CH # 16 ELECTRICITY

ELECTRIC CHARGE:

"Property of the particle due to which it deviates into the electric and magnetic field is known as charge."

INSULATORS:

"Those material objects which do not allow the charge to pass through them are called insulators."

Example:

- Wood, plastic, rubber etc.

CONDUCTORS:

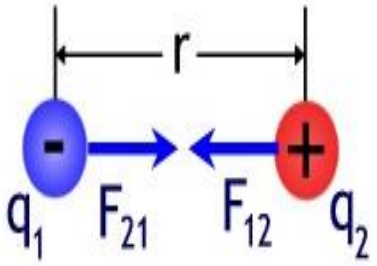
"Those material objects which allow the charge to pass through them are called conductors."

Example:

- Copper, Iron, Silver etc.

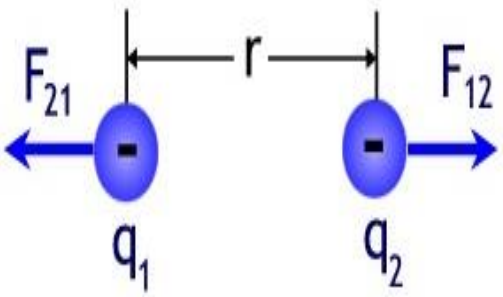
COULOMB'S LAW:

"Two unlike charges attract each other and two like charges repel each other with a force that is directly proportional to the product of the magnitude of the charges and inversely proportional to the square of the distance between them."



Mathematically:

If two charges 'q_1' and 'q_2'are place at a distance 'r' then:



$F \alpha q_1 q_2$ _____(i

$F \alpha \frac{1}{r^2}$ _____(ii

By combining equation (i and (ii

$$F \alpha \frac{q_1 q_2}{r^2}$$

$$\boxed{F = k\frac{q_1 q_2}{r^2}}$$

Where 'K' is constant and its value in SI unit is 9×10^9 Nm^2/C^2. The constant 'K' is commonly expressed as follows.

$$K = \frac{1}{4\pi \epsilon_0}$$

If we place dielectric between the two charges then 'K' Becomes,

$$K = \frac{1}{4\pi \epsilon_0 \epsilon_r}$$

Factors on which Coulomb's force depends:

- Product of charges.
- Distance between charges.
- Presence of dielectric.

ELECTRIC FIELD:

"Space around charge in which a unit positive charge experiences a force of attraction or repulsion is called electric field."

INTENSITY OF ELECTRIC FIELD:

"Force per unit positive charge exerts at a point is called intensity."

$$\text{Intensity} = \frac{\text{Force}}{\text{Charge}}$$

$$\boxed{E = \frac{F}{q}}$$

OR

$$\boxed{E = \frac{Kq}{r^2}}$$

Nature:

It is a vector quantity.

Unit:

S.I unit of charge is Newton/Coulomb (N/C).

Factors on which electrostatic force is depends:

- Electric field intensity is directly proportional to the magnitude of source charge.
- Electric field intensity is inversely proportional to the square of the distance from the charge to the field point.

ELECTROSTATIC INDUCTION:

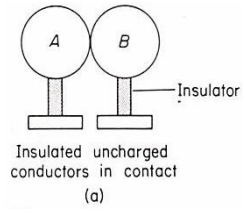
"Change in the distribution of charge of neutral body due to the presence of charged body is called electrostatic induction."

EXPERIMENT OF ELECTROSTATIC INDUCTION:

For Positive Sphere A and negative sphere B:

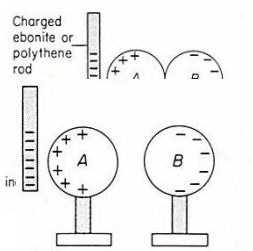
Suppose we want to charge sphere A positive then act as shown below:

1. Two metal spheres A and B resting on insulating stands are placed together so that they touch one another and thus form in effect a single conductor.



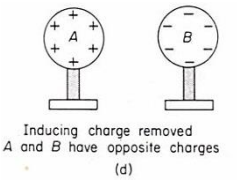
Insulated uncharged conductors in contact
(a)

2. A negatively charged ebonite rod is brought near the sphere A in such a manner that it does not touch sphere A. Due to induction sphere A will attain positive charge and sphere B will attain negative charge.
3. Still keeping the charge rod in the same position, the sphere B is moved away from sphere A at a short distance.



A and B separated in presence of inducing charge
(c)

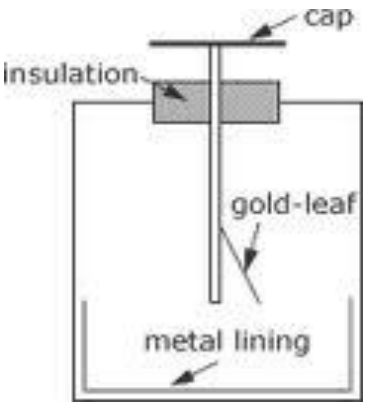
4. Now remove the negatively charged rod as well and test the charge of sphere A and B. Both will possess charge. Sphere A will be negatively charged and B will be positively charged.



Inducing charge removed
A and B have opposite charges
(d)

For negative Sphere A and positive sphere B:
To charge the sphere A negative and B positive then use positively charge rod for inducing the charge.

GOLD LEAF ELECTROSCOPE:
"It is a device used to detect charge and nature of charge."



Construction:
It consists of a glass case which contains two thin gold leaves which are connected to metal ball outside the case through a conductor.

Working principle:
It works on the principle that like charges repel each other and different charges attract each other.

Working:
If a charge object brought close to the ball, separation of charge is induced between the ball and gold leaves. The two leaves become charge and repel each other. The nature of the charge can be determined by bringing it near a charged electroscope.

ELECTRIC POTENTIAL:
"The work done in moving a unit positive charge from one point to the other against electric intensity is called electric potential."

$$\text{Electric potential} = \frac{\text{Work done}}{\text{charge}}$$

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

Unit:
S.I unit of Electric potential is Joule/Coulomb (J/C) or Volts (V).

VOLT:
"Potential difference between two points is one volt when one joule work is required to move one coulomb charge from one point to the other."

CAPACITOR:
"The device which is used for storing electric charge is called capacitor."

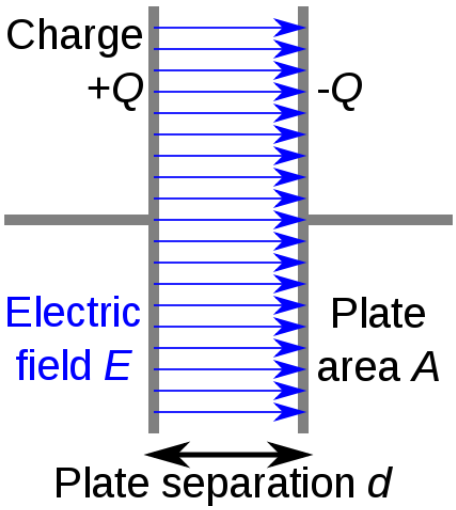
Working:

Typical capacitor consist of two parallel plates placed on insulating stand and are separated by some insulating material known as dielectric.
The charge stored in the capacitor is directly proportional to the potential difference 'V' across the plates of capacitor.

$$q \alpha V$$

$$q = CV$$

Where 'C' is constant called capacitance of capacitor.



CAPACITANCE OF CAPACITOR:

"The charge stored per unit potential difference between the plates of capacitor is called capacitance of capacitor."

$$\text{Capacitance} = \frac{\text{Charge}}{\text{Potential difference}}$$

$$C = \frac{q}{V}$$

Unit:

S.I unit of capacitance is Coulomb/Volt (Col. /V) or Farad.

FARAD:

"The capacitance of a capacitor is one farad if a charge of one coulomb produces a potential difference of one volt between the plates of the capacitor"

1micro farad (1μF) = 10^{-6} Farad

1micro- micro farad (1μμF) = 10^{-12} Farad

FACTOR AFFECTING THE CAPACITY OF CAPACITANCE:

1. **Area of the plates:**
   Greater the area of the plates, greater will be the capacity.

2. **Distance between the two plates:**
   Lesser the distance between the plates greater will be the capacity.

3. **Nature of dielectric:**
   If we use glass in place of air as dielectric then capacity will increase.

ELECTRO-MOTIVE FORCE (E.M.F):

"Energy required to derive charge around the circuit is called Electro-Motive Force."

$$\text{E.m.f} = \frac{\text{Energy supplied}}{\text{Charge}}$$

Unit:

S.I unit of E.M.F is Volt.

CELL:

"Cell is a device which supply electricity."

KINDS OF CELLS:

There are two basic kinds of cell.

1. Primary cell.
2. Secondary cell or storage cell or accumulators.

KINDS OF PRIMARY CELLS:

1. Voltaic cell.
2. Deniell cell.
3. Leclanch cell.
4. Dry cell

KINDS OF SECONDARY CELLS:

1. Lead acid accumulator.

ELECTRIC CURRENT:

"Rate of flow of electric charge under the influence of applied electric field is called electric current."

- It is denoted by 'I'.

$$\text{Electric current} = \frac{\text{Charge}}{\text{Time}}$$

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

Unit:

S.I unit of Electric current is Coulomb/Second or Ampere.

AMPERE:

"If one coulomb of charge flowing through a cross-section of a conductor in one second then current is one ampere"

1milliampere = 10^{-3} Ampere

1micro- Ampere (1μAmp) = 10^{-6} Ampere

TYPES OF CURRENT:

ALTERNATING CURRENT:

"A current which alternates or reverse its direction several times per second is called an alternating current. It is denoted by A.C."

DIRECT CURRENT:

"A current which does not change its direction in the circuit with the time, is called direct current. It is denoted by D.C."

RESISTANCES:

"Resistances are a measure of opposition to the motion of free electron (i.e. current) due to there continues collision with the atoms of lattice of conductor."

Unit:

Unit of resistance is ohm (Ώ).

DEFINITION OF ONE OHM:

"The resistance of a column of mercury of length 106.3 cm having a uniform cross section of one square mille meter and weighing 14.4521 g at 0^0C is one ohm."

One kilo ohm (1kΏ) = 1000 ohm (10^3 Ώ)

One mega ohm (1MΏ) = 1000000 ohm (10^6 Ώ)

Factors affecting on resistance:

The magnitude of resistance of a conductor depends upon the following factors:

- Nature of the conductor.

- Length of the conductor.
- Area of cross section of the conductor.
- Temperature of the conductor.

RESISTOR:

"The device which is used to produce resistance in circuit is called resistor."

Uses/Applications /Advantages of resistor:

- Resistance is use to divide the electric potential in electrical circuit.
- It is use in iron, steamer and electric heater etc for increase in temperature.
- It is use to control the flow of electron.

OHM'S LAW:

"The potential difference between the two ends of the conductor is directly proportional to the current passing through it, provided there is no change in the physical state of the conductor."

Mathematically:

Suppose current 'I' is passing through a conductor and the potential difference between the two ends of conductor is V then

$$V \alpha R$$
$$V = IR$$

Where 'R' is known as resistance of conductor.

ELECTRIC CIRCUIT:

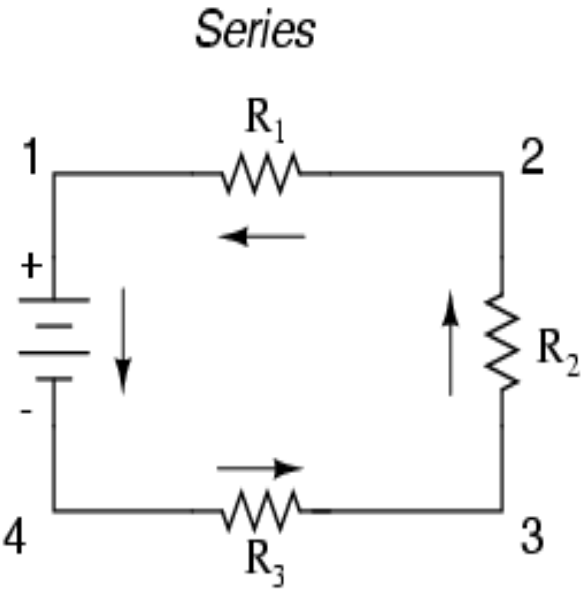
"Any closed path through which an electric current can flow is called electric circuit."

In electric circuit resistance can be connected in the following two ways:

- Series combination.
- Parallel combination.

- **SERIES COMBINATION:**

"Resistors are said to be connected in series when they are connected end to end consecutively so that there is only one path for the flow of current and the same current flow through each resistors."



MATHEMATICALLY:

Let three resistances R_1, R_2 and R_3 are connected in series across a battery of voltage's'. The potential difference across each resistor is V_1, V_2, and V3 respectively, According to ohm's law:

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

As total voltage of the battery,

$$V = V_1 + V_2 + V_3$$

$$IR = IR1 + IR_2 + IR_3$$

$$IR = I\,(R_1 + R_2 + R_3)$$

$$R = R_1 + R_2 + R_3$$

If 'n' resistors are connected then,

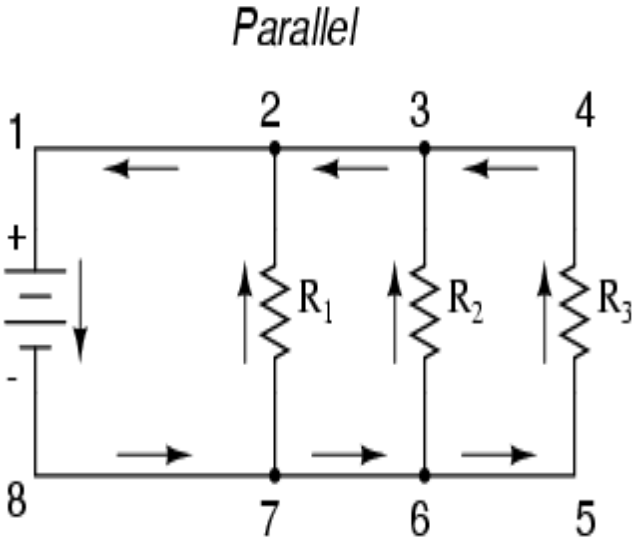
$$R = R_1 + R_2 + R_3 + \ldots\ldots + R_n$$

Characteristics of series combination:

1. Only one path is available for the flow of current.
2. Same current passing through each resistor.
3. Potential difference of the source is equal to the sum of potential difference across each resistor.
4. The resistance R_1, R_2 and R_3 can be replaced by a single resistance R.

- **PARALLEL COMBINATION:**

"Resistors are said to be connected in series when each of them is connected between the two common points."



Mathematically:

Resistances R_1, R_2, R_3 are connected in parallel between the two points. A battery of voltage 'V' is connected. The main current 'I' coming from the battery is divided into I_1, I_2, and I_3 among the resistors R_1, R_2, R_3 respectively. The potential difference across each resistor remains same.

The sum of their currents is equal to,

$I = I_1 + I_2 + I_3$ ---------- (1)

According to ohm's law,

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

Substituting the value of I, I_1, I_2, I_3 we get,

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

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

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

If 'n' resistors are connected then,

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

Characteristics of parallel combination:

1. Many paths available for the flow of current.
2. Current passing through every resistor can be different. Sum of all such currents is equal to the total current supplied by the battery.
3. Potential difference across each resistor will be the potential difference of the source.
4. Hence the resultant resistance of the circuit will be equal to the sum of reciprocals of all the resistance in the circuit.

JOULE'S LAW:

"When a charged body at higher potential is allowed to move towards a point at lower potential then energy released, which is directly potential to the difference potential or in other words heat produced is directly proportional to amount of work done."

Mathematically:

Work done α Amount of heat

Suppose charge 'q' coulombs is passing through a resistance 'R' in time 't' second when potential difference of 'V' volts is maintained across its ends.

$$W \alpha V$$

$$W = qV$$

Since q = It

$$W = (It)V$$

According to Ohm's law V = IR

$$W = (It)(IR)$$

$$\boxed{W = I^2Rt}$$

POWER:

"Rate of doing work of charge is called power."

Mathematically:

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$

$$\text{Power} = \frac{W}{t}$$

According to Joule's law $W = I^2Rt$

$$\text{Power} = \frac{I^2Rt}{t}$$

$$\text{Power} = I^2R$$

$$\text{Power} = I \times (IR)$$

Since V = IR

$$\boxed{\text{Power} = IV}$$

Unit:

Unit of Power is Amp-Volt which is equal to Watt.

WATT:

"If one joule of electric work is done in one second then the power is called one watt"

Commercial unit of Electrical energy is kilo-watt per hour. (Kwh)

KILO-WATT HOUR:

"When a power of one kilo-watt is maintained for one hour then electric energy is kilo-watt hour."

HOUSE CIRCUIT:

Electricity is usually comes to our home by two wires, the live (L) and the neutral (N). The potential difference between these wires is 220V. The neutral wire is connected to the earth about every 100 meter. The potential on the live wire is alternately positive and negative with respect to the neutral wire.

FUSE:

"It is an electrical device generally uses to save the electric appliances from the hazards of potential."

WORKING OF FUSE:

Fuse consists of a piece of metal wire of low melting point. When current exceeds safety limits, heat produced melts the wire, thus breaking the passage of current.