# Electricity

**Charge** :- A fundamental property of matter that causes it to experiences a force (attraction or repulsion) in the presence of the other matter.
It come into action when $e^-$ are transferred from one body to other.

**S.I. Unit** :- Coulomb, $1C = 6.25 \times 10^{18}\ e^-$
The amount of charge due to access of or deficiency of $6.25 \times 18^{18}\ e^-$ is "1 coulomb".

Properties

- **Fundamental** — Like charges repel and Unlike charges attract each other.
- **Conservation of charge** — The net charge in an isolated system is constant.
- **Quantization** — Charge can only exist in the form of integral multiple of charge at one. ($Q = \pm ne$).
- **Additivity** — Charges are additive in nature.

There are two types of charge → Positive, Negative.

**Electric Current** :- The rate of flow of charge is called electric current. $I = \frac{Q}{t}$

S.I. Unit :- Ampere, $1A = 1C\,s^{-1}$

"If 1 coulomb charge is passing through a cross section per second is said to be one Ampere."
It measured by ammeter.

where I = Current, Q = electric charge, t = time.

**Electric Potential** :- The amount of work done in bringing a unit positive charge from infinity to a point is called as electrical potential at that point

- It is a scalar quantity.
- S.I. Unit :- Volt, $1V = 1JC^{-1}$.

$V = \frac{W}{q}$ W = Work Done, q = amount of Charge.

**Electric Potential Difference ($\Delta V$)** :- The amount of work done in bringing one unit positive charge from one point to another is reffered to as electric potential difference between them.

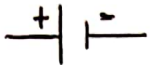
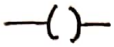
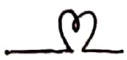
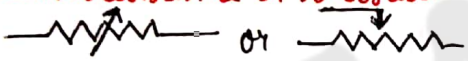
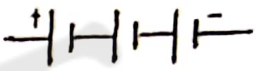
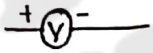
If One joule work is done to bring unit charge from one point to another, the potential difference will be one volt. $V_A = \frac{W_A}{q}$ — (i) $V_B = \frac{W_B}{q}$ — (ii)

$$V_B - V_A = \frac{W_B - W_A}{q}$$

**Voltmeter** :- The potential difference between any two points in an electric field is measured by an instrument called voltmeter.
It is always connected in parallel.

**Electric Circuit** :- A closed and continuous path through which electric current flows, is known as an electric circuit.
A pictorial representation of the electric devices connected in a circuit, is called a "Circuit diagram."

**Symbols of some Commonly Used Components in Circuit Diagrams** :-

- An electric cell 
- A plug key or a switch (open) 
- A wire joint 
- An electric bulb 
- A variable resistance or rheostat 
- A battery or a combination of cells 
- A plug key or a switch (closed) 
- Wires crossing without joining 
- A resistor of resistance R 
- An ammeter 
- A Voltmeter 

**OHM'S LAW** :- Acc. to Ohm's Law, "At constant temperature, pressure and strain, the current flowing through a conductor is directly proportional to the potential difference across the conductor."
Given by German Physicist Georg Simon Ohm.

Acc. to Ohm's Law, $V \propto I$ then, $\boxed{V = RI \text{ or } V = IR}$ $\boxed{\frac{V}{I} = \text{Constant } (R)}$

where, $I$ = electric current $V$ = Potential difference across the conductor
$R$ = Resistance of the Conductor

**V-I Graph** :- The graph between the potential difference (V) and the corresponding current (I) is found to be a straight line passing through the origin for ohmic conductors.

**Resistance** :- It is the property of a conductor that opposes the flow of charge (current) through it. S.I. Unit :- Ohm 'Ω'

If the potential difference across the ends of a conductor is 1 Volt and the current through the conductor is 1 Ampere, the resistance of the conductor is said to be 1 Ohm.

## Factors on which the resistance of a Conductor depends :-

① Length of the Conductor : $R \propto l$

② Area of cross-section of the Conductor : $R \propto \frac{1}{d^2}$

③ Nature of material of the Conductor : different material has different resistivity.
$R \propto$ resistivity.

④ Temperature of the conductor : For a conductor $R \propto$ temperature.

from above discussion : $R = \rho \frac{l}{A}$, where $\rho$ is called resistivity of material.

**Resistivity** :- Resistivity of a material can be defined as the resistance per unit length of unit cross-section of the material.

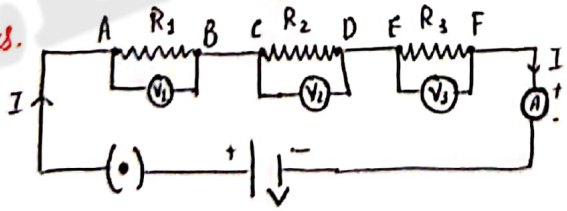
It depends on the nature of the material & temperature and is independent of the length and area of cross-section of the conductor.
It only depends on type of material and temperature.

**Unit** :- Ohm-metre or $\Omega m$.

**Resistance of a System of Resistors** :- The resistors can be combined in two ways.

### Resistors in Series

When two or more resistors are joined end-to-end so that the same current flows through each of them, it is called a series combination of resistors.




Total potential difference (V) = $V_1 + V_2 + V_3$

$V = IR_1 + IR_2 + IR_3$

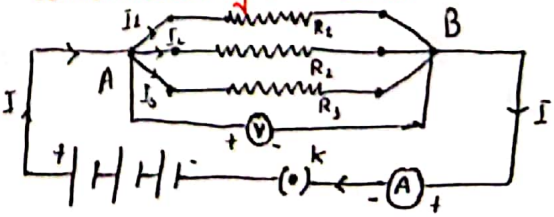
$IR_S = IR_1 + IR_2 + IR_3$

$\boxed{R_S = R_1 + R_2 + R_3}$

$R_S$ = Equivalent resistance (series)

### Resistors in Parallel.

When two or more resistors are connected between two common points such that the same potential difference is applied across each of them, it is called parallel combination of resistors.




Total Current flowing $I = I_1 + I_2 + I_3$

$R_p$ = Equivalent resistance (Parallel)

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

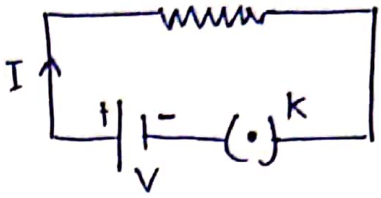
$\boxed{\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$

**Heating Effect of Electric Current :** When an electric current passes through any electric component with non-zero resistance, it produces heat that heats up the corresponding component. This phenomenon is called heating effect of current.

Heat Produced in the resistance in time $t$, $H = QV$

We know that, $I = \frac{Q}{t}$ , $\therefore Q = I \times t$

$\therefore H = I \times t \times V$ or $\boxed{H = VIt}$




We know that, $I = \frac{V}{R}$

$\therefore H = V\left(\frac{V}{R}\right)t \Rightarrow \boxed{H = \frac{V^2}{R}t}$

We know that, $V = IR$

$\therefore H = (IR)It$

$\boxed{H = I^2RT}$

This is known as Joule's law of heating and its implies that the heat produced in a resistance is:

(i) Directly proportional to the square of current for a given resistance & a given time.
(ii) Directly proportional to the resistance for a given current and a given time.
(iii) Directly proportional to the time for which a given current flows through a given resistance.

**Electric Power :** If W be the amount of electric energy consumed in a circuit in t seconds then electric power is given by

$$\text{Electric Power} = \frac{\text{Electric work Done}}{\text{Time taken}}$$

**S.I. Unit :** Watt (W)

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

It is defined as the rate of doing work. also the rate at which energy is consumed or produced.

If $W = QV$, where $Q$ = Charge . $V$ = Potential Difference.

$$P = \frac{VQ}{t} = VI \Rightarrow \boxed{P = VI}$$

from Ohm's Law $\Rightarrow I = \frac{V}{R}$ then, $\boxed{P = \frac{V^2}{R}}$

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