

ELECTRICITY

Electric Current (I)

This is the rate of flow of charged particles, usually electrons

$$I = \frac{\text{Amount of Charge flowing}}{\text{Time Taken}}$$

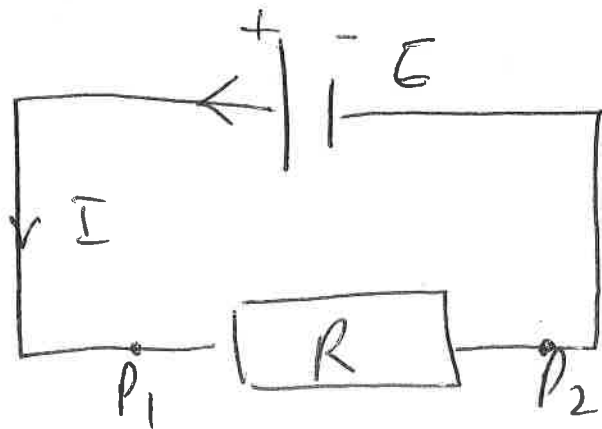
units - A

Electrical Resistance (Ohms Ω)

This is the amount of opposition to the flow of current in a conductor due to collisions between the free electrons and the vibrating ions etc.

Potential Difference: (Volts V)

This occurs between 2 points in a circuit one of a higher potential and one of a lower potential which act like a gradient to drive the current around a circuit.



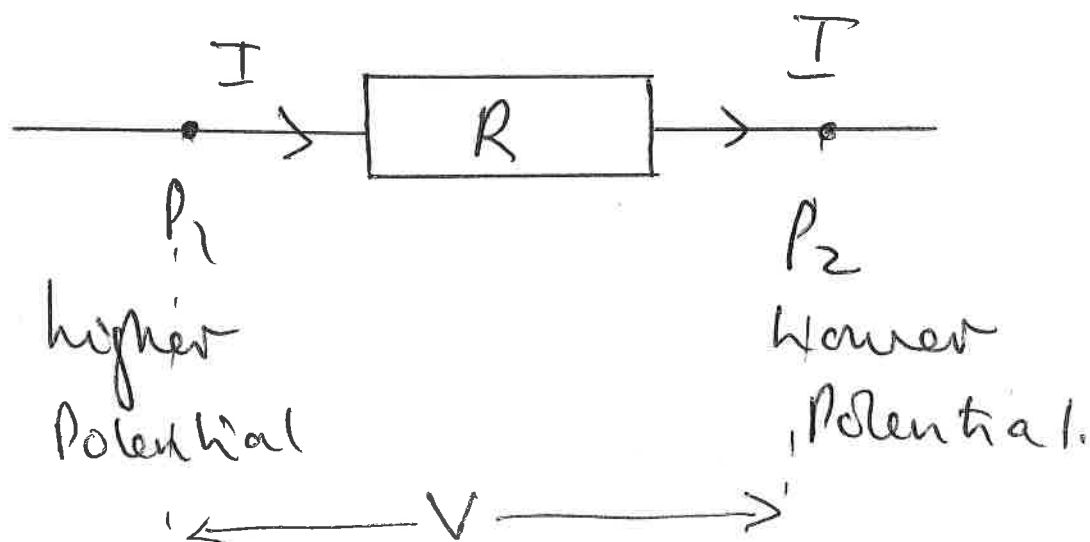
E.M.F : ELECTROMOTIVE FORCE.

This is the amount of Energy converted into electrical energy when a charge of 1 Coulomb passes through the source units of EMF - the Volt.

EMF is the 'driving force' of the current around a circuit.

Potential Difference (P.d)

Consider P_1 and P_2 in the above circuit



Ohm's Law

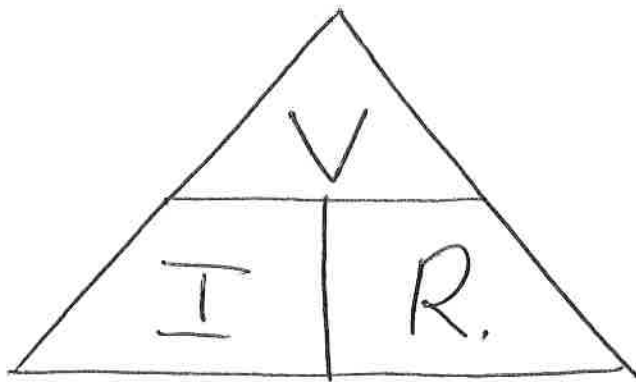
The Current flowing through a metal will be directly proportional to Voltage across the wire provided that the temperature is constant.

$$I \propto V$$

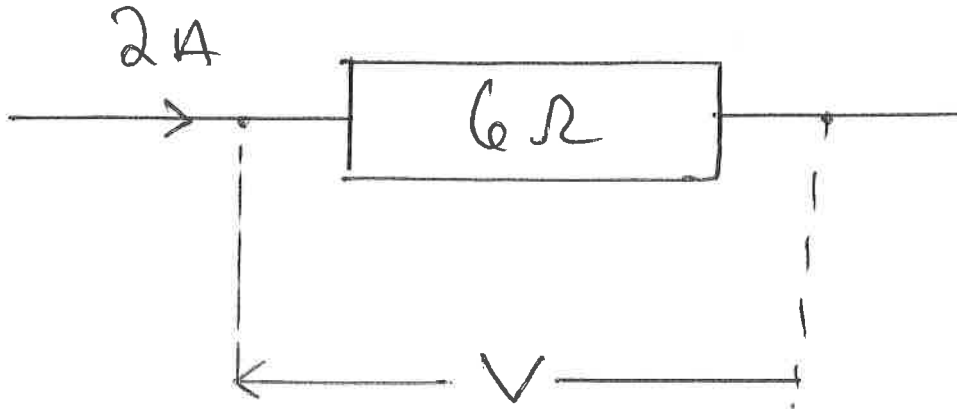
$$I = k \cdot V$$

$$I = \frac{1}{R} \cdot V$$

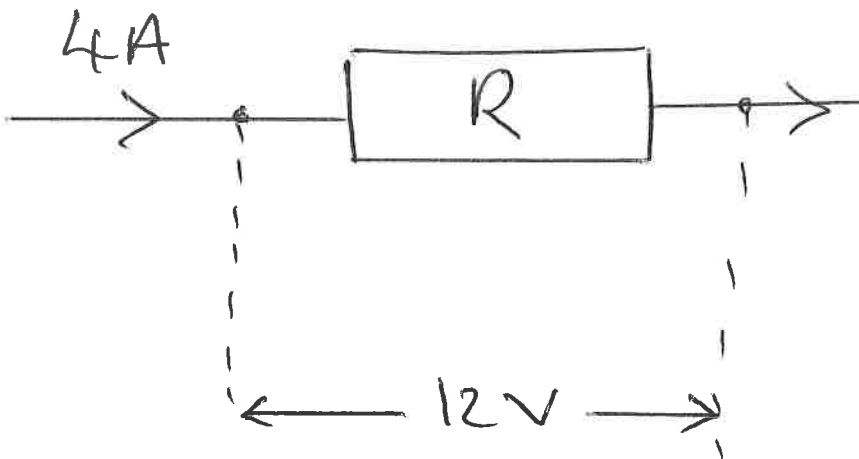
$$\Rightarrow R = \frac{V}{I} \text{ Def}^n \text{ of Resistance.}$$



EXAMPLES

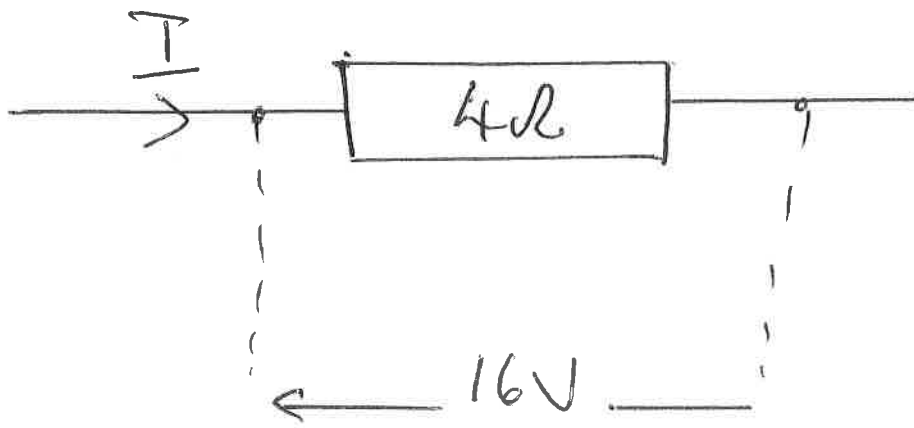


$$\begin{aligned} V &= IR \\ &= 2 \times 6 \\ &= 12 \text{ volts} \end{aligned}$$



$$R = \frac{V}{I} = \frac{12}{4}$$

$$R = 3 \Omega$$



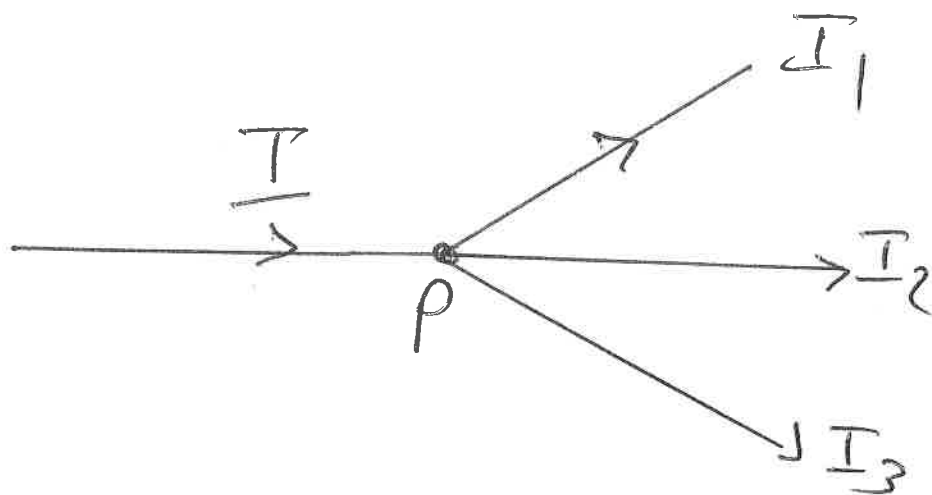
$$I = \frac{V}{R}$$

$$I = \frac{16}{4}$$

$$I = 4A.$$

LAW 1 Kirchoff's Laws

The sum of the currents at a point is Zero in a Branched Circuit



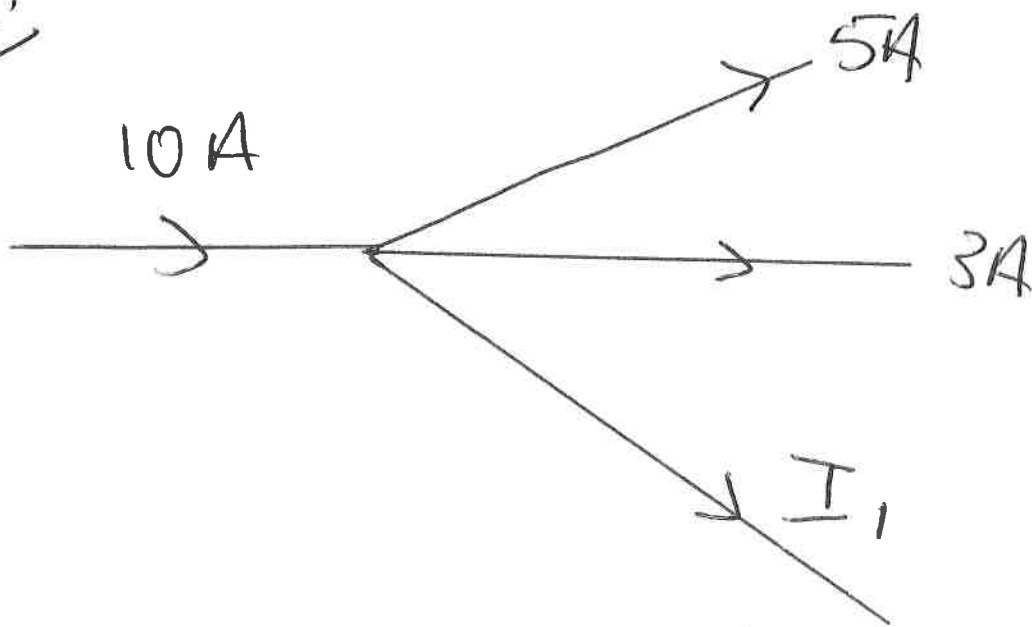
$$I = I_1 + I_2 + I_3$$

$$\text{or } I - I_1 - I_2 - I_3 = 0$$

LAW 2 For a closed Circuit, the sum of all EMF's is equal to the sum of the potential drops across resistors.

$$\sum \epsilon = \sum V$$

Ex.

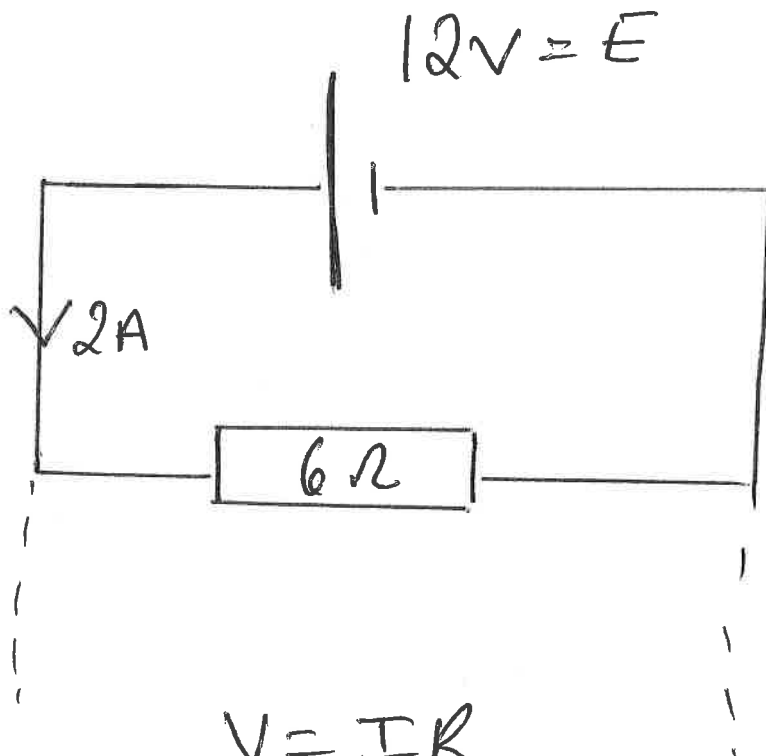


$$10 = 5 + 3 + I_1$$

$$10 = 8 + I_1$$

$$\underline{2A = I_1}$$

Ex-2

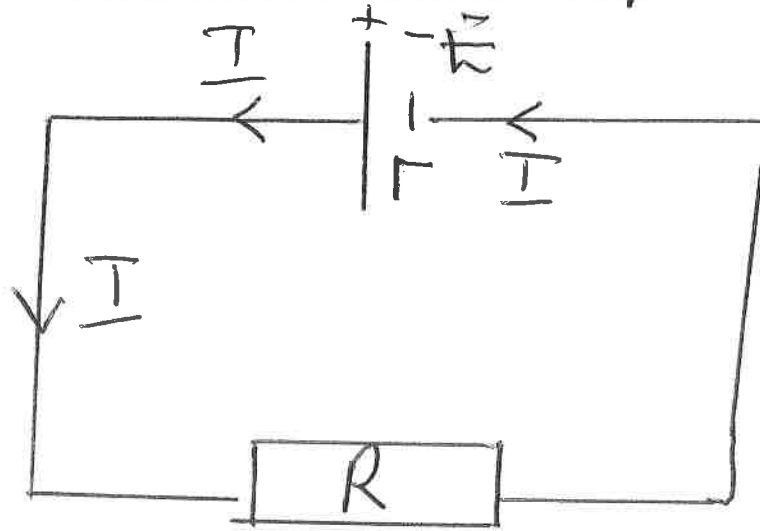


$$V = IR$$

$$V = 2 \times 6$$

$$V = 12 \text{ volts.}$$

The Circuit Equation

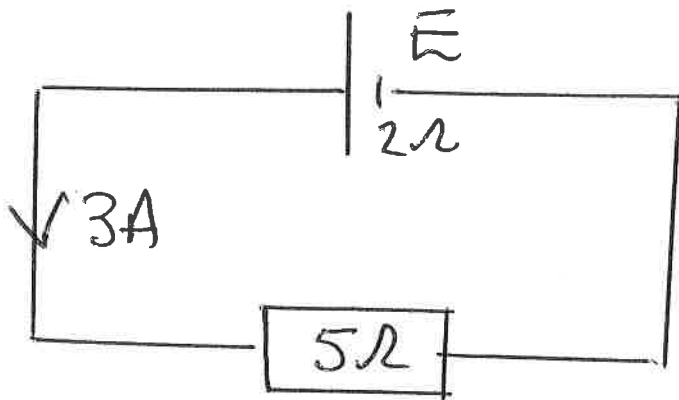


$$\sum \mathcal{E} = \sum V$$

$$\mathcal{E} = IR + Ir$$

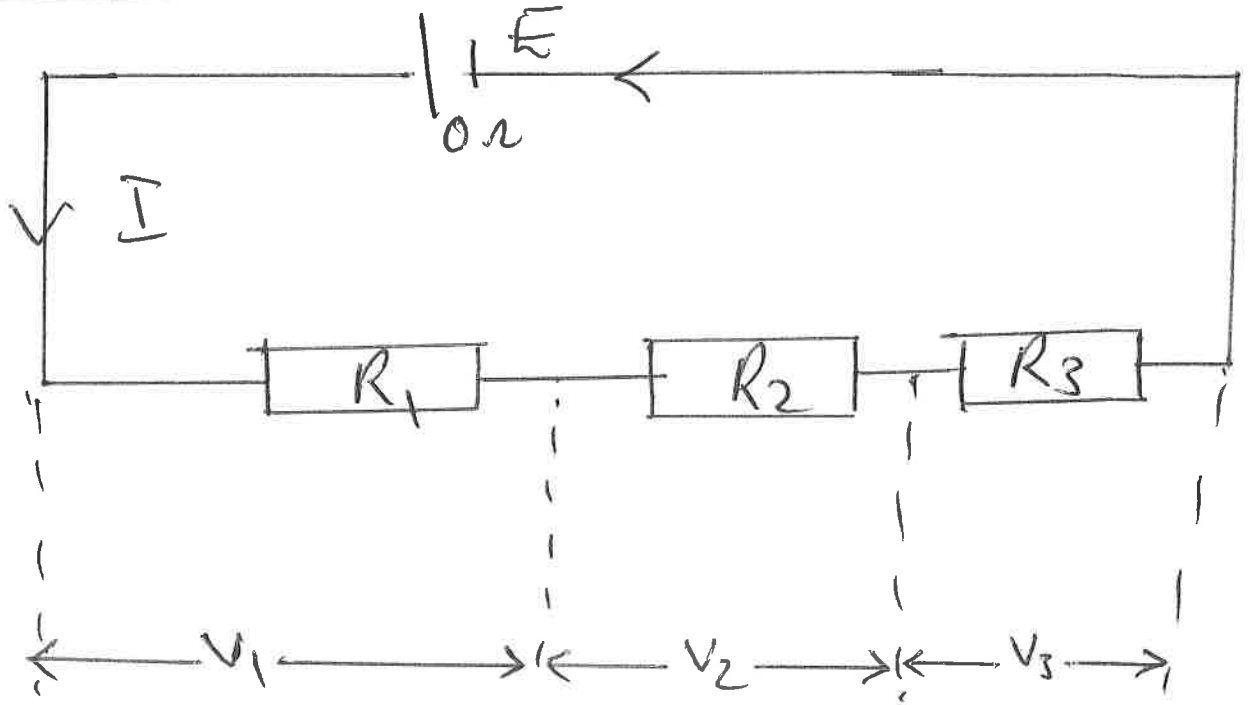
$$\mathcal{E} = I(R+r)$$

Example: Find the EMF in the following circuit.



$$\begin{aligned}\mathcal{E} &= I(R+r) \\ &= 3(5+2) \\ &= 21 \text{ volts.}\end{aligned}$$

Resistors in Series



from Kirchhoff's laws

$$\sum E = \sum V$$

$$E = V_1 + V_2 + V_3$$

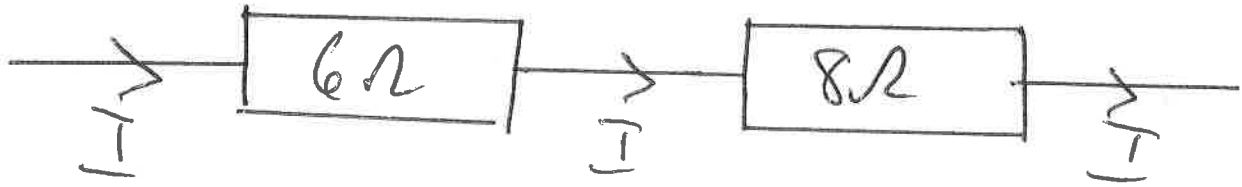
$$IR_{\text{total}} = IR_1 + IR_2 + IR_3$$

$$\div I \Rightarrow$$

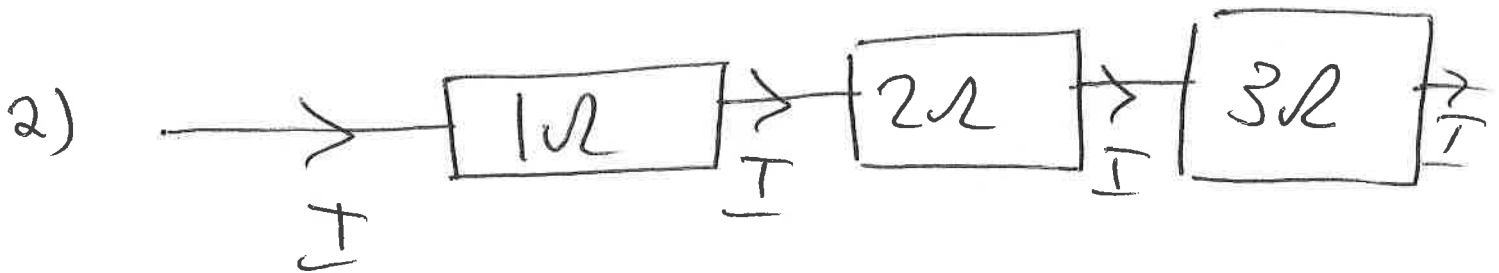
$$\underline{R_{\text{total}} = R_1 + R_2 + R_3 \text{ (etc.)}}$$

Examples

1) Find the Total Resistance of

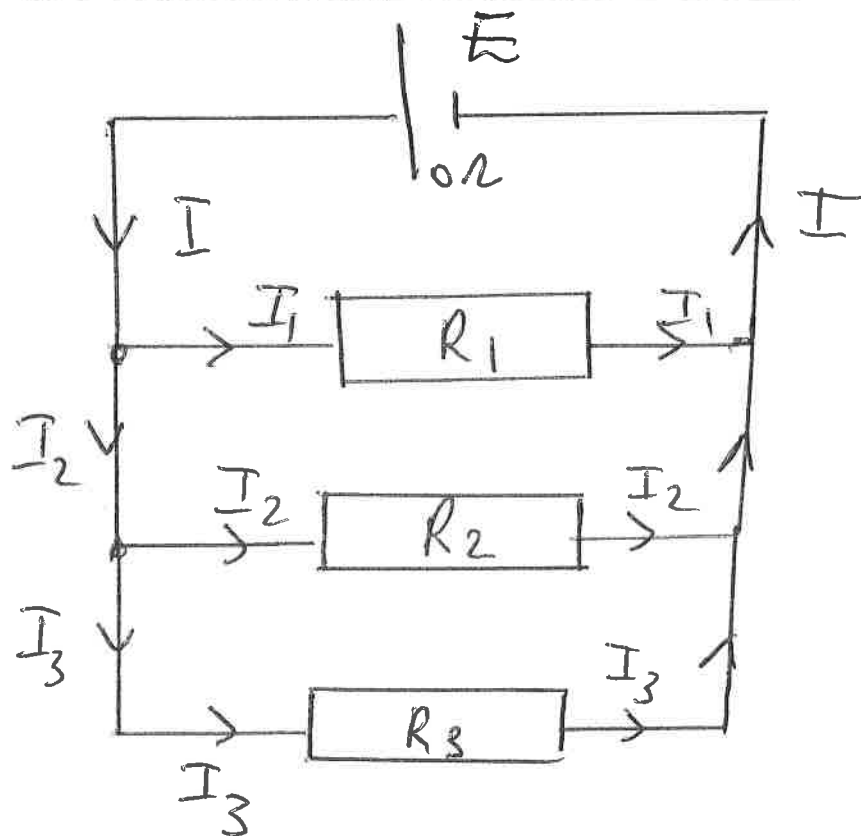


$$\begin{aligned} R_{\text{total}} &= R_1 + R_2 \\ &= (6 + 8)\Omega \\ &= 14\Omega \end{aligned}$$



$$\begin{aligned} R_{\text{total}} &= 1\Omega + 2\Omega + 3\Omega \\ &= 6\Omega. \end{aligned}$$

Resistors in Parallel.



from Kirchhoff's law

$$I = I_1 + I_2 + I_3$$

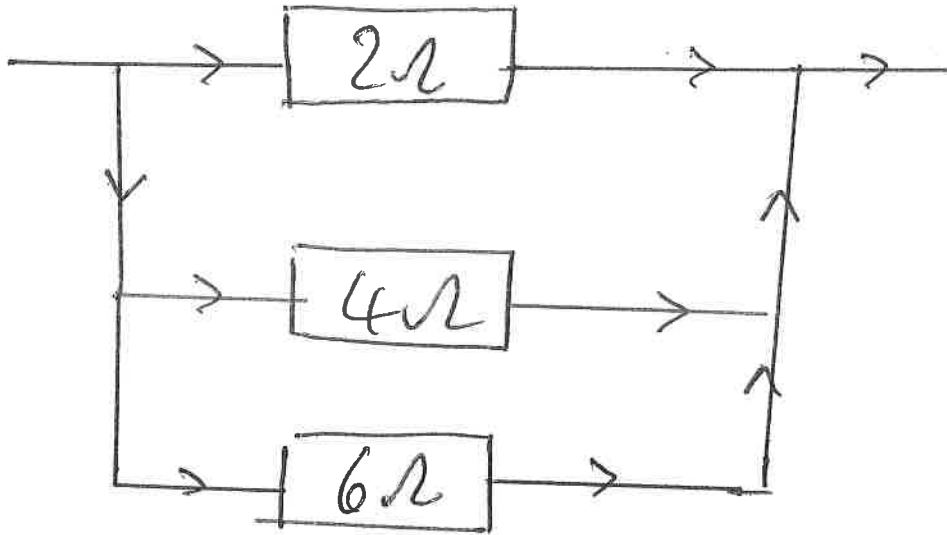
$$\frac{\mathcal{E}}{R_{\text{total}}} = \frac{\mathcal{E}}{R_1} + \frac{\mathcal{E}}{R_2} + \frac{\mathcal{E}}{R_3}$$

$$\frac{1}{R_{\text{total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} (+ \text{etc})$$

$$\Rightarrow \frac{1}{R_{\text{total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} (+ \text{etc})$$

Examples

find the total Resistance of:

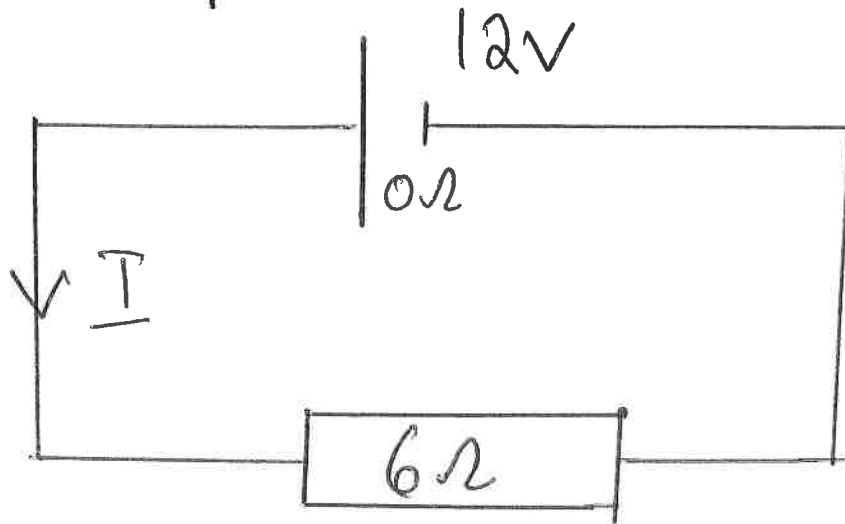


$$\begin{aligned}\frac{1}{R_{\text{total}}} &= \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \\ &= \frac{1}{2} + \frac{1}{4} + \frac{1}{6} \\ &= \frac{6}{12} + \frac{3}{12} + \frac{2}{12}\end{aligned}$$

$$\frac{1}{R_{\text{total}}} = \frac{11}{12} \Omega$$

$$\begin{aligned}\Rightarrow R_{\text{total}} &= \frac{12}{11} \Omega \\ &= 1\frac{1}{11} \Omega.\end{aligned}$$

Simple Circuits



from Circuit equation

$$\mathcal{E} = I(R + r)$$

$$12 = I(6 + 0)$$

$$12 = 6I$$

$$\frac{12}{6} = I$$

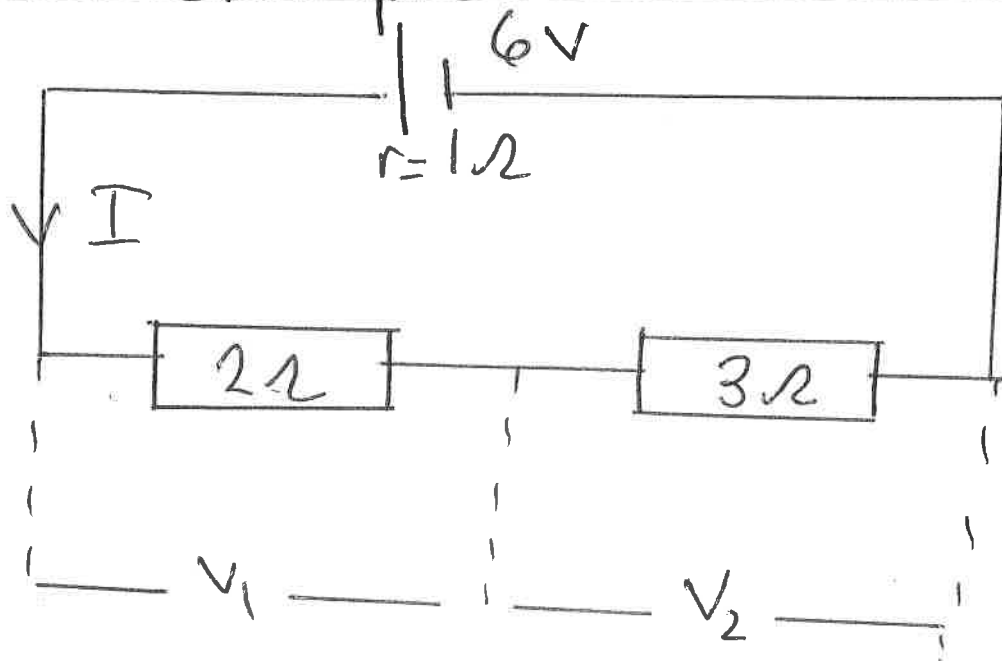
$$2A = I$$

$$\text{P.d. across } 6\Omega = IR$$

$$\begin{aligned}\text{Resistor} &= 2 \times 6 \\ &= 12V\end{aligned}$$

$$\Rightarrow \sum_i \mathcal{E} = \sum V \quad \begin{array}{l} \text{no lost volt} \\ \text{(no internal Resistance)} \end{array}$$

Example.



from Circuit Equation:

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

$$E = 6V \quad R_{\text{total}} = 2\Omega + 3\Omega + 1\Omega$$

$$\Rightarrow 6 = I(6)$$

$$1A = I$$

$$V_1 = IR_1$$

$$V_1 = 1 \times 2$$

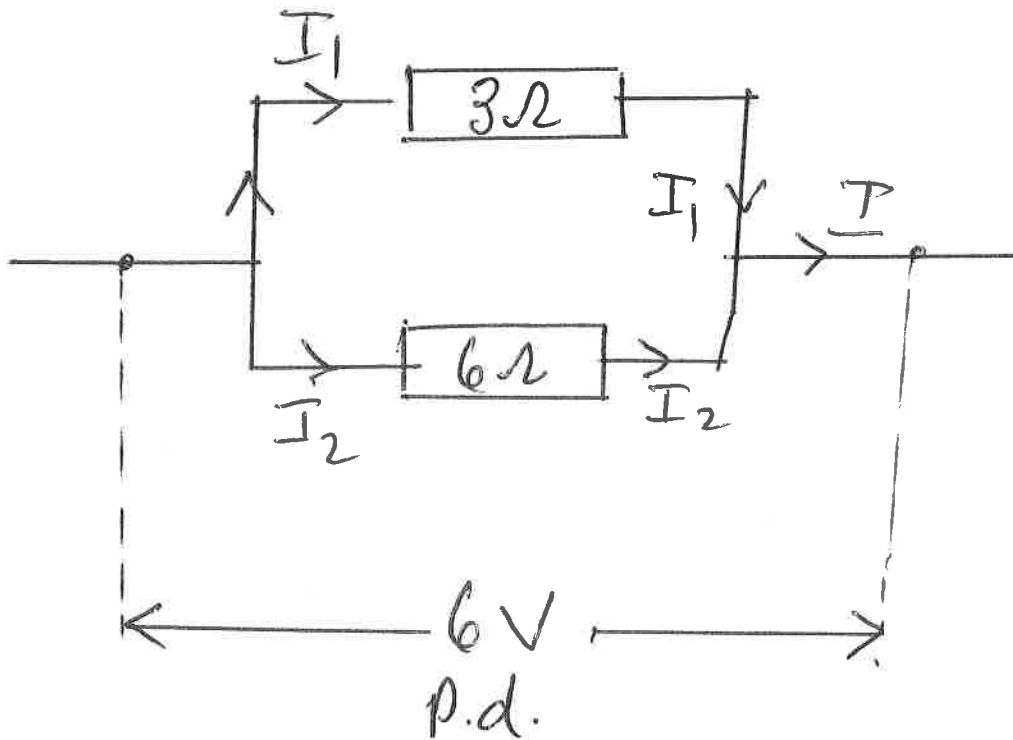
$$V_1 = 2 \text{ volts}$$

$$V_2 = IR_2$$

$$= 1 \times 3$$

$$= 3 \text{ volts.}$$

Branched Circuits



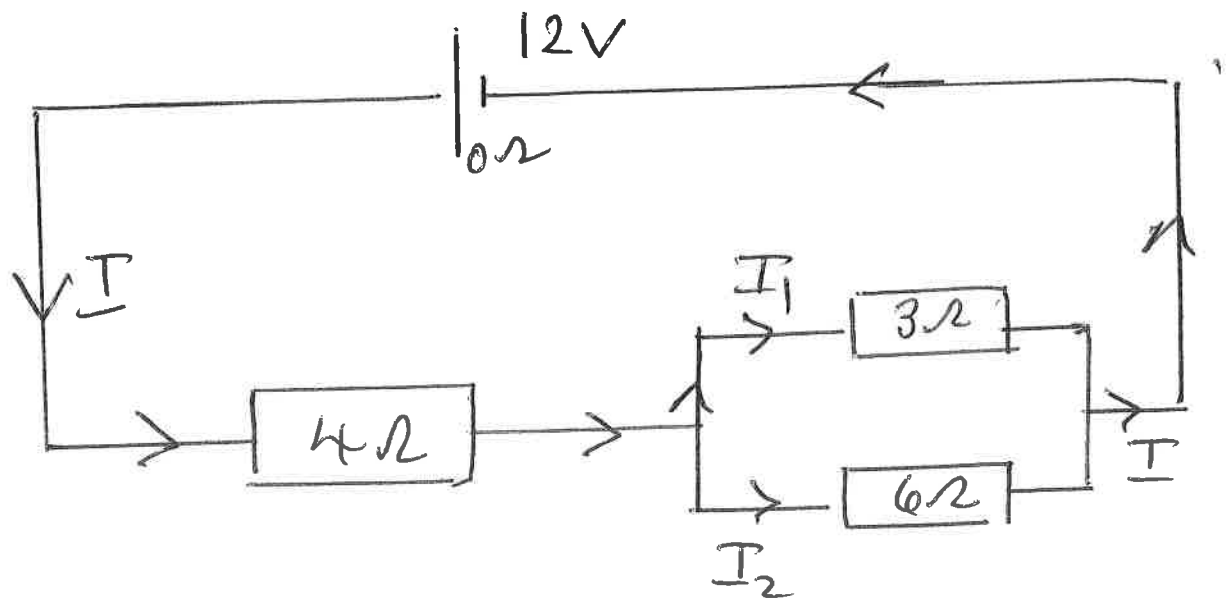
$$I_1 = \frac{6}{3} = 2A.$$

$$I_2 = \frac{6}{6} = 1A.$$

$$I = I_1 + I_2$$

$$= 2A + 1A$$

$$= 3A.$$



- Find
- Total Resistance of Circuit.
 - Current I
 - I_1, I_2
 - P.d. across 4Ω Resistor
 - Power Supplied by Cell.

Solution

For Resistors in Parallel

$$\frac{1}{R} = \frac{1}{3} + \frac{1}{6}$$

$$\frac{1}{R} = \frac{2}{6} + \frac{1}{6}$$

$$\frac{1}{R} = \frac{3}{6}$$

$$\Rightarrow R = \frac{6}{3} = 2\Omega$$

∴ For Resistors in Series

$$R = R_1 + R_2 + R_3$$

$$R = (4 + 2 + 0) \Omega$$

$$R = 6 \Omega$$

∴ from Ohm's law $I = \frac{V}{R}$

$$I = \frac{12}{6}$$

$$I = 2 \text{ A.}$$

P.d. across 4Ω Resistor

$$V = IR_1$$

$$V = 2 \times 4$$

$$V = 8 \text{ volts}$$

(iv) P.d. across Parallel Resistors

$$E = V_1 + V_2$$

$$12 = 8 + V_2$$

$$\Rightarrow \underline{4 \text{ volts} = V_2}$$

∴ For Branched Circuit

$$(iii) \quad I_1 = \frac{V}{R} = \frac{4}{3} A$$

$$I_2 = \frac{V}{R} = \frac{4}{6} = \frac{2}{3} A$$

$$\Rightarrow I = I_1 + I_2$$

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

$$= \frac{6}{3}$$

$$= 2A \quad \checkmark \text{ (check)}$$

$$(v) \quad \text{Power} = IV$$

$$= 2 \times 12$$

$$= \underline{24 \text{ watt.}}$$