Class : 12th Physics
Chapter- 1 : Electric Charges and Fields

Electric Charges and Fields

Conservation of charge

It is not possible to create or destroy net charge of an isolated system.

Quantization of charge

All observable charges must be integral multiple of e. i.e.
Q = ne
where n = integers

- Two kinds of charges + ve and – ve
- S.I unit is coulomb (C)
  1 C = charge flowing through
- a wire in 1 sec if current in it is 1A
  1e = 1.602 × 10^{-19}C

Electric Charges

- Force between two charged particle

$\vec{F} = \frac{k q_1 q_2 \vec{r}}{r^3} = \frac{k q_1 q_2 \hat{r}}{r^2}$, force is attractive when q_1 and q_2 are of opposite sign, otherwise repulsive

$|\vec{F}| = \frac{k q_1 q_2}{r^2}$

$k = \frac{1}{4\pi\varepsilon_0} \approx 9 \times 10^9 \, Nm^{-2}C^{-2}$

- Force between multiple charges

$\vec{F}_{i1} = \vec{F}_{12} + \vec{F}_{13} + \vec{F}_{14} + \vec{F}_{15} + \ = \frac{q_i}{4\pi\varepsilon_0} \sum_{j=2}^{n} \frac{q_j}{r_{ji}^2} \hat{r}_{ji}$

where $\hat{r}_{ji}$ is the unit vector along charge particle under consideration
$\vec{r}_{ji}$ = distance between I and i^{th} particle

"The electric force with which two charges attracts or repel one another are not affected by the presence of other charges". It is known as Superposition Principle.

Coulomb's Law

Electric Flux

$\Delta\phi = \vec{E}.\Delta\vec{S}$, $\Delta\vec{S}$ = area vector
$\vec{E}$ = electric field
$\phi = \int \vec{E}.d\vec{s}$

Gauss's Theorem

$\oint \vec{E}.d\vec{s} = q_{in}/\varepsilon_0 = \phi$

where, q_{in} = net charge enclosed
ϕ = flux through a closed surface

Application of Gauss's Law

- Electric field due to uniformly charged sphere at an
- Outside point
  $E = Q/4\pi\varepsilon_0 r^2$
  Internal point
  $E = Qr/4\pi\varepsilon_0 R^3$
- On the surface
  $E = Q/4\pi\varepsilon_0 R^2$

- Field due to linear charge distribution
  $E = \lambda/2\pi\varepsilon_0 r$,
  λ = linear charge density
- Field due to a plane sheet of charge
  $E = \sigma/2\varepsilon_0$,
  σ = charge per unit area
- Field due to a charged conducting plate
  $E = \sigma/\varepsilon_0$,
  σ = charge per unit area
- Field inside a conductor = 0
- Electric field due to a thin spherical shell at a point
  Outside the shell, $E = Q/4\pi\varepsilon_0 r^2$
  Inside the shell, E = 0
  On the surface $E = Q/4\pi\varepsilon_0 R^2$
- Electric field due to uniformly charged share at an
  Outside point
  $E = Q/4\pi\varepsilon_0 r^2$
  Internal point
  $E = Qr/4\pi\varepsilon_0 R^3$
  On the surface
  $E = Q/4\pi\varepsilon_0 R^2$

Electric field

Electric field lines

- Always normal to conducting surface
- Lines originating from +ve charge
- Terminating at -ve charge
- Never intersect each other
- Never from closed loop
- Are imaginary lines.

Electric field due to point charge

$\vec{E} = \frac{\vec{F}}{q} = k \frac{Q}{r^2}$ (N/C)
∵ unit = N/C

- Due to discrete distribution of charges
  $\vec{E} = \sum_{i=1}^{n} \vec{E}_i$
- Due to continuous distribution of charges
  $\vec{E} = k \int \frac{dQ}{r^2} \hat{r}$
  $|\vec{E}| = k \int \frac{dQ}{r^2}$

Electric Dipole, p = qd

- Electric field due to dipole at axial position
  $\vec{E} = \frac{1}{4\pi\varepsilon_0} \left(\frac{2P}{r^3}\right) \hat{r}$
- Electric field due to dipole at equatorial position
  $|E| = \frac{1}{4\pi\varepsilon_0} \left(\frac{P}{r^3}\right)$
- Torque on an electric dipole placed in an electric field $(\vec{E})$
  $\vec{\tau} = \vec{p} \times \vec{e} = p E \sin\theta$

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