PHYSICS REVISION NOTES

Chapter 1: Electric Charges and Fields

Class 12 - CBSE / JEE / NEET

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Chapter 1

Electric Charges and Fields

1.1. 1. Introduction

Electrostatics is the branch of physics that deals with the study of forces, fields, and potentials arising from static charges. The term 'static' implies that the charges are at rest or moving very slowly.

1.2. 2. Electric Charge

Electric charge is an intrinsic property of elementary particles of matter which gives rise to electric force between various objects.

Fundamental Law of Electrostatics

- Like charges (positive-positive or negative-negative) **repel** each other.
- Unlike charges (positive-negative) **attract** each other.

1.2.1 Visualizing Charge Interaction

1.3. 3. Basic Properties of Electric Charge

1. **Additivity:** Total charge is the algebraic sum of individual charges ($Q = q_1 + q_2 + \dots$).
2. **Conservation:** Charge of an isolated system remains constant.

3. **Quantization:** Charge exists in discrete packets.

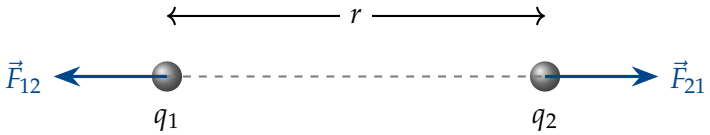
Quantization Formula

$$q = \pm ne \tag{1.1}$$

Where n is an integer and $e = 1.602 \times 10^{-19}$ C.

1.4. 4. Coulomb's Law

The electrostatic force between two stationary point charges is directly proportional to the product of magnitudes of charges and inversely proportional to the square of the distance between them.



Vector Form of Coulomb's Law

$$\vec{F} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}\hat{r} \tag{1.2}$$

Value of k: $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

1.5. 5. Electric Field

The electric field is the region around a charge where its electrostatic influence can be felt by another charge.

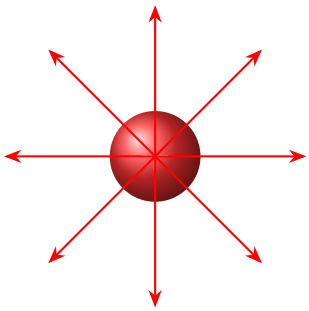
$$\vec{E} = \lim_{q_0 \to 0} \frac{\vec{F}}{q_0} \tag{1.3}$$

1.5.1 Electric Field Lines

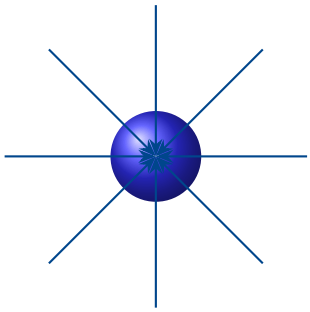
Field lines represent the direction of the electric field. They originate from positive charges and terminate on negative charges.

Pro Tip:

Two electric field lines can **never intersect** each other. If they did, it would mean the electric field has two different directions at the same point, which is physically impossible!



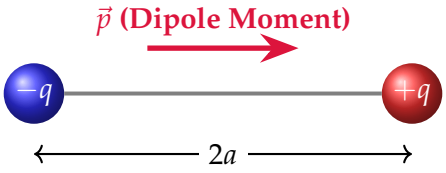
Source: Positive



Source: Negative

1.6. 6. Electric Dipole

An electric dipole consists of two equal and opposite charges separated by a very small distance $2a$.

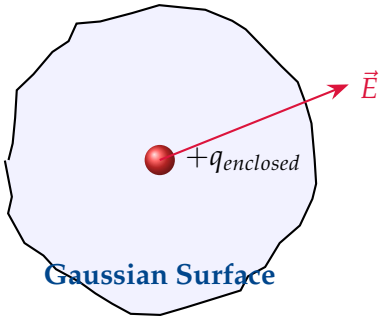


Important Dipole Formulas

- **Dipole Moment:** $\vec{p} = q(2\vec{a})$ *(Direction: $-q$ to $+q$)*
- **Axial Field:** $E_{axial} = \frac{1}{4\pi\epsilon_0}\frac{2p}{r^3}$
- **Equatorial Field:** $E_{equa} = \frac{1}{4\pi\epsilon_0}\frac{p}{r^3}$
- **Torque in Uniform Field:** $\vec{\tau} = \vec{p} \times \vec{E} \implies \tau = pE\sin\theta$

1.7. 7. Gauss's Law

The total electric flux through any closed surface is equal to $1/\epsilon_0$ times the net charge enclosed by the surface.



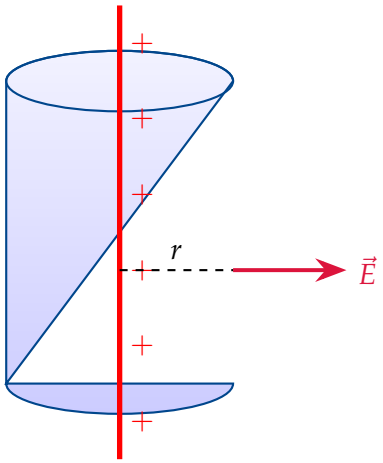
Mathematical Form of Gauss's Law

$$\Phi_E = \oint \vec{E} \cdot d\vec{S} = \frac{q_{in}}{\epsilon_0} \tag{1.4}$$

1.8. 8. Applications of Gauss's Law

1.8.1 A. Field due to Infinite Line Charge

Consider a wire with linear charge density λ.



$$E = \frac{\lambda}{2\pi\epsilon_0 r} \tag{1.5}$$

Quick Revision Summary

Key Formulas Checklist

- ✓ **Quantization:** $q = ne$
- ✓ **Electrostatic Force:** $F = k\frac{q_1 q_2}{r^2}$
- ✓ **Electric Field:** $E = F/q_0$
- ✓ **Dipole Moment:** $p = 2aq$
- ✓ **Torque on Dipole:** $\tau = pE\sin\theta$
- ✓ **Electric Flux:** $\Phi = \vec{E} \cdot \vec{S}$
- ✓ **Gauss's Law:** $\Phi_{total} = q_{in}/\epsilon_0$

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