

Electric Current

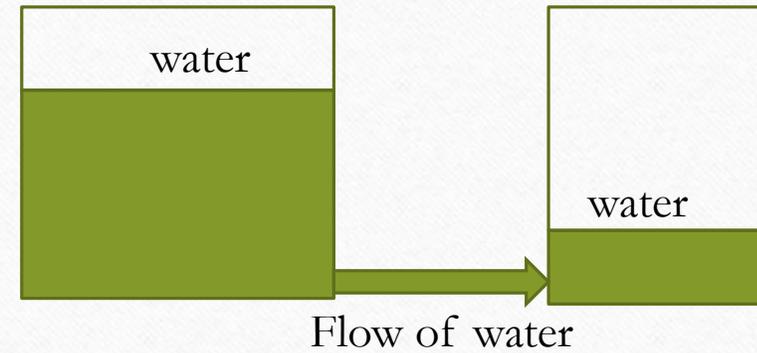
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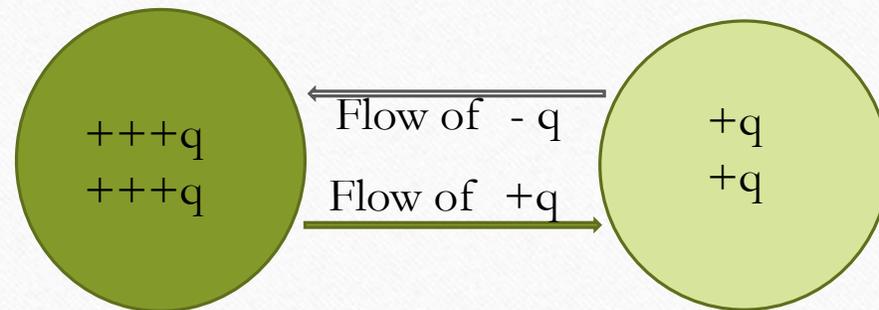
Electric Current:

Simply, it is the flow of electric charge.



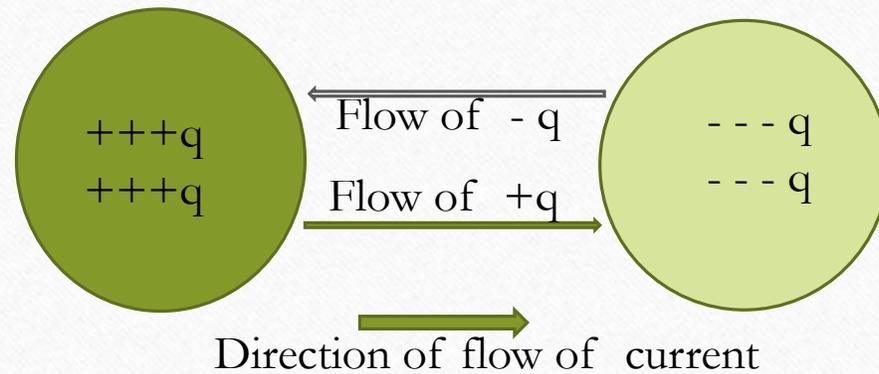
Current strength in a conductor is defined as the rate of flow of charge across any cross section of the conductor. i.e.

$$i = \frac{q}{t} \quad 1 \text{ Amp } (i) = \frac{1 \text{ Coulomb } (q)}{1 \text{ Second } (t)}$$



Conventional Current:

Direction of flow of positive charge is the direction of the flow of Current. This is the convention method of Current.



Drift Velocity:

$$v = \frac{eV}{ml} \tau$$

$$i = \frac{q}{t} = \frac{nAve t}{t} = nAve = nAe \frac{eV}{ml} \tau$$

$$i \propto V$$

Current Density:

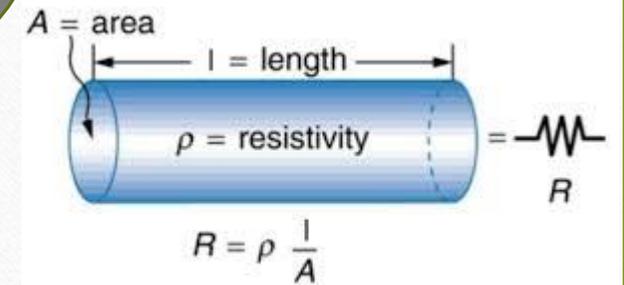
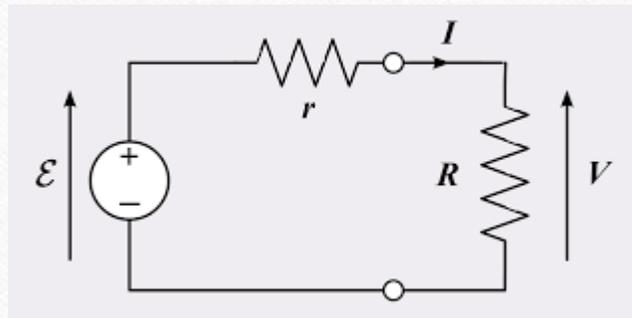
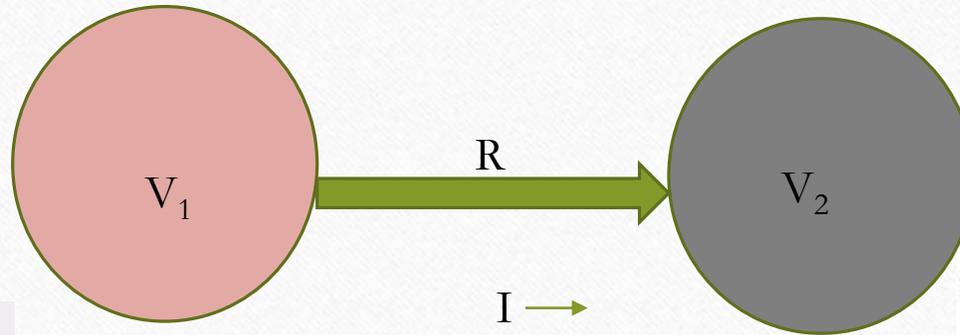
$$j = \frac{i}{A}$$

Ohm's Law:

At constant temperature current flowing through a conductor of uniform area of cross section, is proportional to the Potential difference across its terminals.

$$I \propto V$$
$$\Rightarrow I = \frac{1}{R} V$$
$$\Rightarrow V = IR$$

$$V = (V_2 - V_1)$$



Resistance:

Resistance is the opposition offered by the conductor to the flow of electricity through it.

It is defined as the ratio between potential difference between the two ends of the conductor to the current flow through it.

If V is the potential difference between the two terminals of a conductor and i be the current through it then
$$\frac{V}{i} = R$$
 R is a Constant called Resistance of the conductor.

If $V = 1$ volt and $i = 1$ amp. then $R = 1$ ohm.

i.e
$$1 \text{ ohm} = \frac{1 \text{ volt}}{1 \text{ amp}}$$



Resistance of a conductor is said to be 1 ohm if a current of 1 ampere flows through it for a potential difference of 1 volt across its end.

Resistivity or Specific Resistance:

Resistance R of a conductor depends on the

(i) Length (L): Resistance of a conductor is directly proportional to its length. $R \propto L$

(ii) Area (A): Resistance of a conductor is inversely proportional to its area of cross – section. $R \propto \frac{1}{A}$

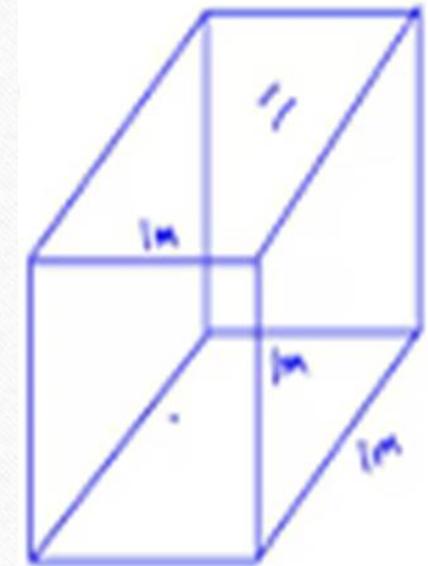
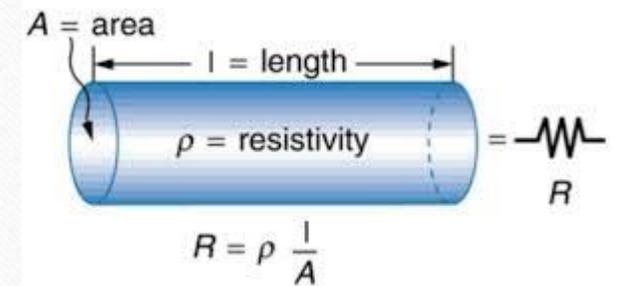
$$\text{Thus } R \propto \frac{L}{A} \Rightarrow R = \rho \frac{L}{A}$$

If $L = 1$ metre, $A = 1$ square metre, then $R = \rho$

Thus resistivity of a material is defined as the resistance of a conductor made up of the material of unit length and unit area of cross section.

$$\text{Resistivity } \rho = R \frac{A}{L} = \text{Ohm} \cdot \text{Metre}^2 / \text{metre} = \text{ohm} \cdot \text{Metre}$$

Thus, unit of resistivity is - - **ohm. metre.**



Dimensions of Resistance:

$$\text{Resistance } R = \frac{V}{i} = \frac{W/q}{i} = \frac{W}{q.i} = \frac{W}{(i.t).i} = \frac{W}{i^2.t}$$

$$\therefore [R] = \frac{[M^1L^2T^{-2}]}{[A^2][T^1]} = [M^1L^2T^{-3}A^{-2}]$$

Dimension of Resistivity:

$$[\rho] = [R] \frac{[A]}{[L]} = [M^1L^2T^{-3}A^{-2}] \frac{[L^2]}{[L]} = [M^1L^3T^{-3}A^{-2}]$$

Conductance:

Conductance of a conductor is defined as the reciprocal of its resistance.

$$\text{Thus, conductance} = \frac{1}{R} = \frac{1A}{\rho L} = 1/\text{ohm} = \text{mho.}$$

Dimension is

$$[\text{Conductance}] = 1/[\text{Resistance}] = \frac{1}{[M^1L^2T^{-3}A^{-2}]} = [M^{-1}L^{-2}T^3A^2]$$

Conductivity (σ):

Conductivity of a conductor is defined as the reciprocal of its resistivity.

$$\text{Thus, conductivity } (\sigma) = \frac{1}{\rho} = 1/\text{ohm. metre} = \text{mho.m}^{-1}$$

Dimension is

$$[\sigma] = 1/[\rho] = \frac{1}{[M^1L^3T^{-3}A^{-2}]} = [M^{-1}L^{-3}T^3A^2]$$

Variation of Resistance with Temperature:

Resistance of a conductor varies with Temperature. If R_0 and R_t are its resistance at 0°C and $t^\circ\text{C}$ respectively, then

$$R_t = R_0(1 + \alpha t)$$

$$R_t = R_0 + R_0 \alpha \cdot t$$

$$\therefore \alpha = \frac{R_t - R_0}{R_0 \cdot t}$$

Here α is known as Temperature coefficient of Resistance.

Temperature coefficient of resistance (α) is defined as change in resistance of the conductor per unit resistance per degree centigrade rise of temperature.

Colour code for Resistance:

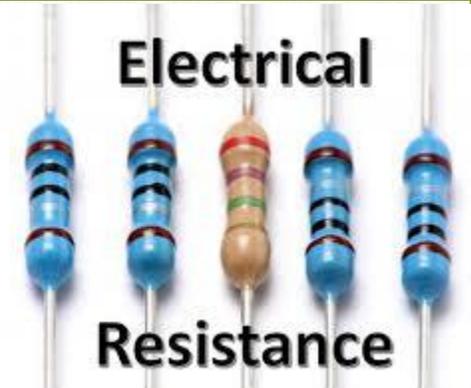
The Resistance of the piece is marked over it in the form of code called Colour Code

Black	–	0
Brown	–	1
Red	-	2
Orange	–	3
Yellow	–	4
Green	-	5
Blue	–	6
Violet	–	7
Grey	–	8
White	–	9
Gold	-	$\pm 5\%$
Silver	-	$\pm 10\%$



Red (2)
Blue (6)
Brown (1)
Gold (5%)

$$= 2 \ 6 \ 0 \ \pm 5\%$$
$$= 260 \pm 5\% \text{ ohm}$$



[B.B. ROY lives in Great Brittain with his Very Good Wife]

Combination of Resistance:

a) **Series:** The resistances are said to be connected in series if same current flows through all of them.

Consider, R_1, R_2, R_3 -- Resistances connected in series.

I -- Current flows through all of them.

V_1, V_2, V_3 -- Potential difference across each resistance

R -- Resistance of combination

V -- total potential across the whole combination

Then

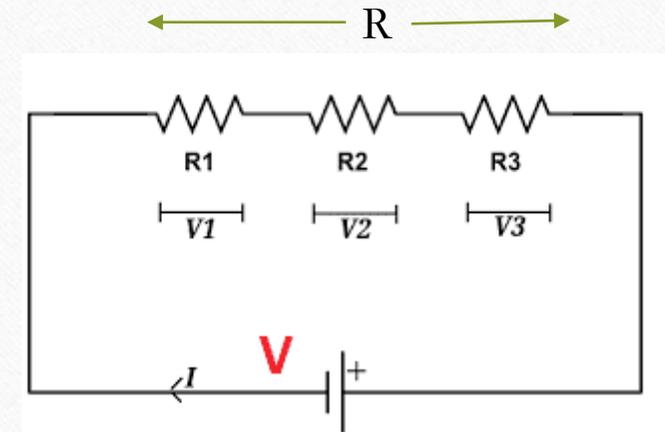
$$V_1 = IR_1, V_2 = IR_2, V_3 = IR_3 \quad \text{and} \quad V = IR$$

Since

$$V = V_1 + V_2 + V_3$$

$$\Rightarrow IR = IR_1 + IR_2 + IR_3$$

$$\Rightarrow R = R_1 + R_2 + R_3$$



b) **Parallel:** The resistances are said to be connected in Parallel if different current flows through them and get added afterwards.

Consider, R_1, R_2, R_3 - - Resistances connected in parallel.

I - - flowing Current divided into three parts.

I_1, I_2, I_3 -- currents passing through resistances

R -- Resistance of combination

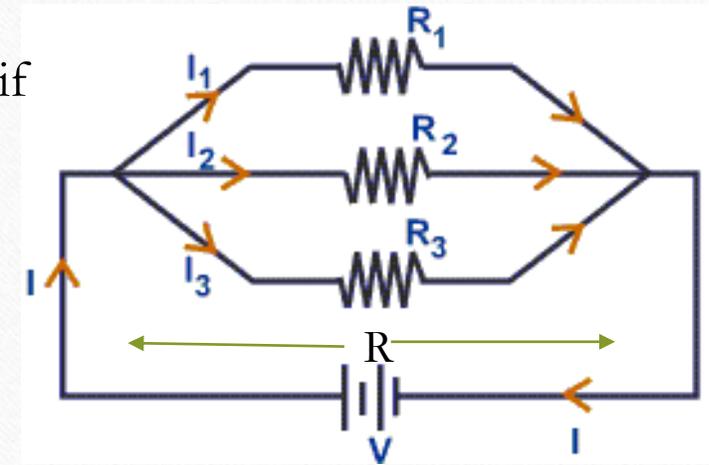
V -- total potential across the whole combination

Then

$$V = I_1 R_1, \quad V = I_2 R_2, \quad V = I_3 R_3 \quad \text{and} \quad V = IR$$

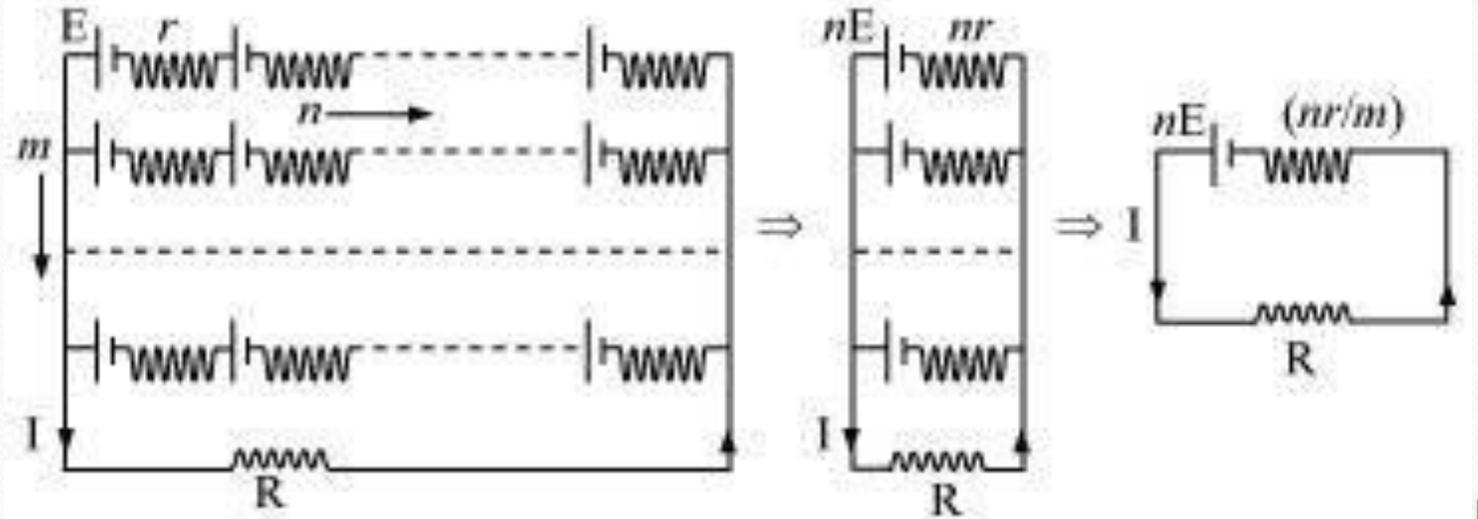
Since

$$\begin{aligned} I &= I_1 + I_2 + I_3 \\ \Rightarrow \frac{V}{R} &= \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} \\ \Rightarrow \frac{1}{R} &= \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \end{aligned}$$



C) Mixed Grouping:

Let n equal resistances are connected in series and there m such rows are connected in parallel.



Then resistance of one row -

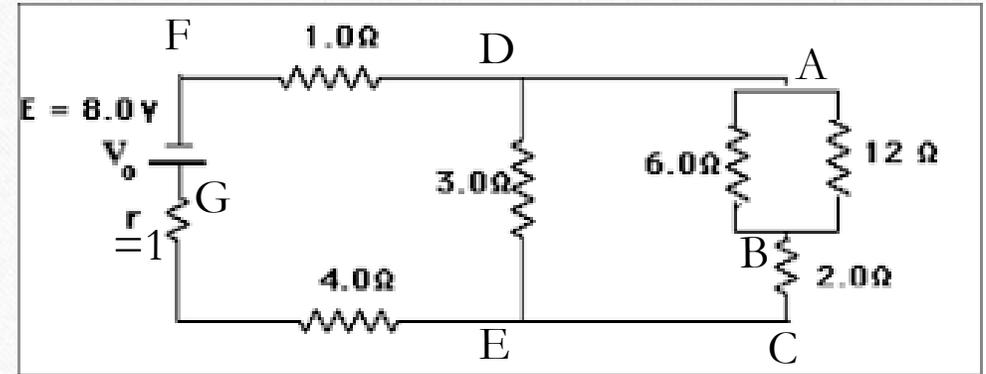
$$R_1 = r + r + \dots + r \text{ (n times)} = nr$$

If R is the total resistance across whole combination, then

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_1} + \frac{1}{R_1} + \dots + \frac{1}{R_1} \text{ (m times)} = \frac{m}{R_1} = \frac{m}{nr}$$

$$\Rightarrow R = \frac{nr}{m} = (\text{resistance}) \times \frac{\text{no. of resistance in one row}}{\text{no. of rows}}$$

Q1. Find the equivalent resistance of the combination. Find the total current and current through each resistance.



Ans: If R_1 is resistance across AB, then

$$\frac{1}{R_1} = \frac{1}{6} + \frac{1}{12} = \frac{3}{12} = \frac{1}{4} \Rightarrow R_1 = 4$$

If R_2 is resistance across AC, then

$$R_2 = 4 + 2 = 6$$

If R_3 is resistance across DE, then

$$\frac{1}{R_3} = \frac{1}{6} + \frac{1}{3} = \frac{3}{6} = \frac{1}{2} \Rightarrow R_3 = 2$$

If R_T is resistance across FG, then

$$R_T = 1 + 2 + 4 + 1 = 8 \text{ ohm}$$

If I is total current through the combination, then

$$I = \frac{V_0}{R_T} = \frac{8 \text{ volt}}{8 \text{ ohm}} = 1 \text{ amp}$$

Thus current through 1, 4, r, DE are same (1 amp)

Now current through 3 ohm

$$I_1 = I \times \frac{\text{resistance of AC } (R_2)}{\text{Total resistance of DE } (R_1 + R_2)} = 1 \times \frac{6}{3+6} = \frac{6}{9} = 0.67 \text{ amp}$$

Current through AC is (also 2 ohm)

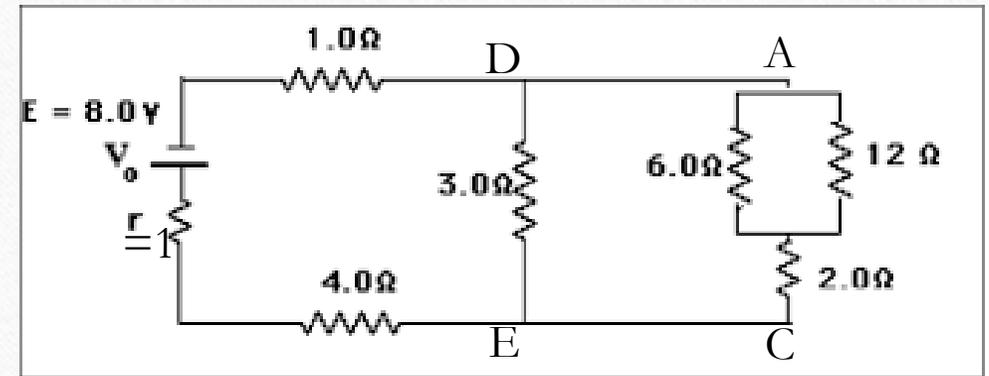
$$I_2 = I \times \frac{\text{resistance of DE } (3)}{\text{Total resistance of DE } (R_1 + R_2)} = 1 \times \frac{3}{3+6} = \frac{3}{9} = 0.33 \text{ amp}$$

Current through 6 ohm

$$I_3 = I_2 \times \frac{\text{resistance of 12 ohm}}{\text{Total resistance } (12+6)} = 0.33 \times \frac{12}{18} = 0.33 \times \frac{2}{3} = 0.22 \text{ amp}$$

Current through 12 ohm

$$I_4 = I_2 \times \frac{\text{resistance of 6 ohm}}{\text{Total resistance } (12+6)} = 0.33 \times \frac{6}{18} = 0.33 \times \frac{1}{3} = 0.11 \text{ amp}$$



For the class NOTE go to.....

GOOGLE CLASSROOM

Code: *laui72*

OR

Link: <https://classroom.google.com/c/MTE0NzM2Mjc1NTQ5>

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