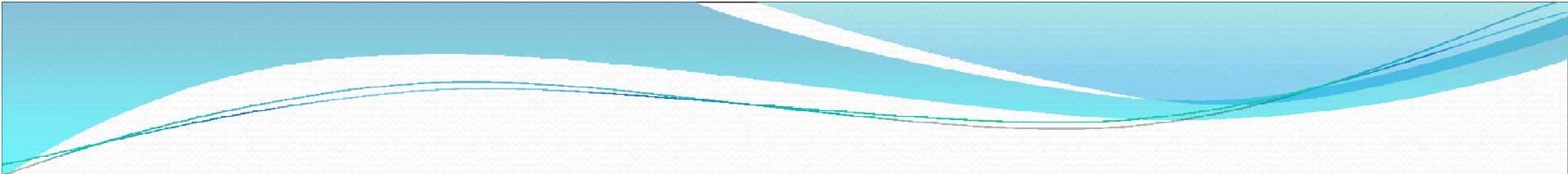


LECTURE NO 13

Electrostatics

Topics

- Electrostatics:
- Electrostatic fields,
- Coulombs law
- Electric field intensity

- 
- Electrostatics is the study of Charges at Rest
 - It is based on two fundamental law
 - Coloumbs law
 - Gauss Law

Coulomb's law states that the force F between two point charges Q_1 and Q_2 is:

1. Along the line joining them
2. Directly proportional to the product Q_1Q_2 of the charges
3. Inversely proportional to the square of the distance R between them.³

Expressed mathematically,

$$F = \frac{k Q_1 Q_2}{R^2} \quad (4.1)$$

where k is the proportionality constant. In SI units, charges Q_1 and Q_2 are in coulombs (C), the distance R is in meters (m), and the force F is in newtons (N) so that $k = 1/4\pi\epsilon_0$. The constant ϵ_0 is known as the *permittivity of free space* (in farads per meter) and has the value

$$\begin{aligned} \epsilon_0 &= 8.854 \times 10^{-12} \approx \frac{10^{-9}}{36\pi} \text{ F/m} \\ \text{or } k &= \frac{1}{4\pi\epsilon_0} \approx 9 \times 10^9 \text{ m/F} \end{aligned} \quad (4.2)$$

Thus eq. (4.1) becomes

$$F = \frac{Q_1 Q_2}{4\pi\epsilon_0 R^2} \quad (4.3)$$

If point charges Q_1 and Q_2 are located at points having position vectors \mathbf{r}_1 and \mathbf{r}_2 , then the force \mathbf{F}_{12} on Q_2 due to Q_1 , shown in Figure 4.1, is given by

$$\mathbf{F}_{12} = \frac{Q_1 Q_2}{4\pi\epsilon_0 R^2} \mathbf{a}_{R_{12}} \quad (4.4)$$

where

$$\mathbf{R}_{12} = \mathbf{r}_2 - \mathbf{r}_1 \quad (4.5a)$$

$$R = |\mathbf{R}_{12}| \quad (4.5b)$$

$$\mathbf{a}_{R_{12}} = \frac{\mathbf{R}_{12}}{R} \quad (4.5c)$$

By substituting eq. (4.5) into eq. (4.4), we may write eq. (4.4) as

$$\mathbf{F}_{12} = \frac{Q_1 Q_2}{4\pi\epsilon_0 R^3} \mathbf{R}_{12} \quad (4.6a)$$

or

$$\mathbf{F}_{12} = \frac{Q_1 Q_2 (\mathbf{r}_2 - \mathbf{r}_1)}{4\pi\epsilon_0 |\mathbf{r}_2 - \mathbf{r}_1|^3} \quad (4.6b)$$

It is important to note that the force

$$\mathbf{F} = \frac{QQ_1(\mathbf{r} - \mathbf{r}_1)}{4\pi\epsilon_0|\mathbf{r} - \mathbf{r}_1|^3} + \frac{QQ_2(\mathbf{r} - \mathbf{r}_2)}{4\pi\epsilon_0|\mathbf{r} - \mathbf{r}_2|^3} + \dots + \frac{QQ_N(\mathbf{r} - \mathbf{r}_N)}{4\pi\epsilon_0|\mathbf{r} - \mathbf{r}_N|^3}$$

$$\mathbf{F} = \frac{Q}{4\pi\epsilon_0} \sum_{k=1}^N \frac{Q_k(\mathbf{r} - \mathbf{r}_k)}{|\mathbf{r} - \mathbf{r}_k|^3}$$