Electricity

Electric Current

- **Electric current** is expressed as the amount of charge flowing through a particular area in unit time.
- Quantitatively, **electric current** is defined as the rate of flow of electric charge.

$$\textbf{Current, I} = \frac{\textbf{Charge flowing (Q)}}{\textbf{Time taken (t)}}$$

- The S.I. unit of current is **ampere (A)**, where 1 ampere = 1 coulomb/second.
- 1 mA = 10^{-3} A, 1 μ A = 10^{-6} A
- The conventional direction of electric current is the one in which positive charges move orderly.

Electric Potential Different

- Electric potential difference (pd) between two points in an electric circuit, carrying some current, is the amount of work done to move a unit charge from one point to another.

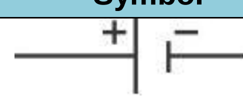
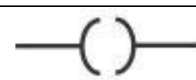
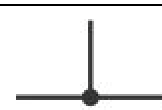
$$\textbf{Potential difference, pd} = \frac{\textbf{Work done (W)}}{\textbf{Quanity of charge moved (Q)}}$$

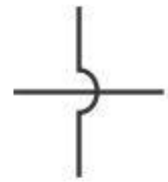
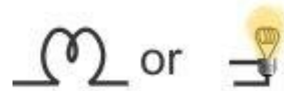
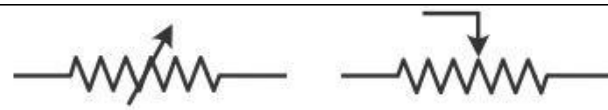
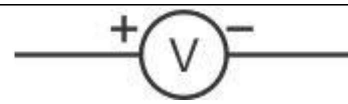
- The S.I. unit of pd is **volt (V)**, where 1 volt = 1 joule/coulomb.

Electric Circuit

A continuous conducting path between the terminals of a source of electricity is called an **electric circuit.**

- A drawing showing the way various electric devices are connected in a circuit is called a **circuit diagram**.
- Some commonly used circuit elements are given below:

Sr. No.	Element	Symbol
1	An electric cell	
2	A battery	
3	Plug key or switch (open)	
4	Plug key or switch (closed)	
5	A wire joint	

6	Wires crossing without joining	
7	Bulb	
8	Resistor	
9	Variable resistor or Rheostat	
10	Ammeter	
11	Voltmeter	

Ohm's law

- According to Ohm's law, the current (I) flowing through a conductor is directly proportional to the potential difference (V) across its ends, provided its physical conditions remain the same.
  V ∝ I
  V/ I = Constant
  V/ I = R
  V = IR
  where R is a constant of proportionality called **resistance** of the conductor.
- **Resistance** is the property of a conductor to resist the flow of charges through it.
- The S.I. unit of resistance is **ohm (Ω).**
  From $R = \frac{V}{I}$, 1 ohm = 1 volt/ampere

Resistivity

- The resistance of a conductor is directly proportional to its length (l) and inversely proportional to its area of cross section (A).
  R ∝ l/ A
  R = ρ l/A
  where ρ is a constant of proportionality called **specific resistance** or **resistivity** of the material of the conductor.
- The S.I. unit of resistivity is **ohm metre (Ω m).**

Combination of Resistances

Resistances in Series

- The current flowing through each resistance is the same.
- The potential difference across the ends of the series combination is distributed across the resistances.
- The equivalent resistance (R_s) of a series combination containing resistances R_1, R_2, R_3... is
  $\mathbf{R_s = R_1 + R_2 + R_3 + ...}$
- The equivalent resistance is greater than the greatest resistance in the combination.

Resistances in Parallel

- The potential difference across each resistance is the same and is equal to the potential difference across the combination.
- The main current divides itself, and a different current flows through each resistance.
- The equivalent resistance (R_p) of a parallel combination containing resistances R_1, R_2, R_3... is given by
  $$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$$
- The equivalent resistance is lesser than the least of all the resistances in the combination

Heating Effect of Electric Current

- The effect of electric current due to which heat is produced in a conductor, when current passes through it, is called the heating effect of electric current.
- The total work (W) done by the current in an electric circuit is called **electric energy** and is given as
  $\mathbf{W = VIt = I^2Rt}$
  $\mathbf{W = V^2 t / R}$
  This energy is exhibited as heat. Thus, we have $H = VIt = I^2Rt$.
  This is called **Joule's Law of Heating**, which states that the heat produced in a resistor is directly proportional to the
  - Square of the current in the resistor
  - Resistance of the resistor
  - Time for which the current flows through the resistance

Practical Applications of the Heating Effects of Electric Current

- Electrical appliances like laundry iron, toaster, oven, kettle and heater are some devices based on Joule's Law of Heating.
- The concept of electric heating is also used to produce light, as in an electric bulb.
- Another application of Joule's Law of Heating is the fuse used in electric circuits.

Electric Power

- Electric power is the rate at which electrical energy is produced or consumed in an electric circuit
  $P = VI = I^2R$
  $P = V^2/R$
- The **S.I. unit** of power is **watt (W).**
- One watt of power is consumed when 1 A of current flows at a potential difference of 1 V.
  The commercial unit of electric energy is **kilowatt hour (kWh)**, commonly known as a **unit**.
  1 kWh = 3.6 MJ

NUMERICAL PROBLEMS

1. Find the charge if the number of electrons is 4×10^{-18}.
2. Find the number of electrons constituting one coulomb of charge.
3. How much work done in moving a charge of 3 coulombs from a point at 118 V to a point at 128 volt?
4. How much work done in moving a charge of 2C across two points having a potential difference of 12V?
5. Calculate the amount of work done to carry 4C from a point at 100 V to a point at 120 volt?
6. How much work will be done in bringing a charge of 2×10^{-3} coulombs from infinity to a point P at which the potential is 5 V?
7. How much work will be done in bringing a charge of 3×10^{-2} coulombs from infinity to a point P at which the potential is 20 V?
8. How much energy is given to each coulomb of charge passing through a 6V battery?
9. How much energy is transferred by a 12 V power supply to each coulomb of charge which it moves around a circuit?
10. What is the potential difference between the terminals of a battery if 250 joules of work is required to transfer 20 coulombs of charge from one terminal of battery to the other?