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Changing your Tomorrow

The Force between multiple charges, Superposition principle, Continuous charge distribution.

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 01
CHAPTER NAME : ELECTRIC CHARGES AND FIELDS

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LEARNING OUTCOME

- The principle of superposition allows the extension of Coulomb's law to include any number of point charges—in order to derive the force on any one point charge by a vector addition of these individual forces acting alone on that point charge.
- Describe charge in terms of continuous charge density; it becomes possible to calculate the charge on the surface of objects as large as celestial bodies.

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REVIEW

- Define 1 C of charge from Coulomb's Law.
- Find out the force of interaction between two particles in air or vacuum at a distance of 1m.
- How far apart the electrons are if the force exerted by one upon another is equal to the weight of the electron?
- State Coulomb’s law.
- Write the law in vector form.
- Show that Coulomb’s law obeys Newton’s third law of motion

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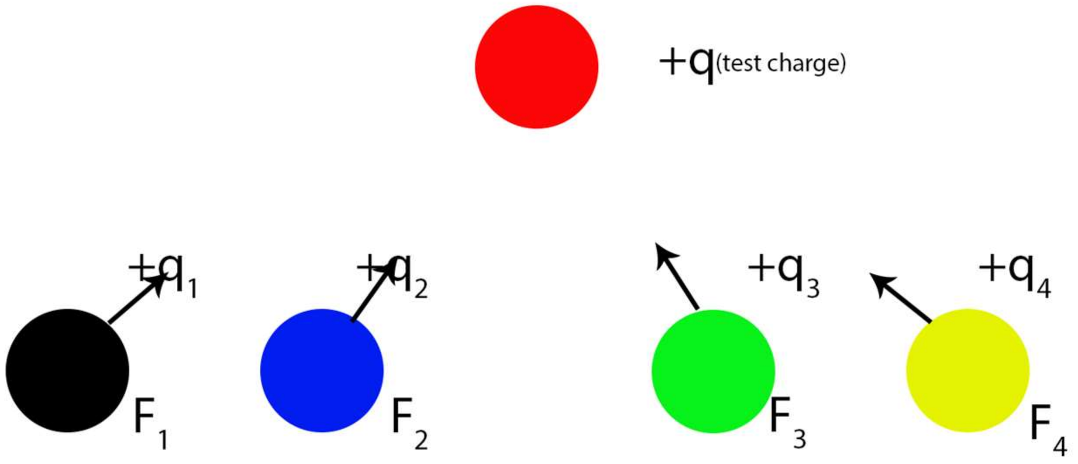
PRINCIPLE OF SUPERPOSITION OF CHARGES

When a no of charges is interacting the total force on a given charge is the vector sum of the forces exerted on it due to all other charges.



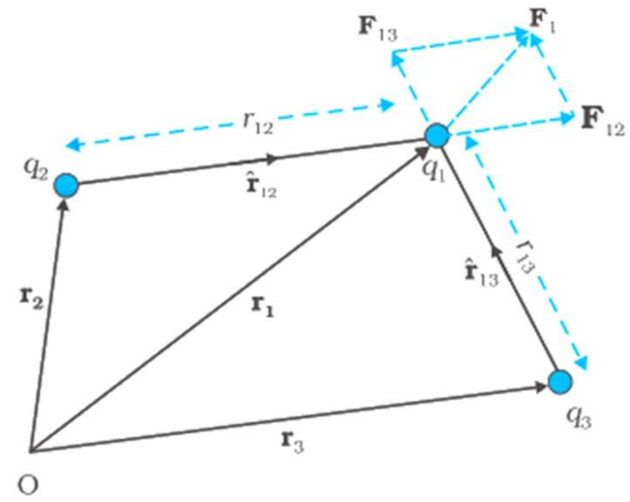
PRINCIPLE OF SUPERPOSITION OF CHARGES

From the figure, the force on charge q_1

$$\vec{F}_1 = \vec{F}_{12} + \vec{F}_{13} \Rightarrow \vec{F}_1 = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1 q_2}{r_{12}^2}\hat{r}_{12} + \frac{q_1 q_3}{r_{13}^2}\hat{r}_{13}\right]$$

For a system consisting of no charge

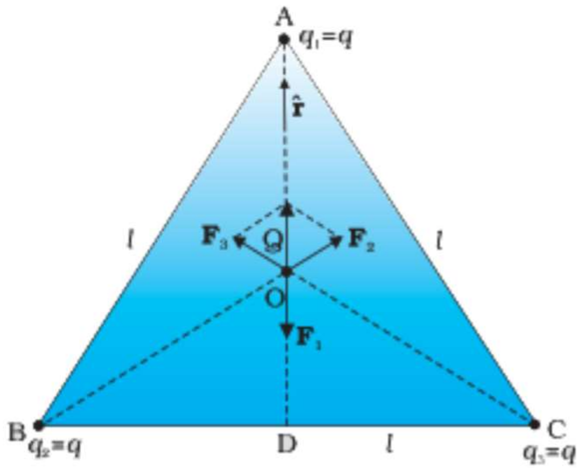
$$\vec{F}_1 = \vec{F}_{12} + \vec{F}_{13} + \vec{F}_{14} + \ldots + \vec{F}_{1n} = \frac{1}{4\pi\varepsilon}\left[\frac{q_1 q_2}{r_{12}^2}\hat{r}_{12} + \frac{q_1 q_3}{r_{13}^2}\hat{r}_{13} + \ldots\ldots + \frac{q_1 q_n}{r_{1n}^2}\hat{r}_{1n}\right] = \frac{q_1}{4\pi\varepsilon_0}\sum_{i=2}^{n}\frac{qi}{r_{1i}}$$



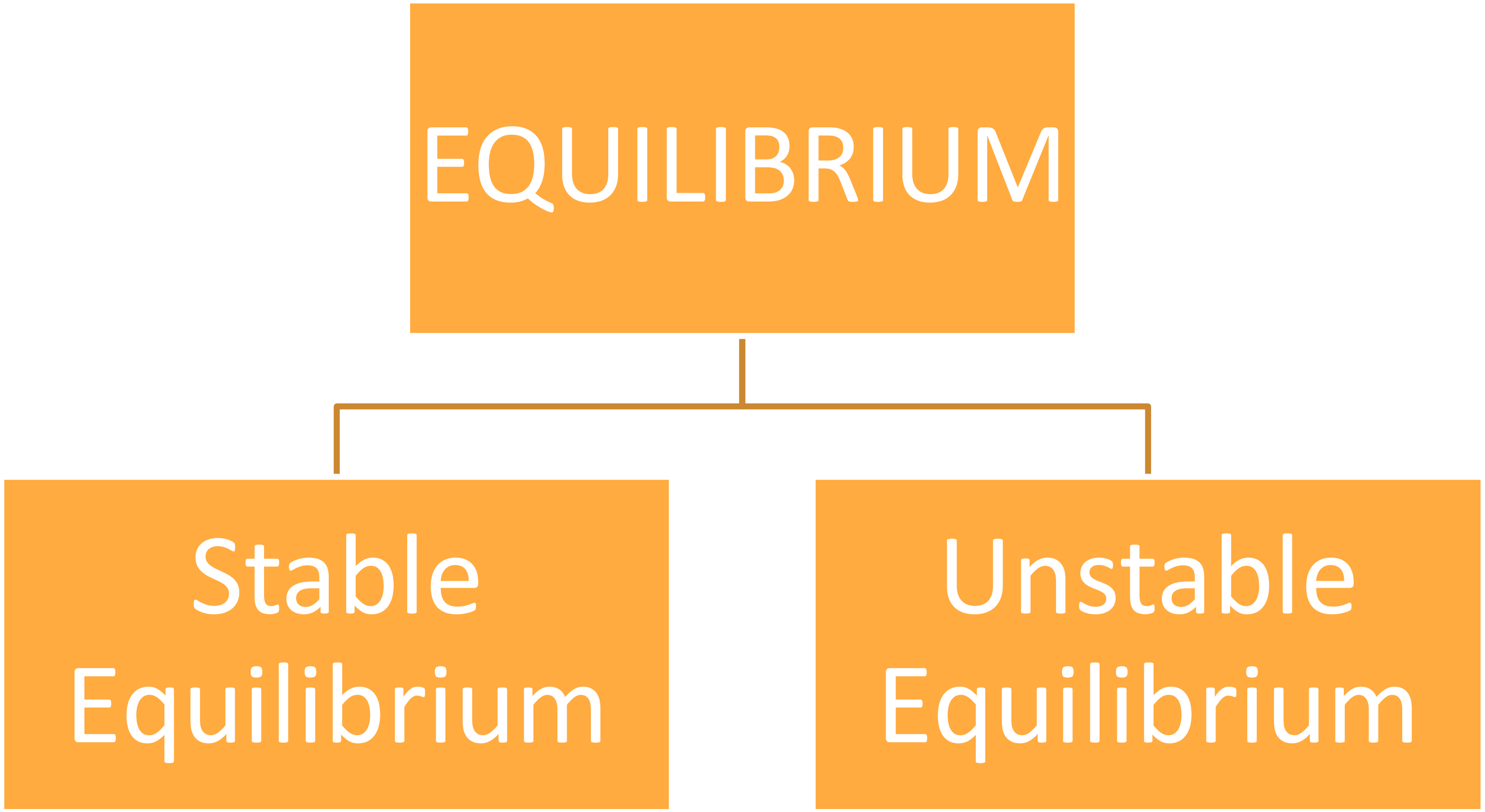
NCERT NUMERICAL

Question:

Consider three charges q_1, q_2, and q_3 each equal to q at the vertices of an equilateral triangle of side '*l*'. What is the force on a charge 'Q' (with the same sign of q) placed at the centroid of the triangle? (NCERT)



EQUILIBRIUM OF CHARGES



EQUILIBRIUM OF CHARGES

Stable Equilibrium:-

- $\vec{F}_{net}$ or $\vec{\tau}_{net}$ on charged particle must be zero
- After displacing the charged particle from its initial position it returns.
- Potential energy must be minimum.

NCERT NUMERICAL

1. A charge q is placed at the centre of the line joining two charges Q. The system of three charges to be in equilibrium, what should be the value of q?

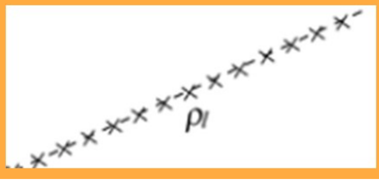
2. Two small spheres each having mass m and charge q are suspended from a point by insulating threads each of length l but negligible mass. If θ is the angle made by each string with the vertical at equilibrium then show that

$$q^2 = \left(4mg\ell^2 \sin^2\theta \tan\theta\right)4\pi\varepsilon_0$$

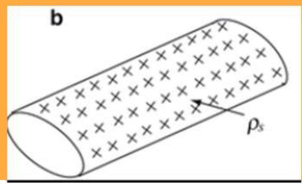
CONTINUOUS CHARGE DISTRIBUTION:-

Continuous Charge Distribution

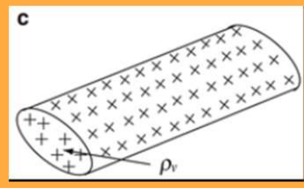
- **Linear charge distribution**



- **Surface charge distribution**



- **Volume charge distribution**



CONTINUOUS CHARGE DISTRIBUTION:-

Linear charge distribution

(a)When the charge is distributed along a line e.g a straight line or circumference of a circle or a curved line, then it is linear charge distribution.

Surface charge distribution

- When the charge is distributed along a surface e.g. a sheet of charge or a charged conducting surface, then it is surface charge distribution

Volume charge distribution

(a)When the charge is distributed throughout the volume of a charged body, then it has a volume charge distribution.

POINTS TO PONDER

1. Volume charge density, $\rho = \frac{dq}{dV}$

2. Surface charge density, $\sigma = \frac{dq}{dS}$

3. Linear charge density, $\lambda = \frac{dq}{dL}$

4. Force exerted on a charge q_0 due to a continuous charge distribution

$$\vec{F} = \frac{q_0}{4\pi\varepsilon_0} \int \frac{dq}{r^2}\, \hat{r}$$

5. Electric field due to a continuous charge distribution

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \int \frac{dq}{r^2}\, \hat{r}$$

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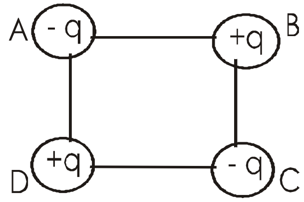
HOME ASSIGNMENT

1. The opposite corners of a square carry Q charge each and the other two opposite corners of the same square carry q charge each. If the resultant force of q is zero, how are Q and q related?



2. Two identical metal spheres A & B of equal and similar charge repel each other with a force of $2 \times 10^{-5} N$. A third identical uncharged sphere C is touched to A and then placed midpoint between A & B. What is the net electric force on C?

3. A small charged body is placed at the center of the line joining two equal charges 'Q'. Prove that the system of three charges will be in equilibrium if $q = -\frac{Q}{4}$

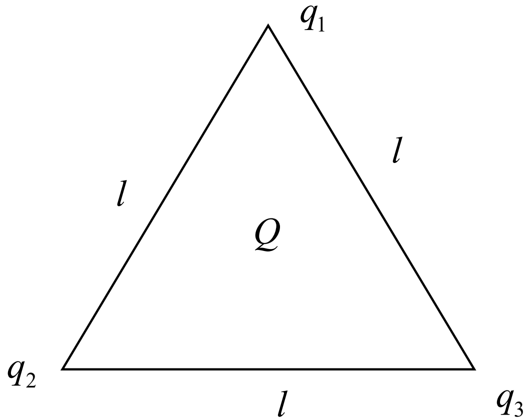


fig.(1.9)

THANKING YOU

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