

# Electricity

## Lecture Notes: Current Electricity

### 3.3 Electric Currents in Conductors

#### Movement of Electric Charge in Conductors:

- **Electric Field:** An electric charge will experience a force when an electric field is applied. If the charge is free to move, it will contribute to an electric current.
- **Thermal Motion:** Without an electric field, electrons move randomly due to thermal energy, resulting in no net current. When an electric field is applied, electrons drift towards the positive terminal, creating a current.

#### Description of Free and Bound Charges:

- **Free Charges:** In conductors, some electrons are not bound to any specific atom and can move freely through the material. These free electrons are responsible for electric current.
- **Bound Charges:** In insulators, electrons are tightly bound to their atoms and cannot move freely. These materials do not conduct electricity under normal conditions.

#### Explanation of Electric Current in Solid Conductors and Electrolytic Solutions:

- **Solid Conductors:** In metals, free electrons move through the lattice of positively charged ions. When an electric field is applied, these free electrons drift in the direction opposite to the field, resulting in an electric current.
- **Electrolytic Solutions:** In solutions, both positive and negative ions are free to move. When an electric field is applied, positive ions move towards the negative electrode, and negative ions move towards the positive electrode, resulting in a current.

### 3.4 Ohm's Law

#### Statement and Explanation of Ohm's Law ( $V = IR$ ):

- **Ohm's Law:** Discovered by Georg Simon Ohm in 1828, this law states that the current ( $I$ ) flowing through a conductor between two points is directly proportional to the voltage ( $V$ ) across the two points and inversely proportional to the resistance ( $R$ ) of the conductor.
- **Mathematical Expression:**  $V = IR$ 
  - $V$  is the voltage across the conductor in volts (V).
  - $I$  is the current through the conductor in amperes (A).
  - $R$  is the resistance of the conductor in ohms ( $\Omega$ ).

#### Dependence of Resistance on Material and Dimensions:

- **Material:** Different materials have different inherent resistivities. Metals like copper and aluminum have low resistivities and are good conductors, while materials like rubber and glass have high

resistivities and are insulators.

- **Length and Cross-Sectional Area:**

- **Length (l):** Resistance is directly proportional to the length of the conductor.  $R \propto l$
- **Cross-Sectional Area (A):** Resistance is inversely proportional to the cross-sectional area of the conductor.  $R \propto \frac{1}{A}$
- **Combined Formula:**  $R = \rho \frac{l}{A}$ , where  $\rho$  is the resistivity of the material.

### Calculations of Resistance in Different Configurations:

- **Series Configuration:** When resistors are connected end-to-end, the total resistance is the sum of the individual resistances.
  - $R_{\text{total}} = R_1 + R_2 + \dots + R_n$
- **Parallel Configuration:** When resistors are connected across the same two points, the total resistance is given by the reciprocal of the sum of the reciprocals of the individual resistances.
  - $\frac{1}{R_{\text{total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n}$

These principles allow for the calculation of resistance in various electrical circuits, facilitating the design and analysis of electrical systems.