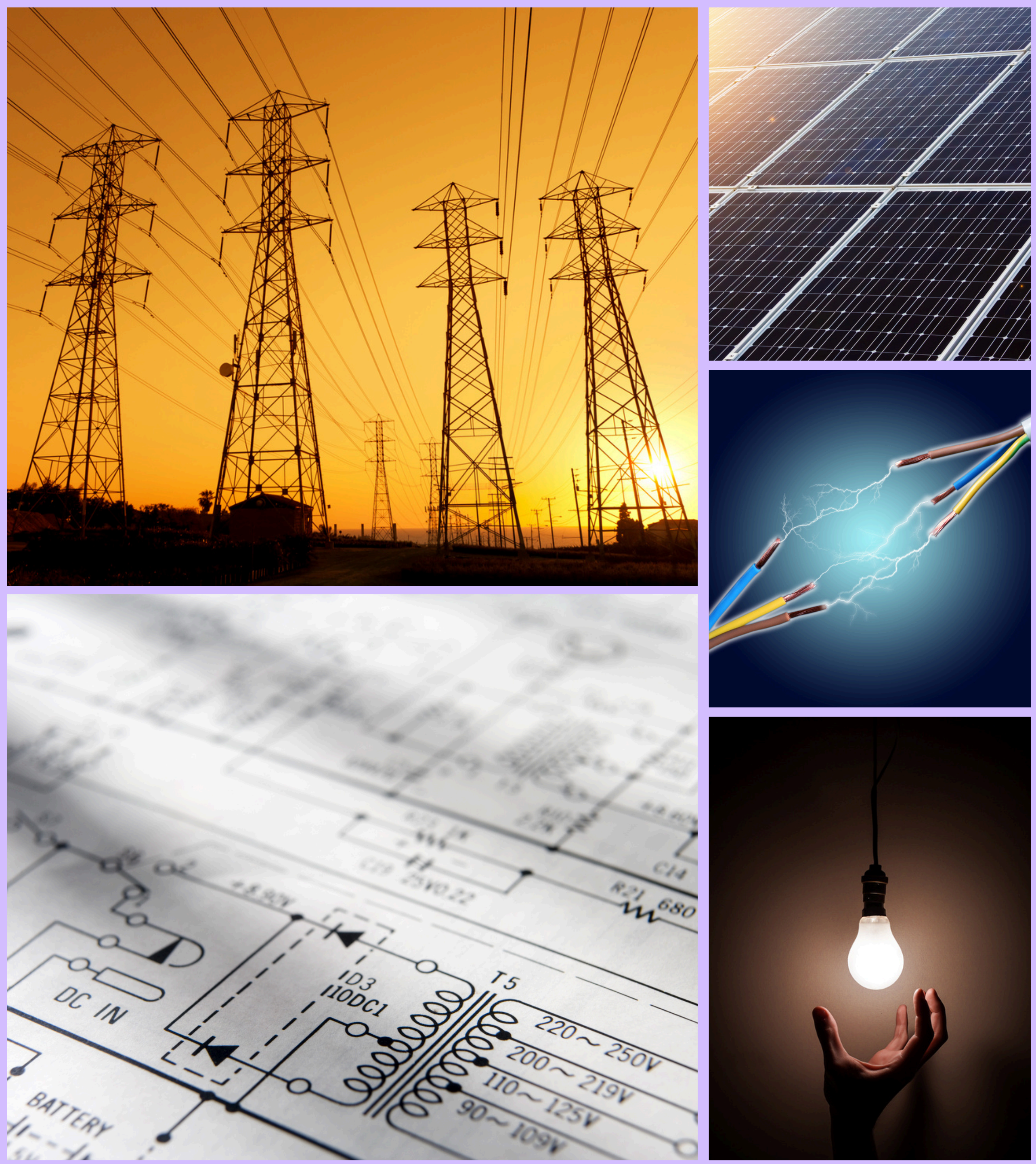


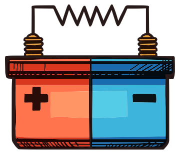
CLASS 10 NOTES

SCIENCE

Electricity

PRASHANT KIRAD

Electric Charge



A physical phenomenon characterized by an excess or deficiency of electrons in a body.
- It is a scalar quantity.
- The SI unit of charge is the Coulomb (C).

Magnitude of Electric Charge

Proton	Neutron	Electron
+ 1.602 × 10^-19 coulombs	0	- 1.602 × 10^-19 coulombs

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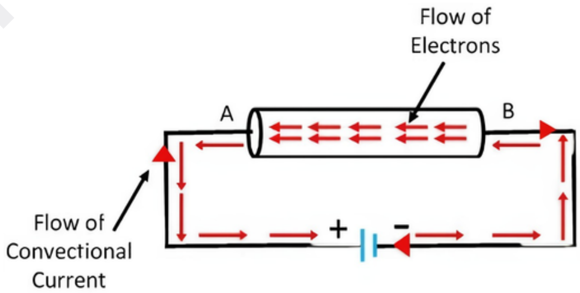
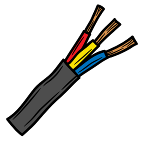
Electric Current (I)

The quantity of electric charge 'Q' flowing through a specific cross-sectional area in unit time 't'.
- It is a scalar quantity.
- The SI unit of current is the Ampere (A).

$$I \text{ (ampere)} = \frac{Q \text{ (coulombs)}}{t \text{ (seconds)}}$$



The direction of **electric current** is considered opposite to the flow of **electrons**, and in a circuit, conventional current flows from the battery's **positive** terminal to the **negative** terminal.



EMA

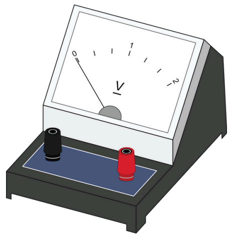
Electric Potential (V)

The amount of **work done (1 W)** when moving a unit **positive charge (1C)** from infinity to a specific point.
- It is a scalar Quantity.
- SI unit is volt (V).

$$V \text{ (Volts)} = \frac{W \text{ (joules)}}{Q \text{ (coulombs)}}$$

Electric Potential Difference (ΔV)

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



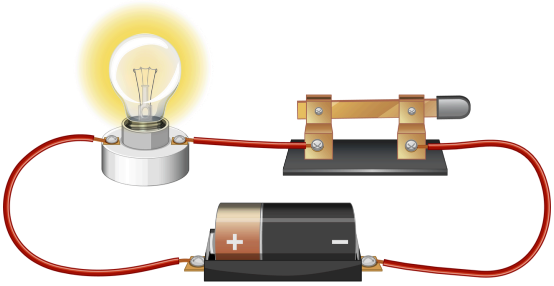
- It is a scalar Quantity.
- SI unit is joules per coulomb.

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

Electric Circuit:

An electric circuit is a closed and unbroken loop that facilitates the flow of electric current. It comprises diverse components, such as a current source (like a cell or battery), a load (such as a bulb or any appliance), a switch (for opening or closing the circuit), a fuse, and interconnecting wires, typically constructed from copper.

- When the switch is closed, the circuit is termed a closed circuit (allowing the current to flow).
- Conversely, when the switch is open, the circuit is referred to as an open circuit (preventing the flow of current).



Circuit Diagram:

It is a visual depiction of a circuit wherein various electrical components are represented by their symbols.

S. No.	Component	Symbol
1	An electric cell	
2	A battery or a combination of cells	
3	Plug key or switch (open)	
4	Plug key or switch (closed)	
5	A wire joint	
6	Wires crossing without joining	
7	Electric bulb	or
8	A resistor of resistance *R*	
9	Variable resistance or rheostat	or
10	Ammeter	A
11	Voltmeter	V

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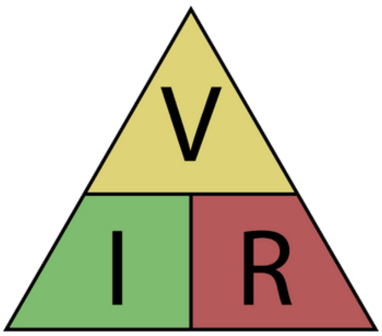
Ohm's Law:

According to this principle, the electric current coursing through a conductor exhibits a direct proportionality to the applied potential difference across its terminals, under the condition that physical factors like temperature remain constant.

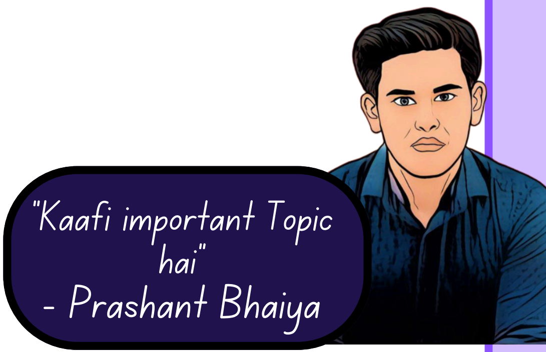


$$\boxed{V = I.R}$$

$$\boxed{I = \frac{V}{R}} \quad \boxed{R = \frac{V}{I}}$$

Resistance (Ω)

It is the characteristic of a conductor that hinders or resists the movement of electric charge through it. This property is known as resistance. Resistance is a scalar quantity, and its unit in the International System of Units (SI) is the ohm, denoted by the symbol Ω.
The resistance of a conductor depends on several factors, including:

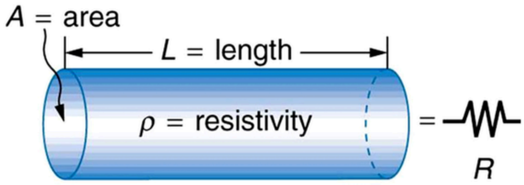


- Length (L): The longer the conductor, the greater the resistance.
- Cross-sectional Area (A): Wider pathways - larger cross-sectional area (A) in a conductor make it easier for electric current to flow by reducing resistance.
- Material Resistivity (ρ): Different materials have different inherent resistances. Resistivity is a property of the material itself.
- Temperature (T): Generally, resistance increases with temperature. This is a more complex relationship and depends on the material.

Resistivity (ρ)

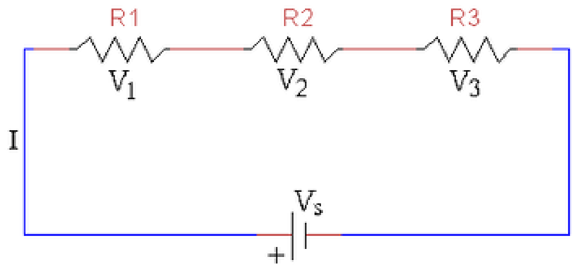
Resistivity is a property of materials that describes their ability to impede the flow of electric current. It is denoted by the symbol (ρ= rho) and is measured in ohmmeters (Ω·m) in the International System of Units (SI). The formula for resistivity (ρ) is:

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



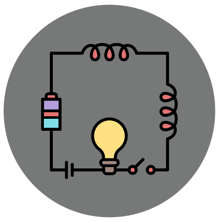
Resistivity (ρ) is a material property measuring its resistance to electrical current flow. Conductors like metals have low resistivity, allowing easy current flow, while insulators have high resistivity. Ohm's Law (I=V/R) relates current (I), voltage (V), and resistance (R), where resistance depends on the material's resistivity (ρ) length (L), and cross-sectional area (A).

Series Combination:



Series combination formula: Total resistance is the sum of individual resistances.

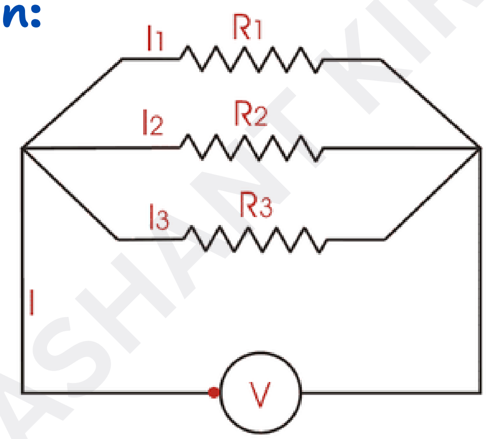
$$R_{eq} = R1 + R2 + R3$$



In Series Combination
- I (Electric Current) remain same
- V (Voltage) Divides

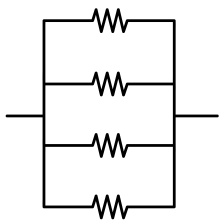
- **Adding Resistances:** In a series circuit, you just add up all the resistances to find the total resistance.
- **Total Resistance is Higher:** The total resistance in a series is greater than any single resistor.
- **One Stops, All Stop:** If one component in a series circuit stops working, everything in the circuit stops.
- **Not for Different Devices:** Series circuits are not good for devices like bulbs and heaters because they need different amounts of current.

Parallel Combination:



Parallel combination formula: Inverse of total resistance equals the sum of inverses of individual resistances

$$\frac{1}{R_{eq}} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$



In Parallel Combination
- I (Electric Current) divides
- V (Voltage) remain same

- **Add Inverses:** In a parallel circuit, sum the inverses of individual resistances to find the reciprocal of the total resistance.
- **Lower Total Resistance:** The overall resistance in parallel is less than that of any single resistor.
- **Diverse Currents:** Different currents flow through components in parallel.
- **Continued Operation:** If one component fails, others continue to operate in a parallel circuit.

Heating effect of electric current:

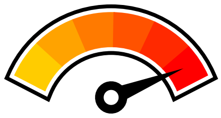
In an electric circuit, the source must continuously provide energy to maintain current flow. Some energy sustains the current, while the rest dissipates as heat—known as the heating effect of electric current.

EMA

Joule's Law of Heating:

This law indicates that the heat generated in a resistor is:

1. Directly proportional to the square of the current (I) flowing through the resistance (R).
2. Directly proportional to the resistance (R) in the circuit.
3. Directly proportional to the time (t) for which the current flows.

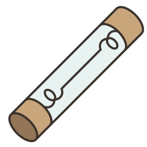


$$\boxed{H = I^2 R T}$$

Practical applications of the heating effects of electric current include:

- **Producing Light (Electric Bulb):** The bulb features a tungsten filament with high resistivity and melting point. The application of voltage heats the filament, making it white-hot and emitting light.

- **Electric Fuse:** A safety device in household circuits, it contains a lead and tin alloy with a specific melting point. If the current surpasses the safe limit, the fuse wire heats, melts, and interrupts the circuit, safeguarding other elements from potential hazards.



Power:

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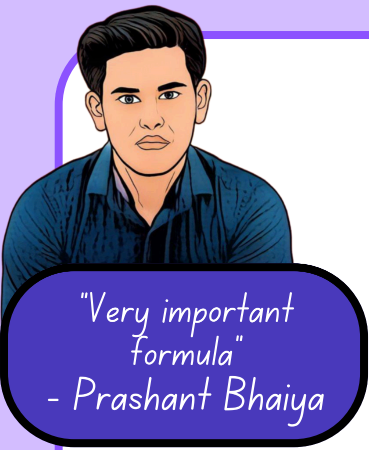
- **Definition of Electrical Power (P):** Electrical power (P) is defined as the rate at which electric charge is consumed or transferred in a circuit per unit of time.
- **Scalar Quantity:** Electrical power is a scalar quantity, meaning it only has magnitude and no direction.
- **Unit of Electrical Power:** The unit of electrical power is the watt (W). The relationship between power (P), current (I), and resistance (R) is given by Ohm's Law (P = I^2R).

$$\boxed{P = V.I}$$

$$\boxed{V = I.R} \longrightarrow \boxed{P = (IR)I = I^2 R}$$

$$\boxed{I = \frac{V}{R}} \longrightarrow \boxed{P = V\frac{V}{R} = \frac{V^2}{R}}$$



$$P = V.I = I^2 R = \frac{V^2}{R}$$

Unit	Conversions
Kilowatt (kW)	1 kilowatt (1 kW) is equivalent to 1000 watts (1000 W).
Megawatt (MW)	1 megawatt (1 MW) is equivalent to (10^6) watts (1,000,000 W).
Gigawatt (GW)	1 gigawatt (1 GW) is equivalent to (10^9) watts (1,000,000,000 W).
Horsepower (HP)	1 horsepower (1 HP) is approximately equal to 746 watts (746 W).

Commercial unit of electrical energy:

1{kilowatt-hour (kWh)} = 1000 watt-hour (Wh)

Since 1 watt-hour is equal to 3600 joules (J)

3.6 * 10^6{J}

This simplifies to 1000 {Wh}

1000 {Wh} = 1000 * 3600 J

So, 1 kilowatt-hour is equivalent to (3.6 times 10^6) joules.

Commercial unit of electrical energy:

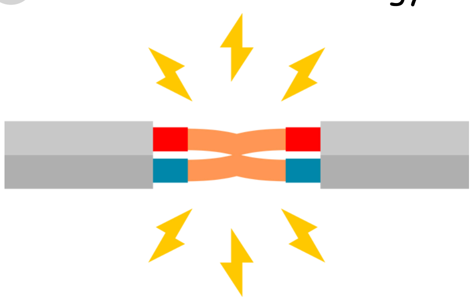
Certainly! The number of units consumed by an electric appliance is calculated by multiplying its power (in kilowatts) by the time it is in use (in hours). The formula is:

Energy (kWh) = Power (kW) * Time (hours)

For example, if you have a 1.5 kW appliance running for 3 hours:

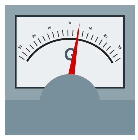
{Energy (kWh)} = 1.5 {kW} * 3 hours = 4.5 {kWh}

So, the appliance consumes 4.5 kilowatt-hours of energy during that period.



TOP 7
IMPORTANT QUESTIONS

1) What is the function of a galvanometer in a circuit? [CBSE 2019]



Solution:

A galvanometer is used to detect and measure electric currents in a circuit. It indicates the presence and direction of current flow.

2) State Ohm's law. [Delhi 2016]

Solution:

If the physical conditions of a conductor remain the same, then the current through a conductor is directly proportional to the potential difference b/w the two ends of the conductor.

$$I \propto V \Rightarrow V = IR$$

Ω

3) The power of a lamp is 60 W. Find the energy in joules consumed by it in 1 s. [CBSE 2014]

Solution:

$$P = 60\ \text{W}\ ,\ t = 1\ \text{s}$$
$$\text{Energy} = (VI)t$$
$$E = P \times t = 60 \times 1\ \text{J}$$
$$E = 60\ \text{J}$$

4) An electric kettle of 2 kW works for 2 h daily. Calculate the [CBSE 2014]
(a) energy consumed in SI and commercial units
(b) cost of running it in the month of June at the rate of ` 3.00 per unit.

Solution:

(a) Given: $P = 2\ \text{kW} = 2000\ \text{W}$
$t = 2\ \text{h}$

Electric energy, $E = P \times t = 2 \times 2 = 4\ \text{kWh}$

(b) Total energy consumed in month of June (having 30 days)

$$\text{Electric kettle} = (4 \times 30)\ \text{kWh} = 120\ \text{kWh}$$
$$= 120\ \text{units.}$$

Cost of running electric kettle:

$$= ₹120 \times 3 = ₹360$$

5) (a) Explain why a conductor offers resistance to the flow of current.
(b) Differentiate between conductor, resistor, and resistance.

Solution:

a. When a current is passed through a conductor, the atoms or molecules of the conductor produce a hindrance in the path of flow of electrons. This hindrance in the path of the flow of charge is called the resistance of the conductor.

b. A substance that allows it to pass the charges through them easily is called a conductor. Resistor: A conductor having some value of resistance is called a resistor. Resistance: It is the property of any conductor by virtue of which it opposes the flow of charge through it.

6) Two conducting wires of the same material, equal length, and equal diameter are connected in series. How does the heat produce by the combination of resistance change? [CBSE 2010]

Solution:

Let the resistances of two wires are R each.
Heat produced by individual resistor

$$H' = \frac{V^2}{R}t$$

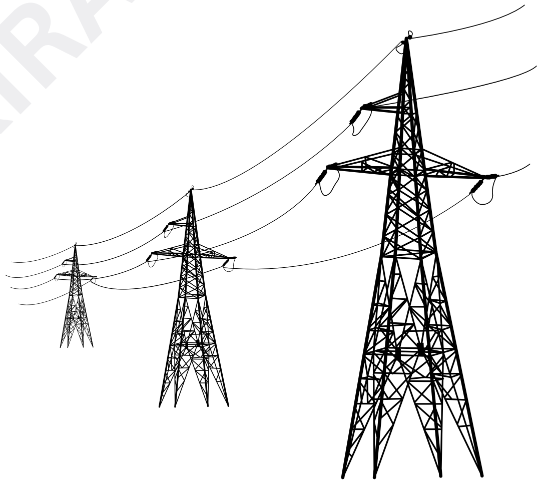
Resistance is series, $R_S = R + R = 2R$

Heat produced by combination of resistors

$$H' = \frac{V^2}{2R}t$$

$$\frac{H'}{H} = \frac{1}{2}$$

$$H' = \frac{H}{2}$$



7) Q7) (a) Define the term 'volt'.
(b) State the relation between work, charge, and potential difference for an electric circuit. Calculate the potential difference between the two terminals of a battery, if 100 joules of work is required to transfer 20 coulombs of charge from one terminal of the battery to the other.

a. Potential difference b/w two points in an electric field is said to be 1 volt if the amount of work done in bringing a unit positive charge from one point to another point is 1 J.

b. Given: $W = 100\,\text{J},\ Q = 20\,\text{C},\ V = ?$

As $$V = \frac{W}{Q} \Rightarrow V = \frac{100}{20}\,\text{JC}^{-1}$$

$$V = 5\,\text{JC}^{-1}$$

$$V = 5\ \text{Volt.}$$