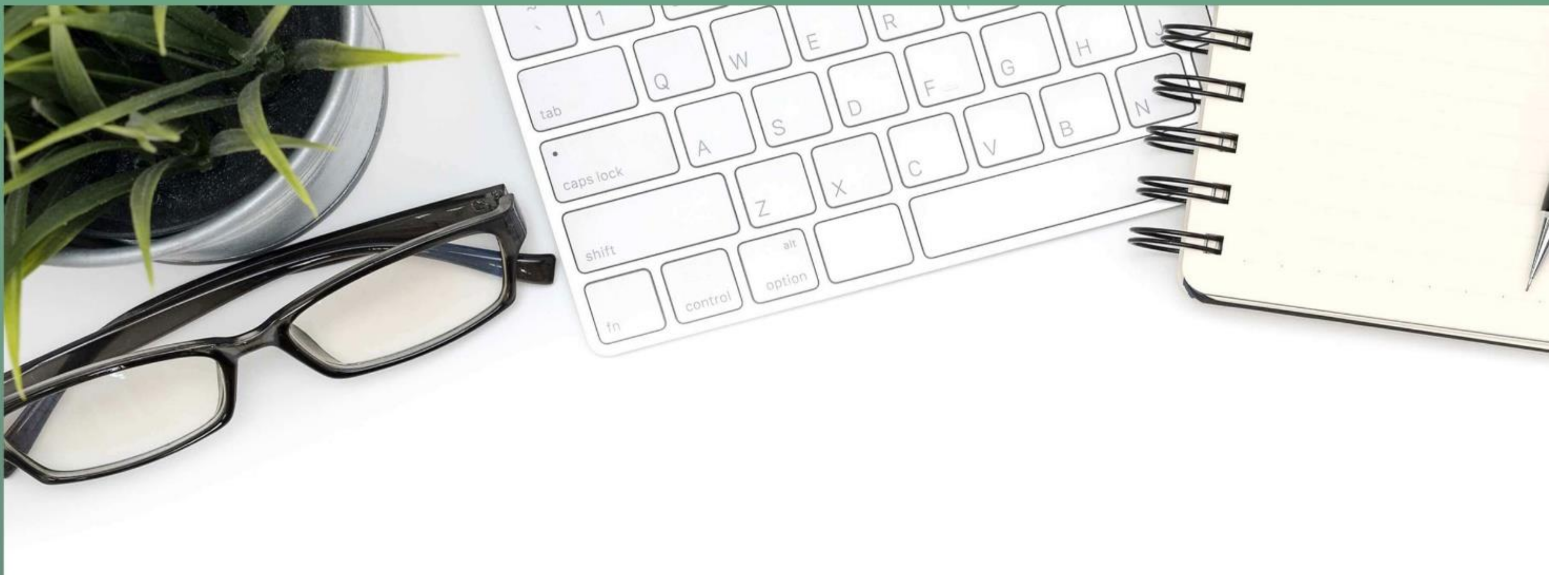

JEE Main Physics

Short Notes

Current Electricity

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Current Electricity is an important topic from JEE Main / JEE Advanced Exam Point of view. Every year there are 1-3 questions asked from this topic. This short notes on Current Electricity will help you in revising the topic before the JEE Main & IIT JEE Advanced Exam.

Drift Velocity and Resistivity

Drift Velocity When the charged particles move around in a conductor because of the interparticle collisions, their motion is in a haphazard manner. Therefore, the average speed of the particle in the conductor is known as the drift velocity.

The current due to this drift factor of electrons in a charged is called as the drift current.

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

Here v_d is the drift velocity, e is the electronic charge, E is the applied electric field across the conductor, m is the mass of the charged particle and τ is the relaxation time.

Mobility The drift velocity per unit electric field is known as the mobility. It tells that how efficiently the charged particles can move freely or its ability to move freely.

$$\mu = \left|\frac{v_d}{E}\right|$$

$$\mu = \frac{eE}{mE}\tau$$

$$\mu = \frac{e}{m}\tau$$

Relation between current and Drift velocity

The charge flowing through an area A is

$$Q = n \times e \times A \times (v_d \times \Delta t)$$

$$\frac{Q}{\Delta t} = neAv_d$$

$$I_{avg} = neAv_d$$

Here, n is the number of charges per unit volume, e is the electric charge, v_d is the drift velocity, A is the cross sectional area and Δt is the time interval.

Relation between current and Mobility

$$v_d = \mu E$$

$$I = neAv_d$$

$$I_{avg} = (neAE)\mu$$

Electrical Conductivity: It is the property of the material that allows the flow of current through the conductor. Mathematically it is the reciprocal of the resistivity.

Resistivity and Conductivity

From the definition of drift current,

$$I = neAv_d$$

$$I = \frac{ne^2 A}{m}\tau |E|$$

$$J|A = \frac{ne^2 A}{m}\tau |E| \qquad \ldots\ldots\left(J = \frac{I}{A}\right)$$

$$|J| = \frac{ne^2}{m}\tau |E|$$

$$J = \sigma E \qquad \ldots\ldots\ldots\ldots\left(\sigma = \frac{ne^2}{m}\tau\right)$$

Here J is the current density i.e. current per unit area and $\left(\sigma = \frac{ne^2}{m}\tau\right)$ is the conductivity of the material.

The resistivity of the material is the reciprocal of the conductivity.

$$\rho = \frac{1}{\sigma}$$
$$\rho = \frac{1}{\frac{ne^2}{m}\tau}$$
$$\rho = \frac{m}{ne^2\tau}$$

Electrical resistivity and Conductivity Electrical resistivity of a material is the property of the material that opposes the flow of the current. It's also known as the specific resistance of the material.

$$\rho = \frac{AR}{l}$$

Electrical energy and power

If in time interval Δt, $\Delta Q = I\Delta t$ amount of charge flows form End A of the conductor to end B of the conductor then the potential energy at both the ends will be QV_A and QV_B.

The total energy in the conductor is the change in the potential energy across the conductor ends.

$$E = Q(V_B - V_A)$$
$$E = -Q\Delta V$$

Electric Power: The amount of energy dissipated per unit time as heat is known as the electrical power of the conductor.

$$\text{Energy Disssipated} = W = IV\Delta t$$

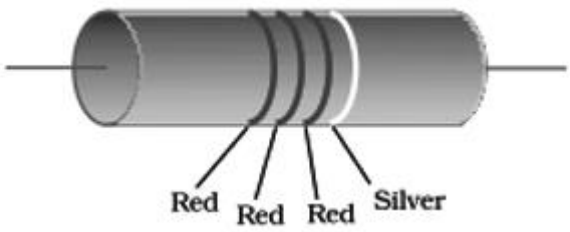
$$W = IV\Delta t$$

$$\frac{W}{\Delta t} = IV \qquad \left(\frac{W}{\Delta t} = P\right)$$

$$P = IV = I^2R = \frac{V^2}{R} \qquad (V = IR)$$

Resistor and their combination

Carbon Resistors Carbon resistors are comparatively small inexpensive therefore it has widespread use in electronic circuits. Carbon resistors are small in size and hence their standards are given using a colour code.



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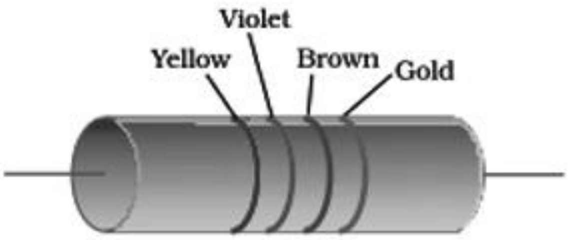
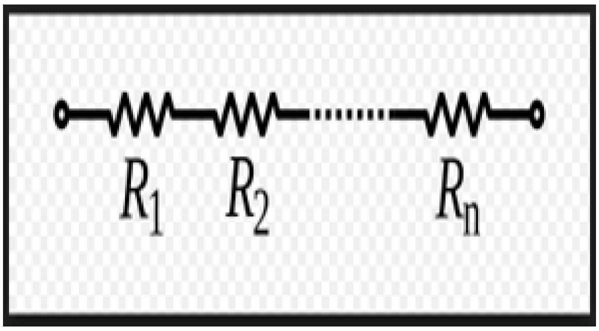


Colour Codes for Carbon Resistors

Colour	Number	Multiplier	Tolerance (%)
Black	0	1	
Brown	1	10^1	
Red	2	10^2	
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	
Blue	6	10^6	
Violet	7	10^7	
Gray	8	10^8	
White	9	10^9	
Gold		10^{-1}	5
Silver		10^{-2}	10
No colour			20

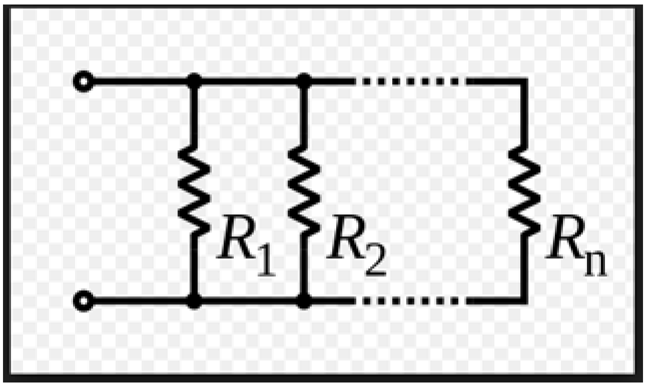
Combination of resistors:

Series Combination:



$$R_{eq} = R_1 + R_2 + R_3 + ... + R_n$$

Parallel Combination:



$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots \frac{1}{R_n}$$

Temperature dependence of resistance:

The resistance of a conductor has a linear dependency on the temperature as

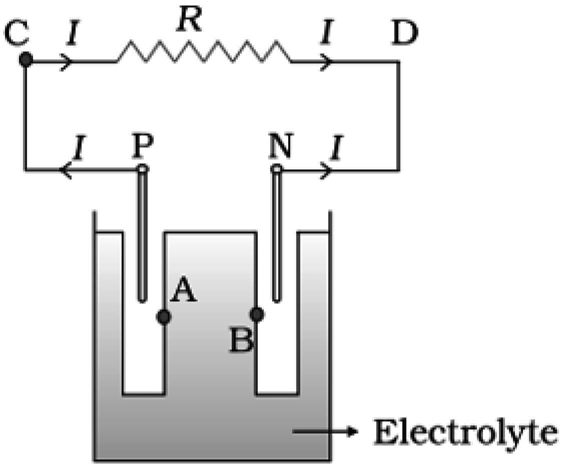
$$R = R_0\left(1+\alpha\left(T-T_0\right)\right)$$
$$\rho = \rho_0\left(1+\alpha\left(T-T_0\right)\right)$$

where α is the temperature coefficient.

Cell and their Combination

Potential difference and potential of Cell

A cell has two electrodes one positive (P) and one negative (N). Both are immersed in an electrolytic solution. In the solution, the electrodes interchange charges with the electrolyte. The positive electrode has a potential difference between itself and the electrolyte solution similarly, the negative electrode develops a negative potential (V– (V– ≥0) relative to the electrolyte. When there is no current, the electrolyte has the same potential throughout, so that the potential difference between the electrodes is known as the Emf of the battery.



$$\varepsilon = V_+ - (-V_-)$$
$$\varepsilon = V_+ + V_-$$

Emf is the potential difference between the positive and negative electrodes when no current is flowing through the cell an open circuit,

This difference is called the electromotive force (Emf) of the cell and is denoted by ε.

If the circuit is closed then, $\varepsilon = V - ir$

Here, r is the internal resistance of the cell.

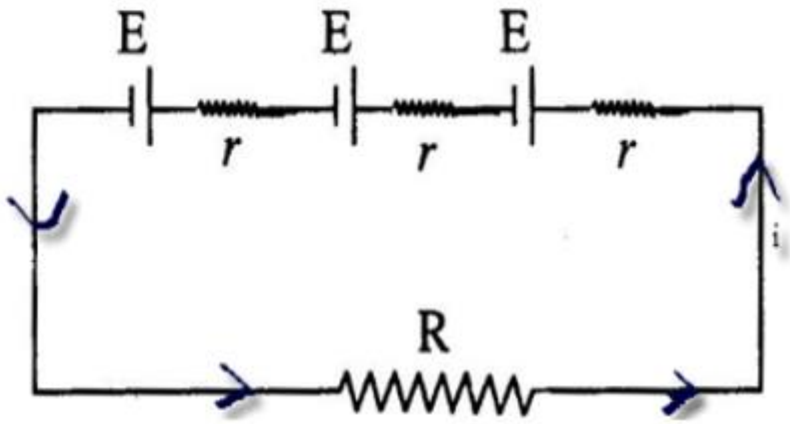
$$\varepsilon = V - ir$$
$$\varepsilon = IR - Ir$$
$$I = \frac{\varepsilon}{R - r}$$

The internal resistance of the cell is the resistance offered by the electrolyte inside the cell.

The maximum current flowing in the circuit is:

$$I_{max} = \frac{\varepsilon}{0 + r} = \frac{\varepsilon}{r}$$

Combination of cells in series:



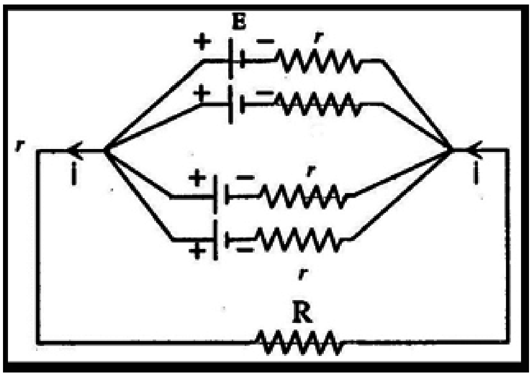
If *n* numbers of cells are connected in series

$$V = \varepsilon_{eq} - Ir_{eq}$$

$$\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2 + \varepsilon_3 ...... + \varepsilon_n$$

$$r_{eq} = r_1 + r_2 + ...r_n$$

Combination of cells in parallel



If *n* numbers of cells are connected in parallel

$$V = \varepsilon_{eq} - Ir_{eq}$$

$$\frac{\varepsilon_{eq}}{r_{eq}} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} + \frac{\varepsilon_3}{r_3} \ldots\ldots + \frac{\varepsilon_n}{r_n}$$

$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_2} + \ldots\ldots\ldots + \frac{1}{r_n}$$

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