Unit 2: CURRENT ELECTRICITY

LEARNING OBJECTIVES

In this unit, the student is exposed to

- Flow of charges in a metallic conductor
- Ohm's law, electrical resistance, V-I characteristics
- Carbon resistors and combination of resistors
- Kirchhoff 's laws - Wheatstone's bridge and its applications
- Electric power and Electric energy
- Heating effect - Joule's law – Experimental verification and applications
- Thermoelectric effects – Seebeck effect – Peltier effect – Thomson effect

Notes and Key Points

- Each atom consists of a positively charged nucleus with negatively charged electrons moving around the nucleus.
- If a net charge Q passes through any cross section of a conductor in time t, then the current is defined as $I = \frac{Q}{t}$.

- Electric current is not only produced by batteries. In nature, lightning bolt produces enormous electric current in a short time. During lightning, very high potential difference is created between the clouds and ground so charges flow between the clouds and ground.
- Any material is made up of neutral atoms with equal number of electrons and protons. If the outermost electrons leave the atoms, they become free electrons and are responsible for electric current. The atoms after losing their outer most electrons will have more positive charges and hence are called positive ions. These ions will not move freely within the material like the free electrons. Hence the positive ions will not give rise to current.
- The typical drift velocity of electrons in the wire is 10^{-4} m s^{-1}. If an electron drifts with this speed, then the electrons leaving the battery will take hours to reach the light bulb. Then how electric bulbs glow as soon as we switch on the battery? When battery is switched on, the electrons begin to move away from the negative terminal of the battery and this electron exerts force on the nearby electrons. This process creates a propagating influence (electric field) that travels through the

wire at the speed of light. In other words, the energy is transported from the battery to light bulb at the speed of light through propagating influence (electric field). Due to this reason, the light bulb glows as soon as the battery is switched on.

- In general, the current I is defined as the scalar product of the current density and area vector in which the charges cross. $I = \vec{J}.\vec{A}$
- The current I can be positive or negative depending on the choice of the unit vector normal to the surface area A.
- The resistance is the ratio of potential difference across the given conductor to the current passing through the conductor.
- The electrical resistivity of a material is defined as the resistance offered to current flow by a conductor of unit length having unit area of cross section.
- The human body contains a large amount of water which has low resistance of around 200 Ω and the dry skin has high resistance of around 500 k Ω. But when the skin is wet, the resistance is reduced to

around1000 Ω. This is the reason, repairing the electrical connection with the wet skin is always dangerous.

- The value of equivalent resistance in series connection will be greater than each individual resistance.
- The value of equivalent resistance in parallel connection will be lesser than each individual resistance.
- While reading the colour code, hold the resistor with colour bands to your left . Resistors never start with a metallic band on the left.
- A multimeter is a very useful electronic instrument used to measure voltage, current, resistance and capacitance. In fact, it can also measure AC voltage and AC current. The circular slider has to be kept in appropriate position to measure each electrical quantity.
- The resistance of certain materials become zero below certain temperatureT_c.This temperature is known as critical temperature or transition temperature. The materials which exhibit this property are known as superconductors. This phenomenon was first observed by Kammerlingh Onnes in 1911. He found that mercury exhibits

superconductor behaviour at 4.2 K. Since R = 0, current once induced in a superconductor persists without any potential difference.

- The electrical power produced (dissipated) by a resistor is I^2R. It depends on the square of the current. Hence, if current is doubled, the power will increase by four times. Similar explanation holds true for voltage also.
- The Tamilnadu Electricity Board is charging for the amount of energy you use and not for the power. A current of 1A flowing through a potential difference of 1V produces a power of 1W.
- If we connect copper and zinc rod in a lemon, it acts as an electric cell. The citric acid in the lemon acts as an electrolyte. The potential can be measured using a multimeter.
- When the car engine is started with headlights turned on, they sometimes become dim. This is due to the internal resistance of the car battery.
- Kirchhoff 's rules can be used to find current and voltage.

- A galvanometer is an instrument used for detecting and measuring even very small electric currents. It is extensively useful to compare the potential difference between various parts of the circuit.
- Seebeck discovered that in a closed circuit consisting of two dissimilar metals, when the junctions are maintained at different temperatures an emf (potential difference) is developed. The current that flows due to the emf developed is called thermoelectric current. The two dissimilar metals connected to form two junctions is known as thermocouple.
- Peltier discovered that when an electric current is passed through a circuit of a thermocouple, heat is evolved at one junction and absorbed at the other junction. This is known as Peltier effect.
- Thomson showed that if two points in a conductor are at different temperatures, the density of electrons at these points will differ and as a result the potential difference is created between these points. Thomson effect is also reversible.