ELECTROMAGNETIC FIELDS AND WAVES

Coulomb's Experimental Law

French physicist **Charles-Augustin de Coulomb** experimentally verified the inverse square law of electrostatic force using a **torsion balance** in 1785.

His experiment established that the force between two charges depends on their magnitudes and the distance between them.

Coulomb's Experimental Law

Coulomb's Experiment:

•**Apparatus Used: Torsion Balance**

- A horizontal bar suspended by a thin wire with small charged spheres at its ends.
- When charges are brought close, they repel/attract, twisting the wire.
- The angle of twist measures the force.

1. Force (F) is directly proportional to the product of charges

$$F \propto q_1 q_2$$

2. Force (F) is inversely proportional to the square of the distance between them

$$F \propto \frac{1}{r^2}$$

3. Combining both, Coulomb's Law is formulated as:

$$F = k\frac{q_1 q_2}{r^2}$$

where k is Coulomb's constant:

$$k = \frac{1}{4\pi\varepsilon_0} \approx 9 \times 10^9\ \mathrm{N}\backslash\mathrm{cdotpm}^2/\mathrm{C}^2$$

- ε_0 (Permittivity of free space) = 8.854×10^{-12} F/m

The **electric field intensity** at a point is defined as the **force per unit charge** experienced by a small test charge placed at that point.

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

Electric Field Due to a Point Charge

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

where:

- E → Electric field intensity (V/m)
- q → Source charge (C)
- r → Distance from the charge (m)

Electric Field Due to Multiple Charges – Superposition Principle

For multiple charges $q_1, q_2, \ldots, q_n$, the total electric field at a point is the vector sum:

$$\mathbf{E} = \sum \mathbf{E_i}$$

where each $\mathbf{E_i}$ is the electric field due to individual charges.

Properties of the Electric Field

- A vector quantity.
- Direction is **radially outward** for **positive** charges and **radially inward** for **negative** charges.
- **Decreases with distance** $(1/r^2)$
- Measured in **volts per meter (V/m).**


Thank you