L1

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CLASS X - SCIENCE

ELECTRICITY

PRASHANT KIRAD

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PK HITS🔥

6 Marks

- Ohm's Law Graph.
- Numerical:
  - Series and Parallel resistance
  - $R = \rho(l/A)$
  - Power Heating effect

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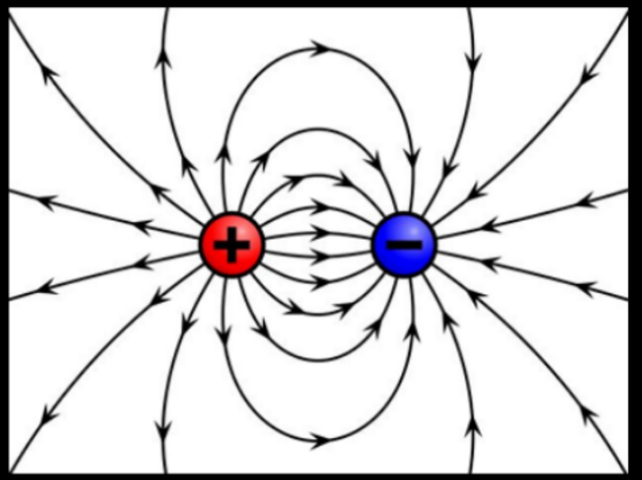
ELECTRIC CHARGE

- Charge is a fundamental particle in an atom.
- It may be positive or negative - Electrons carry a negative charge and protons carry a positive charge.
- Unlike charges attract each other
- **Coulomb (C) : S. I. unit of charge**



1 Coulomb charge = 6×10^{18} electrons

QUANTISATION OF CHARGE

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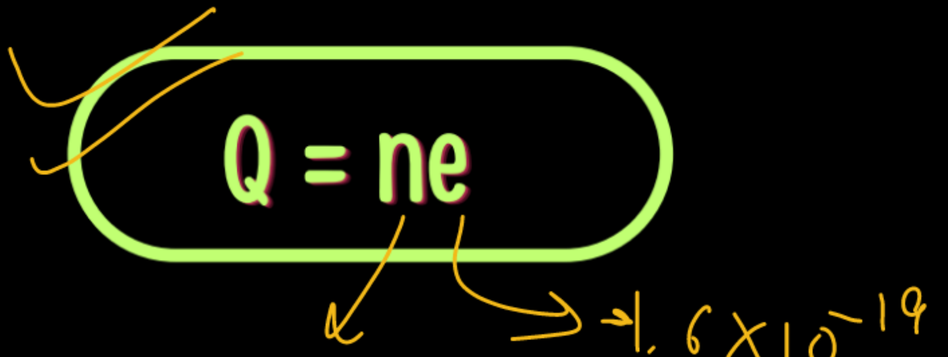
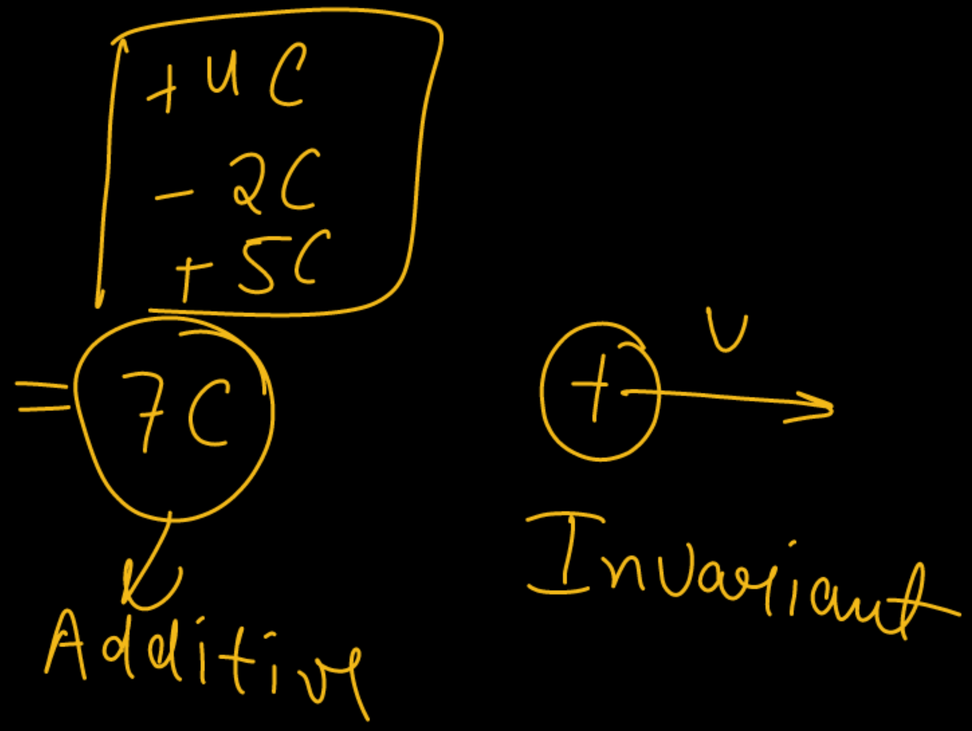
According to charge quantization, any charged particle can have a charge equal to some integral number of e, i.e., **Q = n e** , where n=1, 2, 3,...

$Q = ne$

Q = net charge
n = no of electrons
e = charge on an electrons




+4C
-2C
+5C
7C
Additive
v
Invariant

ELECTRICAL SUBSTANCES

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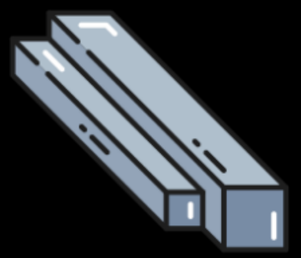
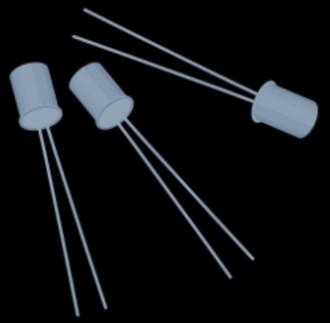
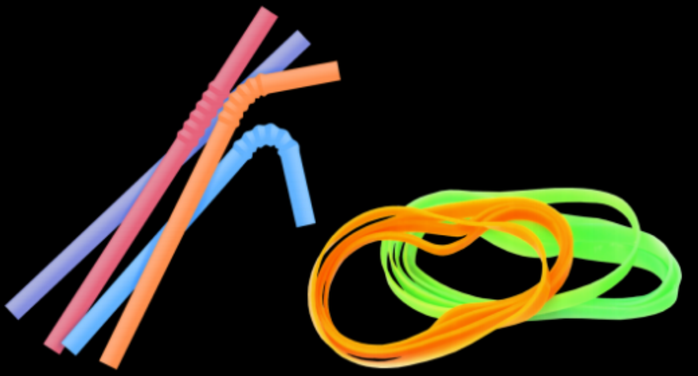
Conductors	Semiconductors	Insulators
Allow electric current to flow easily.	Have electrical conductivity between conductors and insulators.	Do not allow electric current to flow easily.
Contain free electrons.	Conductivity can be altered by adding impurities or changing temperature.	Lack free electrons.
Examples: Copper, aluminum.	Examples: Silicon, germanium.	Examples: Rubber, plastic.



$48C = q$

no. $q = e$

$q = ne$

3

$4.8\,C = n \times 1.6 \times 10^{-19}$

$\frac{3}{10^{-19}}$

3×10^{19}

ELECTRIC CURRENT

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Electric current is defined as the rate of flow of charge through a cross-section of a conductor per unit time.

It is denoted by I.

$$I = \frac{Q}{t}$$

A ← $\frac{1C}{1S}$

SI unit: Ampere (A) or coulomb per second

Charge

$$I = \frac{Q}{T}$$

One ampere is the current flowing through a conductor when 1 coulomb of charge flows per second.

POTENTIAL DIFFERENCE

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Electric Potential Difference : The potential difference between two points in an electric circuit is the work done to move a unit charge from one point to another. It is the driving force that causes the flow of electric current.

It is denoted by V.

$$V = \frac{W}{Q} \rightarrow \frac{1\,J}{1\,C}$$

SI unit: Volt (V) or joule per coulomb

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

1 volt: is the potential difference between two points when 1 joule of work is done to move 1 coulomb of charge between them.

$$1\ \text{volt} = \frac{1\ \text{joule}}{1\ \text{coulomb}}$$

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Q. Work of 14 J is done to move 2 C charge between two points on a conducting wire. What is the potential difference between the two points?

(a) 28 V
(b) 14 V
(c) 7 V
(d) 3.5 V

$W = 14J$

$Q = 2$

$V = \frac{W}{q} = \frac{14}{2} = 7V$

Answer: [redacted](s)

Q. ii. A boy records that 4000 joules of work is required to transfer 10 coulombs of charge between two points of a resistor of 50 Ω. The current passing through it is _____.

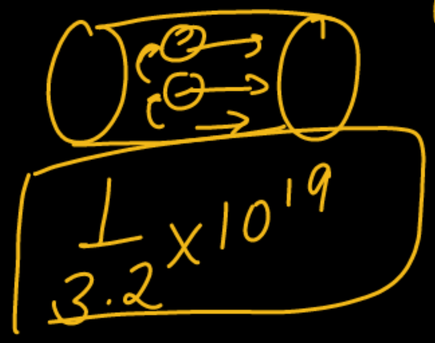
a. 2 A

b. 4 A

c. 8 A

d. 16 A

Answer: Option (c)



1 Sec

$\frac{1}{3.2} \times 10^{19}$

$Q = ?$

$I = ?$

$Q = ne$

$Q = \frac{1}{2} \times 10^{19} \times 1.6 \times 10^{-19}$

$Q = \frac{1}{2} = 0.5\,C$

$I = \frac{Q}{t} = \frac{0.5}{1} = 0.5\,A$

2m → 120 sec

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Q.A current of 10 A flows through a conductor for two minutes.

(i) Calculate the amount of charge passed through any area of cross section of the conductor.

(ii) If the charge of an electron is 1.6×10^{-19} C, then calculate the total number of electrons flowing

$I = \frac{Q}{t}$

$10 = \frac{Q}{120}$

$1200\,C = Q$

$Q = ne$

$1200 = n \times 1.6 \times 10^{-19}$

7.5×10^{21}

Ans (i) 1200 C

(ii) 7.5 × 1021

ELECTRIC CIRCUIT

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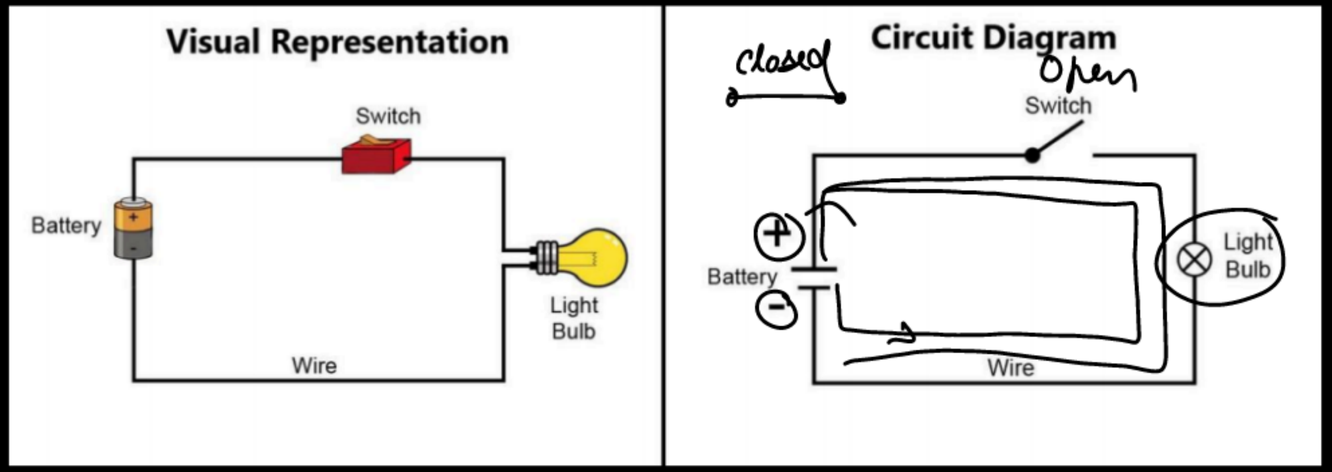
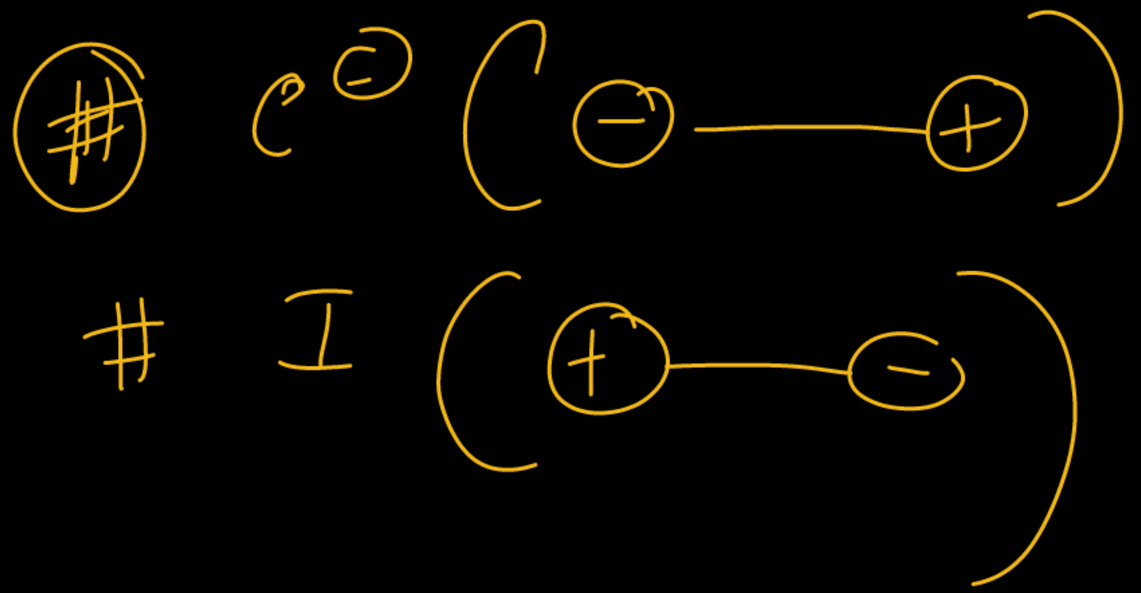
Electrical Circuit: A closed path of wires and components through which electric current flows when a potential difference is applied.

Components:

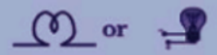
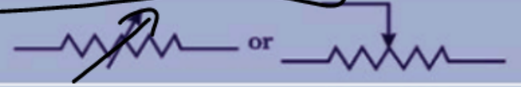
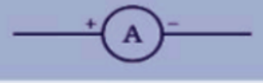
- Electric devices.
- Source of electricity.
- Connecting wires and a switch to control the flow of current.



Imp



CIRCUIT ELEMENTS

Sl. No.	Components	Symbols
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	
11	Voltmeter	

Series

Parallel

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Q.Draw the symbols of commonly used components in electric circuit diagrams for

(i) An electric cell

(ii) Open plug key

(iii) Wires crossing without connection

(iv) Variable resistor

(v) Battery

(vi) Electric bulb

(vii) Resistance

AMMETER

- An ammeter is an instrument used to **measure the electric current flowing through a circuit.**
- It is always *connected in series with the circuit so that the entire current passes through it*.
- The device has very *low resistance* to *minimize its impact on the circuit's overall current flow.*
- Ammeter readings are usually given in **amperes (A) or milliamperes (mA).**

VOLTMETER

- A voltmeter is a device used to measure the potential difference (voltage) between two points in an electric circuit.
- It is *connected in parallel* to the section of the circuit where the voltage is to be measured.
- A voltmeter has very *high resistance* to ensure it does not draw significant current from the circuit, maintaining accurate readings.
- It is represented by **V (Volts).**

OHM'S LAW

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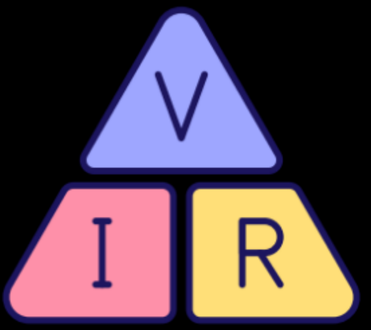
Ohm's Law **states that the current (*I*) flowing through a conductor is directly proportional to the voltage (*V*) across ~~it and inversely proportional to its resistance (*R*).~~**

Same Temperature

R



In the equation, the constant of proportionality R, is called Resistance represented by the symbol Ω.

Ohm Ω Ω

$V \propto I$

$V = IR$

$V=IR$

V-I CHARACTERISTIC GRAPH

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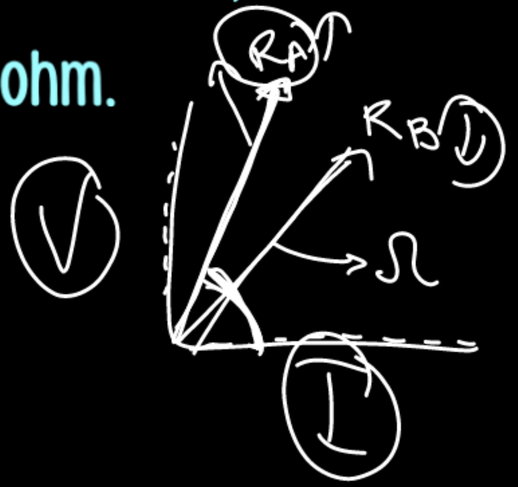
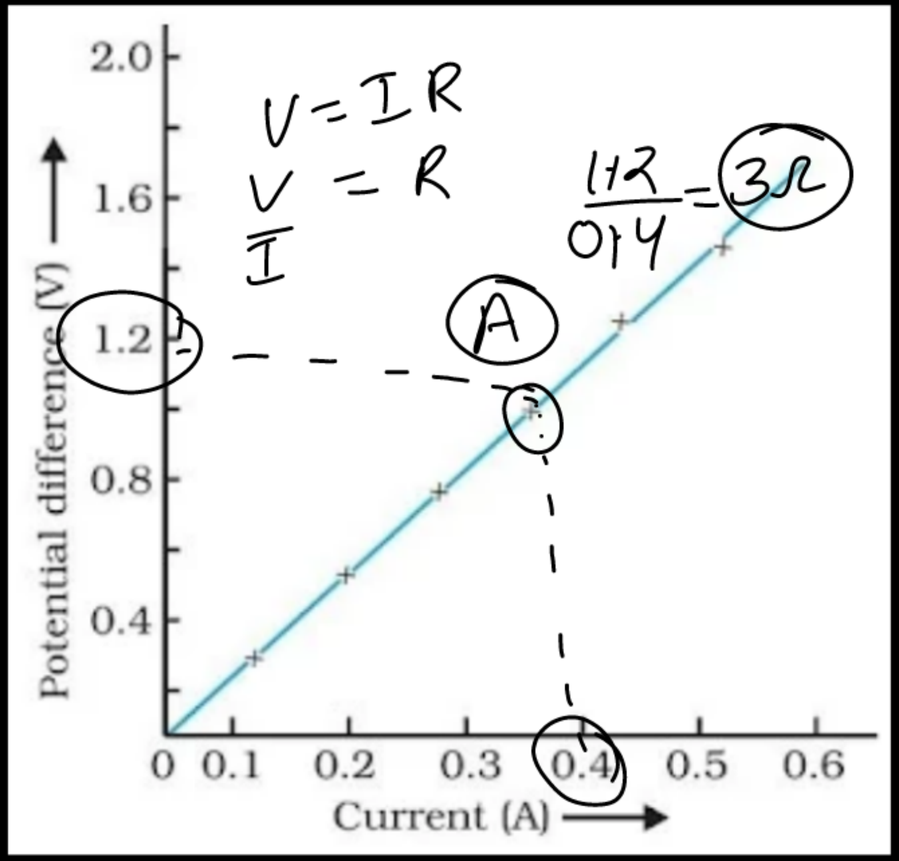
$V \propto I$

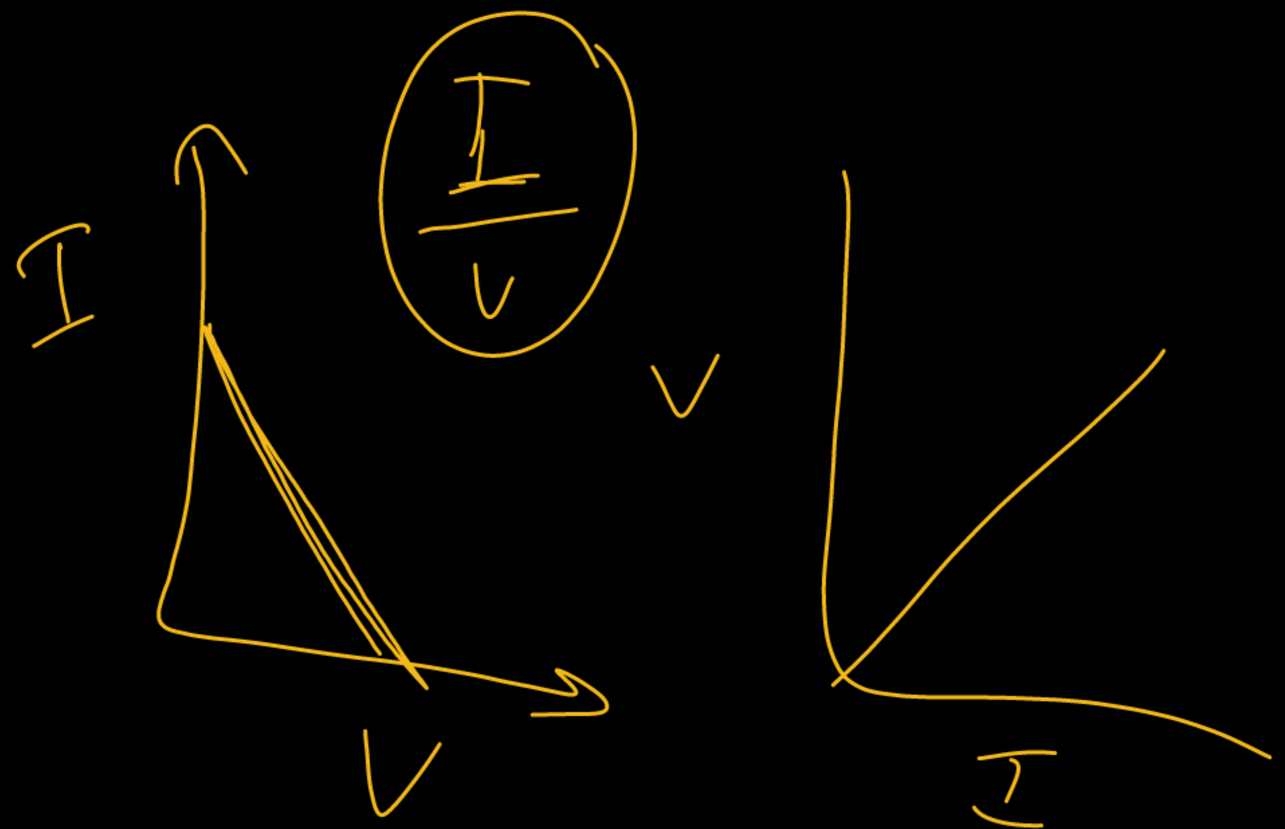
When potential difference is 1 V and current through the circuit is 1 A, then resistance is 1 ohm.





$V = IR$

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



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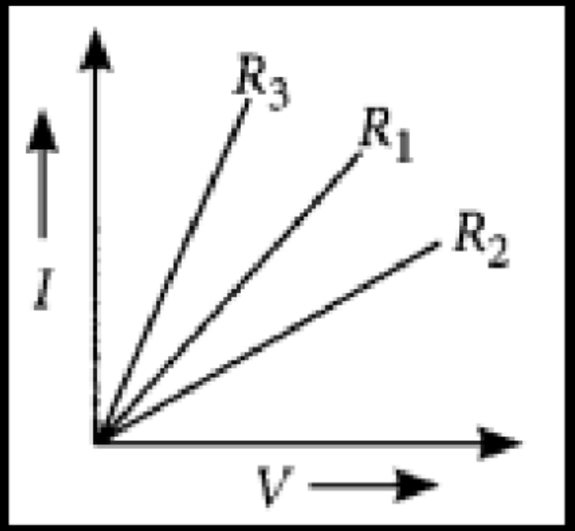
Q. A student plots V-I graphs for three samples of nichrome wire with resistances R_1, R_2, and R_3. Choose the correct statement from the following options:



(a) $R_1 = R_2 = R_3$
(b) $R_1 > R_2 > R_3$
(c) $R_3 > R_2 > R_1$
(d) $R_2 > R_1 > R_3$

Answer: (d)

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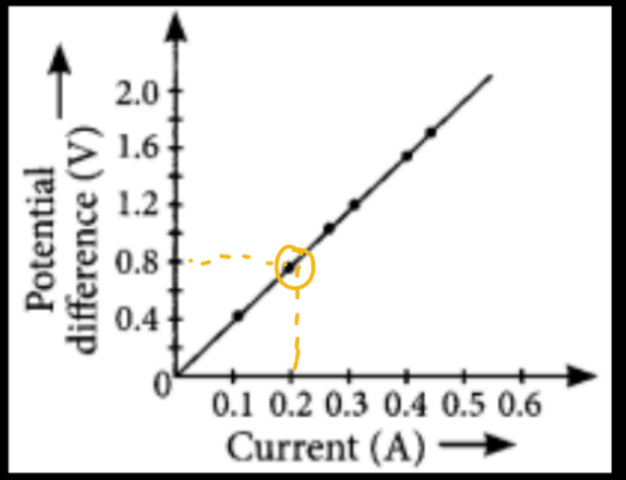
Q.A V-I graph for a nichrome wire is given below. What do you infer from this graph? Draw a labelled circuit diagram to obtain such a graph.



Answer:

As graph is a straight line, so it is clear from the graph that $V \propto I$.

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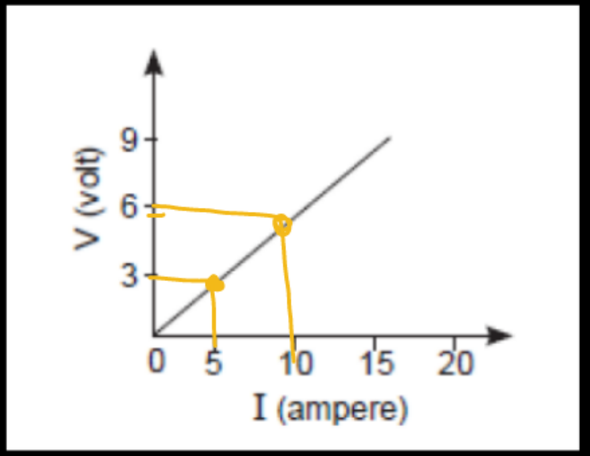
Q.The resistance whose V – I graph is given below is



(a) 5/3 Ω
(b) 3/5 Ω
(c) 5/2 Ω
(d) 2/5 Ω

Answer: Option (b)

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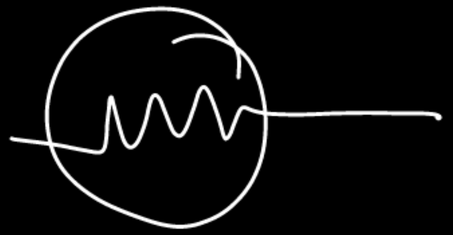
RESISTANCE

Resistance is the property of a material that opposes the flow of electric current through it.

Its S.I. unit is Ohm (Ω).



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

Ω

A component that is used to resist the flow of electric current in a circuit is called a resistor.

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RHEOSTAT

- A rheostat is a variable resistor **used to control the current in a circuit by adjusting its resistance.**
- It is commonly used in *devices like dimmer switches, fans, and other electrical equipment to regulate current flow.*

RTLT ATRI

FACTORS AFFECTING RESISTANCE

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

Resistance of a uniform metallic conductor is:

(i) Directly proportional to the length of conductor: $R \propto L$

(ii) Inversely proportional to the area of cross-section: $R \propto 1/A$

(iii) Directly proportional to the temperature: $R \propto$ Temperature

(iv) Depends on nature of material: (ρ)

$R \propto L/A$

$R = \rho L/A$

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

$$\Omega = \frac{\rho (m)}{m^2}$$

$$\Omega m = \rho$$

RESISTIVITY

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Resistivity is a material's intrinsic property that measures its opposition to the flow of electric current.
It is denoted by ρ.

Resistivity does not change with change in length or area of cross-section but it changes with change in temperature.

$$\rho = (R)A/L$$

	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}

RESISTANCE V/S RESISTIVITY

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Resistance	Resistivity
Resistance refers to the opposition that a material offers to the flow of electric current through it.	Resistivity is a property of a material that describes how strongly it resists the flow of electric current.
Resistance depends on the physical dimensions of the material, specifically its length and cross-sectional area.	Resistivity depends on the temperature and the nature of material.
SI unit: Ω	**SI unit: Ωm**

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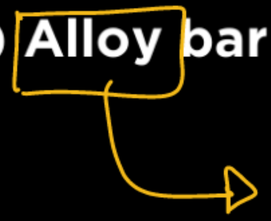
Q.Which one among a bar of an alloy of mass 2 kg and a 3 kg iron bar of the same dimension has greater resistivity?

(a) Iron bar because it has a higher mass

(b) Alloy bar because it has a lower mass

(c) Iron bar because it has the same types of atoms

(d) Alloy bar because it has different types of atoms



2 Kg 3 Kg

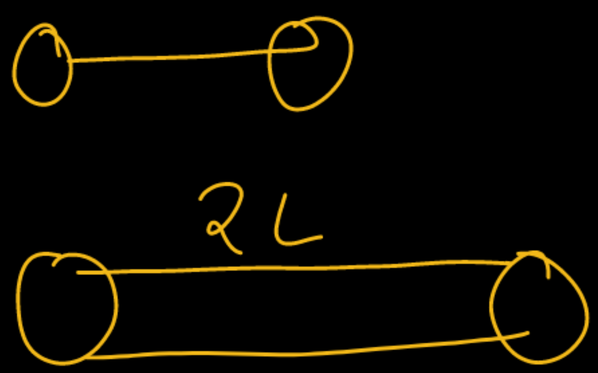
Answer: Option (d)

Q. A resistance wire is stretched so as to double its length. Its new resistivity will have a magnitude

a. 2 times its original value
b. 4 times its original value
c. 8 times its original value
d. Same as its original

→ Resistance

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



$V_{same} = L \times A$

$= 2L \times \frac{A}{2}$

$R = \frac{\rho 2L}{\frac{A}{2}}$

$R = 4\left(\frac{\rho L}{A}\right)$

Ans. Option

Change → Now $R = \boxed{4R}$

% change in $R = ?$ $\frac{\text{Change } R}{\text{Original } R} \times 100$

$R \rightarrow 4R$

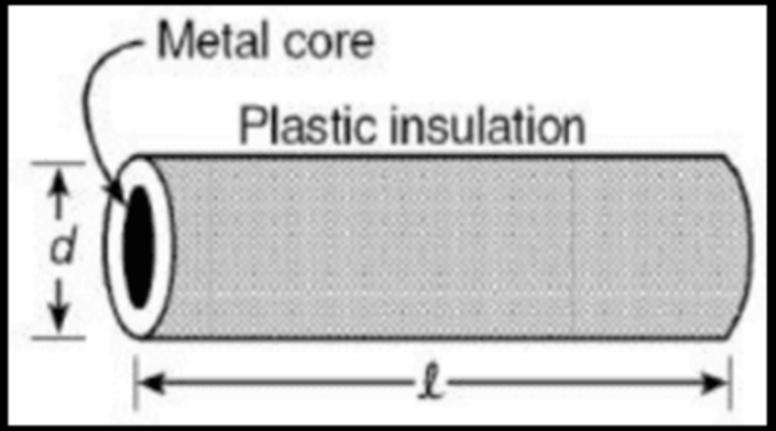
$= \frac{4R - R}{R} \times 100$

$= \boxed{300\%}$

Q. Plastic insulation surrounds a wire having diameter d and length l as shown below.

$R \downarrow$

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



A decrease in the resistance of the wire would be produced by an increase in the:

a. Length l of the wire

b. Diameter d of the wire $\uparrow d \Rightarrow R \downarrow$

c. Temperature of the wire

d. Thickness of the plastic insulation

Ans. Option (b)

Q. When a 4 V battery is connected across an unknown resistor there is a current of 100 mA in the circuit. The value of the resistance of the resistor is:

a. 4 Ω

b. 40 Ω

c. 400 Ω

d. 0.4 Ω

10^{-3}

$V = 4$

$I = 100 \times 10^{-3}$

$V = IR$

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

$\Rightarrow \frac{4}{100 \times 10^{-3}} = \frac{4}{10^{-1}} = 40$

$10^{2} \times 10^{-3}$ 10^{-1}

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Q.Work of 14 J is done to move 2 C charge between two points on a conducting wire. What is the potential difference between the two points?

(a) 28 V

(b) 14 V

(c) 7 V

(d) 3.5 V

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

(2024)

Q. Two wires A and B of the same material, having the same lengths and diameters 0.2 mm and 0.3 mm respectively, are connected one by one in a circuit. Which one of these two wires will offer more resistance to the flow of current in the circuit? Justify your answer. (2024)

Ans. Wire A will offer more resistance.

Justification:

- Resistance $R \propto l/A$, where l is the length and A is the cross-sectional area.
- A thinner wire has a smaller cross-sectional area, leading to higher resistance.
- Wire A (0.2 mm diameter) has a smaller cross-sectional area compared to Wire B (0.3 mm diameter), so it offers higher resistance to the flow of current.

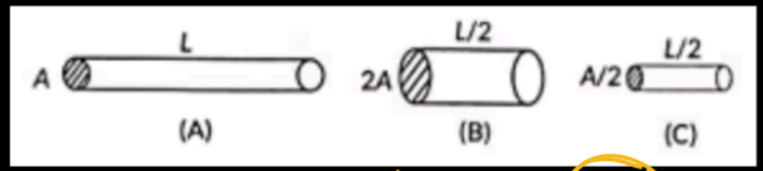
(2022)

Q. In the following figure, three cylindrical conductors A, B, and C are shown along with their lengths and areas of cross-section.

If these three conductors are made of the same material and R_A, R_B, and R_C are their respective resistances, then find:

(i) R_A/R_B, and

(ii) R_A/R_C



Ans.

$\because \quad R = \frac{\rho L}{A}$. So, $R_A = \frac{\rho \times L}{A} = \frac{\rho L}{A}$

$R_B = \frac{\rho \times L/2}{2A} \Rightarrow \frac{\rho L}{4A}$, $R_C = \frac{\rho \times L}{\frac{A}{2} \times 2} \Rightarrow \frac{\rho L}{A}$

Then, (I) $\frac{R_A}{R_B} = \frac{\rho L}{A} \Big/ \frac{\rho L}{4A} \Rightarrow 4$; $\frac{R_A}{R_B} = 4$.

(II) $\frac{R_A}{R_C} = \frac{\rho L}{A} \Big/ \frac{\rho L}{A} \Rightarrow 1$.

$R_C = \rho \frac{L}{2} \Big/ \frac{A}{2}$

$\frac{R_A}{R_B} = \frac{\rho L}{A} \Big/ \frac{\rho L}{2A} = 4$

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

(2022)

(a) List the factors on which the resistance of a uniform cylindrical conductor of a given material depends.

(b) The resistance of a wire of ~~0.01 cm~~0.01 cm radius is 10 Ω. If the resistivity of the wire is 50×10^{-8} Ωm, find the length of this wire. (2022)

πr^2

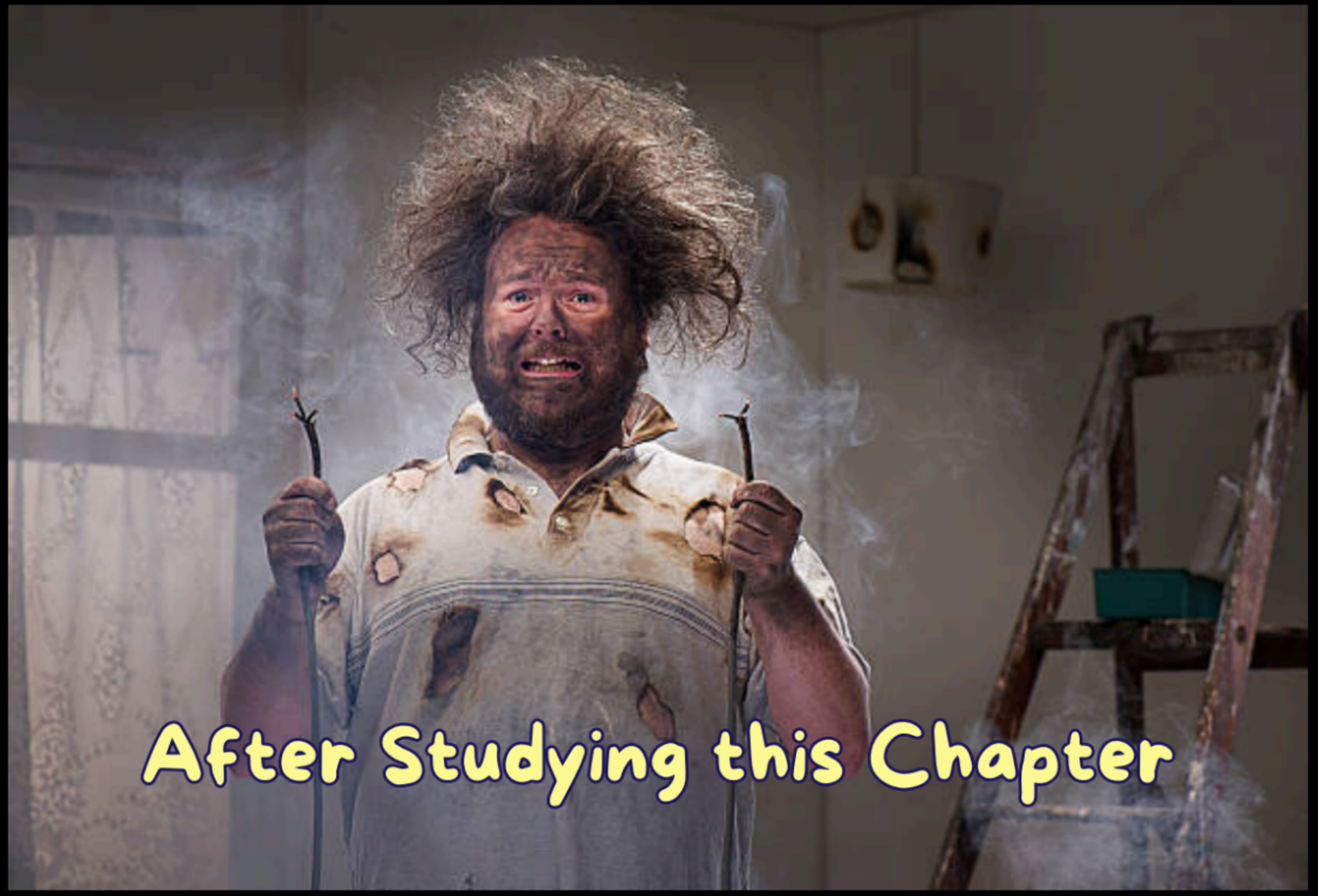
$r = 0.01\ cm$

$R = 10\ \Omega$

$\rho = 50\times10^{-8}$

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

Ans. Length of the wire: $l = 6.28\ m$


After Studying this Chapter

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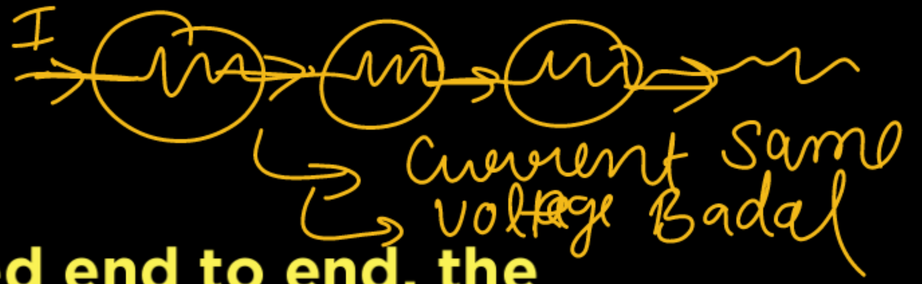
COMBINATION OF RESISTOR IN CIRCUIT

SERIES COMBINATION:

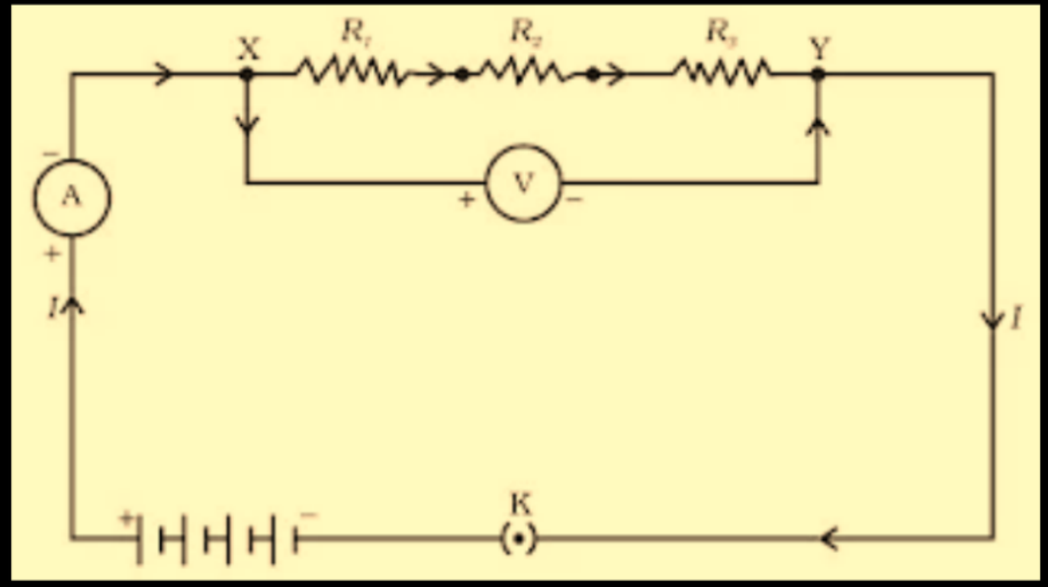


When two or more resistors are connected end to end, the arrangement is called series combination.

R_{net} = Total

Effective resistance in series:

$$R_s = R_1 + R_2 + R_3$$



$V = IR$

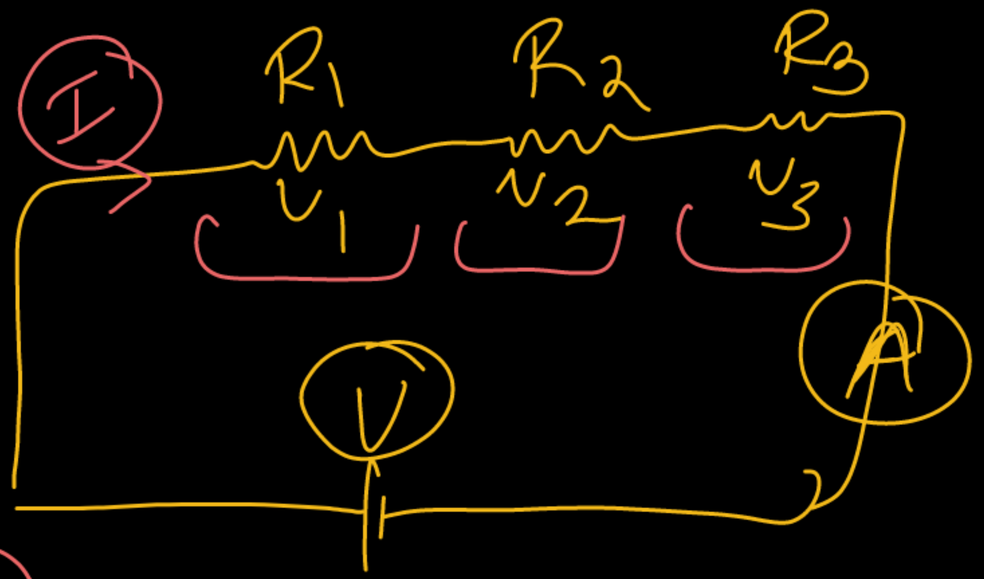
$V = V_1 + V_2 + V_3$

$IR = IR_1 + IR_2 + IR_3$

$R = R_1 + R_2 + R_3$

R_{net}

R_{eq}

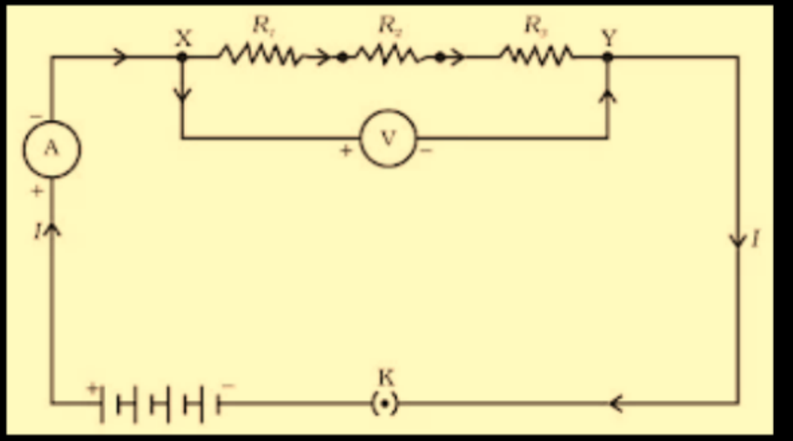


When resistors are connected in series, the total potential difference across the combination is the sum of the potential differences across each resistor.

From the circuit: $V = V_1 + V_2 + V_3$ ---------- **(1)**

Using Ohm's law, the potential difference across each resistor is given as:

$V_1 = IR_1, V_2 = IR_2, V_3 = IR_3$ ----------**(2)**



Substitute these into Eq. (1):

$V = IR_1 + IR_2 + IR_3$

Factor out I:

$V = I(R_1 + R_2 + R_3)$ ----------**(3)**

For the equivalent single resistor R_s, using Ohm's law:

$V = IR_s$ ----------**(4)**

Comparing Eq. (3) and Eq. (4):

$R_s = R_1 + R_2 + R_3$

Conclusion: When resistors are connected in series, the total resistance R_s is the sum of the individual resistances:

$R_s = R_1 + R_2 + R_3$

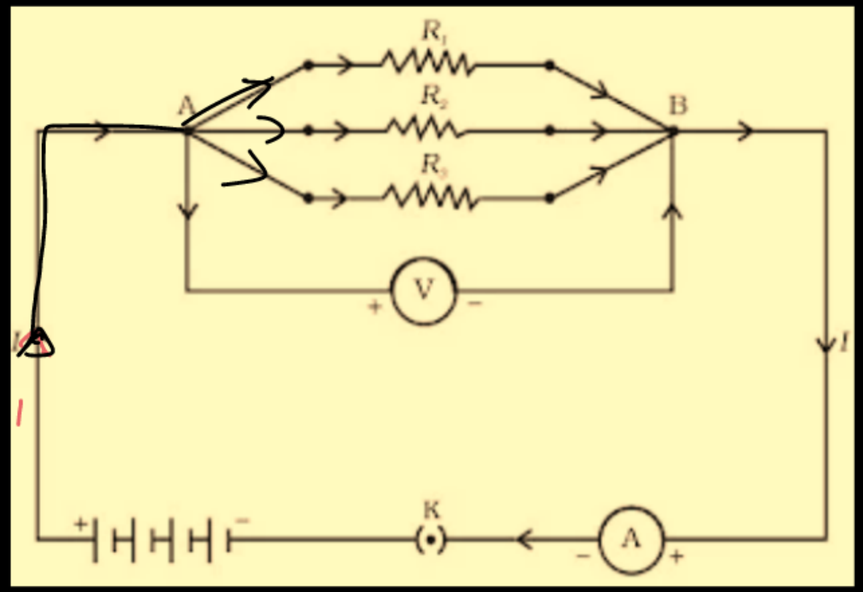
This means the total resistance is greater than any individual resistance.

अभय

PARALLEL COMBINATION

When two or more resistors are connected across multiple branches.

① V same
② I different



Effective resistance in parallel:

$$1/R_p = 1/R_1 + 1/R_2 + 1/R_3$$

$$I = I_1 + I_2 + I_3$$

$$\left[I = \frac{V}{R} \right]$$

$$\frac{V}{R_{net}} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\frac{1}{R_{net}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

When resistors are connected in parallel:
The total current (I) is the sum of currents through each resistor:

$I = I_1 + I_2 + I_3$

Using Ohm's law for the parallel combination:

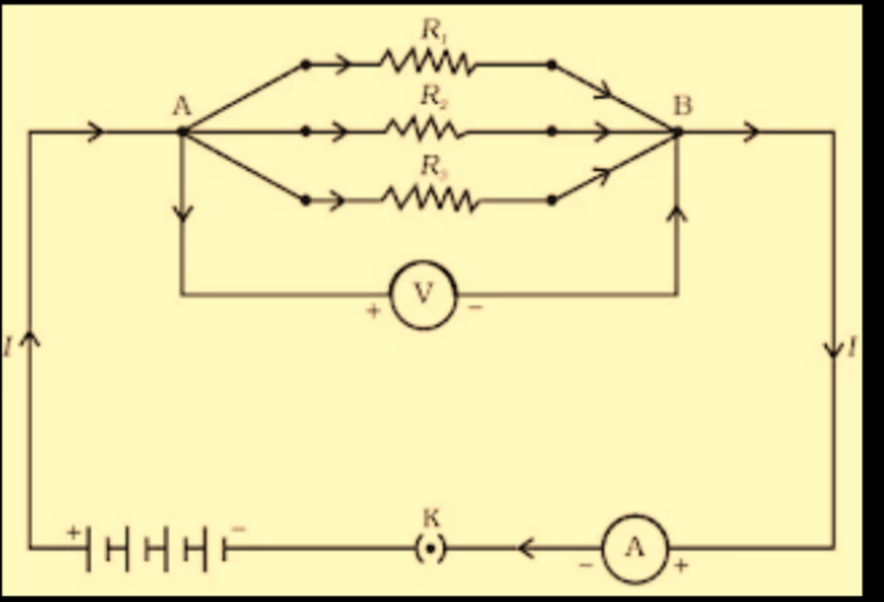
$I = V / R_p$

For each resistor:

$I_1 = V / R_1$, $I_2 = V / R_2$, $I_3 = V / R_3$

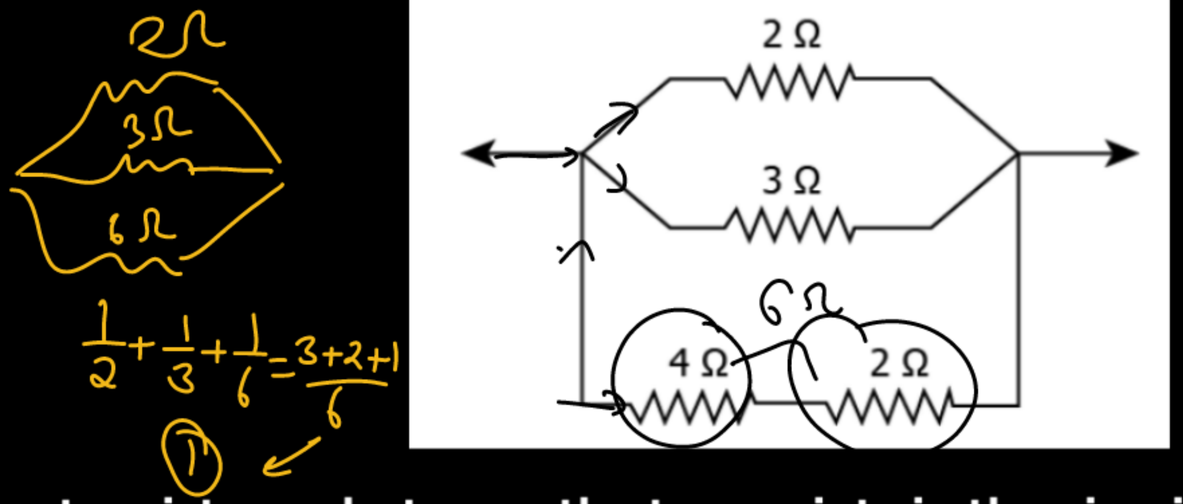
Substituting, we get:

$1 / R_p = 1 / R_1 + 1 / R_2 + 1 / R_3$



Conclusion:
The reciprocal of the equivalent resistance (R_p) is equal to the sum of the reciprocals of the individual

Q.The image shows a combination of 4 resistors.



What is the net resistance between the two points in the circuit?

(a) 0.5 Ω
(b) 1.0 Ω
(c) 1.5 Ω
(d) 2.0 Ω

Answer: Option

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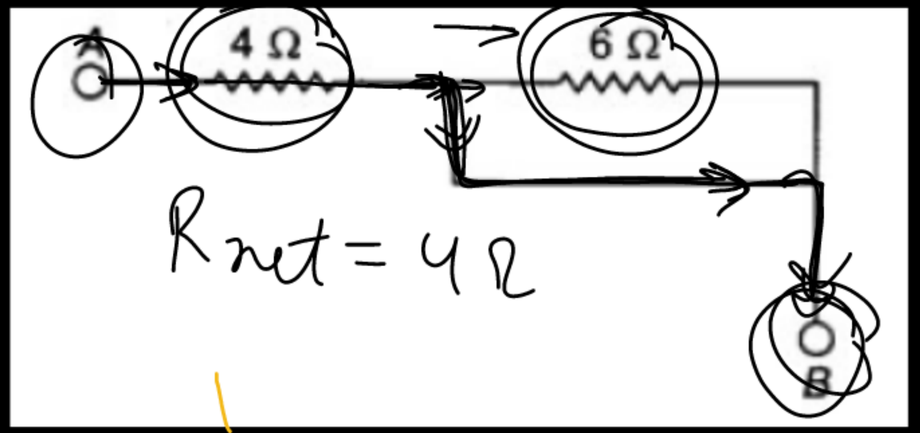
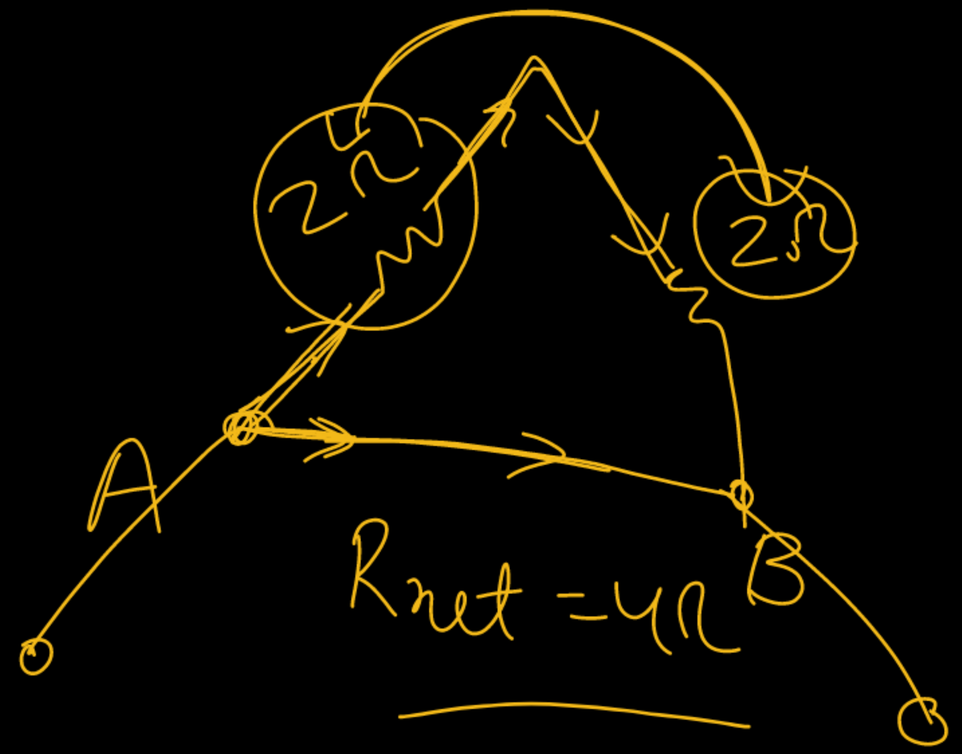
Q.The effective resistance between A and B is



(a) 4 Ω
(b) 6 Ω
(c) May be 10 Ω
(d) Must be 10 Ω

Answer: Option (a)



$\frac{1}{4} + \frac{1}{2} = \frac{3}{4}$

$= \frac{4}{3}\Omega$