Electric Current

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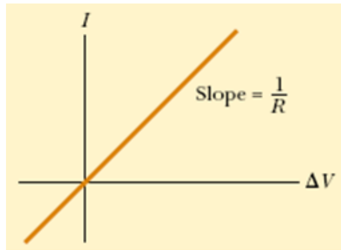
CURRENT :- rate of flow of charge $\longrightarrow I_{av} = \frac{Q}{t}$

INSTANTANEOUS CURRENT :- if the rate at which charge flows varies with time, then the current varies with time, we define instantaneous current as the differential limit of average current $\longrightarrow I = \frac{dQ}{dt}$

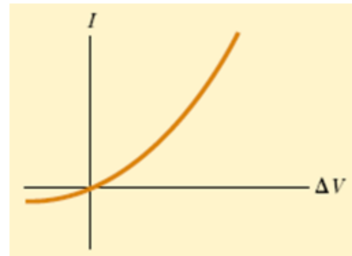
→ It is conventional to assign to the current the same direction as the flow of positive charge, direction of current is opp to the direction of flow of electrons

→ conventional current (pos to neg terminal) established before electron discovery

OHM'S LAW :-
- voltage across an ohmic conductor is $\propto I$, provided that T and R remain constant ($V = IR$)
- for many materials (including most metals), the ratio of the current density to the electric field is a constant δ that is independent of the electric field producing the current)
- valid only for ohmic materials
- $R = \frac{\Delta V}{I} = \frac{L}{\delta A}$
- ohmic ⟶ carbon resistors, most metals, etc
- non ohmic ⟶ semiconductors, diodes, etc



ohmic conductor

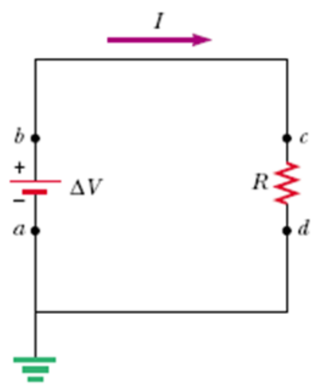


non-ohmic conductor

ELECTRICAL ENERGY & POWER :-

If a battery is used to establish an electric current in a conductor, the chemical energy stored in the battery is continuously transformed into kinetic energy of the charge carriers. The chemical energy stored in the battery is continuously transformed to internal energy associated with the temperature of the conductor.

Consider a simple circuit consisting of a battery whose terminals are connected to a resistor, as shown in Figure. Imagine following a positive quantity of charge Q *that is* moving clockwise around the circuit from point a *through the battery and resistor* back to point *a*. As the charge moves from *a to b through the battery, its electric potential energy U increases by an amount ΔV Δ Q (where Δ V is the potential difference between b and a), while the chemical potential energy in the battery decreases by the same* amount. The charge cannot build up at any point the current is the same everywhere in the circuit.

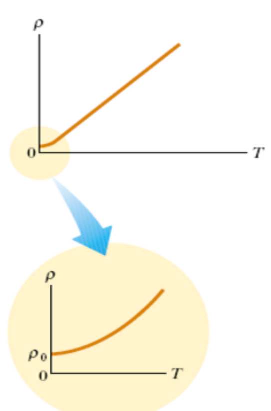


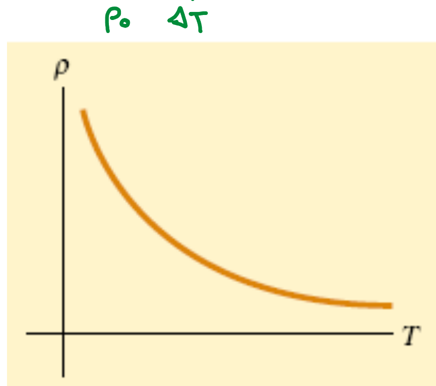
The rate at which the charge ΔQ loses potential energy in going through the resistor is

$$\frac{\Delta U}{\Delta t} = \frac{\Delta Q}{\Delta t}\Delta V = I\Delta V$$

FORMULAE :-
- $\Delta Q = Ne$
- $N = nV$
- $I = nAqv_d$ where v_d = drift speed (average speed of charge carriers)
- $J = \frac{I}{A} = nqv_d$ where J = current density (current per unit area (A/m^2), only valid if J uniform and $A \perp$ to direction of current)
- $J = \delta E$ where δ = conductivity (J & E established in a conductor whenever a potential difference is maintained across the conductor)
- $R = \frac{L}{\delta A} = \frac{\rho L}{A}$
- $\rho = \frac{1}{\delta}$ where ρ = resistivity
- $\rho = \rho_0[1 + \alpha(T - T_0)]$ where α = temperature coefficient of resistivity $\longrightarrow \alpha = \frac{1}{\rho_0}\frac{\Delta\rho}{\Delta T}$

  OR
- $R = R_0[1 + \alpha(T - T_0)]$ as $R \propto \rho$
- $P = I\Delta V$ (general)
- $P = I^2R$ (power dissipated)
- $P = \frac{(\Delta V)^2}{R}$ (power dissipated)





R and T relationship differs for conductors & semi conductors

When the internal resistance of the battery is neglected, the potential difference between points *a* and *b* in Figure 27.14 is equal to the emf $\mathcal{E}$ of the battery—that is, $\Delta V = V_b - V_a = \mathcal{E}$. This being true, we can state that the current in the circuit is $I = \Delta V/R = \mathcal{E}/R$. Because $\Delta V = \mathcal{E}$, the power supplied by the emf source can be expressed as $\mathcal{P} = I\mathcal{E}$, which equals the power delivered to the resistor, I^2R.

else $V = E - IR$ to account voltage drop

resistivity vs temp for a metal such as copper, linear over a wide range of temp, and as T approaches absolute zero, ρ approaches 0.

$R\uparrow$ as $T\uparrow$

resistivity vs temp for pure semiconductor such as silicon or germanium

$R\downarrow$ as $T\uparrow$