📘 Chapter 11: Electricity

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🔹 Introduction

Electricity is a controllable and convenient form of energy used in homes, schools, hospitals, and industries. In this chapter, we explore:

- What constitutes electricity
- How it flows in circuits
- Laws governing current, voltage, and resistance
- Heating effects and power calculation

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🔸 11.1 Electric Current and Circuit

📘 **Electric Current:**
The flow of electric charge (usually electrons) through a conductor.
It is measured as the rate of flow of charge:

I = Q / t
Where:
I = Current (in amperes),
Q = charge (in coulombs),
t = time (in seconds)

📘 1 Coulomb = charge carried by 6 × 10^{18} electrons
📘 1 Ampere = 1 Coulomb/1 second

🧪 **Ammeter:** Used to measure electric current. Always connected in series in a circuit.

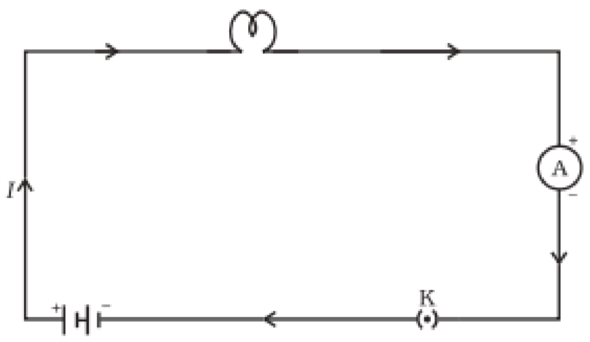

Figure 11.1
A schematic diagram of an electric circuit comprising – cell, electric bulb, ammeter and plug key

🔸 11.2 Electric Potential and Potential Difference

📘 **Electric Potential:**
Work done in moving a unit charge from one point to another.

📘 **Potential Difference (V) =** Work Done (W) / Charge (Q)

Unit: Volt (V)
1 V = 1 Joule / 1 Coulomb

🧪 **Voltmeter:** Measures potential difference; always connected in parallel.

Example: Moving 2 C of charge across 12 V requires 24 J of work.

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🔶 11.3 Circuit Diagram

Circuit diagrams use symbols to represent components.
📋 Examples:

- Cell: |–
- Battery: | |–
- Switch (open): . .
- Switch (closed): –
- Resistor: zig-zag line
- Ammeter: ⓐ
- Voltmeter: ⓥ

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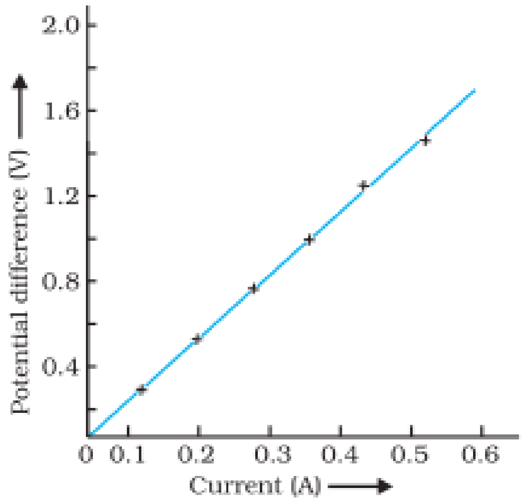
🔶 11.4 Ohm's Law

📘 **Ohm's Law:**
At constant temperature, current (I) through a conductor is directly proportional to the voltage (V).

$V \propto I \rightarrow V = IR$
R = Resistance in ohms (Ω)

📘 **Resistance (R) = V/I**
If V = 1 V and I = 1 A, then R = 1 Ω



📷 *Fig 11.3 – V-I graph*

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🔶 11.5 Factors Affecting Resistance

🧪 **Activity:** Using wires of different lengths, areas, and materials

📘 **Resistance depends on:**

- Length (l): R ∝ l
- Cross-sectional Area (A): R ∝ 1/A
- Material: Resistivity (ρ)

R = ρ × (l / A)

📘 **Resistivity (ρ):**
Characteristic of the material. Unit: Ω m

	Material	Resistivity (Ω m)
Conductors	Silver	1.60×10^{-8}
	Copper	1.62×10^{-8}
	Aluminium	2.63×10^{-8}
	Tungsten	5.20×10^{-8}
	Nickel	6.84×10^{-8}
	Iron	10.0×10^{-8}
	Chromium	12.9×10^{-8}
	Mercury	94.0×10^{-8}
	Manganese	1.84×10^{-6}
Alloys	Constantan (alloy of Cu and Ni)	49×10^{-6}
	Manganin (alloy of Cu, Mn and Ni)	44×10^{-6}
	Nichrome (alloy of Ni, Cr, Mn and Fe)	100×10^{-6}
Insulators	Glass	$10^{10} – 10^{14}$
	Hard rubber	$10^{13} – 10^{16}$
	Ebonite	$10^{15} – 10^{17}$
	Diamond	10^{12} - 10^{13}
	Paper (dry)	10^{12}

📋 *Table 11.2 – Resistivity of various materials (e.g., Copper, Nichrome, Glass)*

🔶 11.6 Resistance in Series and Parallel

📘 Series Combination:

- Current is same through all
- Voltage divides

$R_{total} = R_1 + R_2 + R_3$

📘 Parallel Combination:

- Voltage is same across all
- Current divides

$1/R_{total} = 1/R_1 + 1/R_2 + 1/R_3$

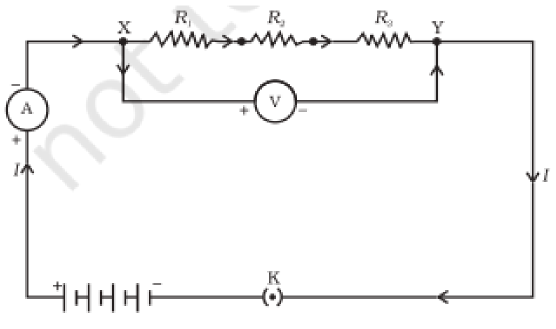

Figure 11.6 *Resistors in series*

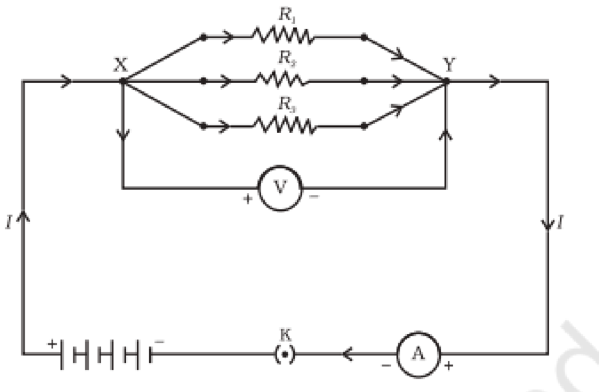

Figure 11.7 *Resistors in parallel*

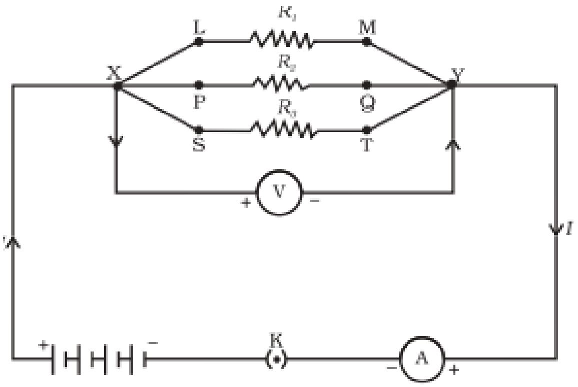

Figure 11.10

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🔶 11.7 Heating Effect of Electric Current

📘 When current flows through a resistor, electrical energy is converted into heat.

Heat (H) = VIt = I^2Rt = V^2t/R

📘 Joule's Law of Heating:

- **H ∝ I^2** (more current, more heat)
- **H ∝ R** (more resistance, more heat)
- **H ∝ t** (longer time, more heat)

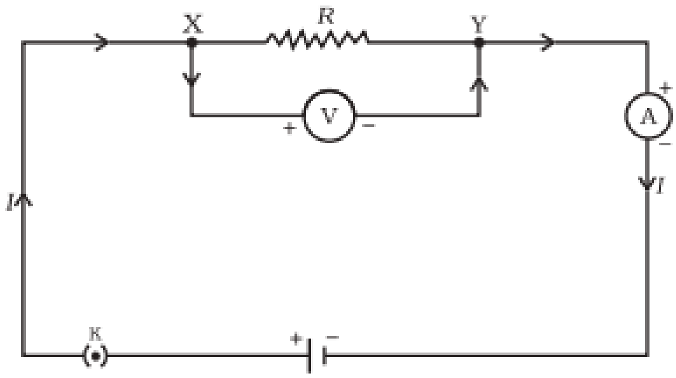

Figure 11.13
A steady current in a purely resistive electric circuit

🧠 **Applications:**

- Electric heaters, toasters, irons
- Electric bulbs (tungsten filament)
- Electric fuse (thin wire that melts when excess current flows)

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🔶 11.8 Electric Power

📘 **Power (P)** = Rate at which electrical energy is used
$P = VI = I^2R = V^2/R$
Unit: Watt (W)

📘 **Commercial unit of energy: kilowatt-hour (kWh)**
1 kWh = 1000 W × 3600 s = 3.6×10^6 J

🧮 Example:
If a 400 W refrigerator works for 8 hrs/day for 30 days:
Energy = 400 × 8 × 30 = 96000 Wh = 96 kWh

If cost is ₹3/kWh → Bill = ₹288

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📌 Summary:

- Electric current is flow of electrons
- Potential difference causes the flow
- Ohm's Law: V = IR
- Resistance depends on length, area, material
- Series: R adds up; Parallel: 1/R adds up
- Heating effect used in daily devices
- Electric power = energy/time; unit = watt, kWh