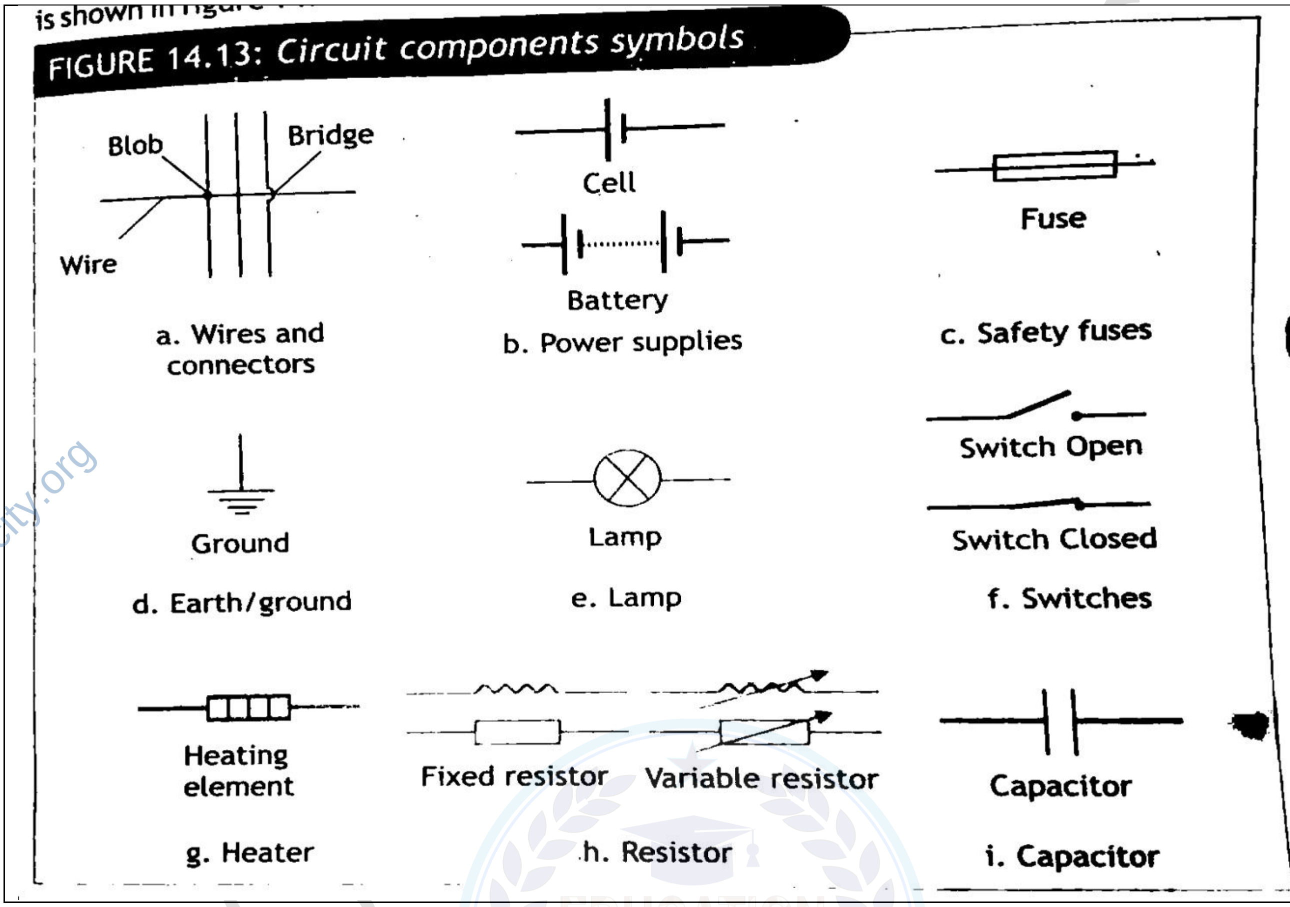
Note:-

- The resistors having fixed value of resistance are known as fixed resistors. Example:- Carbon resistors.

- The resistors whose resistance can be changed are known as fixed resistors. Examples:- Rheostate.

CAPACITOR

It is a device which store the electric charge. It is used with resistors in a timing circuit. Capacitors can be used as block and pass filters as well. The circuit symbol is shown figure 14.13 i.



ELECTRICAL MEASURING INSTRUMENTS

Definition:- Those devices are used for measuring various electrical aspects such as the presence and amount of current, voltage, resistance and power of electrical devices.

Examples:- (A) Galvanometer.**(B)** Ammeter.**(C)** Voltmeter. (D) Multimeter.

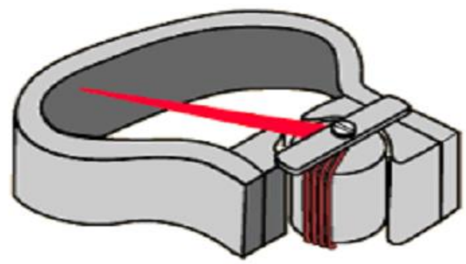
(A)Galvanometer:-

Definition: - It is a device which is used to detect the presence of electric current in a circuit .

Construction:- It consists of a dial on which a needle can rotate.

Working:- In order to detect the current in a circuit galvanometer is connected in series. If its needle shows deflection it would indicates the presence of current in the circuit.

Note: - Galvanometer is also used to indicate the potential difference between two points of a circuit.



AMMETER

Definition:- It is a device which is used for measuring large amount of current.

Conversion of galvanometer into ammeter:-

We can convert galvanometer into ammeter by connecting a shunt of low resistance R_s in parallel with the terminals of galvanometer.

Working OR measuring of current in a circuit:-

In order to measure the current in a circuit the ammeter is connected in series so the current flowing in the circuit also passes through ammeter.

Ammeter

Note:- As the resistance of the ammeter is very small , so its introduction into the circuit does not affect the current of the circuit.

VOLTMETER

Definition:- It is a device which is used to measure the potential difference across two points in an electrical circuit.

Conversion of galvanometer into voltmer:-

We can convert galvanometer into ammeter by connecting a very high resistance R_h in series with the terminals of galvanometer.

Working OR measuring of potential difference:-

In order to measure the potential difference in a circuit voltmeter is connected in series.

MULTIMETER

It is a digital device which can digitally measure the voltage, current and resistance in a desire range in a circuit or component. It has high accuracy as compared to analogue versions.

It can measure both D.C and A.C.

DIRECT CURRENT AND ALTERNATING

DIRECT CURRENT:-

History: - The concept about D. C introduced by **Thomas Alva Edition**.

Definition: - The current which always flows in one direction is known as direct current. OR

The unidirectional current is known as direct current.

Abbreviation: - It is abbreviated by “D.C”.

Symbol: - Its symbol is (▬).

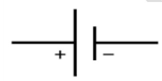
Frequency: - Its frequency is zero.

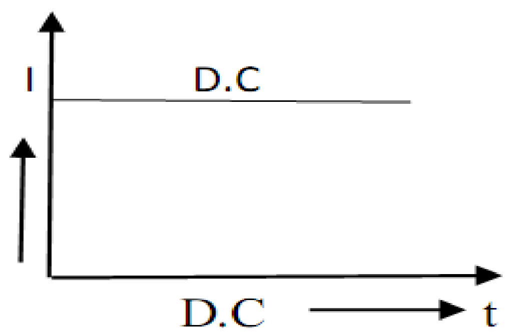
Transmission:- It cannot be transmitted through a large distance.

Measurement:-

Effect of transformer:- Transformer is of no use for D.C .

Conversion-:-It can be converted into D.C by invertor.

Symbol of source in circuit: - Its symbol in circuit is 



Sources:- Its sources Batteries, dry cells etc.

Uses:- It is used in TV remount , phone , laptop , watches etc.

ALTERNATING CURRENT:-

History:- The concept about A.C was introduced by Nikola Tesla.

Definition:- The current which change its direction a number of times in one second is known as alternating current. OR

The current which change the direction is known as known as alternating current.

Abbreviation:- It is abbreviated by “A.C” .

Symbol:- Its symbol is (**~) .**

Frequency:-Its frequency is 50 Hz .

Transmission:- It can transmitted through a large distance.

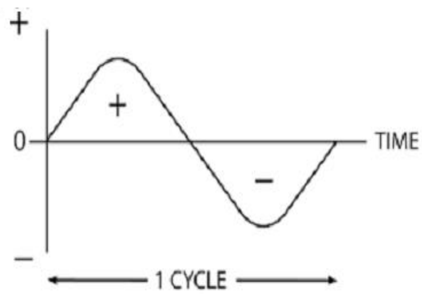
Measurement:-

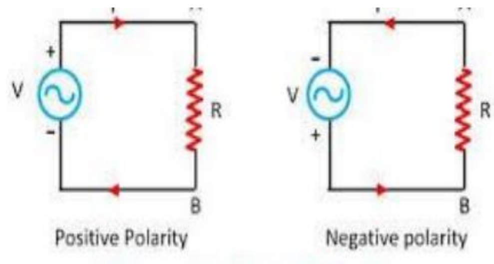
Effect of transformer:- It can be stepped up or stepped down by transformers.

Conversion:- It can be converted into D.C by using electronic rectifiers.

Symbol of source in circuit:-

Graph:-





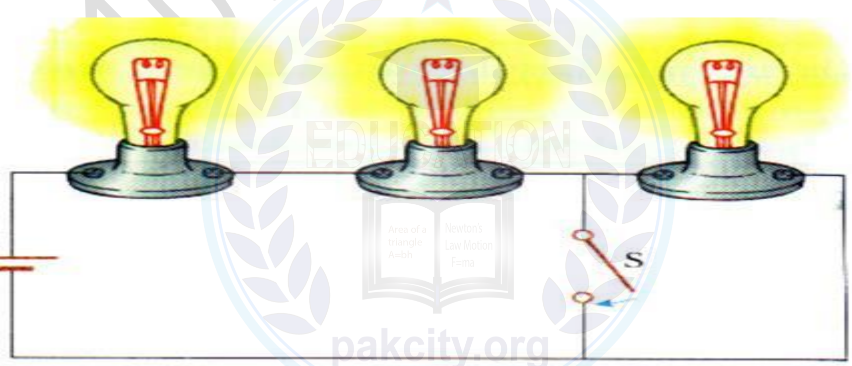
Alternating Current Circuit

Sources:- Its sources are A.C generators ,

Uses:- **It** is used in TV , Fans , Home , refrigerators etc.

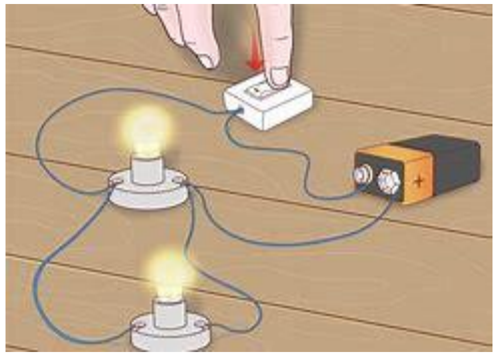
Series and Parallel circuits:-

Series :- In series circuit same amount of current is passes through each circuit element one after the other, but the potential drop will be different for different resistor or circuit components because the source has to push same number of electrons through different resistor so it would need different energies.



Parallel circuit :-

In parallel circuit the current divided itself in available branches, but the potential drops is the same through each resistor or circuit component.



It must be remember that if we connected a number of light bulbs in parallel the it will give more illumination, because each bulb has the maximum voltage across it and hence maximum power dissipation taking place.

House circuit:-

Electricity usually comes to our homes by two wires or lines , the live and the neutral. The potential difference between these two wires is 220 v .

Circuit in parallel:- Every circuit in our homes is connected in parallel with the main supply i.e across the live wire and neutral wire and receives the full mains potential difference of 220V.

Connection of switches and fuses:-

These are always in the live wire side of the circuit.

Staircase:- the lamp is controlled from two places by two ways switches.

Ring main circuit:- The live and neutral wires are thick and each run in a complete ring around the house and power the sockets, each rated at 13A are trapped off from them. Thinner wires can be used for each socket since the current to each socket is less than 13A .The ring has 30A fuse and if it has ten socket , all can be used so long as the total current does not exceed 30 A.

Fused plug:-Only one type of plug is used in a ring main circuit. It has its own cartridge fuse.

Earthling and safety:- A ring main circuit has third wire connected to a metal pipe in house or to the earth connection of the main supply . This third wire is a safety precaution to prevent electric shock.

Safe use of Electricity in Homes :-

1. Fuse
2. Circuit Breakers

3. Earth wire.

1. Fuse: -

Definition: -It is a small wire connected in series with live wire. OR
It is a safety device used to protect equipment and wiring from excessive current flow.

Other Name:- It is also called fuse wire.

Construction:- It consists of a thin piece of metal wire which has a low melting temperature.

Symbol for fuse in circuit:-

Use:- when too much of current flows through the fuse wire piece of metal gets hot and melt . This Opens the circuit. The fuse will melt before the copper wires in the circuit get hot enough to do any damage.

Circuit Breakers:-

Definition:- It is a safety device which is used in place of fuse.

Principle:- Electromagnetic effect.

Explanation:- They are automatic switches which are connected in the live wire . They contains an electromagnet which when the current exceeds the rated of the circuit breaker, becomes strong enough to separate a pair of contracts and breaks the circuit.When the current becomes normal the breaker turn ON again by pressing the button.

Earth Wire

Definition:- An additional wire which is used with live and neutral wire.

Purpose:- It is used for safety from electric shock.

Explanation:-This wire is either connected to power socket or directly with the appliance. In case of any fault this wire prevent the shock by blows the fuse. In case of touching a faulty appliance this wire allowed a huge current to flow to earth (through earth wire) thus blows the fuse.

ELECTRICITY HAZARDS: -

Hazards:- One must to know that electricity either caused death or fatal burns. This happened when a person touches a live wire while standing on a wet ground especially or touched water pipes etc. As electric charges always flow from higher potential to lower potential so once a man touched a live wire while standing on a ground without any shoes then electric charges passes through his body towards the ground thus due to ionization effect the person may be electrocuted or received server burns.

CONCEPTUAL QUESTIONS

Q#01:- As water is made of atoms having protons (charge +e) and electrons (charge –e) , does the water flowing through pipe carry an electric current ? Explain.

Ans:- Statement:- Water is made of atoms having protons (charge +e) and electrons (charge –e). The water flowing through pipe does not carry an electric current.

Reason:- It is because that the net charge is zero.

Explanation:- As we know that atoms as a whole are neutrals. Current is possible either of flow of positive, negative or both charges. Since the water molecules are neutral. So it does not cause any current while flowing through a pipe.

OR

Explanation:- As we know that

$$\text{Electric Current} = \frac{Electric\ Charge}{time\ taken}$$

$$I = \frac{Q}{t} \text{ .... (i)}$$

Condition:- if Q = 0 then equation (i) becomes

$$I = \frac{0}{t} = 0$$

So it does not cause any current while flowing through a pipe.

Conclusion:- As conclusion we find that Water is made of atoms having protons (charge +e) and electrons (charge –e). The water flowing through pipe does not carry an electric.

Q#02:- A car has two headlights , when the filaments in one headlights burns out , the other headlight stays on. Are the headlights connected in series or in parallel.

Ans:- Statement:- A car has two headlights , when the filaments in one headlights burns out , the other headlight stays on. When the headlights are connected in parallel .

Reason: - It is because parallel combination provides more than one path for electric current flow.

Explanation:- As we know that in series combination of resistors there is only one path for flow of current. So if one bulb gets fused the other one will also not glow. So for safety reasons the two bulbs are connected in parallel. If one bulb gets fused the other one will glow on because in series combination of resistors there are more than one path for flow of current.

Conclusion:- As conclusion we find that A car has two headlights , when the filaments in one headlights burns out , the other headlight stays on. When the headlights are connected in parallel.

Q#03:- Qurat – ul –Ain needs a 100 Ω resistor for a circuit but she only has a box of 300 Ω resistors . What can she do?

Ans:- Statement:- She can get the desired resistance by connecting the three resistors in parallel combination each of 300Ω.

Reason:- It is because in case of parallel combination of resistors the equivalence decreases.

Explanation:- As we know that

$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \quad \text{..........................(A)}$$

As $R_1 = 300\Omega$, $R_2 = 300\Omega$ and $R_3 = 300\Omega$ then equation (A) becomes

$$\frac{1}{R_e} = \frac{1}{300} + \frac{1}{300} + \frac{1}{300} = \frac{1+1+1}{300} = \frac{3}{300}$$

OR $R_e = \frac{300}{3} = 100\ \Omega$

Conclusion:- As conclusion we find that She can get the desired resistance by connecting the three resistors in parallel combination each of 300Ω.

Q#04:-A number of light bulbs are connected to a single power outlet will they provide more illumination when connected in the series or in the parallel? Why?

Ans:- Statement:- :- A number of light bulbs are to be connected to a single power outlet, they will provide more illumination if connected in parallel combination.

Reason:- It is because in case of parallel combination of resistors the potential difference across each resistor is the same.

Explanation:- As we know that

(i) It provides more than one path for current flow.

(ii) The same voltage across each resistor i-e

$$V_1 = V_2 = V_3 = V$$

(iii) The different current pass through each resistor i-e $I_1 \neq I_2 \neq I_3$

(iv) In this case equivalent resistance decreases.

Conclusion:- As conclusion we find that a number of light bulbs are to provide more illumination from a single power outlet, should be connected in parallel combination.

Q#05:- Explain why light bulbs almost always burn out just as they are turned on and after they have been on for some time?

Ans:- Statement:- Light bulbs almost always burn out just as they are turned on and after they have been on for some time.

Reason:- It is because of low resistance of filament at room temperature.

Explanation:- As we know that

(i)Initially the temperature of the filament is low (small) so the resistance is also small. So large current can pass through the filament which may burn it .

(ii)When the bulb is stay ON for a time the temperature and hence its resistance increases which in turn decreased the current through the filament hence chances of burn decreases.

Conclusion:- As conclusion we find that Light bulbs almost always burn out just as they are turned on and after they have been on for some time.

Q#06:- Explain why is it possible for birds to perch safely on high tension wires without being electrocuted?

Ans:- Statement:- It is possible for a bird to perch on a high voltage wire without being electrocuted.

Reason:- Because of zero potential difference.

Explanation:- As we know that current is the result of potential difference. As birds are sitting on a high voltage wire so both of its claws are at the same potential means that there is zero potential difference. If the potential difference is zero then the current flow through the body of the birds is also zero. Therefore birds are not electrocuted sitting on a high voltage wire.

Conclusion:- Due to zero potential difference(same P.D) It is possible for a bird to perch on a high voltage wire without being electrocuted.

Q#07:- An electrician working on "Live" circuits wears insulated shoes and keeps one hand behind his or her back . Why?

Ans:- Statement:- An electrician working on "Live" circuits wears insulated shoes and keeps one hand behind his or her back **.**

Reason:- It is because for safety purpose from electric shock.

Explanation:- Insulated shoes keeps the electrician isolated from the ground by making higher resistance in a circuit that would connect him to ground. This higher resistance would result in a very low current and will reduce the dangers of electric shock. The same person working on live circuit also keeps one hand behind his or her back just to prevent the possibility of touching a neutral wire or another conductor wire to make a complete circuit.

Conclusion:- As conclusion an electrician working on "Live" circuits wears insulated shoes and keeps one hand behind his or her back .

Q#08:- Explain why is it dangerous to turn on a light bulb when you are in both tub?

Ans:- Statement:- It is dangerous to turn on a light when you are in bath tub.
Reason:- Because of weak insulation and less resistance.
Explanation:- As we know that human body becomes an excellent conductor when becomes wet because in this case the resistance of our body becomes negligibly small hence a large current may flow through our body, so it is very dangerous to turn on a bulb while we are in bath tub.

Dry skin resistance= 100000Ω
Wet skin resistance= 1000Ω
High voltage can reduce 1000 to 500Ω.

Conclusion:- So as a result it is very dangerous to turn on a bulb while we are in bath tub.

Q#09:- Why circuit breaker, fuse and switches are installed to "Live wire"?

Ans:- Statement:- Circuit breaker, fuse and switches are installed to "Live wire".

Reason:- It is because to Prevent the shock in the switched OFF mode.
Explanation:- As we know that if they are installed to the neutral wire, electrical appliances and power sockets would be live even when switches are in " off mode" or the fuses "Blown". A fetal shock could then be obtained even in switched off condition.
Note:- (i) Fuse and circuit breaker are installed to "Live wire" to protect the wiring and equipment from overloading and potentially catching fire.
(ii)switches are installed to "Live wire" to break or connect electric circuit.
Conclusion:- As conclusion we find that Circuit breaker, fuse and switches are installed to "Live wire".

NUMERICAL QUESTIONS

Pb# 01:A small electric heater has a resistance of 15 ohms when the current in it is 2 amperes. What voltage is required to produce this current?

GIVEN DATA:- Resistance = R = 15 Ω Current = I = 2 A **REQUIRED DATA:-** Voltage = V = ? **SOLUTION:-** **FORMULA:-** pakcity.org	By using ohm's law V= I R -------------------- **(1)** **CALCULATION:-** Put values in equation (1) V = 2 × 15 = 30 v **RESULT:-** V = 30 v

Pb# 02:-If a potential difference of 10 V is maintained across a 1 m long of the Nichrome wire having resistance of 3.1 Ω, what is the current in the wire?

GIVEN DATA:- Potential difference = V = 10 v Length of wire = L =1 m Resistance = R = 3.1 Ω **REQUIRED DATA:-** Current = I = ? **SOLUTION:-** **FORMULA:-**	By using ohm's law V= I R ------------------- **(1)** **CALCULATION:-** $I = \frac{V}{R} = \frac{10}{3.1} = 3.2$ A **RESULT:-** I = 3.2 A

Pb#03: What resistor would have a 15 mA current if connected across the terminals of a 9.0 V battery?

GIVEN DATA:-

Current = I = 15 mA = 15×10^{-3} A

Voltage = V = 9.0 v

REQUIRED DATA:-

Resistance = R =?

SOLUTION:-

FORMULA:-

By using ohm's law

V= I R ------------------- **(1)**

CALCULATION:-

$R = \frac{V}{I}$ put the values in equation

$R = \frac{9.0}{15 \times 10^{-3}} = \frac{9.0}{15} \times 10^3 = \frac{3.0}{5} \times 1000 = 600\ \Omega$

RESULT:-

$R = 600\ \Omega$

Pb#04: Consider a circuit with three resistor R_1 = 250.0 Ω, R_2 = 150.0 Ω, R_3 = 350.0 Ω connected in parallel with a 24.0 V battery. Find the total current supplied by the battery.

GIVEN DATA:-

$R_1 = 250.0\ \Omega$,

$R_2 = 150.0\ \Omega$,

$R_3 = 350.0\ \Omega$

Voltage = V = 24.0 v

REQUIRED DATA:-

Total current = I =?

SOLUTION:-

First we calculate the equivalent Resistance = R_e =?

FORMULA:-

In case of parallel combination

$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ -------------- (1)

CALCULATION:-

$$\frac{1}{R_e} = \frac{1}{250} + \frac{1}{150} + \frac{1}{350}$$

$$\frac{1}{R_e} = \frac{21+35+15}{5250} = \frac{21+35+15}{5250} = \frac{71}{5250}$$

$R_e = \frac{5250}{71} = 73.94\ \Omega$

Now using ohm's law

$V = I R_e$

Hence $I = \frac{V}{R_e} = \frac{24.0}{73.94} = 0.32$ A

RESULT:-

I = 0.32 A

Pb#05:An electric hair dryer is rated at 1,875 watts when operating on 120 volts. What is the current flowing through it? If the hair dryer is used for 3 minutes, how much energy does it consume?

GIVEN DATA:-

Power = P = 1875 watt

Voltage = V = 120 v

(a)

REQUIRED DATA:-

(a) Current = I =?

(b) When time = t = 3 min = 3 × 60 sec = 180 sec

Energy = E =?

SOLUTION:-

FORMULA:-

(a) As we know that P = VI

Hence $I = \frac{P}{V}$ put values in the given equation

$I = \frac{P}{V}$ ------------------ (1)

(b) $P = \frac{E}{t}$

Hence $E = P \times t$ ------------ (2)

CALCULATION:-

(a) Put values in equation (1)

$I = \frac{P}{V} = \frac{1875}{120} = 15.6\ A$

I = 15.6 A

(b) Put values in equation (2)

E = 1875 × 180

E = 337500 J=337.5 KJ

Pb#06: A battery with an emf of 12 V is connected to a 545 Ω resistor. How much energy is dissipated in the resistor in 65 s?

GIVEN DATA:-

Voltage or potential difference (PD) = V = 12 v

Resistance = R = 545 Ω

Time = t = 65 sec

REQUIRED DATA:-

Energy dissipated = E =?

SOLUTION:-

FORMULA:-

As we know that

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

CALCULATION:-

$E = \frac{(12)^2 \times 65}{545} = \frac{144 \times 65}{545} = 17.17\ J$

RESULT:-

E = 17.17 J.

Pb# 07: If the unit of electricity cost 8.11 Rs/kWh, what is cost of running two 160 W fans and four 100 W light bulbs for 6 hours in school?

GIVEN DATA:-	CALCULATION:-
Power = P = $(2 \times 160) + (4+100) = 720$ Watt Time = t = 6 hour 1 unit = 1 kwh = 8.11 Rs/ kwh **REQUIRED DATA:-** **SOLUTION:-** **FORMULA:-** $E = P\times t$ ------------ (1)	Put values in equation (1) $E = 720 \times 6 = 4320 = 4.32 \times 10^3$ wh =4.32 khw Cost of electrical energy = $4.32 \times 8.11 = 35$ Rs **RESULT:-**