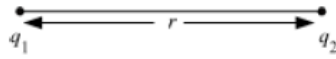


1. Electric Charge and Fields

Quantisation of electric charge → All observable charges are always some integral multiples of elementary charge e ($= \pm 1.6 \times 10^{-19} \text{C}$).

$$q = \pm ne \quad \text{Where, } n = 1, 2, 3, \dots$$

Coulomb's law →



$$F = \frac{1}{4\pi\epsilon_0 k} \frac{q_1 q_2}{r^2}$$

Where,

ϵ_0 → Absolute permittivity of free space

k → Dielectric constant

The product $\epsilon_0 k = \epsilon$ (absolute permittivity of the dielectric medium)

If the two point charges are located in vacuum, then

$$k = 1, \epsilon = \epsilon_0$$

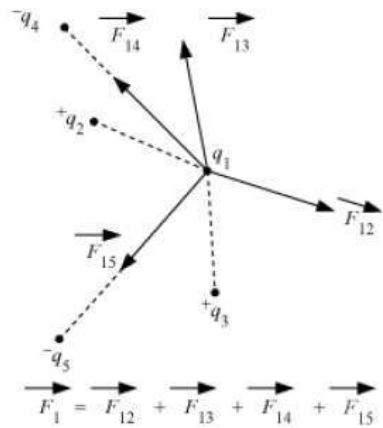
$$\therefore F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$$

The value of $\epsilon_0 = 8.8542 \times 10^{-12} \text{C}^2 \text{N}^{-1} \text{m}^{-2}$

The value of $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{Nm}^2 \text{C}^{-2}$

Relative permittivity or Dielectric constant → k or $\epsilon_r = \frac{\epsilon}{\epsilon_0}$

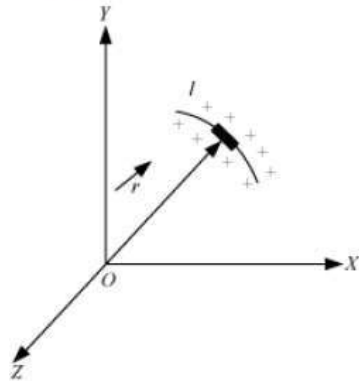
Principle of superposition of electric forces → When a number of charges are interacting, the total force on a given charge is the vector sum of the individual forces exerted on the given charge by all the other charges.



Continuous charge distribution →

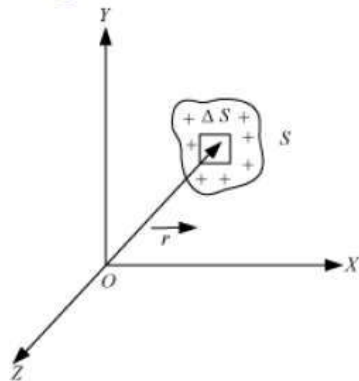
- Linear charge density:

$$\lambda = \frac{q}{l}$$

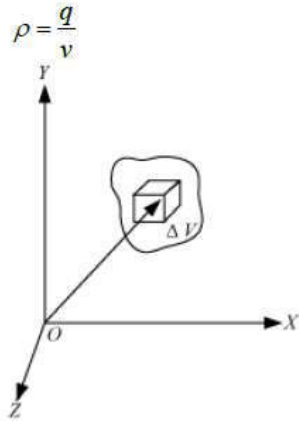


- Surface density of charge:

$$\sigma = \frac{q}{s}$$



- Volume density of charge:



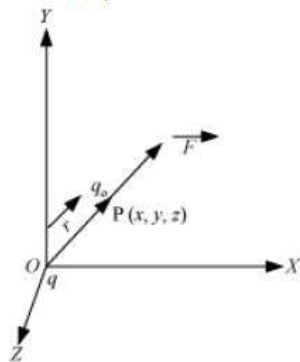
Electric field strength:

$$\vec{E} = \frac{\vec{F}}{q_0}$$

Where, q_0 is a positive test charge

Electric field due to a point charge:

$$E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2}$$



Electric field due to a uniformly charged ring at a point on the axis of the ring is

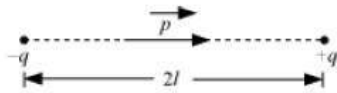
$$E = \frac{1}{4\pi\epsilon_0} \frac{qx}{(r^2 + x^2)^{\frac{3}{2}}}$$

Where,

$x \rightarrow$ Distance of the point from the centre of the ring

$r \rightarrow$ Radius of the ring

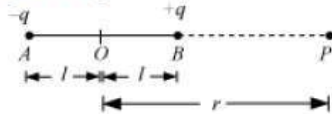
Electric dipole moment (\vec{p}) \rightarrow



$$p = q \times 2l$$

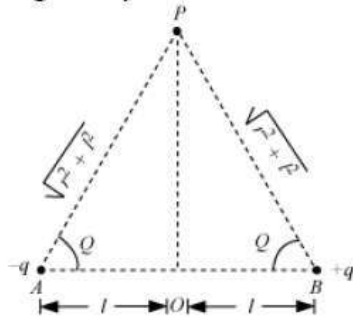
The direction of \vec{p} is from negative charge to positive charge.

Electric field intensity due to an electric dipole at a point on its axial line is given by



$$E = \frac{1}{4\pi\epsilon_0 k} = \frac{2pr}{(r^2 - l^2)^2}$$

Electric intensity due to an electric dipole at a point on the equatorial line is given by



$$E = \frac{1}{4\pi\epsilon_0 k} = \frac{p}{(r^2 + l^2)^{\frac{3}{2}}}$$

Torque

In a uniform electric field E , a dipole experiences a torque τ , given by

$$\tau = p \times E$$

Electric flux

The flux $\Delta\phi$ of an electric field E , through a small area element Δs is given by

$$\Delta\phi = E \cdot \Delta s$$

The vector area element Δs is

$$\Delta s = \Delta s \hat{n}$$

Where, Δs is the magnitude of the area element and \hat{n} is the normal to the area element. For an area element of a closed surface, \hat{n} is, by convention, taken to be the direction of outward normal.

Gauss's law \rightarrow The flux of electric field through any closed surface s is $\frac{1}{\epsilon_0}$ times the total charge enclosed by s .

- Electric field intensity due to an infinitely long straight wire of linear charge density λ is given by

$$E = \frac{1}{2\pi\epsilon_0} \frac{\lambda}{r}$$

- Electric field intensity due to a uniformly charged infinite plane sheet of surface charge density σ is given by

$$E = \frac{\sigma}{2\epsilon_0}$$

- Electric field intensity due to a uniformly charged thin spherical shell of surface charge density σ is given by

$$E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} (r \geq R)$$

$$E = 0 (r < R)$$

Where, r is the distance of the point from the centre of the shell and R the radius of the shell

Exam

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