ELECTROMAGNETIC FIELDS AND WAVES

1. Coulomb's Law

Coulomb's Law states that the force between two stationary point charges is:

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

Key Points:

- F → Force between two charges (N)
- q_1, q_2 → Magnitude of the charges (C)
- r → Distance between the charges (m)
- ε_0 → Permittivity of free space 8.854×10^{-12} F/m
- The force is **attractive** for opposite charges and **repulsive** for like charges.

Vector Form of Coulomb's Law

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

where $\hat{r}$ is the unit vector along the line joining the charges.

2. Electric Field Intensity (E)

Electric field intensity at a point is the force per unit charge experienced by a small positive test charge placed at that point.

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

Electric Field Due to a Point Charge

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

Superposition Principle

For multiple charges, the total electric field is the vector sum:

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

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

3. Electric Flux Density (D)

Electric flux density (D) relates to the electric field and is given by:

$$D = \varepsilon E$$

where

- D → Electric flux density (C/m²)
- E → Electric field intensity (V/m)
- ε → Permittivity of the medium

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Gauss's Law in Terms of D

Gauss's Law states that the total electric flux through a closed surface is equal to the charge enclosed:

$$\oint \mathbf{D} \cdot d\mathbf{A} = Q_{\text{enclosed}}$$

where dA is the differential surface element.

4. Comparison of E and D

Property	Electric Field Intensity (E)	Electric Flux Density (D)
Definition	Force per unit charge	Charge per unit area
Unit	V/m	C/m^2
Medium Dependency	Depends on ε	Independent of ε
Relationship	$E = D/\varepsilon$	$D = \varepsilon E$

Coulomb's Law: Used to calculate forces in electrostatic fields.

Electric Field (E): Determines how charges interact in free space and materials.

Flux Density (D): Essential in **Gauss's Law** and **capacitor design**.

Thank you