# PARMAR SSC

# ELECTRICITY

## Lecture - 7



BY PARMAR SIR

# Electric Current

- Electric current is the rate of flow of electrons in a conductor, (represented by "I")
- The SI Unit of electric current is the Ampere.
- Electric current is also expressed as the flow of charge per unit time or flow of electrons per unit time (1 e = $1.6 \times 10^{-19}$ Coulomb).
- It is measured by Ammeter.

**I (Electric Current) = q (Charge) / t (Time)**

**q = I × t**

**q = n × e**
**1 C = n × $1.6 \times 10^{-19}$**
**n = 1 / $1.6 \times 10^{-19}$**
**= $6.25 \times 10^{18}$ e⁻**
**n ≈ $6 \times 10^{18}$ e⁻**

**q = Total charge (in Coulombs)**
**n = No. of electrons**
**e = Charge of a single e- ($1.6 \times 10^{-19}$ C)**

# Conductor

- A conductor is an object or type of material that allows the flow of charge (electric current) in one or more directions.

# Potential Difference

- Potential difference is the amount of work done in moving a unit positive charge from one point to other in an electric field.
- The S.I. unit of potential difference is Volt.
- It is measured using a Voltmeter.

$V = \frac{W}{Q}$ W=qV

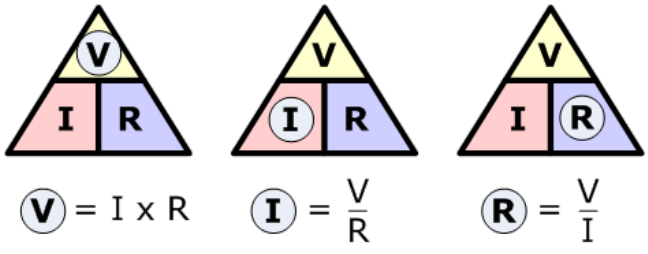
**1 Volt: It is the amount of energy needed to move a unit charge from one point to another.**

$1\ \text{VOLT} = \frac{1\ \text{Joule}}{1\ \text{Coulomb}}$

# Ohm Law

- The Ohm's Law states that "The current flowing in a conductor is directly proportional to the voltage across the conductor, provided all the physical condition and temperature remain constant".
- Ohm's Law is given by George Simon Ohm in 1827.
- Ohm's law can be rewritten in three different forms.

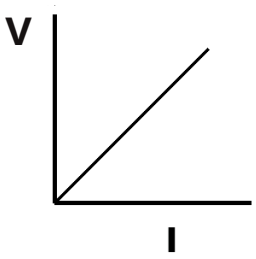
$V \propto I$



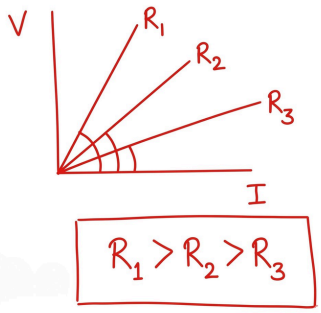

$V = I \times R$ $I = \frac{V}{R}$ $R = \frac{V}{I}$

**V = Voltage**
**I = Current**
**R = Resistance**

- When voltage increases, current generally also increases, assuming the resistance and temperature remain constant.




Higher the slope, higher the resistance



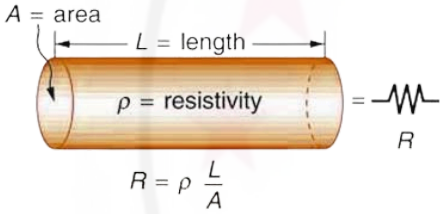

## Resistance

- Resistance is defined as the property of an electrical component to resist the flow of electric current.
- The S.I. unit of resistance is Ohm (Ω).

$$R = \rho \frac{L}{A}$$

**R = Resistance**
**ρ = Resistivity of the material**
**L = Length of the conductor**
**A = Area of cross-section**

### Resistivity ρ/Specific Resistance




- The resistivity of a material is a measure of how strongly a material opposes the flow of electrical current.
- Resistivity is constant.

### Factors Affecting Resistance

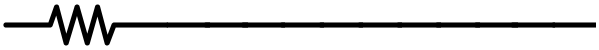
#### Length of the Conductor (L)



Resistance is directly proportional to length.

$$R \propto L$$

#### Area of Cross-Section (A)



Resistance is inversely proportional to the area of cross-section.

$$R \propto \frac{1}{A}$$

A thicker conductor has a lower resistance because electrons have more space to flow with fewer collisions.
E.g. A wire with a larger diameter offers less resistance.

## Temperature (T)

For metallic conductors, resistance increases with temperature.
This happens because atoms vibrate more at higher temperatures, increasing collisions (increase movement of electrons and K.E.).
For semiconductors, resistance decreases with temperature.

Note: The temperature-resistance relationship depends on the material.

## Nature of the Material (Resistivity)

Different materials have different intrinsic resistivities.
Lower resistivity → better conductor (E.g., copper, silver)
Higher resistivity → poorer conductor or insulator (E.g. rubber, plastic)

## Nature of the Material (Resistivity)

$$\Omega = \rho \times \frac{m}{m^2}$$
$$\Omega m = \rho$$
$$S.I.\ unit\ of\ resistivity = \Omega m$$

$$R \propto L$$
$$R \propto \frac{1}{A}$$
$$R \propto \frac{L}{A}$$
$$R = \frac{\rho L}{A}$$

## Conductance (Symbol: G)

- It measures how easily electricity flows through a component.
- The S.I unit of conductance is Siemens (S)

## Materials are classified into

### 1 Conductors

- Materials that readily allow the flow of electric current, exhibiting high electrical conductivity and low resistivity.
- E.g. Copper, silver, gold, aluminium, steel.




### 2 Semiconductors

- Materials with conductivity values between conductors and insulators, offering the possibility to control their conductivity.
- E.g. Silicon, germanium, and various compounds like arsenide.



## 3 Insulators

- Materials that resist the flow of electric current, having high electrical resistivity and low conductivity.
- **E.g.** Rubber, glass, plastic, air, pure water.



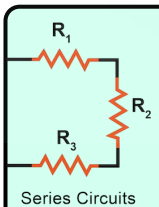
| | Material | Resistivity (Ω m) |
|---|---|---|
| **Conductors** | Silver | $1.60 \times 10^{-8}$ |
| | Copper | $1.62 \times 10^{-8}$ |
| | Aluminium | $2.63 \times 10^{-8}$ |
| | Tungsten | $5.20 \times 10^{-8}$ |
| | Nickel | $6.84 \times 10^{-8}$ |
| | Iron | $10.0 \times 10^{-8}$ |
| | Chromium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

## Resistance Combination

- In electrical circuits, resistors can be connected in two primary ways: **Series and Parallel.**

### Series Connection

- In a series circuit, resistors are connected end-to-end, forming a single path for current flow.
- Current (I) is the same through each resistor.
- Voltage (V) is divided across each resistor depending on its resistance.



Series Circuits

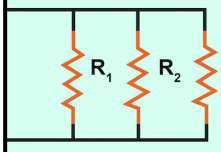
**Req = RI + R2 + R3 + ... + Rn**

**Where, R1, R2, R3 ... Rn are individual resistor value.**
**Same current, different potential difference.**

### Parallel Connection

- In a parallel circuit, resistors are connected across the same two points, creating multiple paths for current flow.
- Voltage (V) is the same across each resistor.
- Current (I) is divided based on the resistance of each branch.

$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \cdots \frac{1}{R_n}$$



Parallel Circuit

**Same potential difference, different current.**

# Heating Effect of Electric Current

- When an electric current flows through a conductor, it produces heat due to the resistance of the conductor.
- This phenomenon is called the heating effect of electric current.

## Joule's Law of Heating

- The heat produced in a resistor due to the flow of current is given by:

$$\text{Heat (H)} = I^2Rt$$

Where
H = Heat energy (in Joules)
I = Current (in amperes)
R = Resistance (in ohms)
t = Time (in seconds)

- Using Ohm's Law (V = IR), the formula can also be written as:

$$H = VIt \text{ or } H = V^2t / R$$

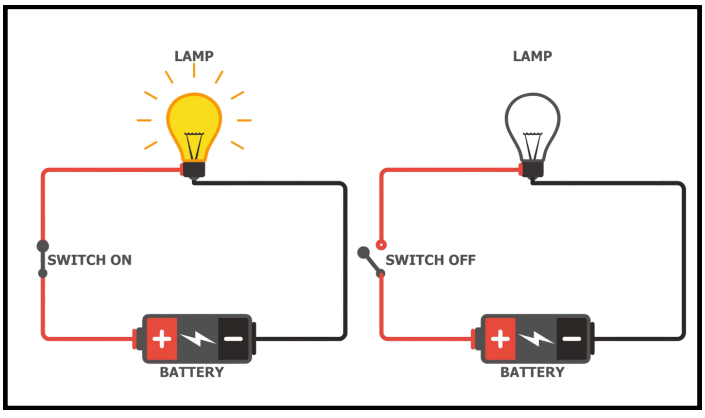
## Applications of Heating Effect of Electric Current

| Application | Details |
|---|---|
| Electric Heater | Nichrome wire used as heating element |
| Electric bulb | Tungsten filament (high melting point) |
| Electric iron | Uses the heating effect to iron clothes |
| Fuse | Thin wire with low melting point to protect |

## Note

- Nichrome is commonly used in heating devices because it has high resistance and it does not oxidize easily at high temperatures.
- A fuse melts when excessive current flows, breaking the circuit and preventing damage. It is used to protect electrical appliances from excessive current and to prevent short circuits or mismatched loads.

## Open and Closed Circuit



## Electric Power

- Electric power is the rate at which electrical energy is consumed or produced.

$$P = VI$$
$$P = I^2R \rightarrow (\because V = IR)$$
$$P = V^2 / R$$

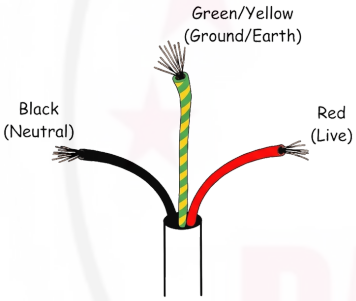
V = Voltage
I = Current
R = Resistance

## Commercial Unit of Energy → kWh

**1 unit = 1kWh**

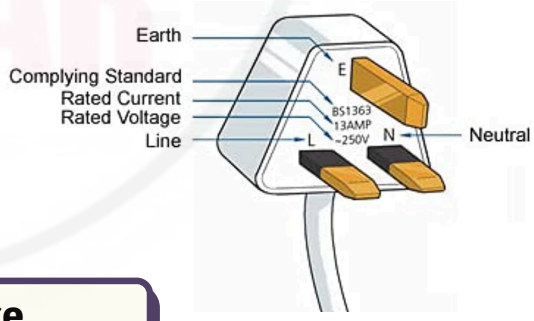
$$1\ kWh = 1\ kW \times 1\ hour = 1000\ watts \times 3600\ secs$$
$$= 3{,}600{,}000\ watt\text{-}seconds\ or\ joules$$
$$= 36 \times 10^5\ Ws$$
$$= 3.6 \times 10^6\ J$$

## Colour Coding in Household Wiring



Electrical Wires Colour Coding

- **Live wire:** Red (high voltage)
- **Neutral:** Black (V = 0)
- **Ground/Earth:** Green/Yellow
- **In electrical appliances:** 220V; 50Hz

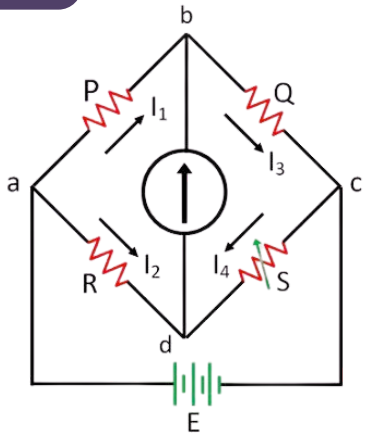



- Earth wire is made thick such that it can manage higher currents with low resistance

## Wheatstone Bridge

- A Wheatstone bridge is an electrical circuit used to accurately measure an unknown resistance by balancing two legs of a bridge circuit using 4 resisters.

$$\frac{P}{R} = \frac{Q}{S}$$



Wheatstone Bridge

# Kirchoff's Law

## Law of Current

- It states that the total current entering a node (junction) in a circuit is equal to the total current leaving that node.

$$\sum I_{In} = \sum I_{Out}$$

## Law of Voltage

- The sum of all voltages (EMFs and voltage drops) around any closed loop in a circuit is equal to zero (ΣV = 0).



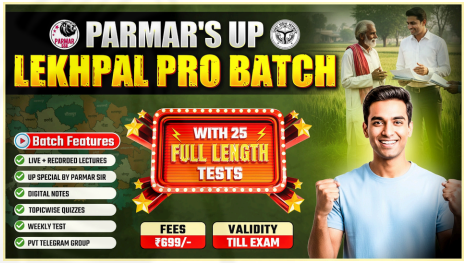

Join Now – Start Your
Smart Preparation Today!

CLICK HERE



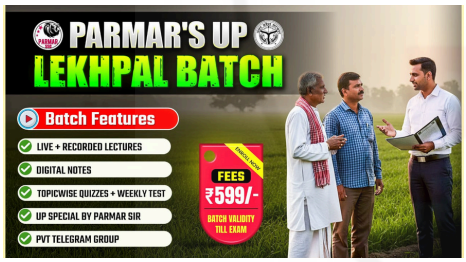

Join Now – Start Your
Smart Preparation Today!

CLICK HERE




Join Now – Start Your
Smart Preparation Today!

CLICK HERE




Join Now – Start Your
Smart Preparation Today!

CLICK HERE




Join Now – Start Your
Smart Preparation Today!

CLICK HERE






Now Listen Parmar ssc classes
on SPOTIFY CLICK HERE