1. Electric Charge and Fields

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

$\boxed{q = \pm ne}$ Where, $n = 1, 2, 3, \ldots$

Coulomb's law →

$$F = \frac{1}{4\pi\varepsilon_0 k}\frac{q_1 q_2}{r^2}$$

Where,

$\varepsilon_0 \rightarrow$ Absolute permittivity of free space

$k \rightarrow$ Dielectric constant

The product $\varepsilon_0 k = \varepsilon$ (absolute permittivity of the dielectric medium)

If the two point charges are located in vacuum, then

$k = 1$, $\varepsilon = \varepsilon_0$

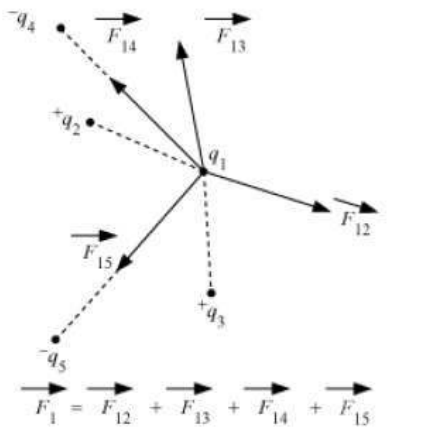
$$\therefore F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

The value of $\varepsilon_0 = 8.8542 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\text{m}^{-2}$

The value of $\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \text{Nm}^2\text{C}^{-2}$

Relative permittivity or Dielectric constant → k or $\varepsilon_r = \dfrac{\varepsilon}{\varepsilon_0}$

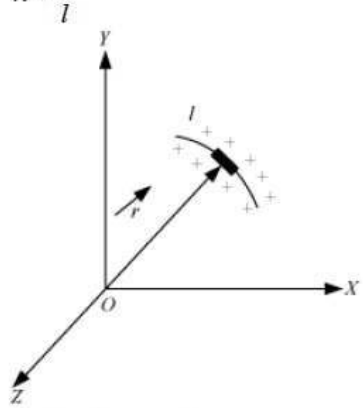
Principle of superposition of electric forces → When a number of charges are interacting, the total force on a given charge is the vector sum of the individual forces exerted on the given charge by all the other charges.



Continuous charge distribution →

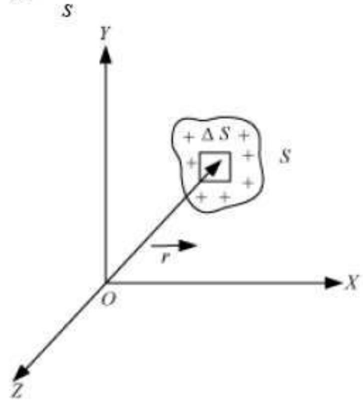
- Linear charge density:

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



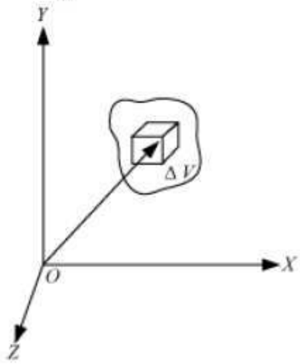
- Surface density of charge:

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



- Volume density of charge:

$\rho = \frac{q}{v}$



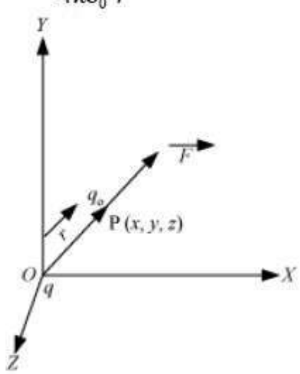
Electric field strength:

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

Where, q_0 is a positive test charge

Electric field due to a point charge:

$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$



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

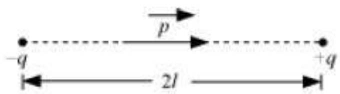
$$E = \frac{1}{4\pi\varepsilon_0}\frac{qx}{\left(r^2 + x^2\right)^{\frac{3}{2}}}$$

Where,

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

$r \rightarrow$ Radius of the ring

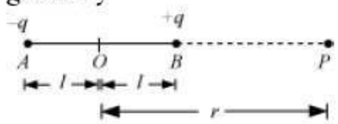
Electric dipole moment $(\vec{p}) \rightarrow$



$$\boxed{p = q \times 2l}$$

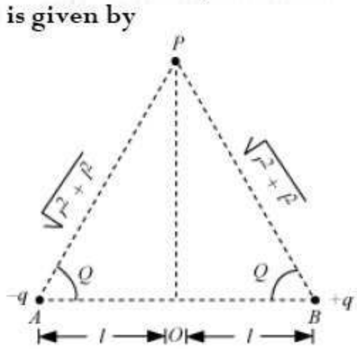
The direction of $\vec{p}$ is from negative charge to positive charge.

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



$$\boxed{E = \frac{1}{4\pi\varepsilon_0 k} = \frac{2pr}{\left(r^2 - l^2\right)^2}}$$

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



$$E = \frac{1}{4\pi\varepsilon_0 k} = \frac{p}{\left(r^2 + l^2\right)^{\frac{3}{2}}}$$

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 → The flux of electric field through any closed surface s is $\frac{1}{\varepsilon_0}$ 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

  $$\boxed{E = \frac{1}{2\pi\varepsilon_0}\frac{\lambda}{r}}$$

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

  $$\boxed{E = \frac{\sigma}{2\varepsilon_0}}$$

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

  $$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}(r \geq R)$$

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

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