

# Electrostatic Fields

## 2.1. Coulomb's law

It was found experimentally that there is a force of attraction between two oppositely charged bodies and the force of repulsion between two similarly charged bodies. Coulomb in 1787, gave a law for the force of attraction or repulsion between two electrically charged bodies separated from each other by a definite distance which is known as Coulomb's law after his name and is given below:

*The force of attraction or repulsion between two electric point charges at a fixed distance apart is directly proportional to the product of two point charges and inversely proportional to the square of the distance between them. The direction of the force is always along a straight line joining the point charges.*

If  $q_i$  and  $q_j$  are the magnitudes of the point charges separated from each other by a distance  $r_{ij}$ , then the force acting on charge  $q_j$  due to charge  $q_i$  is given by

$$F_{ij} = \lambda \frac{q_i q_j}{r_{ij}^2} \hat{r}_{ij}$$

where  $\hat{r}_{ij}$  is the unit vector directed from  $q_i$  to  $q_j$  and  $\lambda$  is a constant of proportionality whose numerical value depends upon the medium of separation between the charges and the units in which various physical quantities are expressed. In M.K.S. system force  $F_{ij}$  is in Newton, charge  $q$  is in Coulomb and constant  $\lambda$  is written as

$$\lambda = \frac{1}{4\pi\epsilon}$$

where  $\epsilon$  is known as the (absolute) permittivity of the medium between the charges. Thus in M.K.S. system Coulomb's law may be expressed as

$$\begin{aligned} F_{ij} &= \frac{1}{4\pi\epsilon} \frac{q_i q_j}{r_{ij}^2} \hat{r}_{ij} \\ &= \frac{1}{4\pi\epsilon} \frac{q_i q_j}{r_{ij}^3} \mathbf{r}_{ij} \end{aligned}$$

If the medium between the charges is air or vacuum, then  $\epsilon = \epsilon_0$ , the permittivity of free space and value

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ Coul}^2/\text{N}\cdot\text{m}^2.$$

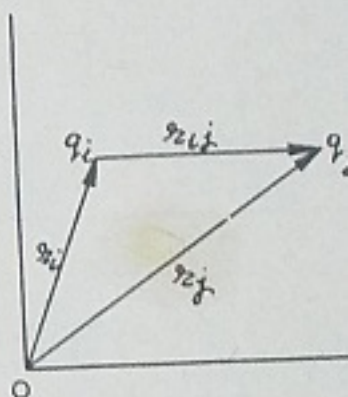


Fig. 2.1

Coulomb's law for force on point charge  $q_j$  due to point charge  $q_i$  in free space or air is expressed