

## Electric Charge

Charge is a property of matter due to which two bodies interact with each other electromagnetically. There are two kinds of charges- positive and negative. SI unit is coulomb. Charge is quantized and additive.

## Coulomb's Law

Force between two charges

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

$\epsilon_r$  = dielectric constant of the medium,  $\epsilon_0$  = permittivity of free space



• Coulomb's Law is applicable only for static point charges.

## Principle of Superposition

Force on a point charge due to many charges is given by

$$\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \dots$$

• The force due to one charge is not affected by the presence of other charges.

## Electric Field or Electric Field Intensity

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

Unit is N/C or V/m.

## Electric Field due to Point Charge Q

$$\vec{E} = \lim_{q_0 \rightarrow 0} \frac{\vec{F}}{q_0} = \frac{1}{4\pi \epsilon_0} \frac{Q}{r^2} \hat{r}$$

## Null Point for Two Charges



⇒ Null point is near  $Q_2$

$$x = \frac{\sqrt{Q_1}r}{\sqrt{Q_1} \pm \sqrt{Q_2}}$$

$x \rightarrow$  distance of null point from  $Q_1$  charge

(+) for like charges [null point will be in between  $Q_1$  &  $Q_2$ ]  
 (-) for unlike charges [null point will be outside  $Q_1$  &  $Q_2$  and near weaker charge]

## Equilibrium of Three Point Charges



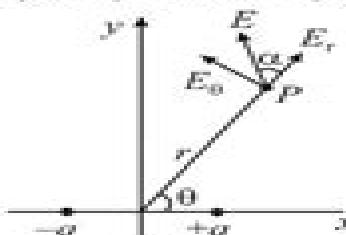
(i)  $Q_1$  &  $Q_2$  must be of like nature.

(ii)  $q$  should be of unlike nature.

$$x = \frac{\sqrt{Q_1}}{\sqrt{Q_1} + \sqrt{Q_2}} r \text{ and } q = \frac{-Q_1 Q_2}{(\sqrt{Q_1} + \sqrt{Q_2})^2}$$

## Electric Dipole

- Electric dipole moment  $\vec{p} = q\vec{d}$ , where  $\vec{d}$  is distance from negative to positive charge.
- Torque on dipole placed in a uniform electric field  $\vec{\tau} = \vec{p} \times \vec{E}$
- Electric field at a general point due to a dipole.



$$\text{Electric field: } E = \frac{1}{4\pi \epsilon_0} \frac{p \sqrt{1 + 3 \cos^2 \theta}}{r^3}$$

$$\text{Direction: } \tan \alpha = \frac{E_x}{E_y} = \frac{1}{2} \tan \theta$$

## 21 Study Guide Electric Fields

**James Kyle, Ken W. Sessions**

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## Table of Contents 21 Study Guide Electric Fields

1. Understanding the eBook 21 Study Guide Electric Fields
  - The Rise of Digital Reading 21 Study Guide Electric Fields
  - Advantages of eBooks Over Traditional Books
2. Identifying 21 Study Guide Electric Fields
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an 21 Study Guide Electric Fields
  - User-Friendly Interface
4. Exploring eBook Recommendations from 21 Study Guide Electric Fields
  - Personalized Recommendations
  - 21 Study Guide Electric Fields User Reviews and Ratings
  - 21 Study Guide Electric Fields and Bestseller Lists
5. Accessing 21 Study Guide Electric Fields Free and Paid eBooks
  - 21 Study Guide Electric Fields Public Domain eBooks
  - 21 Study Guide Electric Fields eBook Subscription Services
  - 21 Study Guide Electric Fields Budget-Friendly Options
6. Navigating 21 Study Guide Electric Fields eBook Formats
  - ePub, PDF, MOBI, and More
  - 21 Study Guide Electric Fields Compatibility with Devices
  - 21 Study Guide Electric Fields Enhanced eBook Features
7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of 21 Study Guide Electric Fields
  - Highlighting and Note-Taking 21 Study Guide Electric Fields
  - Interactive Elements 21 Study Guide Electric Fields
8. Staying Engaged with 21 Study Guide Electric Fields

- Joining Online Reading Communities
- Participating in Virtual Book Clubs
- Following Authors and Publishers 21 Study Guide Electric Fields

9. Balancing eBooks and Physical Books 21 Study Guide Electric Fields

- Benefits of a Digital Library
- Creating a Diverse Reading Collection 21 Study Guide Electric Fields

10. Overcoming Reading Challenges

- Dealing with Digital Eye Strain
- Minimizing Distractions
- Managing Screen Time

11. Cultivating a Reading Routine 21 Study Guide Electric Fields

- Setting Reading Goals 21 Study Guide Electric Fields
- Carving Out Dedicated Reading Time

12. Sourcing Reliable Information of 21 Study Guide Electric Fields

- Fact-Checking eBook Content of 21 Study Guide Electric Fields
- Distinguishing Credible Sources

13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
- Exploring Educational eBooks

14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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