



Electric Charges and Fields

Electric Charge

Charge is a property of matter due to which two bodies interact with each other electromagnetically. There are two kinds of charges- positive and negative. SI unit is coulomb. Charge is quantized and additive.

Coulomb's Law

Force between two charges

$$\vec{F} = \frac{1}{4\pi\epsilon_0\epsilon_r} \frac{q_1q_2}{r^2} \hat{r}$$

ϵ_r = dielectric constant of the medium, ϵ_0 = permittivity of free space



- ◆ Coulomb's Law is applicable only for static point charges.

Principle of Superposition

Force on a point charge due to many charges is given by

$$\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \dots$$

- ◆ The force due to one charge is not affected by the presence of other charges.

Electric Field or Electric Field Intensity

$$\vec{E} = \frac{\vec{F}}{q}$$

Unit is N/C or V/m.

Electric Field due to Point Charge Q

$$\vec{E} = \lim_{q \rightarrow 0} \frac{\vec{F}}{q} = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2} \hat{r}$$

Null Point for Two Charges



$$x = \frac{\sqrt{Q_1}r}{\sqrt{Q_1} \pm \sqrt{Q_2}}$$

$x \rightarrow$ distance of null point from Q_1 charge

(+) for like charges [null point will be in between Q_1 & Q_2]

μ_s (-) for unlike charges [null point will be outside Q_1 & Q_2 and near weaker charge]

Equilibrium of Three Point Charges



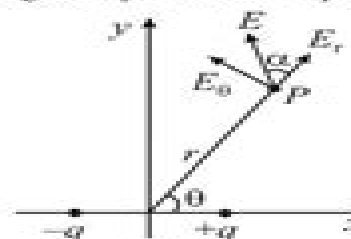
(i) Q_1 & Q_2 must be of like nature.

(ii) q should be of unlike nature.

$$x = \frac{\sqrt{Q_1}}{\sqrt{Q_1} + \sqrt{Q_2}} r \text{ and } q = \frac{-Q_1Q_2}{(\sqrt{Q_1} + \sqrt{Q_2})^2}$$

Electric Dipole

- ◆ Electric dipole moment $\vec{p} = q\vec{d}$, where \vec{d} is distance from negative to positive charge.
- ◆ Torque on dipole placed in a uniform electric field $\vec{\tau} = \vec{p} \times \vec{E}$
- ◆ Electric field at a general point due to a dipole.



$$\text{Electric field: } E = \frac{1}{4\pi\epsilon_0} \frac{p\sqrt{1+3\cos^2\theta}}{r^3}$$

$$\text{Direction: } \tan\alpha = \frac{E_\theta}{E_r} = \frac{1}{2} \tan\theta$$

21 Study Guide Electric Fields

James Kyle, Ken W. Sessions



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