

# Unit 4 Effects Of Current

## Chapter 11:

# Electricity

A physical phenomenon characterized by an excess or deficiency of electrons in a body is known as charge. Charge is a scalar quantity, and its SI unit is the coulomb (C).

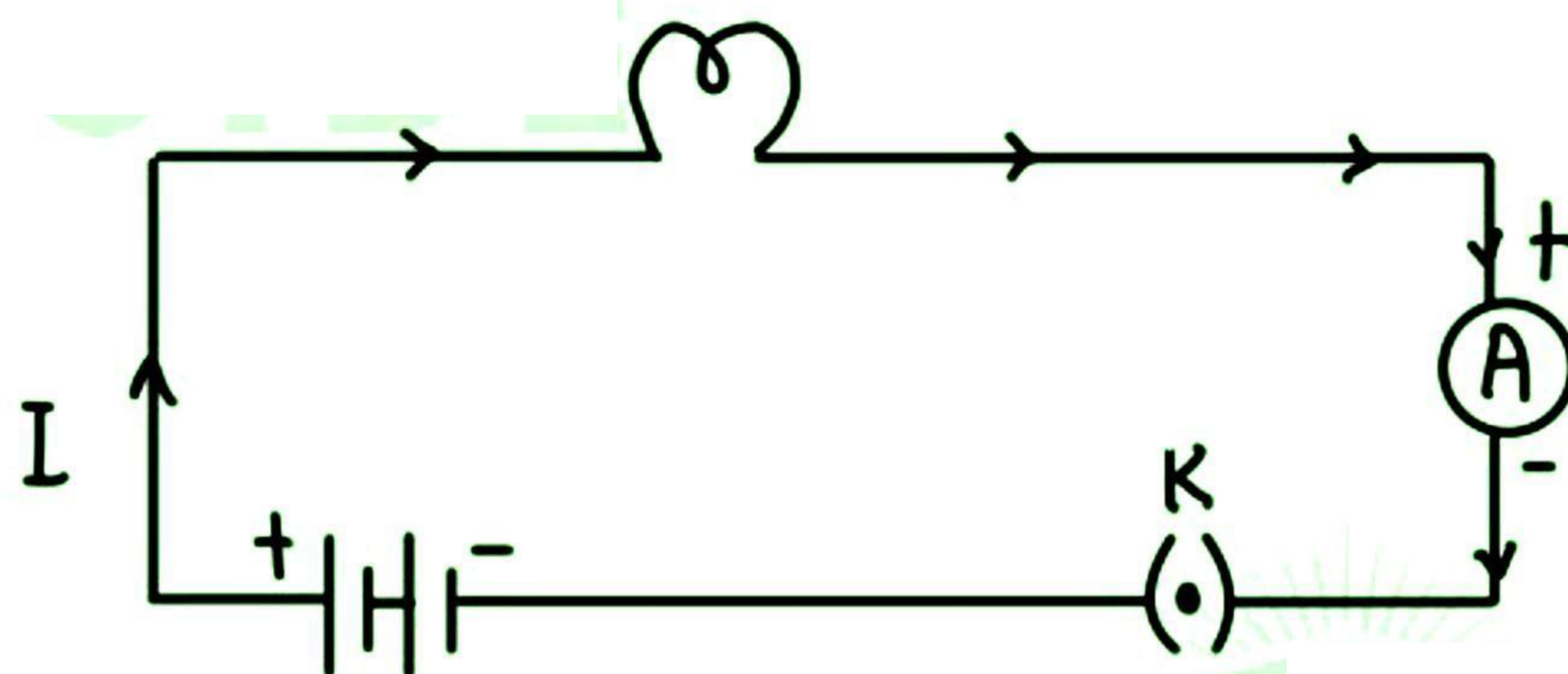
## → Electric Current

When an electric charge is free to move in an electric field, it starts moving in the direction of force due to the field. The dynamic state of electric charge is called **electric current**.

$$I = Q/T$$

$I$  = Electric Current  
 $Q$  = Electric charge  
 $T$  = Time

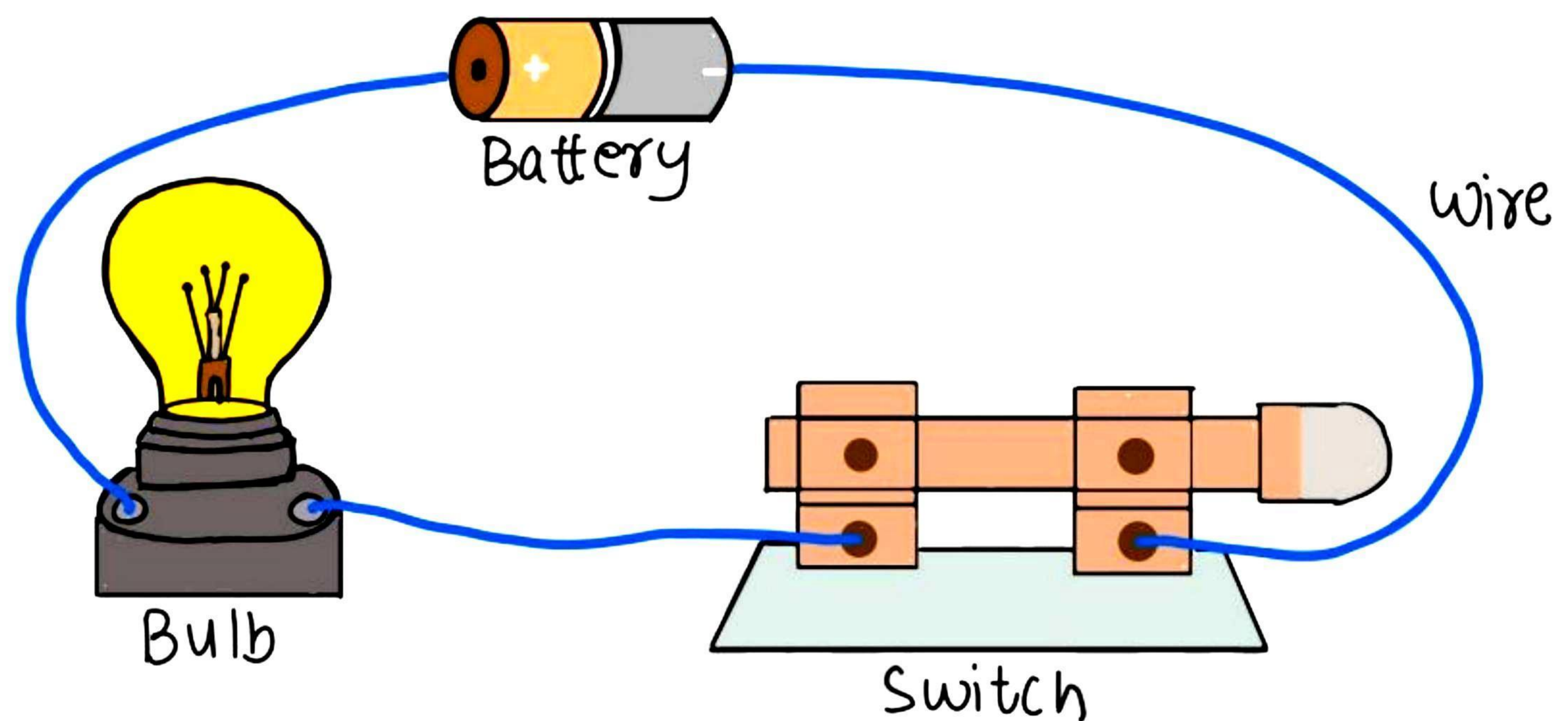
- The S.I unit of Electric Current  $I$  = Ampere
- 1 Ampere: It is constituted by the flow of one coulomb of charge per second.
- Charge of  $e^- = -1.6 \times 10^{-19} \text{C}$
- $1 \text{ mA} = 10^{-3} \text{ A}$  (milliampere)
- $1 \text{ }\mu\text{A} = 10^{-6} \text{ A}$  (microampere)
- 1 coulomb contained  $= 6.25 \times 10^{16}$  electron



## → Electric Circuit

An electric circuit is a pathway for electric current, including components like a power source, load, switch, fuse and wires. When the switch is closed, it's a closed circuit allowing current.

flow, when open circuit, stopping the current flow.



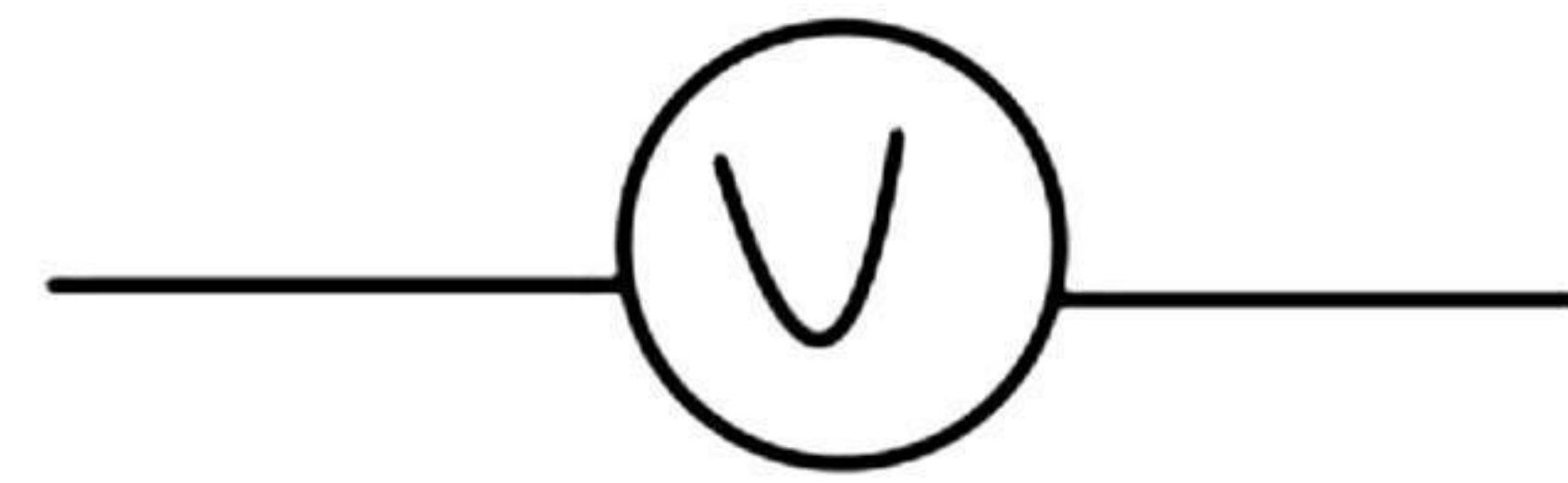
## → Electric Potential

One watt (1W) is the amount of work done to move a unit of positive charge (1C) from infinity to a specific point. This quantity is scalar in nature, and its SI unit is the volt (V).

## 📌 Electric Potential Difference

It quantifies the energy expended per unit of electric charge. Electric potential, delineated as the variance in electric field, corresponds to the energy expended for each charging unit when transporting it from one point to another in an electric field.

- It is a scalar quantity
- SI unit is joules per coulomb



The measurement of the electric potential difference between two points in a circuit is accomplished using a device known as **voltmeter**.



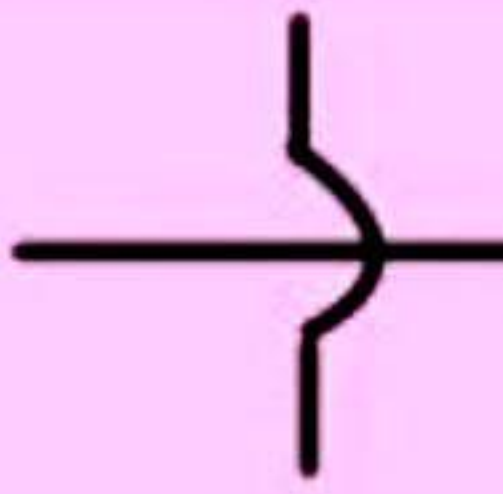


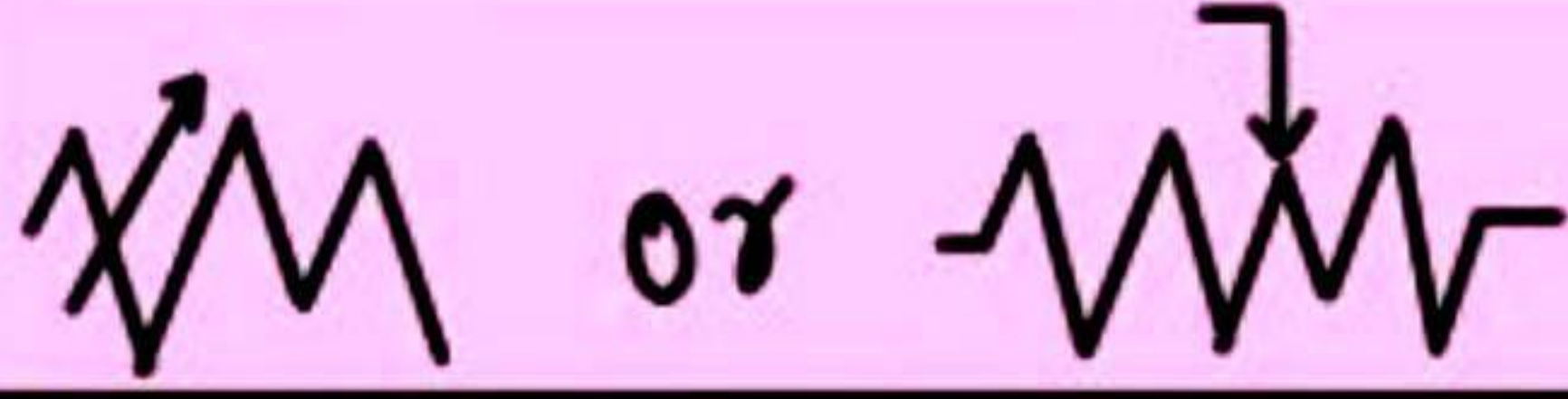


$$V = W/Q$$

Q = charge  
W = work  
V = Potential difference

- SI unit of electric potential difference is **volt (V)**

1 volt - It is a potential difference between two points in a current carrying conductor when 1 joule of work is done to move a charge of 1 coulomb from one point to the other.

S.N	COMPONENTS	SYMBOLS
1.	An electric cell	$\text{---} \begin{array}{c} + \\   \\ - \end{array} \text{---}$
2.	A battery or a combination of cells	$\text{---} \begin{array}{c} + \\   \\ - \end{array} \begin{array}{c} + \\   \\ - \end{array} \begin{array}{c} + \\   \\ - \end{array} \text{---}$
3.	Plug key or switch (open)	$\text{---} ( ) \text{---}$

4.	Plug Key or switch (closed)	
5.	A wire Joint	
6.	Wires Crossing without Joining	
7.	Electric bulb	$\Omega$ or 
8.	A resistor of resistance R	
9.	Variable resistance or rheostat	
10.	Ammeter	
11.	Voltmeter	

## → Ohm's Law

According to this principle, the electric current flowing through a conductor is directly proportional to the applied potential difference across its terminals, provided that physical factors such as temperature remain constant.

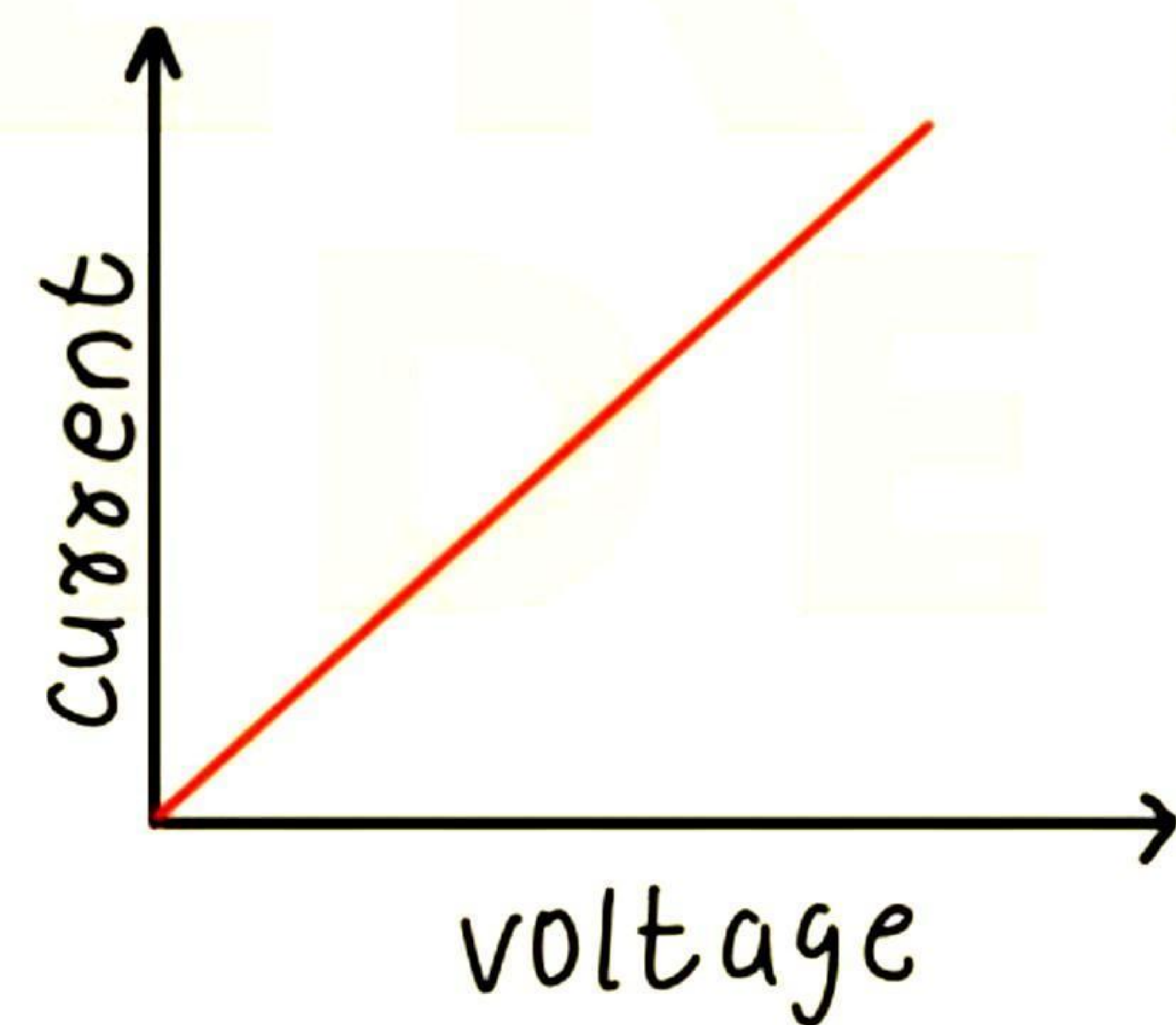
- The  $V-I$  graph is a straight line

$V/I$  is a constant ratio

$$V \propto I$$

$$V = RI$$

$$V/I = R = \text{Constant}$$



## 📌 Resistance

Resistance refers to the property of a conductor that obstructs or opposes the flow of electric charge through it. It's a scalar quantity and its unit in the international system of Units (SI) is the ohm, symbolized by  $\Omega$ .

- Current through a resistor is inversely proportional to its resistance.
- A component used to regulate current without changing the voltage source is called **variable resistance**.
- **Rheostat** is used to change the **resistance**.

- A conductor having some appreciable resistance is called a **resistor**.

The resistance of a conductor depends on

- Its length
- Its area of cross-section
- The nature of its material

$$R \propto l$$

$$R \propto 1/A$$

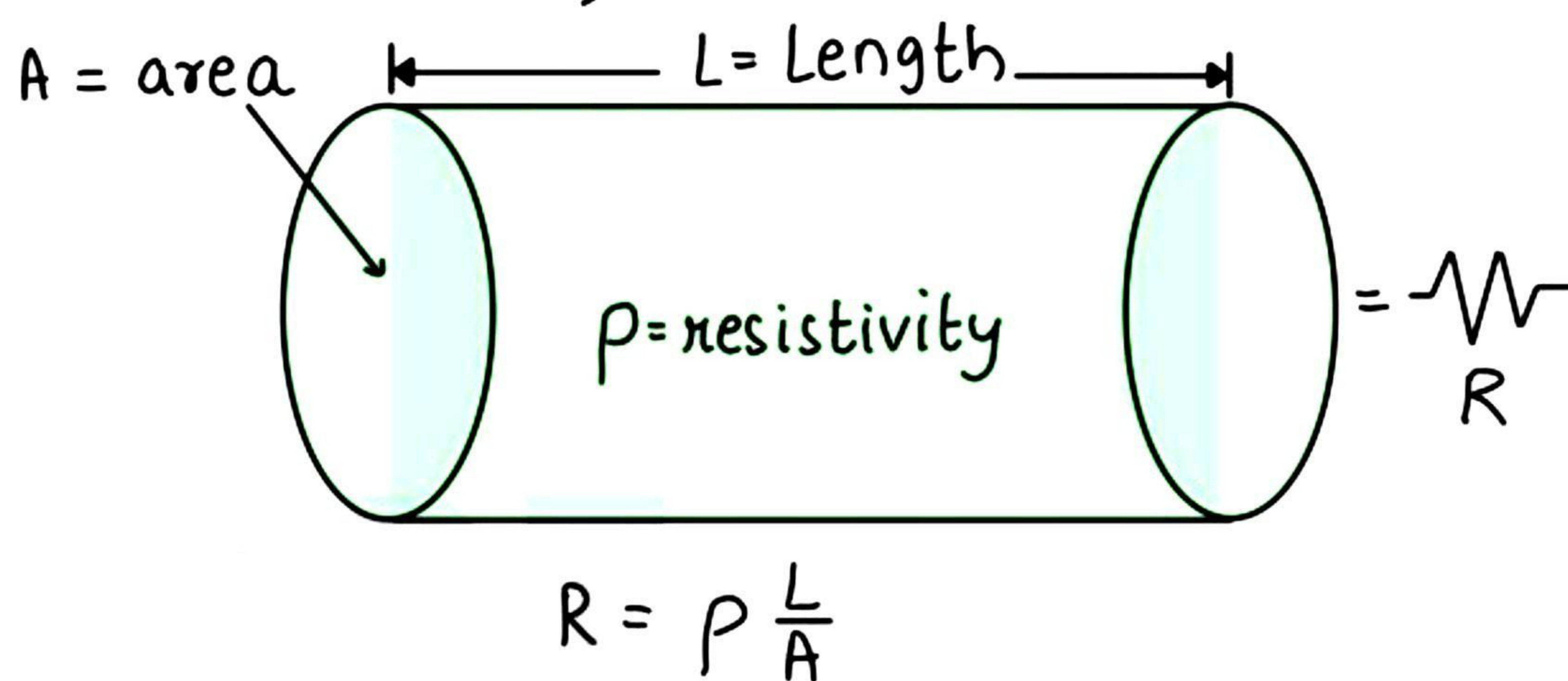
$$R = \rho l/A$$

$\rho$  ( $\rho$ ) is an **constant of proportionality** and is called the electrical resistivity of the material of the conductor.

### 📌 Resistivity

Resistivity is a property of materials that describes their ability to impede the flow of electric current. It is denoted by the symbol  $\rho$  ( $\rho$ ) and is measured in ohm-meters ( $\Omega\text{m}$ ) in the International System of units (SI). The formula for resistivity ( $\rho$ ) is  $R = \rho(L/A)$

Resistivity ( $\rho$ ) characterizes a material's resistance to the flow of electrical current. Conductive materials such as metals exhibit low resistivity, facilitating easy current flow, while insulators have high resistivity. Ohm's Law ( $I = V/R$ ) establishes a relationship between current ( $I$ ), voltage ( $V$ ) and resistance ( $R$ ). Resistance depends on the material's resistivity ( $\rho$ ), as well as its length ( $L$ ) and cross sectional area ( $A$ ).

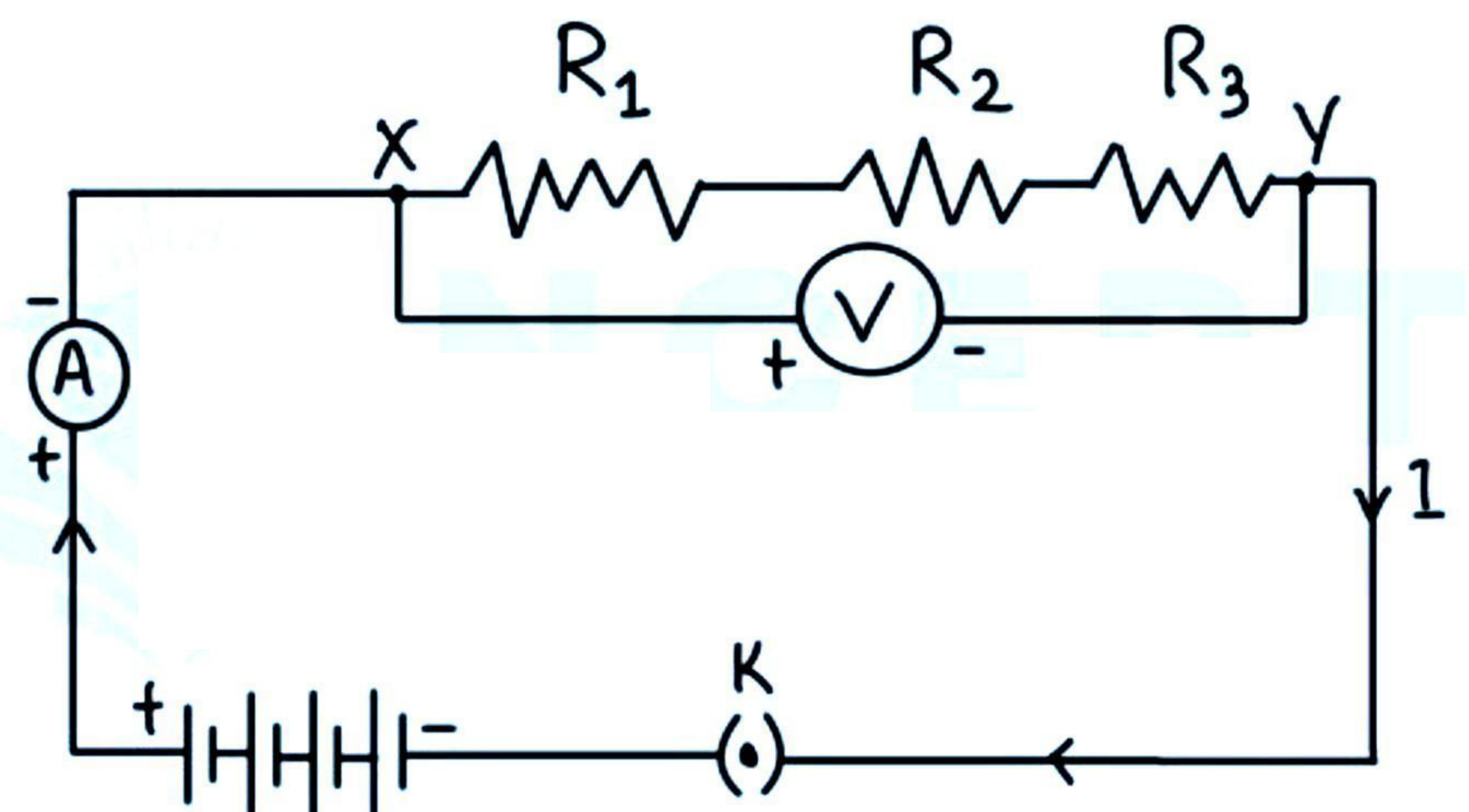


## ➔ Resistance of A system of Resistors

### 📌 Resistors in Series

Resistors in Series  
 $R_{\text{total}} = R_1 + R_2 + R_3 + \dots + R_n$

$I = \text{Same}$   
 $V = \text{Divide}$

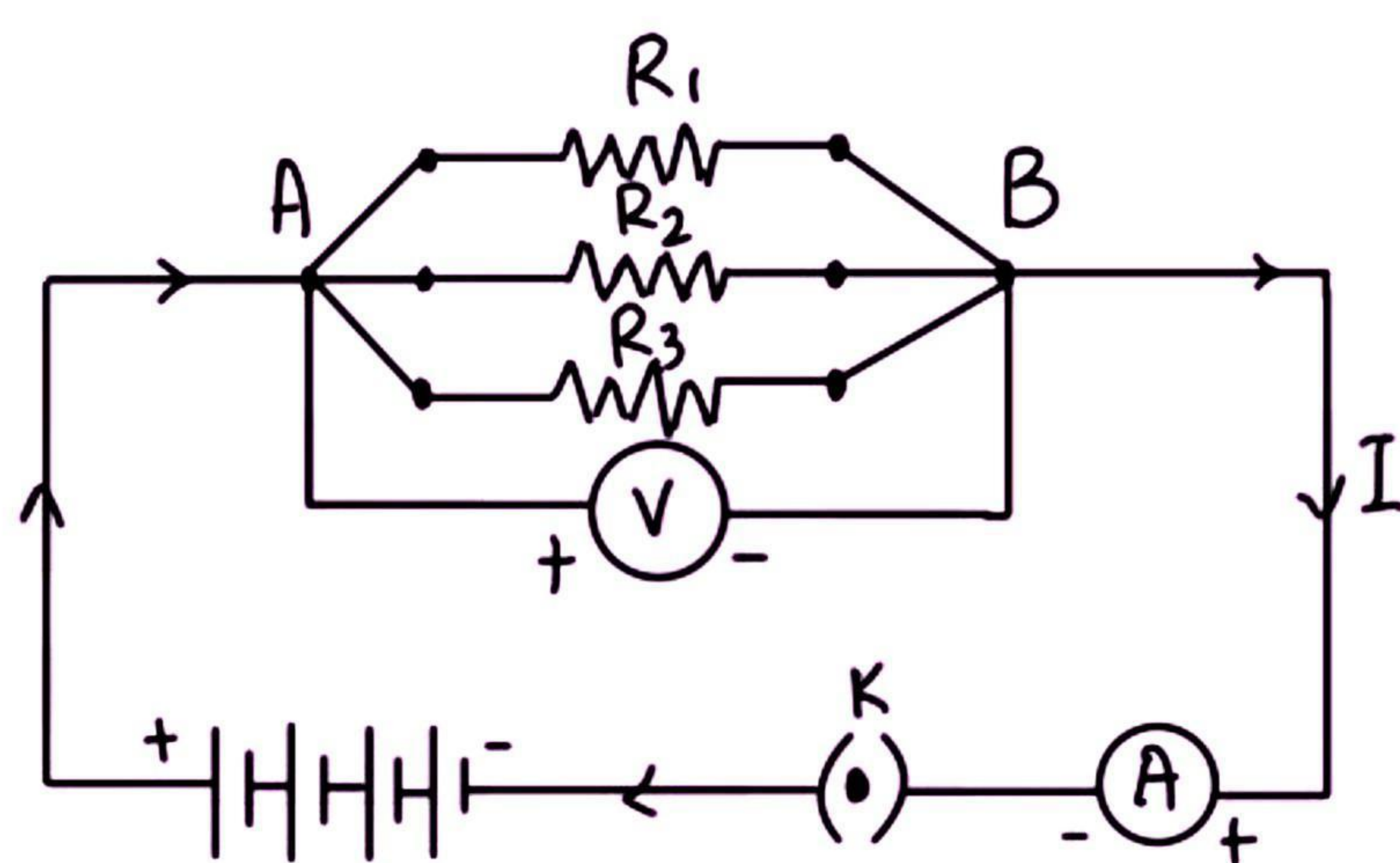


- Series combination formula: Total resistance is the sum of individual resistances.
- When calculating total resistance in a series circuit, simply sum up all individual resistances.
- Total resistance in a series circuit surpasses the resistance of any single resistor.
- In a series circuit, if one component fails, the entire circuit ceases to function.
- Series circuits are unsuitable for devices such as bulbs and heaters as they demand varying levels of current.

### 📌 Resistors in Parallel

Multiple resistors in Parallel

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



- Parallel combination formula: Inverse of total resistance equals the sum of inverses of individual resistances.
- When dealing with a series circuit, you simply sum all the resistance together to determine the total resistance.
- The total resistance in a series circuit always exceeds that of any individual resistor.
- In a series circuit, if one component fails, the entire circuit becomes inoperative.
- Series circuits are unsuitable for devices like bulbs and heaters because they require varying levels of current.

### ➔ Heating Effect of Electric Current

In an electric circuit, the energy source must consistently supply energy to sustain the flow of current. Part of this energy sustains the current itself, while the remaining portion dissipates as heat, referred to as the heating effect of electric current.

## Joule's Law of Heating

This law states that the heat produced in a resistor is :

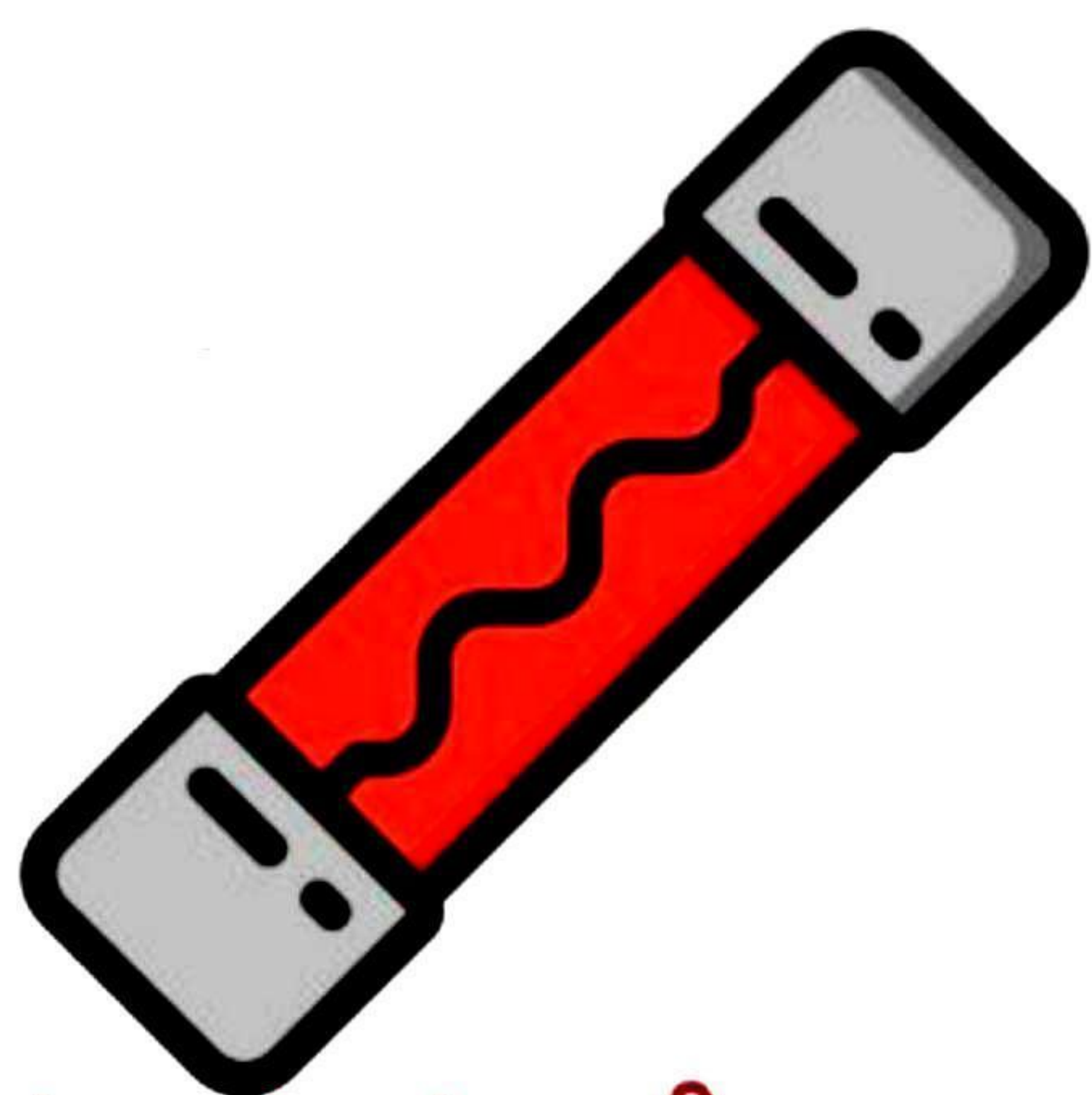
- Directly proportional to the square of the current ( $I$ ) passing through the resistance ( $R$ )
- Directly proportional to the resistance ( $R$ ) in the circuit.
- Directly proportional to the duration ( $t$ ) for which the current flows.  $H = I^2 R T$

## Practical Applications of heating Effect of Electric Current

- Producing Light (Electric Bulb) : Electric bulbs utilize a tungsten filament renowned for its high resistivity and melting point. When voltage is applied, the filament heats up, reaching a white-hot state and emitting light.



Electric Bulb



Electric fuse

- Electric fuse: Serving as a safety mechanism in household circuits, electric fuses consist of a lead and tin alloy with a designated melting point. Should the current exceed the safe threshold, the fuse wire heats up, melts and breaks the circuit, shielding other components from potential dangers.

## Electric Power

- Electrical Power ( $P$ ) is the measure of the rate at which electric charge is used or transferred in a circuit per unit of time.  $P = VI$      $P = I^2 R$      $P = \frac{V^2}{R}$

- Electrical power is a scalar quantity, signifying it passes magnitude but not direction.

- The unit of electrical power is the watt ( $W$ ). The relationship between power ( $P$ ), current ( $I$ ), and resistance ( $R$ ) is expressed Ohm's Law as  $P = I^2 R$ .

$$1 \text{ kW (Kilowatt)} = 1000 \text{ W}$$

$$1 \text{ MW (Megawatt)} = 10^6 \text{ W}$$

$$1 \text{ GW (gigawatt)} = 10^9 \text{ W}$$

$$1 \text{ HP (Horsepower)} = 746 \text{ W}$$

### Commercial unit of commercial energy

The unit 'watt' is very small. Larger unit called 'kilowatt'.  
The commercial unit of electric energy is kilowatt hour (kWh)  
commonly known as 'unit'.

$$1 \text{ kW} = 1000 \text{ W}$$

$$\begin{aligned} 1 \text{ kWh} &= 1000 \text{ watt} \times 3600 \text{ Second} \\ &= 3.6 \times 10^6 \text{ watt second} \\ &= 3.6 \times 10^6 \text{ joule (J)} \end{aligned}$$