Chapter 3: Electricity: Circuits and their Components

1. Introduction to Electricity

- **Generation of Electricity:** Electricity can be generated through various methods, such as using windmills (wind energy), solar panels (the Sun's energy), falling water (hydroelectric power, like the Bhakra Nangal Dam), natural gas, or coal. This electricity travels from power plants to our homes and factories via wires.
- **Uses of Electricity:** Electricity powers almost every aspect of modern life, classified into categories:
    - *Lighting:* Homes, offices, streets, markets, and factories.
    - *Heating and Cooling:* Fans, room heaters, immersion rods, geysers, refrigerators, and air conditioners.
    - *Transportation:* Trains, buses, cars, scooters, lifts, and escalators.
    - *Cooking:* Ovens, microwaves, electric kettles, mixer grinders, and toasters.
    - *Entertainment & Communication:* Televisions, radios, mobile phones, and the Internet.

2. The Electric Cell and Battery

An electric cell is a portable source of electrical energy.

- **Activity 3.1: Exploring a Torchlight**
    - *Action:* Take a torchlight, slide its switch ON, and then slide it back to the OFF position.
    - *Observation:* The torch lamp glows in one switch position and stops in the other. Opening the torch reveals two or more electric cells inside.
- **Activity 3.2: Observing an Electric Cell**
    - *Action:* Carefully examine a single electric cell.
    - *Observation:* The cell has two terminals marked with a positive (+) sign and a negative (-) sign. The **small protruding metal cap** is the positive terminal, and the **flat metal disc** at the base is the negative terminal.
- **Activity 3.3: Experimenting with a Battery's Alignment**

- *Action:* Take two cells from a torch and place them back in a different order (e.g., reversing the direction of one cell).
- *Observation & Conclusion:* The lamp only glows when the positive terminal of one cell is connected directly to the negative terminal of the next cell. This specific combination of two or more cells is called a **battery**. (Note: In common language, even a single cell used in a mobile phone is often called a battery).
- *Dive Deeper (Side-by-Side Cells):* In devices where cells are placed side-by-side, a thick wire or metal strip inside the compartment connects the positive terminal of one cell to the negative terminal of the next.

3. Types of Electric Lamps

There are two main types of small lamps used in torches and school experiments.

- **Activity 3.4: Observing an Incandescent Lamp**
  - *Action:* Remove and examine a traditional incandescent torch bulb. Switch it on to see what produces the light.
  - *Observation:* Inside the glass bulb is a very thin wire called a **filament**. When current passes through it, the filament gets hot and glows to produce light.
  - *Structure:* The filament is supported by two thicker wires connected to the lamp's two terminals—one at the metal case of the base, and one at the metal tip at the very bottom (these terminals do not touch). If a lamp is "fused," it means this filament is broken, stopping the flow of current.
- **Activity 3.5: Observing an LED (Light Emitting Diode)**
  - *Action:* Examine an LED lamp of any colour.
  - *Observation:* LEDs do not have filaments. They have two wire terminals of unequal length: the **longer wire is the positive terminal**, and the **shorter wire is the negative terminal**.

4. Electrical Circuits (Making the Lamp Glow)

An electrical circuit is a setup that provides a complete, unbroken path for electric current to flow through a device. The direction of current is always from the positive terminal to the negative terminal of the cell.

- **Activity 3.6: Constructing a Simple Electrical Circuit**
  - *Materials:* Electric cell, incandescent lamp, holders, and four wires (with 1 cm of plastic insulation removed from the ends).

    - *Action:* Connect the cell and lamp in 6 different arrangements (e.g., leaving a wire broken, or connecting both wires to a single terminal).
    - *Conclusion:* The lamp *only* glows when there is a complete, closed circuit. One terminal of the lamp must connect to one cell terminal, and the other lamp terminal to the remaining cell terminal. For an incandescent lamp, it does not matter which terminal connects to positive or negative.
- **Activity 3.7: Making an LED Glow (Directional Current)**
    - *Action:* Connect an LED to a 2-cell battery. First, connect the longer wire to the positive terminal and the shorter wire to the negative terminal. Then, strictly interchange the wires.
    - *Observation & Conclusion:* The LED only glows in the first arrangement. Electric current can pass through an LED in **one direction only**. If connected backwards, it will not glow.

5. The Electric Switch

A switch is a simple mechanical device used to either complete (close) or break (open) an electrical circuit.

- **Activity 3.8 & 3.9: Constructing and Testing a DIY Switch**
    - *Construction:* Insert a drawing pin through the ring of a safety pin (or paper clip) and fix it to a piece of cardboard so it can rotate. Fix a second drawing pin nearby. Connect wires to both drawing pins.
    - *Testing (ON Position):* When the safety pin is rotated to touch both drawing pins, it closes the gap. This completes the circuit, allowing current to flow, and the lamp glows.
    - *Testing (OFF Position):* When the safety pin is moved away, it creates an air gap. This breaks the circuit, stopping the current, and the lamp does not glow.

6. Circuit Diagrams and Standard Symbols

To make drawing and designing circuits easier globally, scientists use circuit diagrams with universal symbols created by organizations like the IEC, ANSI, and IEEE.

- **Electric Cell:** A long vertical line (positive terminal) next to a shorter, thicker vertical line (negative terminal).
- **Battery:** Multiple cell symbols connected in a row.
- **Incandescent Lamp:** A circle with a cross (X) inside it.

- **LED:** A triangle pointing in the direction of current flow, with a vertical line at the tip (negative terminal) and two arrows pointing outward to indicate light emission.
- **Switch:** A line with a break/raised flap (OFF) or a continuous line with dots (ON).
- **Activity 3.10 (Drawing Circuit Diagrams):** Students use these standard international symbols to accurately draw the exact circuits created in the previous Switch and LED activities on paper.

7. Electrical Conductors and Insulators

Why are wires made of metal and coated in plastic?

- **Activity 3.11: Identifying Conductors and Insulators**
    - *Action:* Build a "conduction tester" by connecting a cell and a lamp, but leaving the two far ends of the wires free. Touch these two free ends to various objects: a wooden stick, a plastic scale, a glass bangle, a paper strip, a wax candle, a metal key, and a rubber eraser.
    - *Observation:* The lamp only glows when the wires touch the metal key.
- **Electrical Conductors (Good Conductors):** Materials that allow electric current to flow through them easily.
    - *Examples:* Metals like silver, copper, and gold are the best conductors. Copper is widely used for making wires due to its lower cost and abundant supply. They are used to make the inner wires, switches, and plug pins.
- **Electrical Insulators (Poor Conductors):** Materials that block electric current from passing through.
    - *Examples:* Plastic, rubber, glass, wood, wax, paper, and ceramics. They are used to coat electrical wires, plug tops, and switches to protect people from lethal electric shocks.

8. Types of Current & Electrical Safety

- **Direct Current (DC) vs. Alternating Current (AC):**
    - *DC:* Electricity coming from batteries and cells flows in one single direction and is used to power smaller, portable devices.
    - *AC:* Electricity generated from power plants that reaches our home wall sockets. It is much more powerful and can run large household appliances.

- **Safety Warning:** The human body is a conductor of electricity. Electric current from main power supplies can cause severe injury or death. Never touch switches/plugs with wet hands, use devices in wet areas, or handle equipment with damaged wire insulation. Experiments should *only* be performed with low-power batteries/cells, never with the main wall socket.

9. Exploratory Projects

The chapter ends with hands-on projects to test the students' knowledge:

- **Solar Powered Fan:** Using a solar panel as the primary electrical energy source, connect its positive and negative wires to a small motor attached to a toy fan blade. Placing the panel in direct sunlight will generate electricity and cause the fan to spin.
- **The Battery Tester Challenge:** You are given six cells (marked A to F), some of which are working and some are dead. Using the conduction tester from earlier (wires and a lamp), you must systematically connect each cell one by one to determine which cells successfully complete the circuit and make the lamp glow.
- **Household Sorting Activity:** Walk around your home and create a list of objects, categorizing them strictly into three groups: (i) Objects that are purely electrical insulators, (ii) Objects that are purely electrical conductors, and (iii) Objects made of both (e.g., a copper wire coated in rubber)