Resistance

(i) The property of substance by virtue of which it opposes the flow of current through it, is known as the resistance.

(ii) **Formula of resistance :** For a conductor if l = length of a conductor A = Area of cross-section of conductor, n = No. of free electrons per unit volume in conductor, τ = relaxation time then resistance of conductor $R = \rho \frac{l}{A} = \frac{m}{ne^2\tau} \cdot \frac{l}{A}$; where ρ = resistivity of the material of conductor

(iii) **Unit :** It's S.I. unit is *Volt/Amp.* or *Ohm* (Ω). Also 1 *ohm*

$$= \frac{1 volt}{1 Amp} = \frac{10^8 \, emu \text{ of potential}}{10^{-1} \, emu \text{ of current}} = 10^9 \, emu \text{ of resistance}$$

(iv) **Dependence of resistance :** Resistance of a conductor depends upon the following factors.

(a) Length of the conductor : Resistance of a conductor is directly proportional to it's length *i.e.* $R \propto l$ and inversely proportional to it's area of cross-section *i.e.* $R \propto \frac{1}{A}$

(b) Temperature : For a conductor

Resistance $\propto$ temperature .

If R_0 = resistance of conductor at $0^\circ C$

R_t = resistance of conductor at $t^\circ C$

and α = temperature co-efficient of resistance

then $R_t = R_0(1 + \alpha t)$ for $t \le 300^\circ C$ or $\alpha = \frac{R_t - R_0}{R_0 \times t}$

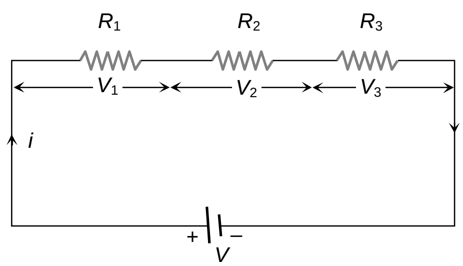
If R_1 and R_2 are the resistances at $t_1{}^\circ C$ and $t_2{}^\circ C$ respectively then $\frac{R_1}{R_2} = \frac{1 + \alpha t_1}{1 + \alpha t_2}$.

The value of α is different at different temperature. Temperature coefficient of resistance averaged over the temperature range $t_1{}^\circ C$ to $t_2{}^\circ C$ is given by $\alpha = \frac{R_2 - R_1}{R_1(t_2 - t_1)}$ which gives $R_2 = R_1 [1 + \alpha (t_2 - t_1)]$. This formula gives an approximate value.

Combination of Resistors

(1) Series Combination

(i) Same current flows through each resistance but potential difference distributes in the ratio of resistance *i.e.* $V \propto R$

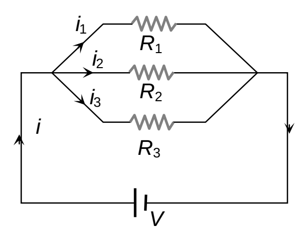


(ii) $R_{eq} = R_1 + R_2 + R_3$ equivalent resistance is greater than the maximum value of resistance in the combination.

(iii) If n identical resistance are connected in series $R_{eq} = nR$ and potential difference across each resistance $V' = \frac{V}{n}$

(2) Parallel Combination

(i) Same potential difference appeared across each resistance but current distributes in the reverse ratio of their resistance *i.e.* $i \propto \frac{1}{R}$



(ii) Equivalent resistance is given by $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ or

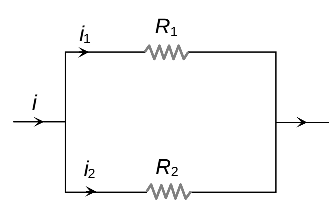
$R_{eq} = (R_1^{-1} + R_2^{-1} + R_3^{-1})^{-1}$ or $R_{eq} = \frac{R_1 R_2 R_3}{R_1 R_2 + R_2 R_3 + R_2 R_1}$

Equivalent resistance is smaller than the minimum value of resistance in the combination.

(iv) If two resistance in parallel $R_{eq} = \frac{R_1 R_2}{R_1 + R_2} = \frac{\text{Multiplication}}{\text{Addition}}$

(v) Current through any resistance

$$i' = i \times \left[\frac{\text{Resistance of opposite branch}}{\text{Total resistance}}\right]$$



Where i' = required current (branch current),

i = main current

$$i_1 = i\left(\frac{R_2}{R_1 + R_2}\right) \text{ and } i_2 = i\left(\frac{R_1}{R_1 + R_2}\right)$$

(vi)In *n* identical resistance are connected in parallel

$R_{eq} = \frac{R}{n}$ and current through each resistance $i' = \frac{i}{n}$

Electric cell :

a) It is a device which converts chemical energy into electrical energy.
b) There are two types of cells
   i) Primary cell   ii) Secondary cell
c) **comparison of primary and secondary cells:**

Electromotive force (e.m.f) of a Cell :

a) The work done is carrying a unit positive charge once in the whole circuit including the cell, is defined as the electromotive force.
b) Electromotive force is the potential difference between the terminals of a cell in open circuit.
c) Electromotive force depends on –(1) nature of electrolyte (2) metal of the electrodes.
d) Electromotive force does not depend on (1) area of plates (2) distance between the electrodes (3) Quantity of electrolyte (4) size of the cell.
e) Electromotive force is the characteristic property of the cell. The direction of current inside the cell is always from negative to positive electrode.
f) The unit of electromotive force is volt.

Internal resistance (r) :

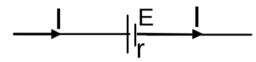
The internal resistance of a cell is the resistance offered by the column of the electrolyte between the positive plate and the negative plate.

i) The internal resistance of a perfect cell or ideal cell is zero.
ii) Internal resistance depends on
   a) strength of electrolyte (r $\propto$ strength)
   b) distance between plates (r $\propto$ d)
   c) area of the plates $\left[r \propto \frac{1}{A}\right]$
   d) temperature of electrolyte $\left[r \propto \frac{1}{t}\right]$

Relation between EMF and PD:

(i) In case of charging of a cell

a) The current flows from +ve to –ve terminal inside the cell.



b) $V > E$

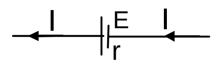
c) $V = E + ir$

(ii) In case of discharge of a cell

a) The current flows from –ve to +ve terminal inside the cells

b) $V < E$

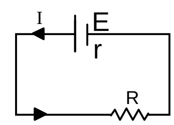
c) $V = E - ir$



(iii)The difference between E and V is called **lost volts**

$\therefore$ lost volts = $E - V = ir$

(iv) A cell of emf 'E' and its resistance 'r' is connected to resistance 'R'.



a) $i = \frac{E}{R+r}$

b) P.D. across resistance R is given by

$V = iR = \frac{ER}{R+r}$

c) Fraction of energy useful $= \frac{V}{E} = \frac{R}{R+r}$

d) % of fractional useful energy$= \left(\frac{V}{E}\right)100 = \left(\frac{R}{R+r}\right)100$

e) Fraction of energy lost $= \frac{E-V}{E} = \frac{ir}{E} = \frac{r}{R+r}$

f) % of lost energy $= \left(\frac{r}{R+r}\right)100$

g) $r = \frac{(E-V)R}{V}$

h) For single cell, the condition for maximum current is $R = r$.

Back emf :

a) The copper electrode gets covered with a layer of hydrogen and this hinders flow of current. In the neighbourhood of both electrodes, the concentrations of ions get altered. This results in an emf acting in a direction opposite to the emf of the cell. This is called *back emf*.

b) This formation of hydrogen around the anode is called *polarization*.

c) To reduce the back e.m.f manganese dioxide and potassium dichromite are added to electrolyte of cell. These are called ***depolarizers***.