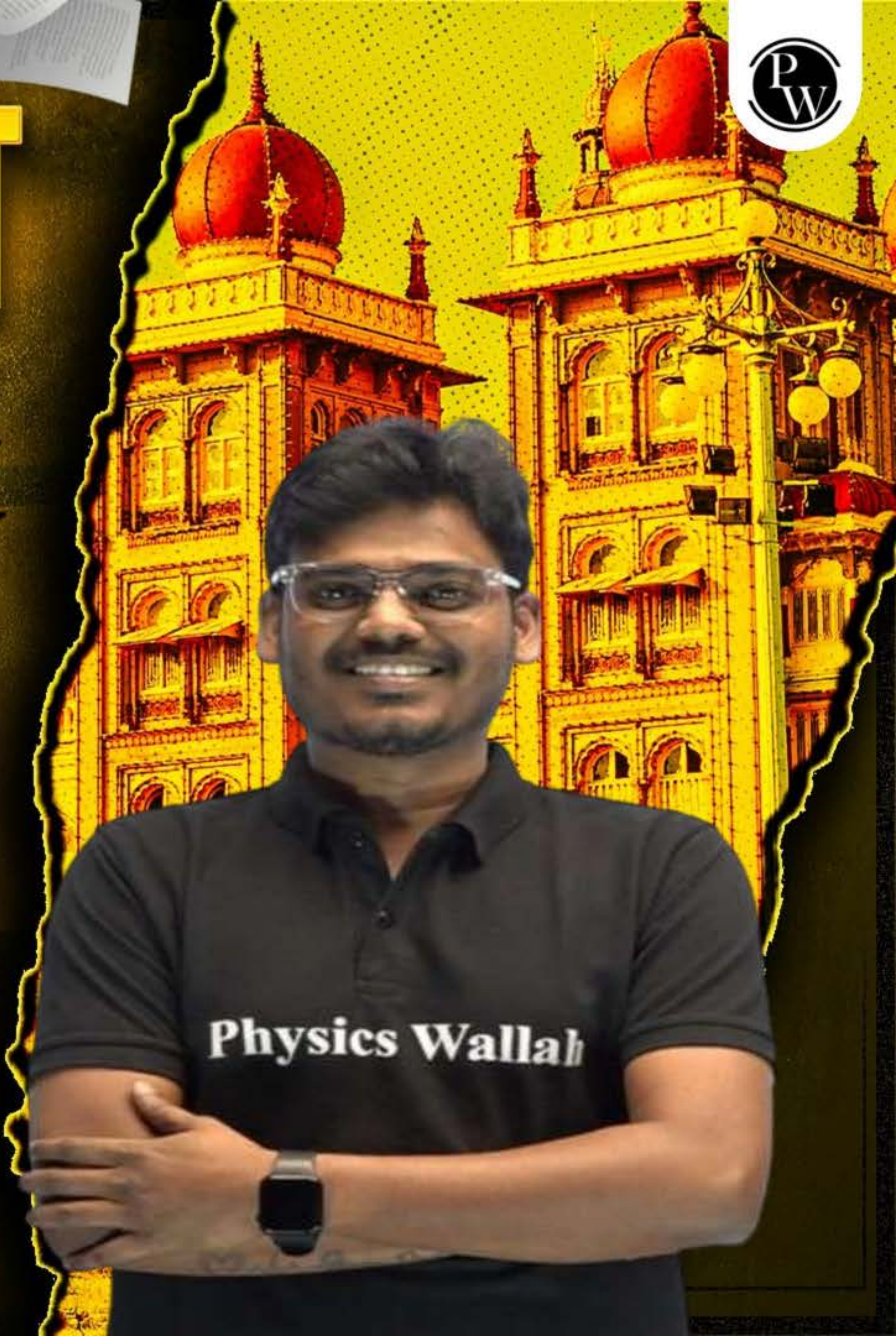
ULTIMATE KCET

CRASH COURSE 2026

PHYSICS | Lecture - 02

CURRENT ELECTRICITY

By – AK SIR

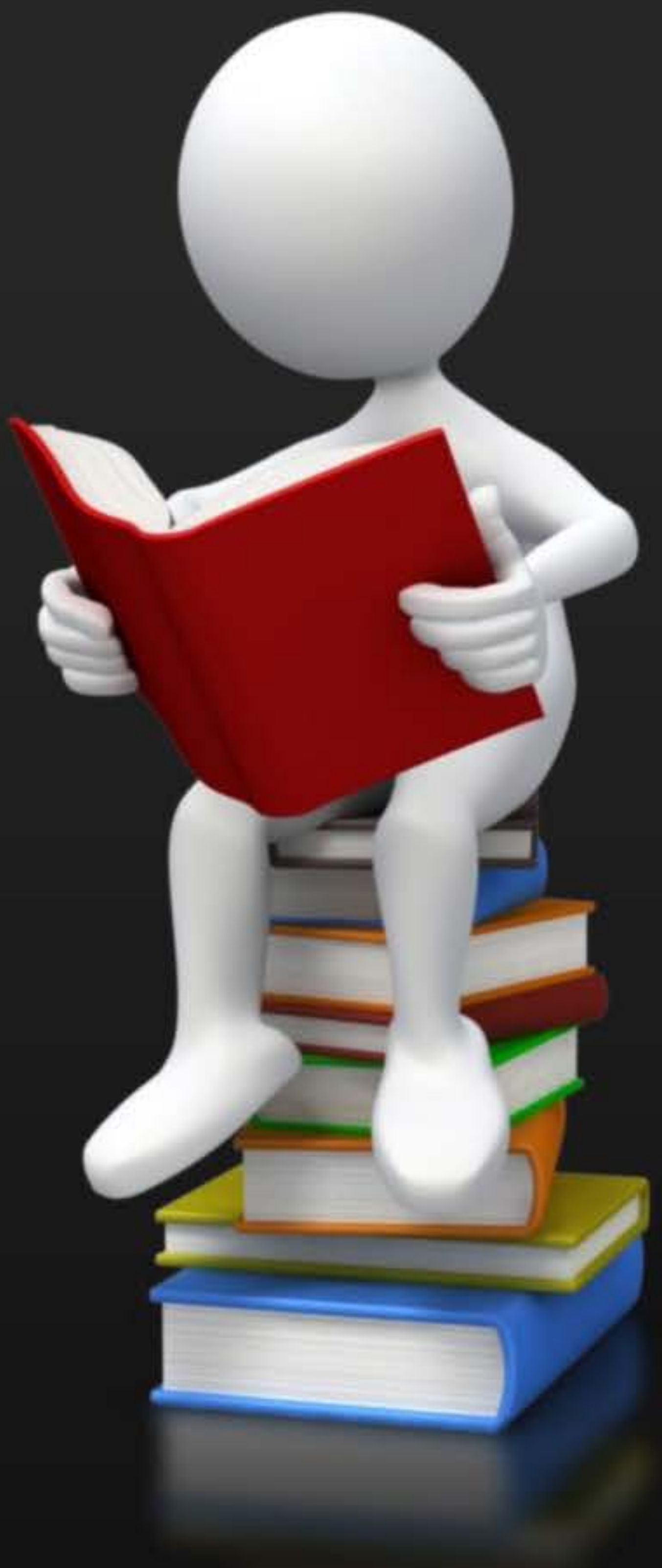


Recap *of previous lecture*

1. COMBINATION OF CAPACITOR
2. ELECTRIC CURRENT AND SPECIAL CASES
3. RESISTANCE AND CONDUCTANCE
4. QUESTIONS

Topics *to be covered*

1. OHM'S LAW AND ITS IMPORTANT POINTS
2. ELECTRICAL ENERGY AND POWER
3. ELECTRIC CELL AND COMBINATION OF CELLS
4. WHEAT-STONE BRIDGE



OHM'S LAW

Statement :

"Potential differences across the ends of the conductor is directly proportional to current flowing through the conductor provided temperature and other physical conditions remains constant"

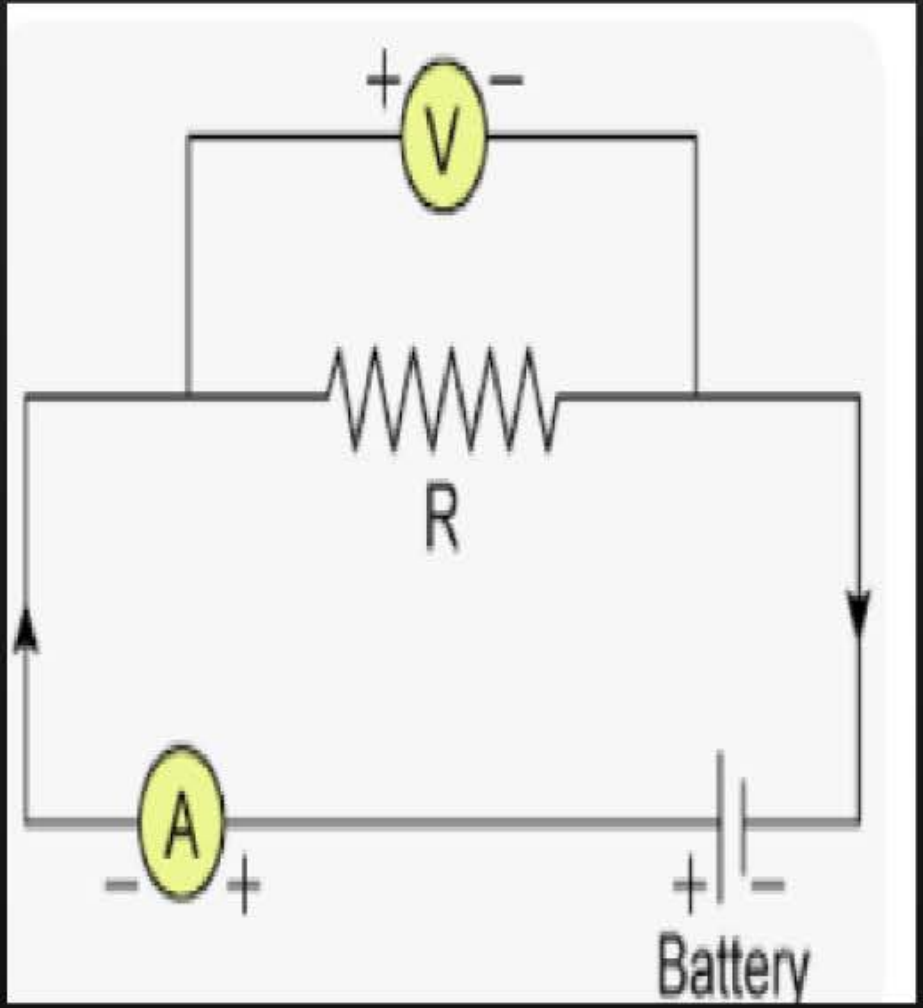
$V \propto I$

$V = RI$

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

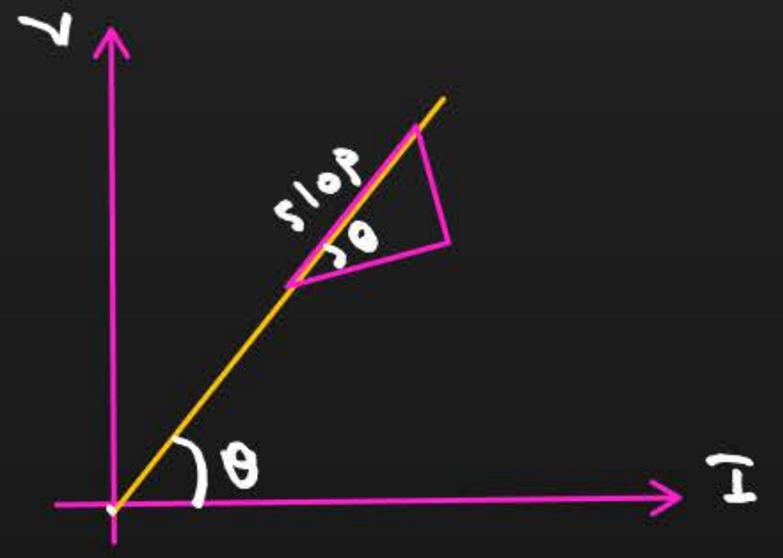
$R = \rho \frac{l}{A}$

$R = \frac{ml}{ne^2 \tau A}$



OHM'S LAW

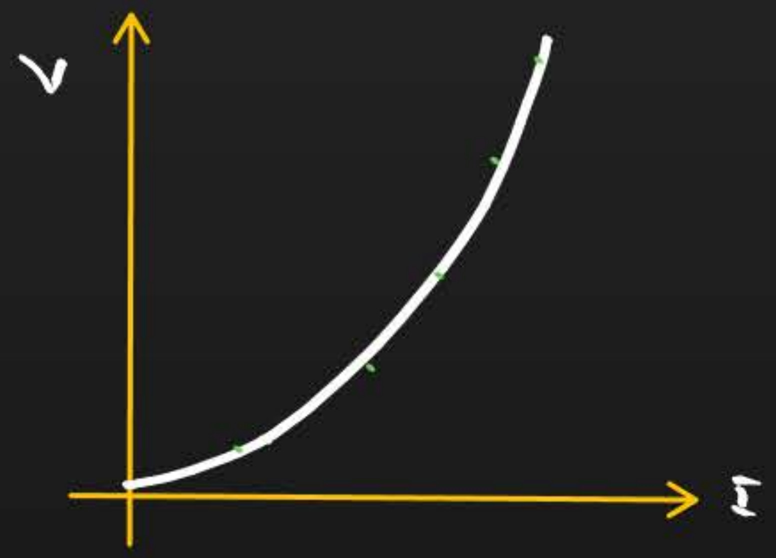
Case (i) : Linear V-I Characteristics OR Ohmic Resistance , Ex: Metals
Resistors



slope V-I graph, $R = \frac{\Delta V}{\Delta I}$ = constant

OHM'S LAW

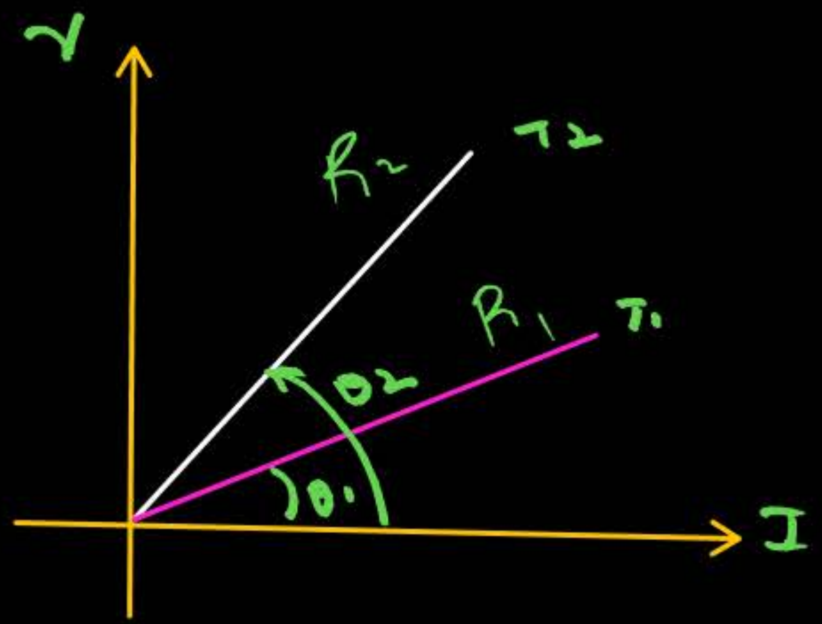
Case (ii): Non-linear V-I Characteristics OR Non-Ohmic Resistance, Diode, Transistor, Tungsten, Semi conductor.



Slope, $R = \frac{\Delta V}{\Delta I} \neq \text{constant}$

↳ Dynamic Resistance

Resistance (R)



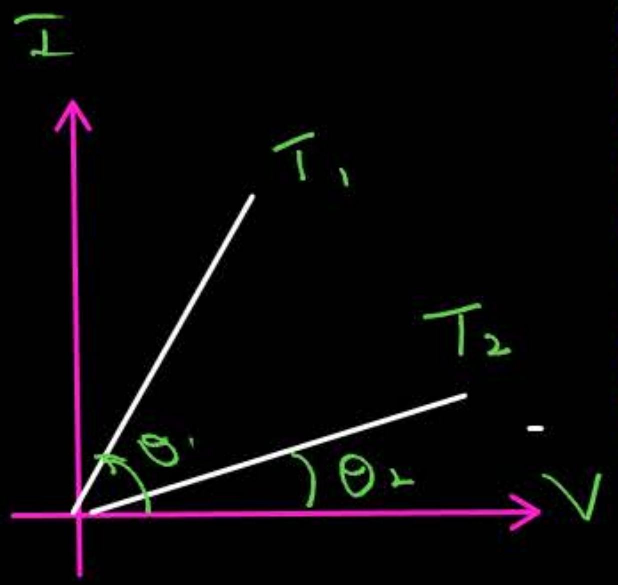
more the slope, more is the resistance

$\theta_2 > \theta_1$

$\tan\theta_2 > \tan\theta_1$

$R_2 > R_1$

$T_2 > T_1$



$\theta_1 > \theta_2$

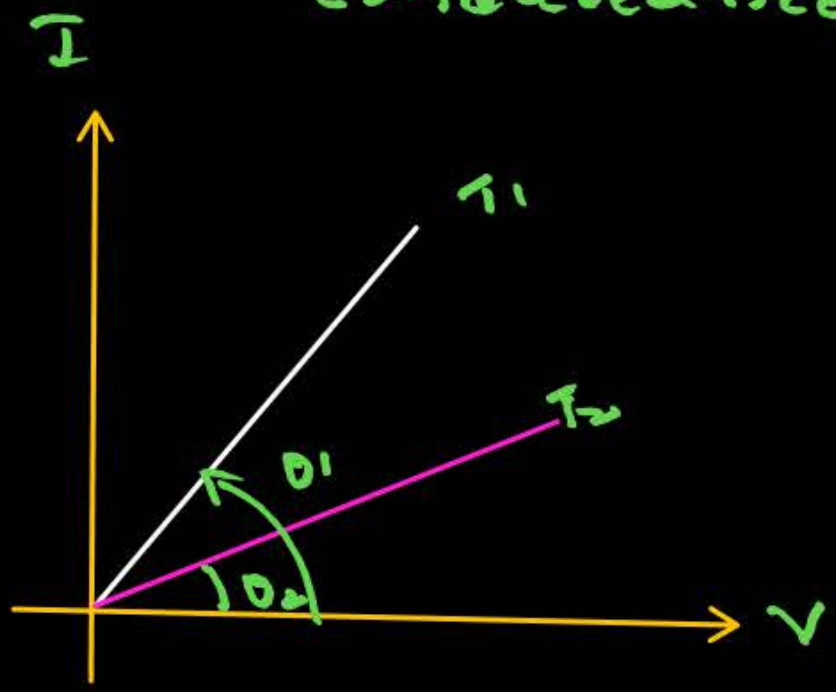
$\tan\theta_1 > \tan\theta_2$

$G_1 > G_2$

$R_1 < R_2$

$T_1 < T_2$

conductance (G)



$G = \frac{1}{R}$

$\theta_1 > \theta_2$

$\tan\theta_1 > \tan\theta_2$

$G_1 > G_2$

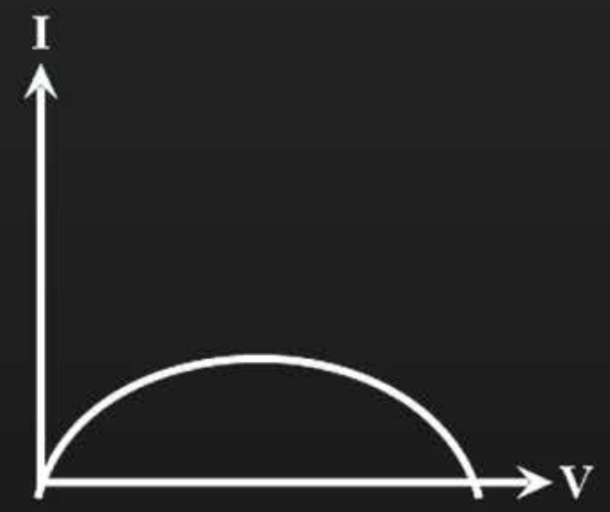
$R_1 < R_2$

$T_1 < T_2$

Question

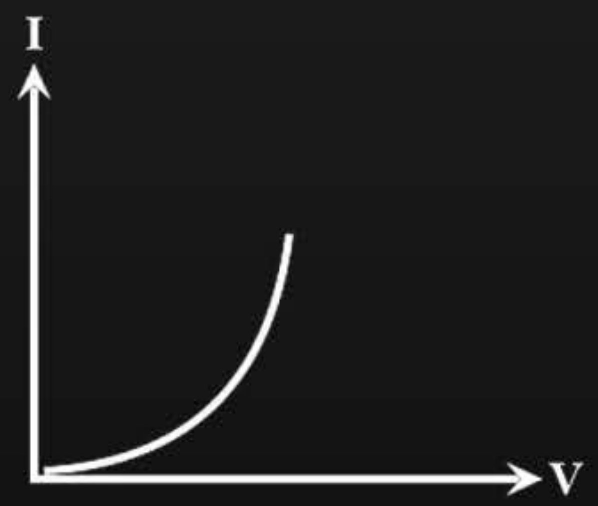
Of the following graphs, the one that correctly represents the I-V characteristics of a 'Ohmic device' is

A



B

C



D

Question

The voltage V and current I graph for a conductor at two different temperatures T_1 and T_2 and shown in the figure. The relation between T_1 and T_2 is

(A) $T_1 > T_2$

(B) $T_1 < T_2$

(C) $T_1 = T_2$

(D) $T_1 = 1/T_2$

Resistance = slope

$\theta_1 > \theta_2$

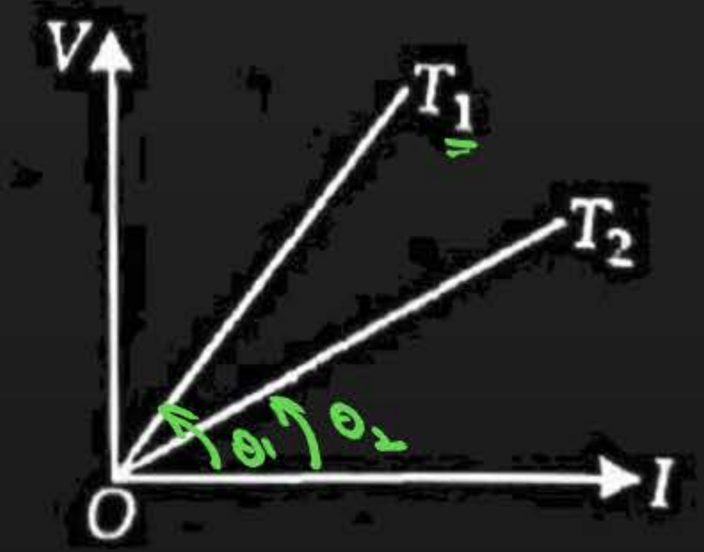
$\tan\theta_1 > \tan\theta_2$

$R_1 > R_2$

$R \propto$ Temp

$T_1 > T_2$

$T_2 < T_1$



Question

The I-V graphs for two different electrical appliances P and Q are shown in the diagram. If R_P and R_Q be the resistances of the devices, then

Conductance

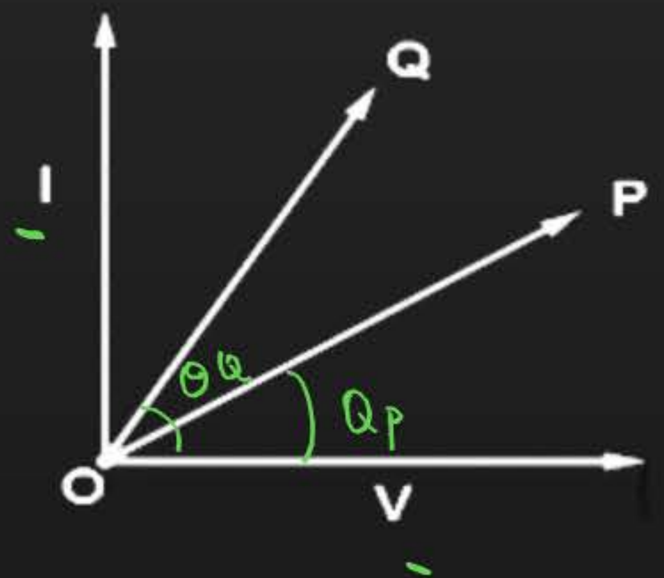
$\theta_Q > \theta_P$

$\tan\theta_Q > \tan\theta_P$

$G_Q > G_P$

$R_Q < R_P$

$R_P > R_Q$



(A) $R_p = R_Q$

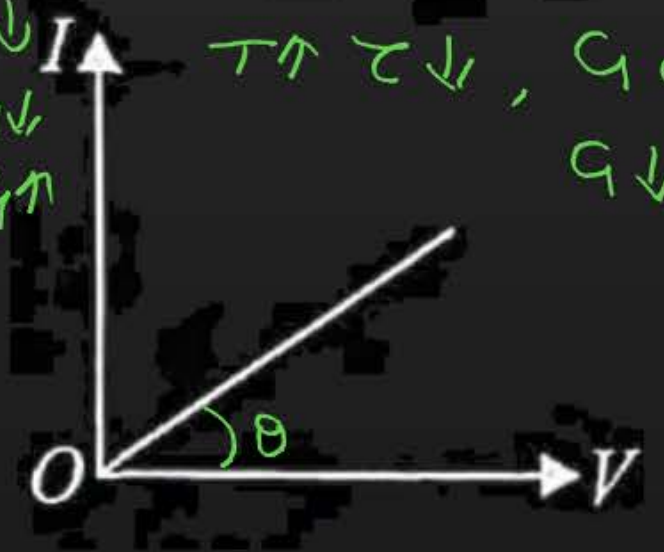
(B) $R_p > R_Q$

(C) $R_p < R_Q$

(D) $R_p = \frac{R_Q}{2}$

Question

I-V characteristic of a copper wire of length L and area of cross-section A is shown in figure. The slope of the curve becomes



A More if experiment is performed at higher temperature

B More if a wire of steel of same dimension is used

C Less if the area of the wire is increased

D Less if the length of the wire is increased

$$R = \rho \frac{l}{A} = \frac{ml}{ne^2 \tau A}$$

$$G = \frac{1}{R} = \frac{ne^2 \tau A}{ml}$$

$G \propto \tau$

(A) $T \uparrow$ $\tau \downarrow$ $G \downarrow$

(B) $G \propto n$, $n = \frac{N}{Vol}$

$n_c > n_s$

$10^{28} > 10^{25}$

$n_s < n_c$

$G_s < G_c$

(C) $G \propto A$

$A \uparrow$ $G \uparrow$

(D) $G \propto \frac{1}{l}$

$l \uparrow$ $G \downarrow$

$l \downarrow$ $G \uparrow$

Ohm's Law in Vector Form

$$V = IR$$

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

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

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

If $l = 1\,m$ $A = 1\,m^2$

$$R = \rho$$

$$\boxed{\rho = \frac{\vec{E}}{\vec{J}}}$$

$$R = \frac{1}{G}$$

$$\vec{E} = \rho \vec{J}$$

$$\rho = \frac{1}{\sigma}$$

$$\vec{E} = \frac{1}{\sigma} \vec{J}$$

*

$$\boxed{\begin{aligned} \vec{J} &= \sigma \vec{E} \\ \vec{E} &= \rho \vec{J} \end{aligned}}$$

Question

$\vec{E}$ is the electric field inside a conductor whose material has conductivity σ-and resistivity ρ. The current density inside the conductor is $\vec{j}$. The correct form of Ohm's law is

A. $\vec{E} = \sigma\vec{j}$

B. $\vec{j} = \rho\vec{E}$

C. $\vec{E} = \rho\vec{j}$

D. $\vec{E}.\vec{j} = \rho$

Ohm's Law Limitations

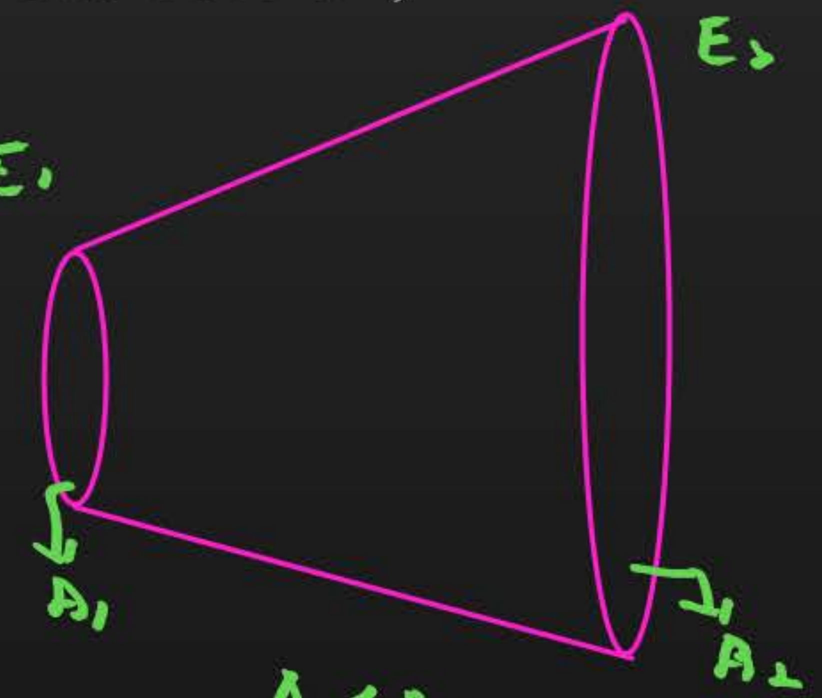
1. It is not applicable at very high temperature and very low temperature.

2. It is not applicable to electron tubes and discharge tube, Diodes, Transistors and semiconductors.

3. It is applicable for metallic conductors.

IMPORTANT POINTS

When a steady current flows through a conductor of non-uniform cross-section,



Case (i) Current is same along the conductor [wire] $\Rightarrow \frac{dq}{dt} = I \Rightarrow$ $I = \text{const}$

By continuity equation, $VA = \text{const}$

Case (ii) Current density

$\vec{J} = \frac{I}{\vec{A}}$, $\vec{J} \propto \frac{1}{\vec{A}}$

$A_2 > A_1$

$J_2 < J_1$

$J_1 > J_2$

(iii) Electric field

$E = \rho J$, $E \propto J \propto \frac{1}{A}$

$A_2 > A_1$

$E_2 > E_1$

$E_1 > E_2$

IMPORTANT POINTS

Case (iv) Drift velocity

$$V_d = \frac{I}{ne^2\tau A}$$

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

$A_1 < A_2$

$(V_{d_1})_1 > (V_d)_2$

$(V_d)_2 < (V_{d_1})$

P.D (V)

$$V_d = \frac{I}{ne^2\tau A}$$

$$V_d = \frac{V}{R \times ne^2\tau A}$$

$$V_d = \frac{V}{\frac{\rho l}{A} \times ne^2\tau A}$$

$$V_d = \frac{V}{\rho l n e^2 \tau}$$

$V_d \propto V$

→ $V = const$, $V_d = const$

→ $V \neq const$, $V_d \neq const$

Question

Given, a current carrying wire of non-uniform cross-section, which of the following is constant throughout the length of the wire?

A. Current only

B. Current, electric field, and drift speed

C. Drift speed

D. Current and drift speed

Question

The drift velocity of electrons for a conductor connected in an electrical circuit is V_d. The conductor is now replaced by another conductor with same material and same length but double the area of cross-section. The applied voltage remains same. The new drift velocity of electrons will be

(A) V_d

(B) $V_d/2$

(C) $V_d/4$

(D) $2V_d$

$$v_d = \frac{V}{\rho l n e^2 \tau}$$

$$v_d = \frac{eE\tau}{m}$$

A - Independent.

Question

Across a metallic conductor of non-uniform cross-section, a constant potential difference is applied. The quantity which remains constant along the conductor is

$V \propto I \Rightarrow I = \text{const}$

(A) Current density

(B) Current *

(C) Drift velocity

(D) Electric field

Linear expansion: $\Delta L = L \alpha \Delta T$

$R = \frac{ml}{ne^2 \tau A} \propto \frac{1}{n\tau}$, $T \uparrow$ $\tau \downarrow$ $R \uparrow$ $T \propto R$ => conductors

$\Delta R = R \alpha \Delta T$

$\Delta R = R_1 \alpha \Delta T$

$R_2 - R_1 = R_1 \alpha \Delta T$

Effect of temperature on resistance and resistivity

Resistance of materials : When temperature of metallic wire is raised, its electrical resistance increases.

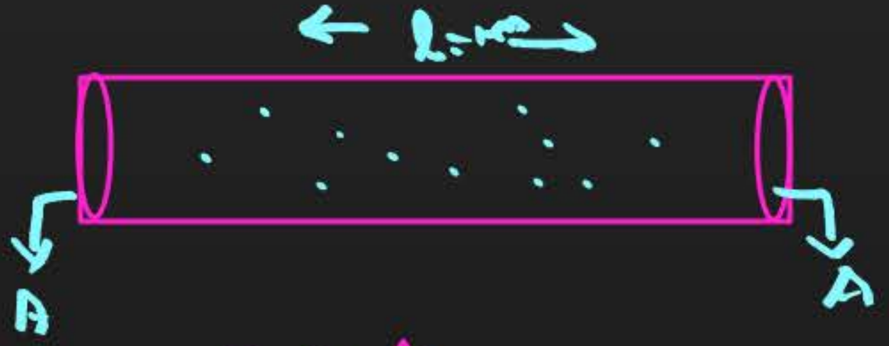
$R = \frac{ml}{ne^2\tau A}$

$m = 9.1\times10^{-31}$ kg

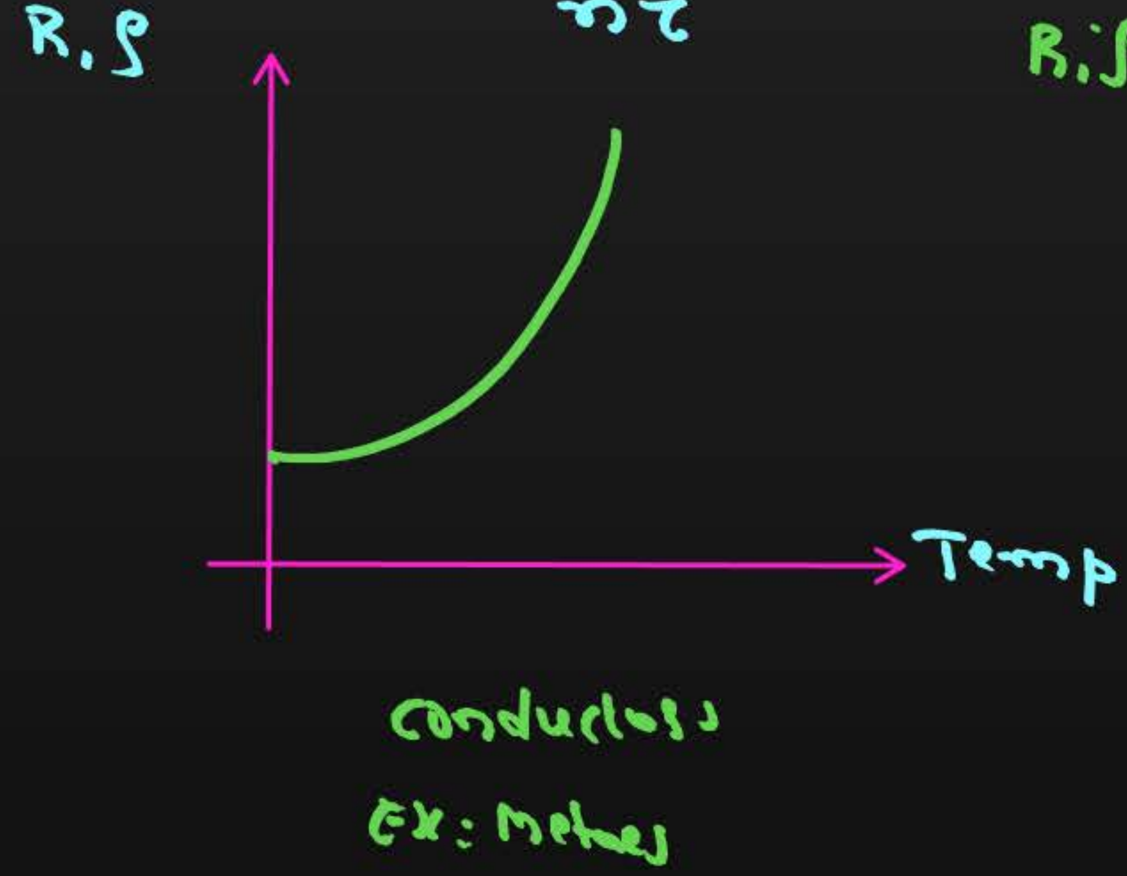
$e = 1.6\times10^{-19}$ C

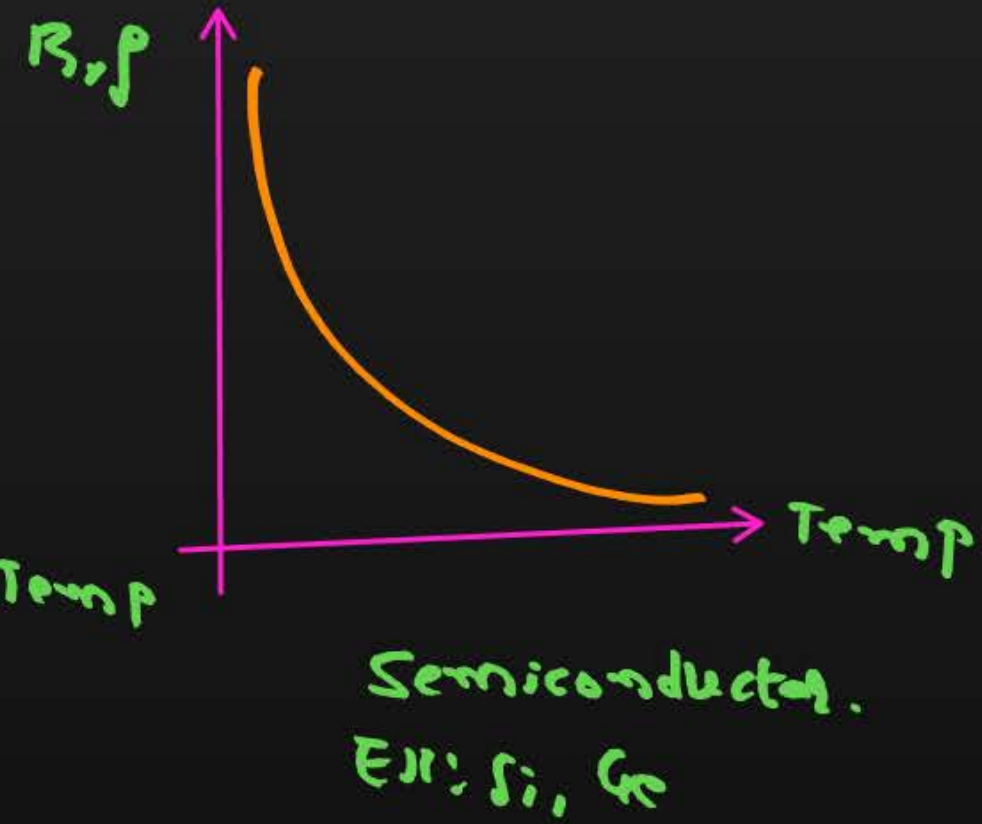
A = const

$R \propto \frac{1}{n\tau}$



T↑ G↑ R↓





Question

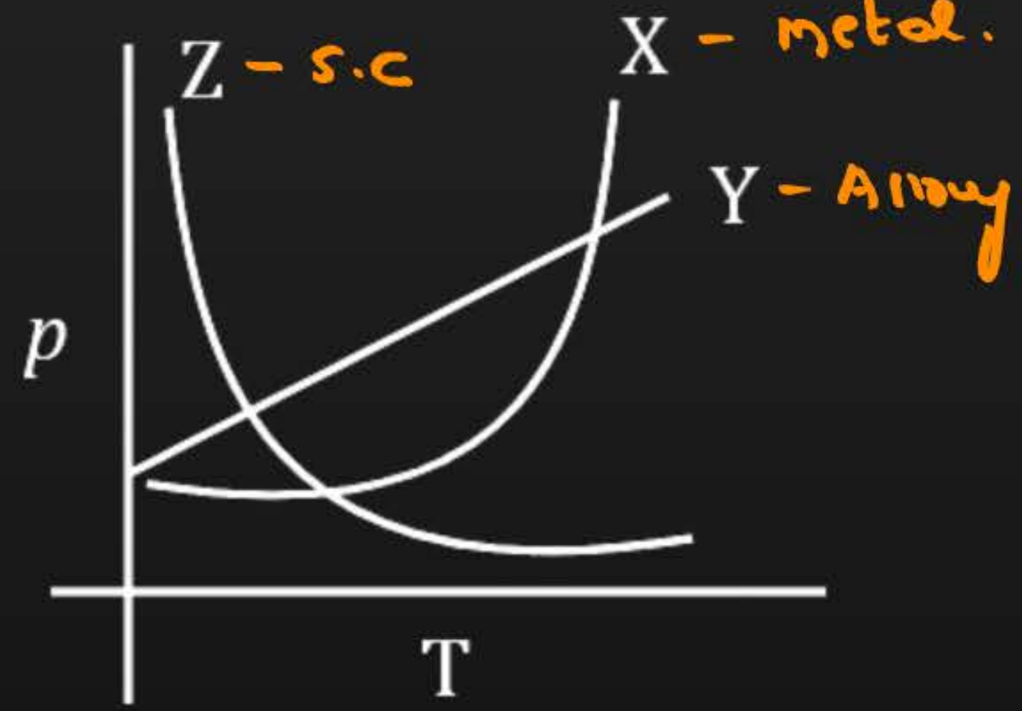
The variations of resistivity ρ with absolute temperature T for three different materials X, Y, and Z are shown in the graph below. Identify the materials X, Y, and Z

(A) $X =$ nichrome, $Y =$ copper, $Z =$ semiconductor

(B) $X =$ copper, $Y =$ nichrome, $Z =$ semiconductor

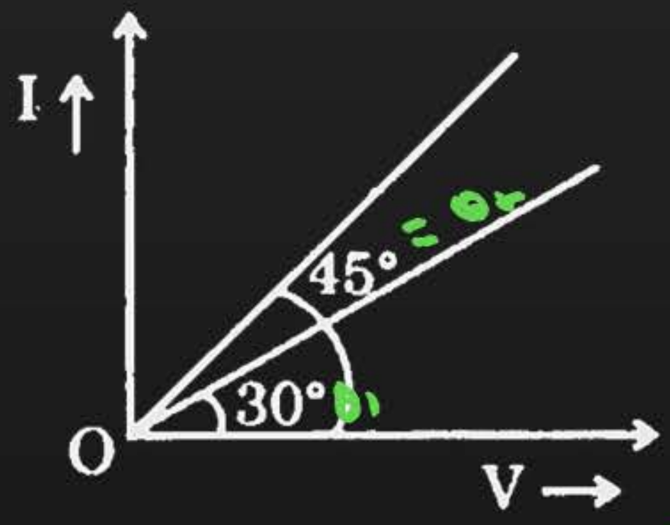
(C) $X =$ copper, $Y =$ semiconductor, $Z =$ nichrome

(D) $X =$ semiconductor, $Y =$ nichrome, $Z =$ copper



Question

The I-V graph for a conductor at two different temperatures 100°C and 400°C is as shown in the figure. The temperature coefficient of resistance of the conductor is about (in per degree Celsius)



(A) 3×10^{-3}

(B) 6×10^{-3}

(C) 9×10^{-3}

(D) 12×10^{-3}

$T \uparrow \; R \uparrow \; G \downarrow$

$G = \text{slope}$

$G = \tan\theta$

$G_1 = \tan 30^\circ = \frac{1}{\sqrt{3}}$

$G_2 = \tan 45^\circ = 1$

$G_2 > G_1$, $R_2 < R_1$, $R = \frac{1}{G}$

$\frac{G_1}{G_2} = \frac{1}{\sqrt{3}} \times \frac{1}{1} = \frac{1}{\sqrt{3}}$

$\frac{R_2}{R_1} = \frac{\sqrt{3}}{1} \Rightarrow R_2 = \sqrt{3} R_1$

$\Delta R = R_2 - R_1$

$\Delta R = R_1 \alpha \Delta T$

$\alpha = \frac{\Delta R}{R_1 \Delta T} = \frac{R_2 - R_1}{R_1 \Delta T}$

$\alpha = \frac{\sqrt{3} R_1 - R_1}{R_1 (400 - 100)}$

$\alpha = \frac{R_1(\sqrt{3} - 1)}{R_1 (300)}$

$\alpha = 0.00244$

$\alpha = 2.44 \times 10^{-3} /^\circ C$

Question

The resistance of platinum wire at 0° C is 2Ω and 6.8 Ω at 80° C . The temperature coefficient of resistance of the wire is

(A) $3 \times 10^{-1}\ °c^{-1}$

(B) $3 \times 10^{-4}\ °c^{-1}$

(C) $3 \times 10^{-3}\ °c^{-1}$

(D) $3 \times 10^{-2}\ °c^{-1}$

$$\alpha = \frac{R_2 - R_1}{R_1\ \Delta T} = \frac{6.8 - 2}{2(80° - 0°)} = \frac{4.8}{2 \times 80}$$

$$\alpha = 0.03$$

$$\alpha = 3 \times 10^{-2} /°C$$

Question

In a conductor, if the number of conduction electrons per unit volume is $8.5 \times 10^{28}\ m^{-3}$ and mean free time is 25 *f*s (femto second), it's approximate resistivity is: ($m_e = 9.1 \times 10^{-31}$ kg)

(A) $10^{-7}\ \Omega\ m$

(B) $10^{-6}\ \Omega\ m$

(C) $10^{-5}\ \Omega\ m$

(D) $10^{-8}\ \Omega\ m$

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

$R = \frac{m l}{n e^2 \tau A}$

$\rho = \frac{m}{n e^2 \tau} = \frac{9.1 \times 10^{-31}}{8.5 \times 10^{28} \times (1.6 \times 10^{-19})^2\ 25 \times 10^{-15}}$

$\rho = 0.016 \times 10^{-6}$

$\rho = 1.6 \times 10^{-8}\ \Omega \cdot m$

combination of resistors

Series combination, $R_{eq} = R_1 + R_2 + \ldots$ I = const, V = vary

parallel ", $R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$, $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$ V = const, I = vary

Question

Three resistances 2Ω, 3Ω and 4Ω are connected in parallel. The ratio of currents passing through them to when a potential difference is applied across its ends will be

→ V = const

$V = IR$

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

$I_1 : I_2 : I_3 = \frac{1}{R_1} : \frac{1}{R_2} : \frac{1}{R_3}$

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

$I_1 : I_2 : I_3 = 6 : 4 : 3$

(A) 5:4:3

(B) 6:3:2

(C) 4:3:2

(D) 6:4:3

Question

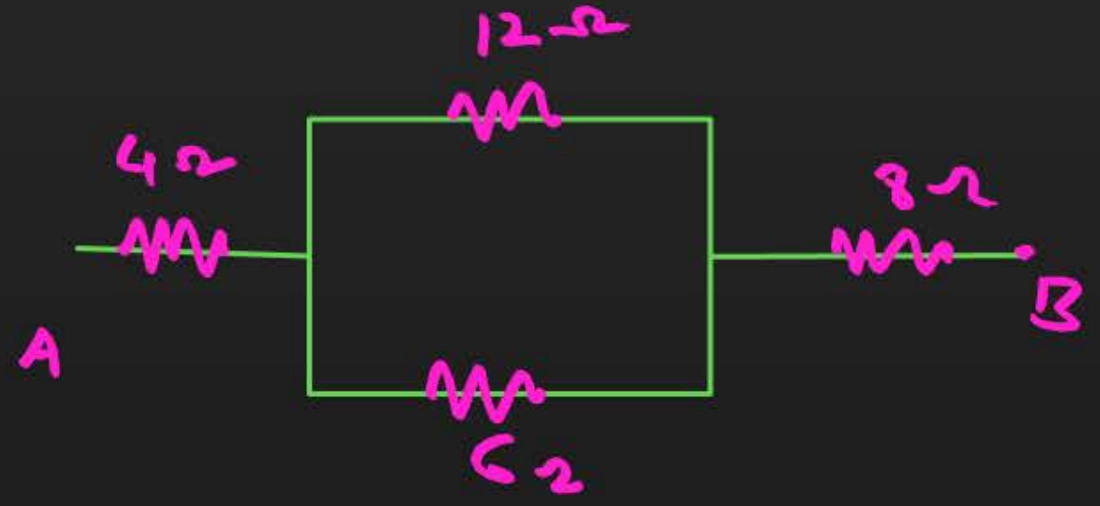
The equivalent resistance between A and B for the mesh shown in the figure is

(A) 7.2 Ω

(B) 4.8 Ω

(C) 30 Ω

(D) 16 Ω



$$R_{eq} = \frac{12 \times 6}{18} = 4\,\Omega$$

$$R_{AB} = 4+4+8 = 16\,\Omega$$

Electric Energy and Power

Electrical Power: The rate at which electric energy is transferred into other forms of energy is called 'Electric power'

$$P = \frac{W}{t} = \frac{E}{t}, \quad P = IV$$

Electrical Energy : Suppose, A current of 'I' amperes flows in the circuit for 't' seconds. It carries a charge 'q' from one end to another.

$$P = \frac{E}{t} \quad E = P \times t$$

Commercial unit of electrical energy

1 kWh : 1 kilowatt-hour is the quantity of electric-energy which dissipated in 1 hour in a circuit when the electric power in the circuit is 1 kilowatt.

$$E = p \times t$$

$$E = 1kW \times 1h = 10^3 W \times 3600 s$$

$$= 10^3 \times 36 \times 10^2 \, Ws$$

$$= 36 \times 10^5 J$$

$$1kWh = 3.6 \times 10^6 J$$

ELECTRICAL APPLIANCES

$H = I^2Rt$

1. Filament of electrical bulb : It is made of tungsten which has low resistivity and high melting point.

2. Filament of heating devices : It is made of nichrome which has high resistivity and high melting point.

3. Standard resistances (Resistance box) : Standard resistances are made of manganin or constantan. These materials have moderate resistivity and very low temperature coefficient of resistance.

4. Fuse wire : It is made of tin-lead alloy. It has low resistivity and low melting point. It is used in series with the circuit to prevent the electrical appliances from burning by melting itself to open the circuit.

ELECTRIC BULB

Rated or design values :

(100W, 110V)

$P = IV$

$P = \frac{V}{R} \cdot V$

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

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

$R = \frac{(110)^2}{100}$

$R = 121\Omega$

Safe limit of current

$P = IV$

$I = \frac{P}{V} = \frac{100}{110}$

$I = 0.90A$

$I' < I_b \rightarrow$ Work

$I' > I_b \rightarrow$ Burn

Question

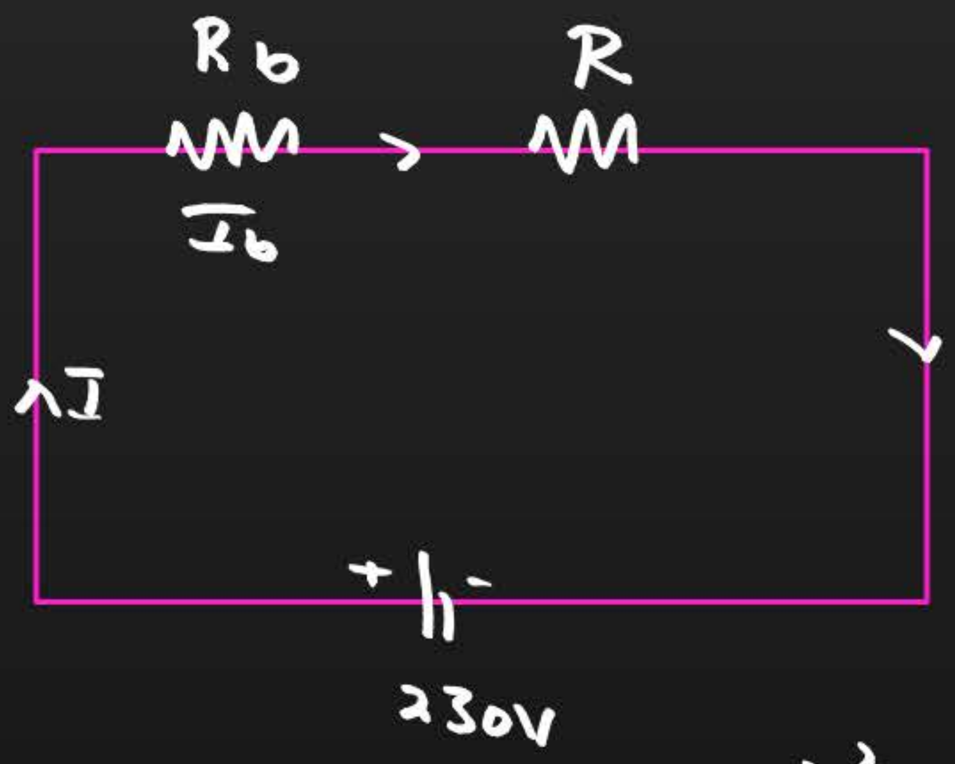
A filament bulb (500 W, 100 V) is to be used in a 230 V main supply. When a resistance R is connected in series, the bulb works perfectly and consumes 500 W. The value of R is

(A) 230 Ω

(B) 46 Ω

(C) 26 Ω

(D) 13 Ω



$$I_b = \frac{P_b}{V_b} = \frac{500}{100}$$

$$I_b = 5A = I$$

$$R_b = \frac{V_b^2}{P_b}$$

$$R_b = \frac{(100)^2}{500} = 20\,\Omega$$

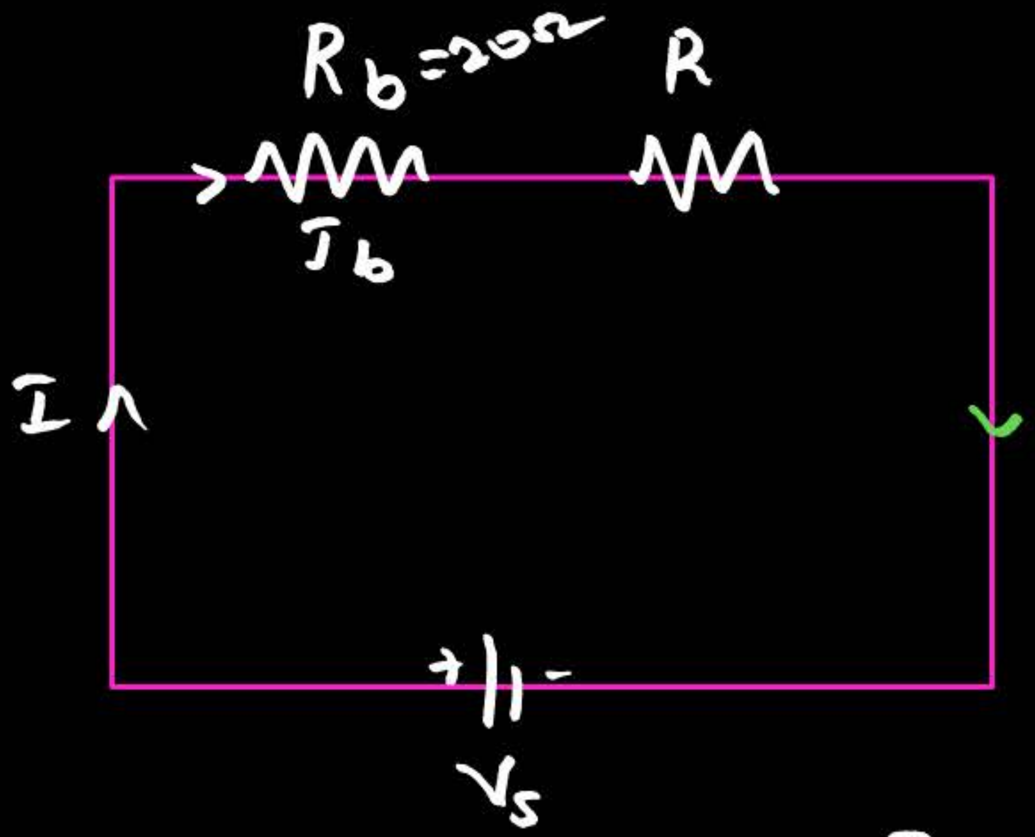
$$V_s = I R_T$$

$$230 = 5(R_b + R)$$

$$R_b + R = \frac{230}{5} = 46$$

$$20 + R = 46$$

$$R = 26\,\Omega$$



Ratings: $P_r = 500W$

$V_r : 100V$

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

$P_r = \frac{V_r^2}{R_b}$

$R_b = \frac{V_r^2}{P}$

$R_b = \frac{100 \times 100}{500}$

$R_b = 20\Omega$

$P = IV$

$P_r = I_b V_r$.

$I_b = \frac{P_r}{V_r}$

$I_b = \frac{500}{100}$

$I_b = 5A = I$

$V = IR$.

$V_s = I(R_b + R)$

$230 = 5(20 + R)$

$R = 26\Omega$

Question

An electric bulb of 60 W, 120 V is to be connected to 220 V source. What resistance should be connected in series with the bulb, so that the bulb glows properly? [H.W]

(A) 50 Ω

(B) 100 Ω

(C) 200 Ω

(D) 288 Ω

Question

V_R P_R

An electric heater rated 220 V and 550 W is Connected to AC mains. The current drawn by it is

(A) 0.8 A

(B) 2.5 A

(C) 0.4 A

(D) 1.25 A

$$P = IV$$

$$P_R = I V_R$$

$$I = \frac{P_R}{V_R} = \frac{550}{220}$$

$$I = 2.5\,A$$

Question

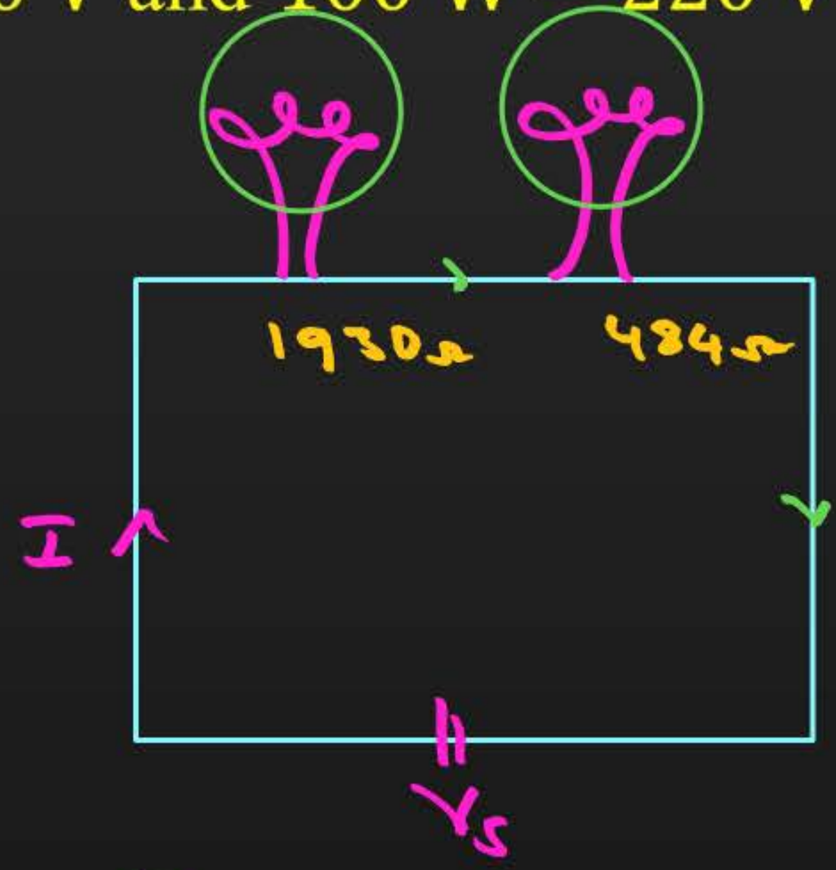
Two bulbs rated 25 W – 220 V and 100 W – 220 V are connected in series to a 440 V supply. The,

A 100 W bulb fuses

B 25 W bulb fuses

C both the bulbs fuse

D neither of the bulb fuses



B-2: $P_2 = 100\,W$ $V_2 = 220\,V$

$R_{b2} = \frac{(V_2)^2}{P_2} = \frac{(220)^2}{100} = 484\,\Omega$

$I_2 = \frac{P_2}{V_2} = 0.45\,A$

Now: Series $R = 1936 + 484$

$R = 2420\,\Omega$ $I = \frac{V_s}{R} = \frac{440}{2420}$

$V_s = 440\,V$

$I = 0.18\,A$

$I_1 < I \rightarrow$

$I_2 > I \rightarrow$

B-1: $P_1 = 25\,W$ $I_1 = \frac{P_1}{V_1}$

$V_1 = 220\,V$

$I_1 = 0.11\,A$

$R_{b1} = \frac{V_1^2}{P_1} =$

$R_{b1} = 1936\,\Omega$

Question

The power dissipated in the circuit shown in the figure is 30 Watt. The value of R is

(A) 20Ω

(B) 15Ω

(C) 10Ω

(D) 30Ω

$$P = \frac{V^2}{R_T} = \frac{(10)^2}{R_P}$$

$$30 = \frac{100}{R_P}$$

$$R_P = \frac{10}{3}$$

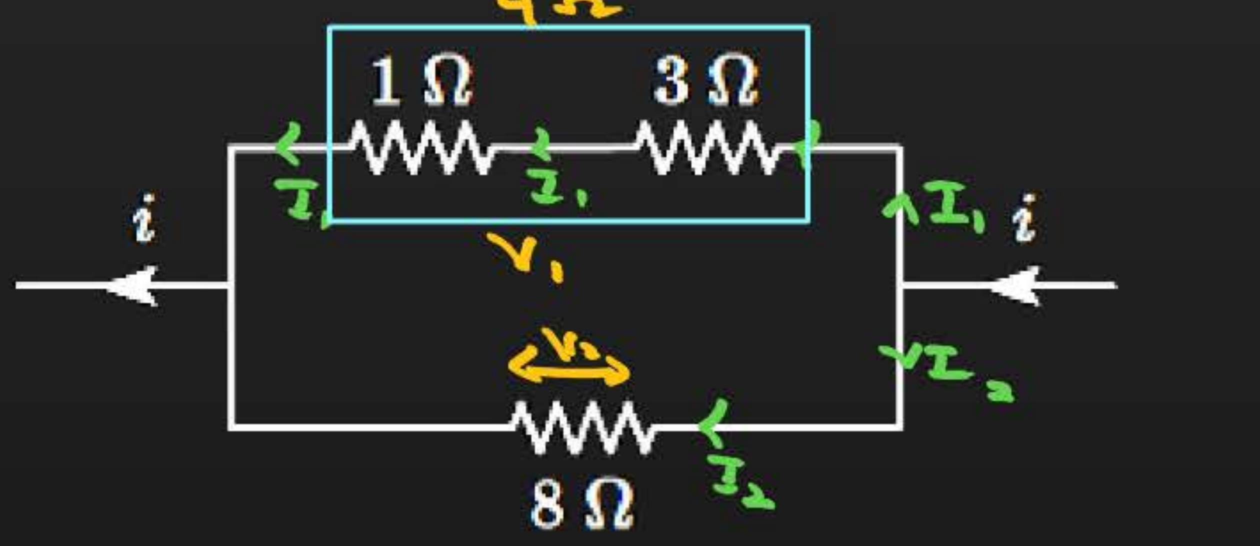
$$\frac{R \times 5}{R+5} = \frac{10}{3}$$

$$\frac{R}{R+5} = \frac{2}{3} \Rightarrow 3R = 2R + 10$$

$$R = 10\Omega$$

Question

The power dissipated across the 8 Ω resistor in the circuit shown here is 2 W. The power dissipated in watts across the 3 Ω resistor is:



(A) 2.0

(B) 1.0

(C) 0.5

(D) 3.0

① $P_3 = I_1^2 R_{3\Omega}$

② $P_{8\Omega} = I_2^2 R_{8\Omega}$

$2 = I_2^2 \times 8$

$I_2^2 = \frac{1}{4}$

$I_2 = \frac{1}{2}$ A

③ $V_1 = V_2$

$I_1 R_T = I_2 R$

$I_1 \times 4 = \frac{1}{2} \times 8 = 4$

$I_1 = 1$ A

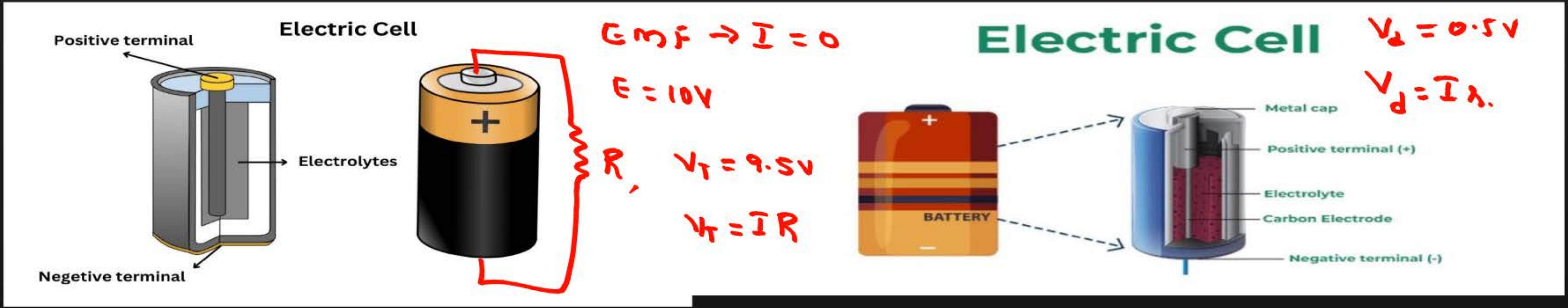
④ $P_3 = I_1^2 R_3$

$P_3 = (1)^2 \times 3$

$P_3 = 3$ W

Electric Cell

Electric Cell: An electric cell is a source of electrical energy which maintains a continuous flow of charge in circuit



Cells, EMF, internal Resistance

$$E = V_T + V_d$$

$$E = IR + Ir = I(R+r)$$

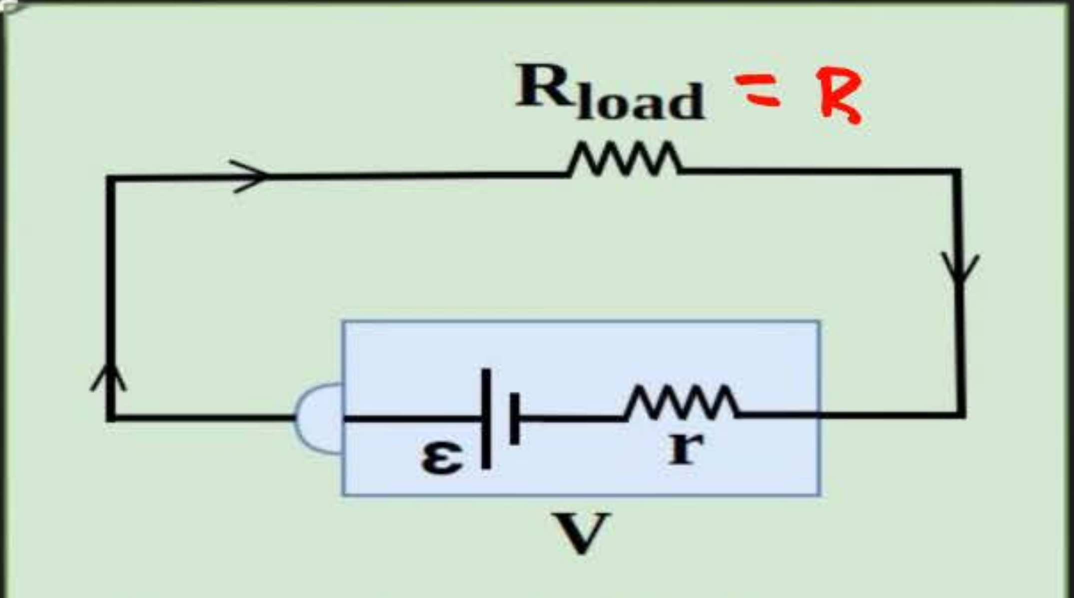
$$I = \frac{E}{R+r} \Rightarrow I_{max} \Rightarrow R_{ext} = 0$$

$$I_{max} = \frac{E}{r}$$

$$E = V_T + V_d$$

$$V_T = E - V_d$$

$$V_T = E - Ir \qquad V_d = Ir$$



Terminal Voltage

Relation between E, V_T and r

RELATION BETWEEN E & V

$V_T = E - Ir.$

1. If cell is not in use

$V_T = E$

$I = 0,$

2. If cell is discharging : When current is taken/drawn from cell

$I \neq 0$

$V_T = E - Ir.$

$V_T < E$

3. If cell is charging : When current is send in the cell by some other electric source like battery

$I \neq 0$

$V_T = E + Ir$

$V_T > E$

Question

When a load resistance R = 4Ω is connected to a cell of emf E and internal resistance r, then current flowing through in circuit is 2A, then terminal voltage will be-

$V_T = IR$

$V_T = E - Ir$

$V_T = 2 \times 4$

$V_T = 8V$

Question

If A cell of emf $E = 10\ V$ and internal resistance $r = 0.5\ \Omega$ is connected with load resistance R, then current flowing in circuit is $I = 2A$, then terminal voltage will be-

$V_T = IR$

$V_T = 2 \times 10$

$V_T = 20V$ ✗

$V_T = E - Ir$

$V_T = 10 - 2 \times 0.5$

$V_T = 10 - 1$

$V_T = 9V$

Question

When a cell of emf $E = 8$ V and internal resistance $r = 0.5\ \Omega$ is charging by an external supply and charging current is 4A, then terminal voltage across cell is-

$$V_T = E + Ir.$$

$$V_T = 8 + 4 \times 0.5$$

$$V_T = 8 + 2$$

$$V_T = 10V$$

Question

For driving a current of 3 A for 5 minutes in an electric circuit, 1350 J of work is to be done. Find the emf of the source in the circuit.

$$V = \frac{W}{q} \qquad I = \frac{q}{t}$$

$$q = It$$

$$E = \frac{W}{It} = \frac{1350}{3 \times 5 \times 60} = 1.5\text{ V}$$

Question

The storage battery of a car has an emf of 12 V. If the internal resistance of the battery is 0.4 Ω. What is the maximum current that can be drawn from the battery?

↳ $R_{ext} = 0$

$$I_{max} = \frac{E}{r} = \frac{12}{0.4} = \frac{120}{4} = 30$$

$$\boxed{I_{max} = 30\,A}$$

Question

A secondary cell after long use has emf of 1.9 V and a large internal resistance of 380 Ω. What maximum current can be drawn from the cell? Could the cell drive the starting motor of a car?

$$I_{max} = \frac{E}{r} = \frac{1.9}{380}$$

$$I_{max} = 5 mA$$

Question

A current of $2A$ flows through a 2Ω resistor when connected across a battery. The same battery supplies a current of $0.5A$ when connected across a 9Ω resistor. The internal resistance of the battery is

(A) $1/3\ \Omega$

(B) $1/4\ \Omega$

(C) $1\ \Omega$

(D) $0.5\ \Omega$

$I = \frac{E}{R+r}$

$E = I(R+r)$

$E_1 = 2(2+r)$

$E_2 = 0.5(9+r)$

$\frac{E_1}{E_2} = \frac{2(2+r)}{0.5(9+r)}$

$E_1 = E_2 = E$

$\frac{1}{1} = \frac{2(2+r)}{0.5(9+r)}$

$0.5(9+r) = 2(2+r)$

$9+r = 4(2+r)$

$9+r = 8+4r$

$9-8 = 4r-r$

$1 = 3r$

$r = \frac{1}{3}\Omega$

Question

In the following circuit, the terminal voltage across the cell is

(A) 1.95 V

(B) 2.71 V

(C) 0.52 V

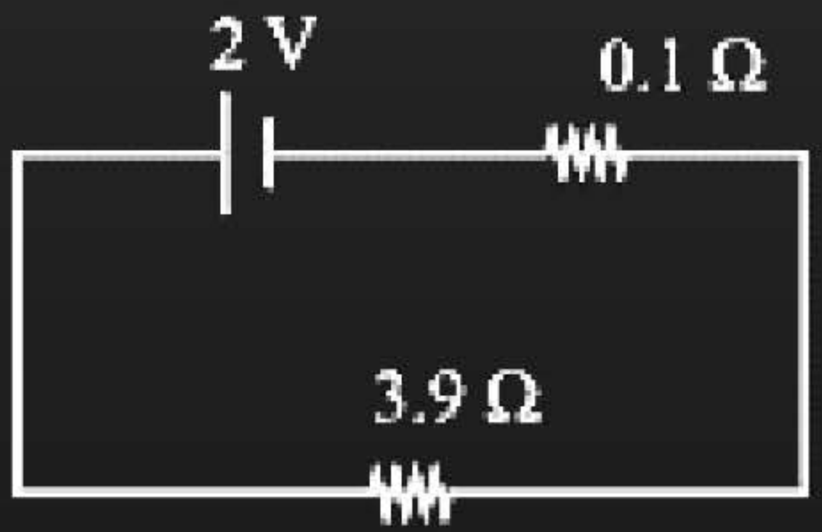
(D) 1.68 V

$V_T = IR$

$I = \frac{E}{R+r} = \frac{2}{3.9+0.1} = \frac{2}{4} = \frac{1}{2} A$

$V_T = \frac{1}{2} \times 3.9$

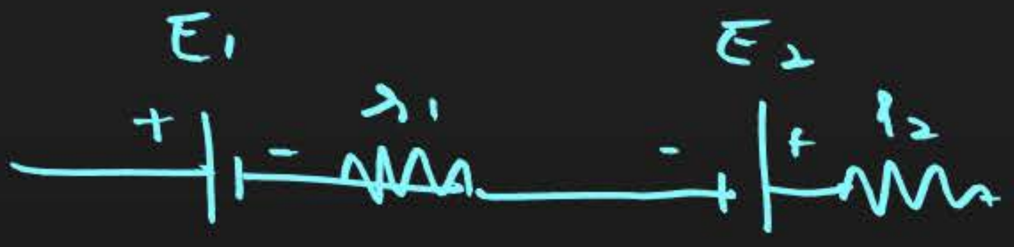
$V_T = 1.95 V$



Combination of Cells

(i) When two cells connected in series :

Consider two cells of emf and its internal resistances E_1 , r_1 and E_2 , r_2 are connected in series. I is the current through the combination.



$E_{eq} = E_1 \pm E_2$

$r_{eq} = r_1 + r_2$

$E_{eq} = E_1 - E_2$, $E_1 > E_2$

$r_{eq} = r_1 + r_2$

Combination of Cells

What if 'm' cells are wrongly connected in series combination?

$$E_{eq} = nE - 2mE$$

Total Wrongly

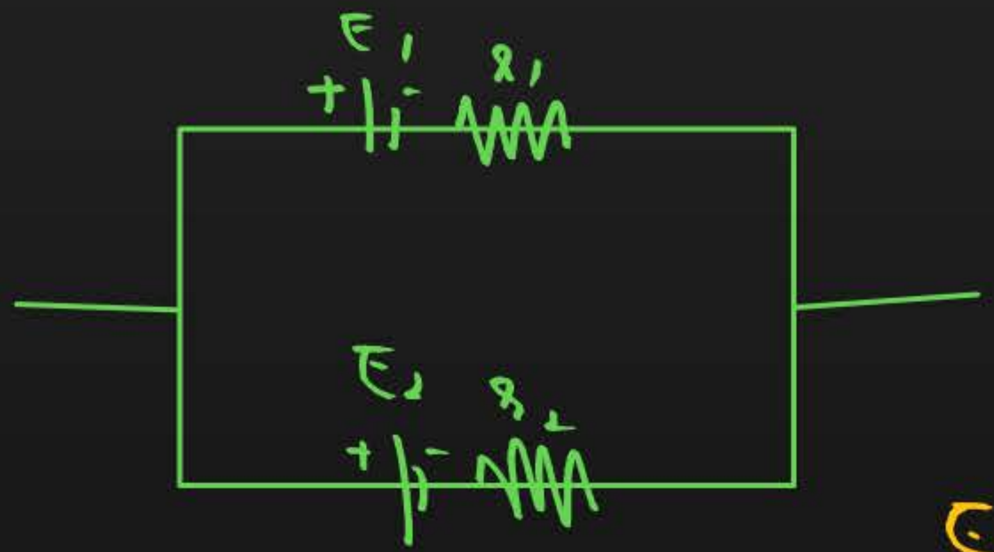
Note :

When a single cell is wrongly connected in a circuit. For identical cells case, A single wrong connection will cancel out two cells from overall circuit. Hence the total emf will be $E_{total} = nE - 2mE$

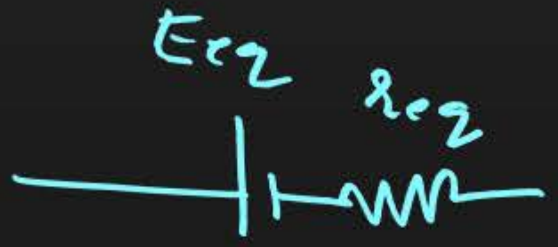
Combination of Cells

(ii) When two cells connected in parallel :

Consider two cells of emf and its internal resistances E_1 , r_1 and E_2 , r_2 are connected in parallel. I_1 and I_2 be the currents through the cell E_1 and E_2 .



$\Rightarrow$



$$E_{eq} = \frac{E_1 r_2 \pm E_2 r_1}{r_1 + r_2}$$

$$r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$$

$$E_1 = E_2 \Rightarrow E_{eq} = \frac{Er + Er}{r + r} = \frac{2Er}{2r} = E$$

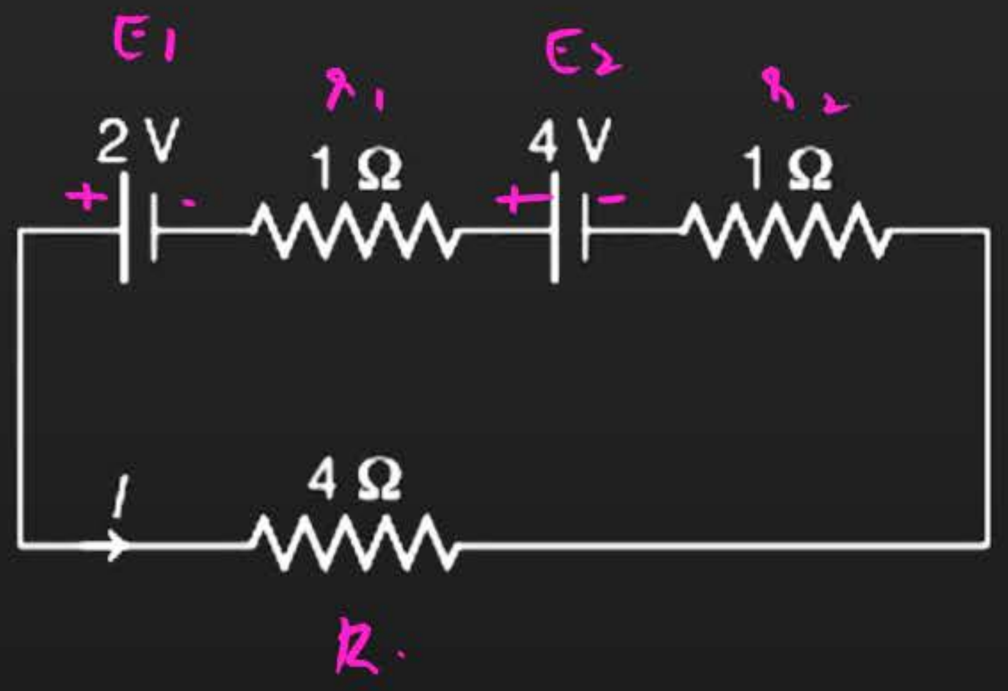
$$\boxed{E_{eq} = E}$$

$$I = \frac{E}{R+r} \rightarrow \text{Single Cell}$$

$$I = \frac{E_{eq}}{R+r_{eq}} \rightarrow \text{combination of cells}$$

Question

For the circuit shown in the figure, the current I will be



$$E_{eq} = E_1 + E_2 = 2 + 4 = 6\,V$$

$$r_{eq} = r_1 + r_2 = 1 + 1 = 2\,\Omega$$

$$I = \frac{E_{eq}}{R + r_{eq}} = \frac{6}{4+2} = \frac{6}{6}$$

$$I = 1\,A$$

(A) 0.75 A

(B) 1 A

(C) 1.5 A

(D) 0.5 A

Question

Ten identical cells each emf 2 V and internal resistance 1 Ω are connected in series with two cells wrongly connected. A resistor of 10 Ω is connected to the combination. What is the current through the resistor?

(A) 1.8 A

(B) 2.4 A

(C) 0.6 A

(D) 1.2 A

$n = 10$, $r = 1\,\Omega$, R

$E_{eq} = nE - 2mE$

$= 10 \times E - 2 \times 2E$

$= 10E - 4E$

$E_{eq} = 6E = 6 \times 2$

$E_{eq} = 12\,V$

$r_{eq} = nr = 10 \times 1$

$r_{eq} = 10\,\Omega$

$$I = \frac{E_{eq}}{R + r_{eq}}$$

$$I = \frac{12}{10+10} = \frac{12}{20} = 0.6\,A$$

Question

A battery with an EMF of 10 V and an internal resistance of 1 Ω is connected to an external resistance of 4 Ω, as shown in the figure. The terminal voltage of the battery in this configuration is

(A) 6 V

(B) 8 V

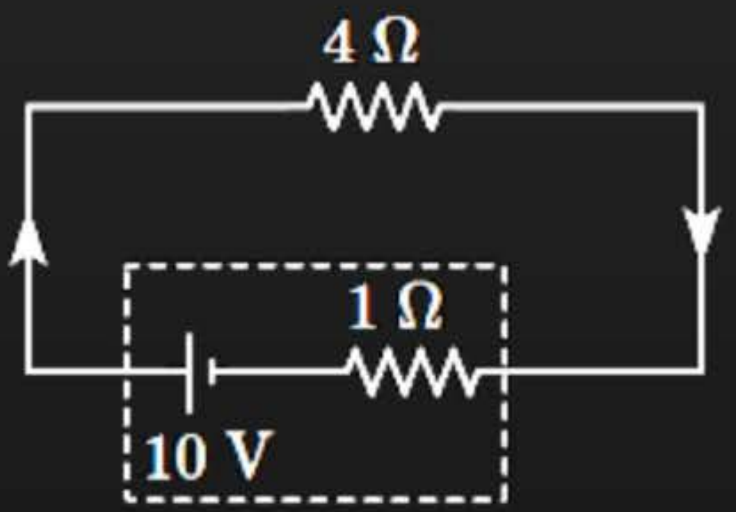
(C) 10 V

(D) 4 V

$I = \frac{E}{R+r} = \frac{10}{4+1} = \frac{10}{5} = 2A$

$V_T = IR = 2 \times 4$

$V_T = 8V$



Question

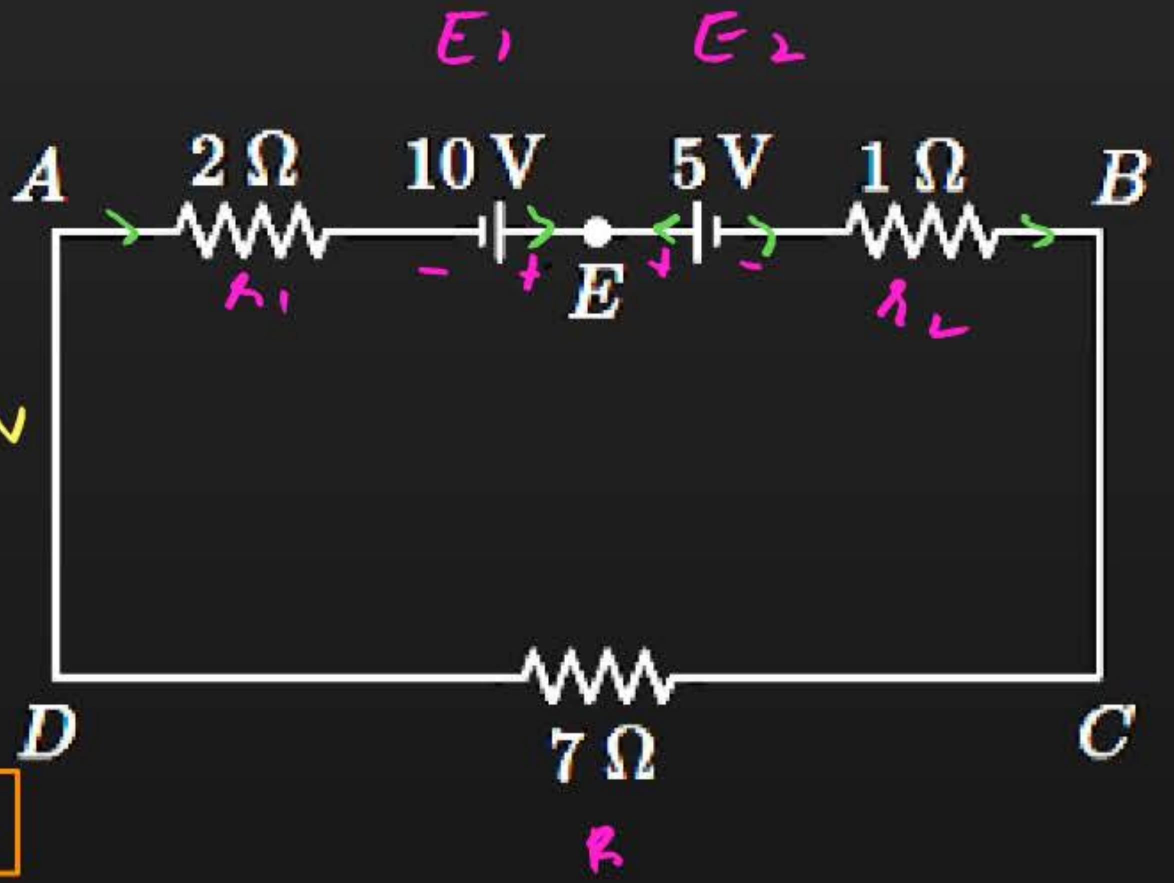
The magnitude and direction of the current in the following circuit is

(A) 1.5 A from B to A through E

(B) 0.2 A from B to A through E

(C) 0.5 A from A to B through E

(D) 5/9 A from A to B through E



$E_{eq} = E_1 - E_2$

$= 10 - 5 = 5V$

$E_{eq} = 5V$

$r_{eq} = r_1 + r_2$

$= 2 + 1 = 3\Omega$

$I = \frac{E_{eq}}{R + r_{eq}} = \frac{5}{7+3} = \frac{5}{10} = 0.5A$

Question

$V_T = E - Ir = 4 - 0.5 \times 0.5$
$= 4 - 0.25 = 3.75\text{V}$

A cell of emf 4 V and internal resistance 0.5 Ω is connected to a 7.5 Ω external resistance. The terminal potential difference of the cell is:

(A) 3.75 V

(B) 4.25 V

(C) 4 V

(D) 0.375 V

$I = \frac{E}{R+r}$

$I = \frac{4}{7.5+0.5} = \frac{4}{8} = \frac{1}{2}$

$I = 0.5\text{A}$ ✓

$V_T = IR$

$= 0.5 \times 7.5$

$V_T = 3.75\text{V}$

Question

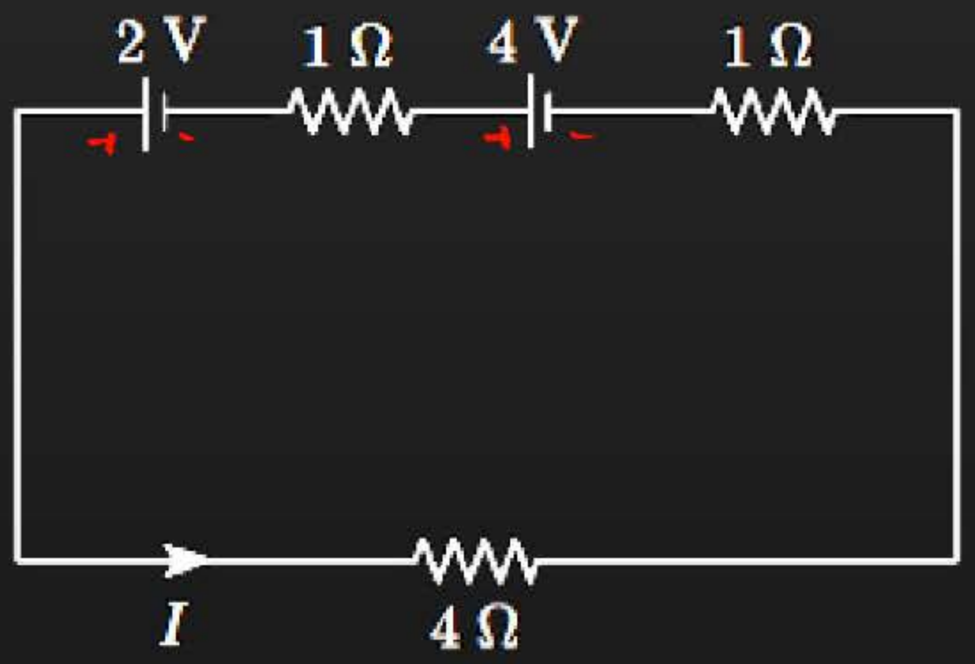
For the circuit shown in the figure, the current I will be:

$E_{eq} = 2 + 4 = 6V$

$r_{eq} = 1 + 1 = 2\Omega$

$R = 4\Omega$

$$I = \frac{E_{eq}}{R + r_{eq}} = \frac{6}{4+2} = 1A$$



(A) 0.75 A

(B) 1 A

(C) 1.5 A

(D) 0.5 A

Kirchhoff's 1ST Law

There are two laws given by Kirchoff's for determination of p.d and current in different branches of any complicated network.

1. First Law or Junction Law or KCL

KCL states that "In an electric circuit the algebraic sum of the currents meeting at any junction in the circuit is zero"

$\sum I = 0$

$5+2 = 7A$ $\quad I_{in} = I_{out}$

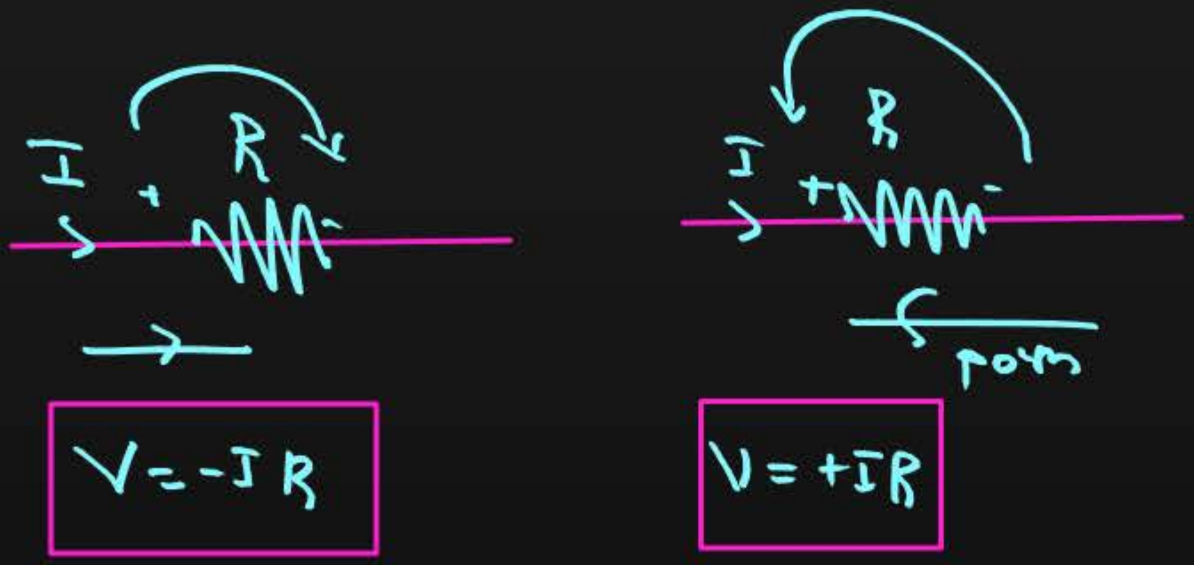
$I = \frac{dq}{dt}$ = conservation of charge

Sign conventions

SIGN CONVENTIONS:

ACROSS CELL

ACROSS RESISTOR



Kirchhoff's 2ND Law

2. Second Law or Loop Law or KVL:

KVL states that "In a closed loop of the circuit, The algebraic sum of the products of current and the resistance in each part of the loop is equal to the algebraic sum of emf's in that loop"

$\sum V = 0$
$\sum IR = 0$
} conservation of Energy

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

Question

Kirchhoff's first law, i.e. $\sum i = 0$ at a junction, deals with the conservation of

A. charge

B. energy

C. momentum

D. angular momentum

Question

Kirchhoff 's junction rule is a reflection of

(A) conservation of current density vector

(B) conservation of energy → Loop Rule

(C) conservation of momentum

(D) conservation of charges → junction Rule

Question

Consider the following two statements:

1. Kirchhoff's junction law follows from the conservation of charge.
2. Kirchhoff's loop law follows from the conservation of energy.

Which of the following is correct

(A) Both (A) and (B) are wrong

(B) (A) is correct and (B) is wrong

(C) (A) is wrong and (B) is correct

(D) Both (A) and (B) are correct

Question

The figure shows a network of currents. The magnitude of currents is shown here. The current i will be:

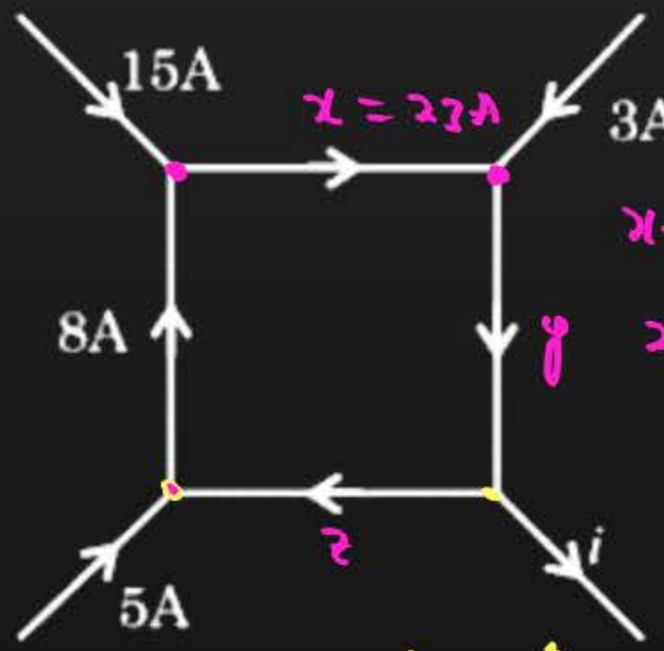
(A) 3 A

(B) 13 A

(C) 23 A

(D) – 3A

KCL



$x + 3 = y$

$23 + 3 = y$

$y = 26A$

$y = i + z$

$26 = i + z$ —(1)

$z = 26 - i$

$z + 5 = 8$

$26 - i + 5 = 8$

$31 - i = 8$

$i = 31 - 8$

$i = 23A$

Question

Potential of point A, B & C are 90 V, 20 V, 10 V respectively, then potential of junction X will be -

(A) 5 V

(B) 95 V

(C) 40 V

(D) 100 V

KCL = $\sum I = 0 \Rightarrow \sum \frac{V}{R} = 0$

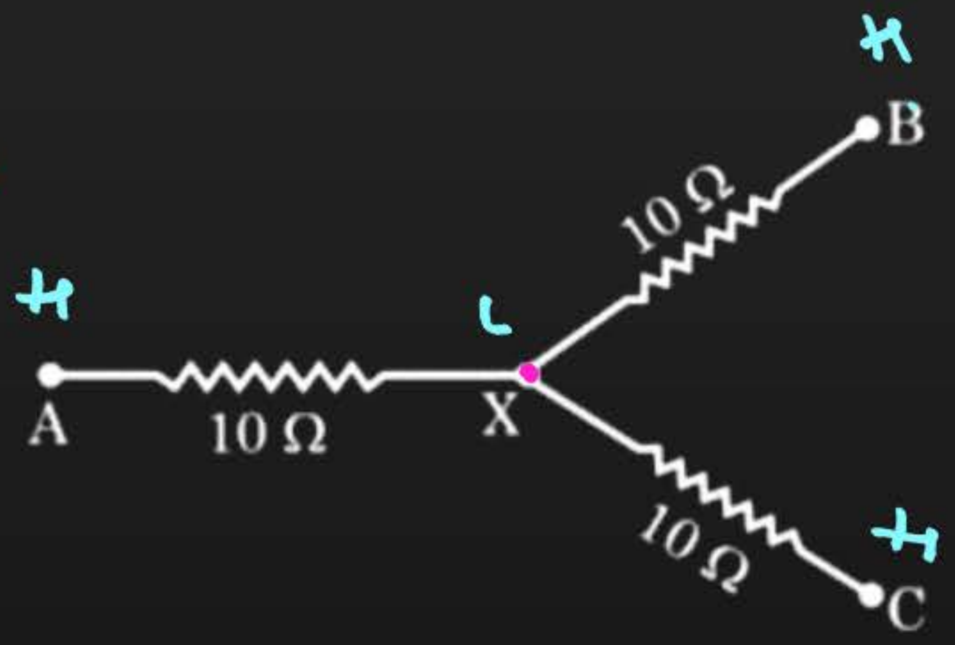
$$\frac{V_A - V_x}{R_A} + \frac{V_B - V_x}{R_B} + \frac{V_C - V_x}{R_C} = 0$$

$$\frac{90 - V_x}{10} + \frac{20 - V_x}{10} + \frac{10 - V_x}{10} = 0$$

$$90 - V_x + 20 - V_x + 10 - V_x = 0 \times 10$$

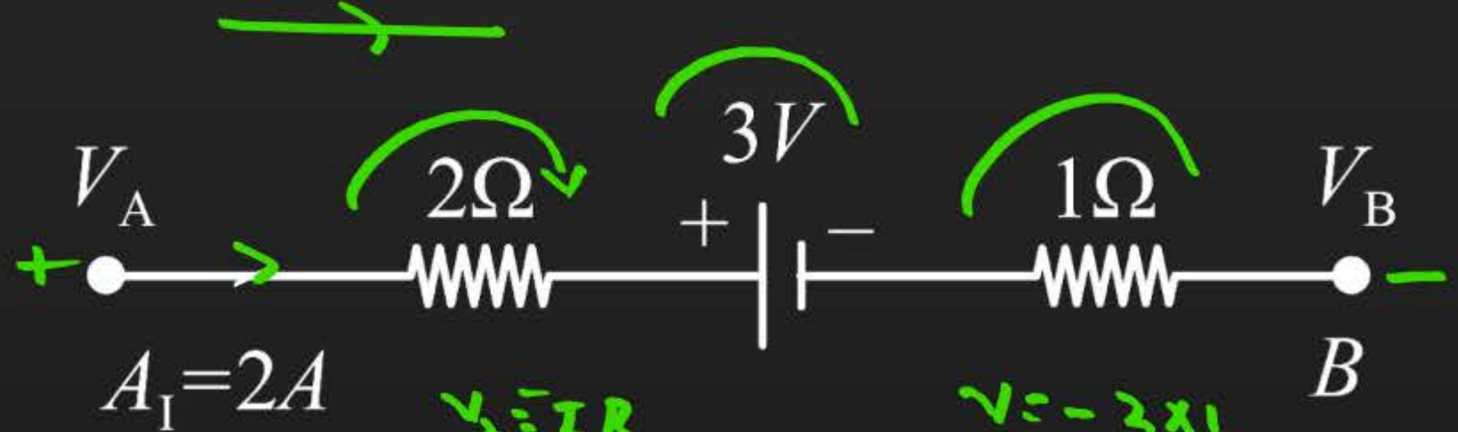
$$120 - 3V_x = 0$$

$$V_x = \frac{120}{3} = 40V$$



Question

The potential difference $(V_A - V_B)$ between the points A and B in the given figure



(A) -3 V

(B) $+3$ V

(C) $+6$ V

(D) $+9$ V

KVL, $\Sigma V = 0$

$V_A - 4 - 3 - 2 - V_B = 0$

$V_A - 9 - V_B = 0$

$V_A - V_B = +9V$

$V_2 = IR$

$V_2 = -2 \times 2$

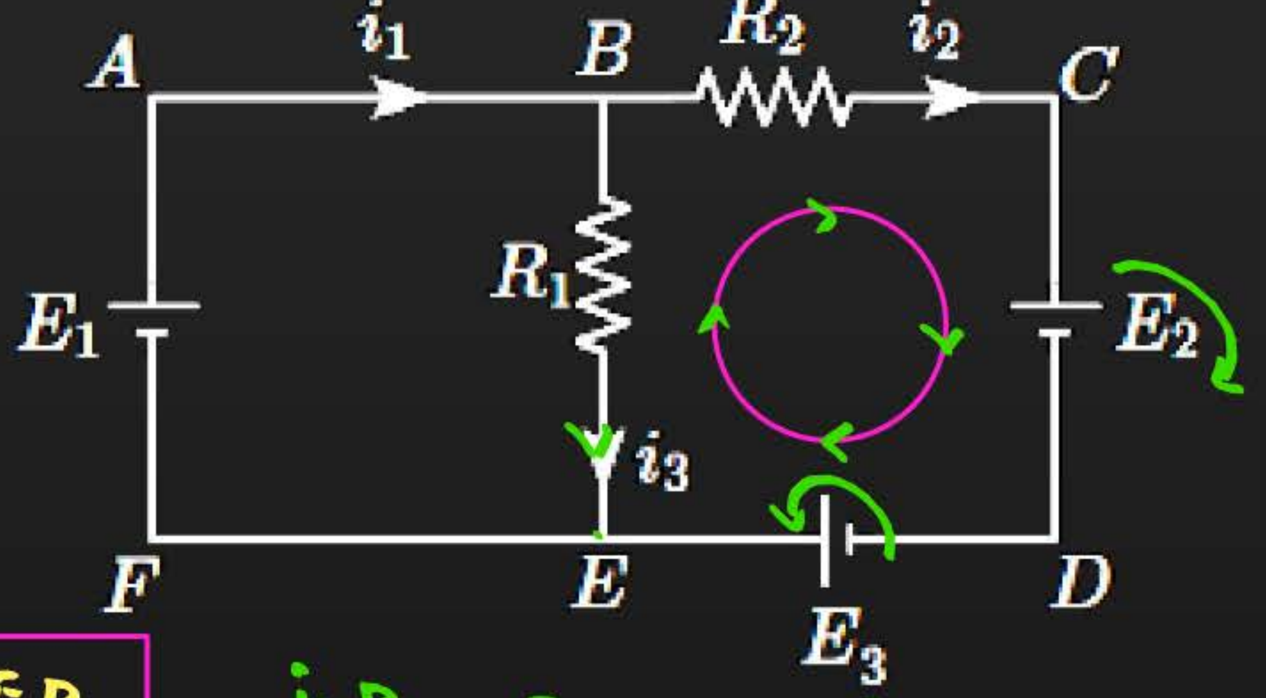
$= -4$

$V = -2 \times 1$

$V = -2$

Question

For the circuit given below, Kirchhoff's loop rule for the loop *BCDEB* is given by the equation:



(A) $-i_2R_2 + E_2 - E_3 - i_3R_1 = 0$

(B) $i_2R_2 + E_2 - E_3 - i_3R_1 = 0$

(C) $i_2R_2 + E_2 + E_3 + i_3R_1 = 0$

(D) $-i_2R_2 + E_2 + E_3 + i_3R_1 = 0$

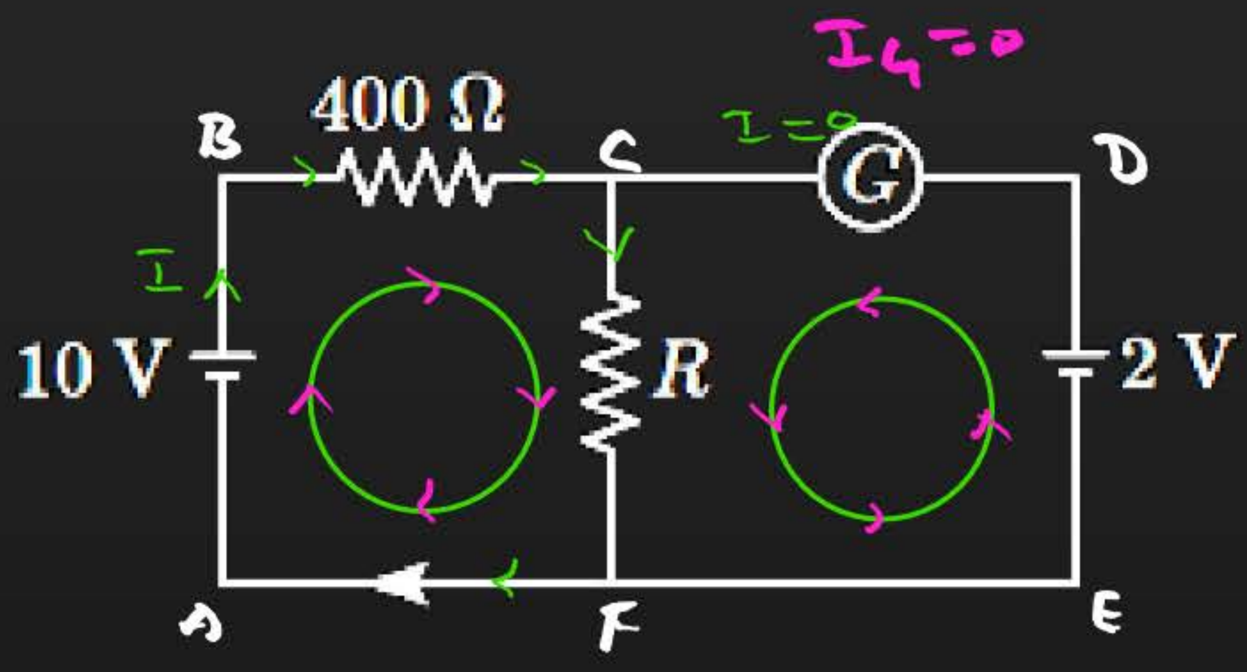
Loop BCDEB

$-i_2R_2 - E_2 + E_3 + i_3R_1 = 0$

$i_2R_2 + E_2 - E_3 - i_3R_1 = 0$

Question

If the galvanometer G does not show any deflection in the circuit shown, the value of R is given by



(A) 400 Ω

(B) 200 Ω

(C) 50 Ω

(D) 100 Ω

Loop ABCFA

$10 - I \times 400 - IR = 0$

$10 - 400I - IR = 0$ — (1)

Loop EDCFE

$2 - IR = 0$

$I = \frac{2}{R}$

(1) $10 - 400 \times \frac{2}{R} - \frac{2}{R} \times R$

$10 - 2 - \frac{800}{R} = 0 \Rightarrow 8 = \frac{800}{R} \Rightarrow R = \frac{800}{8} = 100\,\Omega$

Question

H.D

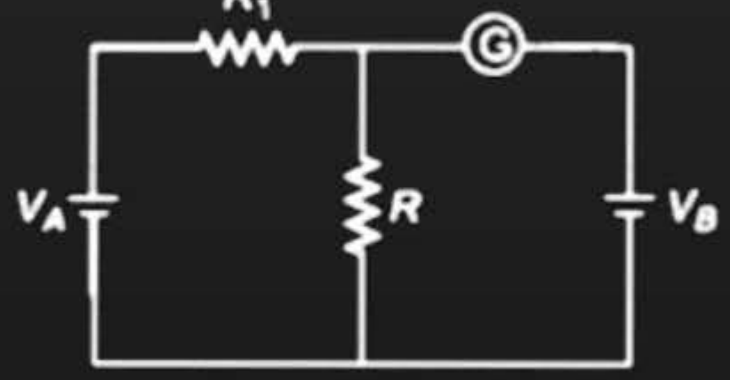
In the circuit shown the cells A and B have negligible resistances. For V_A 12V, $R_1 = 500\Omega$ and R = 100Ω the galvanometer (g) shown no deflection. The value of V_B is

(A) 4V

(B) 2V

(C) 12V

(D) 6V



Thank

You