Toppersnotes

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CBSE

CLASS 12TH

THE CENTRAL BOARD OF SECONDARY EDUCATION

PART – VIII

PHYSICS - I

SIERRA INNOVATIONS

PHYSICS - 1

Chapter 1
Electric Charges and Fields

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Electric Charge

The excess and deficiency of electron at an atom in normal state is called electric charge.

It means “electric charge is produced due to the transferring of electrons”.

- If an atom have ‘n’ electron is excess then,

$q = ne$ Negative charge

- If an atom have ‘n’ electron in deficiency then,

$q = ne$ positive charge

Positive charge emits electric force of lines and charge absorbs these lines hence, they are approaching to each other it is called attraction.

Similarly, “ like charge repel each other”.

$q = ne$

Where, ‘e’ called electronic charge. Its value is 1.6×10^{-19}C. It is also called basic charge or fundamental charge because there is no existence this charge. It is also called unit charge because it is whole multiple of any charge.

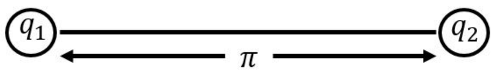
Unit of charge

1. Coloumb
2. Faraday
3. Franklene
4. e.s.u. (ectrostatic charge)
5. e.m.u (electromagnetic charge)

Coloumb law

The force of attraction and repulsion between the two point charges is directly proportional to the product of their magnitude and inversely proportional to the square of the distance between them direction along line joining them.

Suppose two point charges q_1 and q_2 are placed at a distance 'r' apart in a medium of di-electric constant 'k' then the force between them is given by,



Value of k

1. air = 1.008
2. water = 81
3. metal = ∞
4. vacuum = 1

$$\in = \in_0 K$$

$$\in_0 \rightarrow absolute\ permitivity\ of\ medium$$

$$K = \frac{\in}{\in_0}$$

$$\in_r \rightarrow relative\ perimitivity$$

Coloumb law (vector form)

$$\hat{r} = unit\ vector\ [Magnitude\ only]$$

$$r = |\vec{r}| = mode\ of\ \vec{r}\ [\ directly\ only]$$

$$\vec{r} = \hat{r}|\vec{r}| = \hat{r}r$$

$$\hat{r} = \frac{r^2}{r}$$

$$=> F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\ [Scaler\ form]$$

$$=> F = \frac{1}{4\pi\varepsilon_0}.\frac{q_1q_2}{r^2}.\hat{r}\ [unit\ vector]$$

$$\boxed{=> F = \frac{1}{4\pi\varepsilon_0}.\frac{q_1q_2}{r^3}\ \vec{r}}$$ [Vector form]

$$\vec{F}_{12} \rightarrow force\ of\ 1\ due\ to\ 2.$$

$$\vec{F}_{21} \rightarrow Force\ of\ 2\ due\ to\ 1.$$

$$\vec{r}_{12} \rightarrow Direction\ from\ 1\ to\ 2.$$

$$\vec{r}_{21} \rightarrow Direction\ from\ '2'\ to\ 1.$$

$$\vec{F} = \frac{1}{4\pi\varepsilon_0}.\frac{q_1q_2}{r^2}.\hat{r}$$

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0 K}.\frac{q_1q_2}{r_{21}}\ \vec{r}_{21}$$

$$F_{21} = \frac{1}{4\pi\varepsilon_0 K}.\frac{q_1q_2}{r_{12}^3}.\vec{r}_{12}$$

Position vector form

$$\vec{r}_{12} + \vec{r}_1 = \vec{r}_2$$

$$\vec{r}_{12} = \vec{r}_2 - \vec{r}_1$$

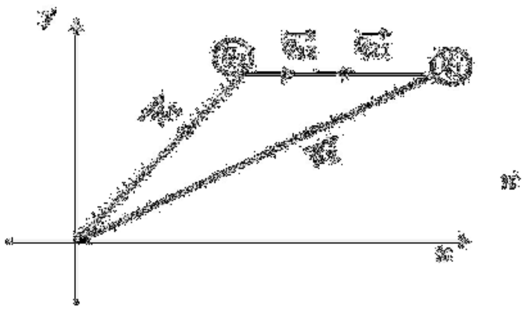
$$\vec{r}_2 = \vec{r}_{21} = \vec{r}_1$$

$$\vec{r}_{21} = \vec{r}_1 - \vec{r}_2$$

$$\boxed{\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0}.\frac{q_1q_2}{r^3}.\vec{r}_{21}}$$

in vector form

$$\vec{r}_{21} = \vec{r}_1 - \vec{r}_2$$



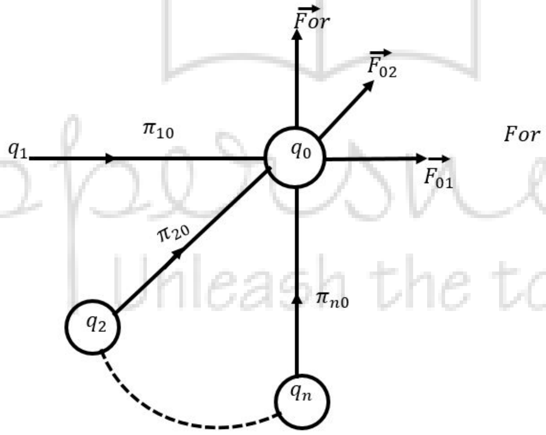
$$F_{12} = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 q_2}{(\vec{r}_1 - \vec{r}_2)^3} \ (\overrightarrow{r_1} - \overrightarrow{r_2})$$

$$\vec{r}_{12} = \vec{r}_2 - \vec{r}_1$$

$$F_{21} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{(\vec{r}_2 - \vec{r}_1)^3} \cdot (\vec{r}_2 - \vec{r}_1)$$

Principal of superposition

It is the vector sum of all forces acting on a given charge.



$$=> \ \vec{F} = \vec{F}_{01} + \overrightarrow{F_{02}} + \cdots \ldots \ldots \ldots . + \vec{F}_{0n}$$

$$=> \ \vec{F} = \frac{1}{4\pi\epsilon_0}\left[\frac{q_1 q_2 \ \vec{r}_{10}}{r_{10}^3} + \frac{q_2 q_0 \ \vec{r}_{20}}{r_{20}^3} + \cdots \ldots \ldots . . \frac{q_n q_0}{r_{n0}^3} \ \vec{r}_{n0}\right]$$

$$=> \ \vec{F} = \frac{1}{4\pi\epsilon_0} \cdot q_0 \ \sum_{i=1}^{i=n} \frac{qp}{r_{i0}^3} \cdot \vec{r}_{i0}$$

Law of conservation of electric charge

Charge cannot be created or destroyed because charge is produced due to transferring of electron.

Electric field

The space surrounding a charge in which any other test charge experience a force of attraction and repulsion is called electric field.

Electric field can be expressed in two terms

1. electric field intensity
2. electric potential

Test charge

It is always taken as the positive and small in magnitude.

Electric field intensity

The force acting per unit test charge at any point in electric field is called electric field intensity (E).

It is a vector quantity. If force charge is positive then its direction away from the charge and for negative charge its direction is toward the charge.

Suppose a test charge 'q_0' experience a force 'F' at a point in electric field, the electric field intensity is given by,

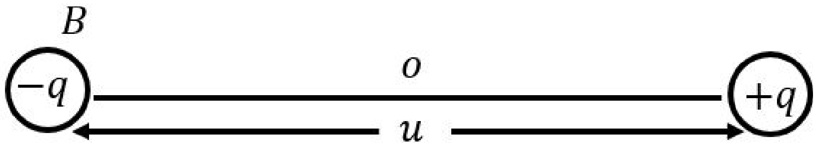
$$(\vec{E} = \frac{\vec{F}}{q_0} = \frac{Newton}{Coulomb} = \left[\frac{MLT^{-2}}{AT}\right] = [MLT^{-3}A]$$

$$If\ q_0 \to 0$$

$$\boxed{\vec{E} = \frac{lim}{q_0 \to 0} . \frac{\vec{F}}{q_0}}$$

Electric field intensity due to a point charge

Suppose a charge 'q' is placed at a point 'O' there is point 'P' at distance 'r' at which we have to determine electric field intensity. For this we kept a test charge 'q_0'at 'P' then the force between is given by,



$$\vec{F} = \frac{1}{4\pi E_0} \frac{q q_0}{r^2} \hat{r}$$

$$\vec{E} = \frac{\vec{F}}{q_0} = \frac{1}{4\pi\epsilon_0} . \frac{q\ q_0}{r^2} \hat{r}/q_0$$

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

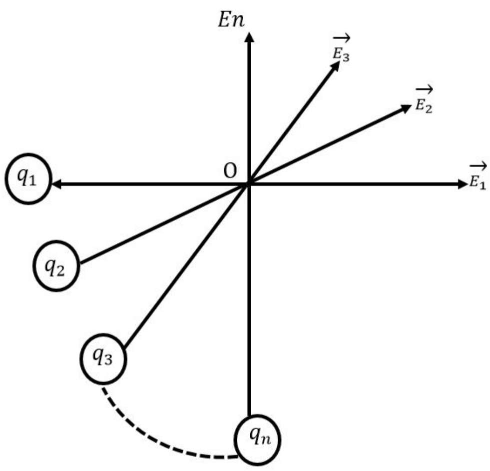
$$\boxed{\vec{E} = \frac{1}{4\pi\varepsilon_0} . \frac{q\vec{r}}{r^3}}$$

Principal of superposition in electric field intensity

$$=> \vec{F} = \frac{1}{4\pi E_0} . \frac{q_1}{r^2} \hat{r}$$

$$=> \vec{E} = \vec{E}_1 + \vec{E}_2 + \cdots \dots \dots \vec{E}_n$$

$$=> \vec{E} = \frac{1}{4\pi\varepsilon_0} \left[\frac{q_1 \hat{r}_1}{r_1^2} + \frac{q_2 \hat{r}_2}{r_2^2} + \cdots \dots .. + \frac{q_n}{r_n^2} \hat{r}_n \right]$$



Electric dipole

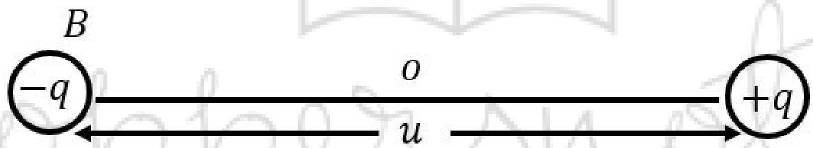
When two equal and opposite charge are displaced at very short distance is called electric dipole.

For eg. HCl, H_2O etc.

Electric dipole moment

The product of one charge and the distance between them is called electric dipole moment (P). It is vector quantity its direction from negative to positive.

Suppose an electric dipole consisting of charges (-q) and (-q) and having the distance (2l) between them electric dipole moment is given by,



$$\vec{P} = q \times 2l$$

$$\vec{P} = coul. \times mt.$$

$$\vec{P} = [ATL]$$

It is vector quantity

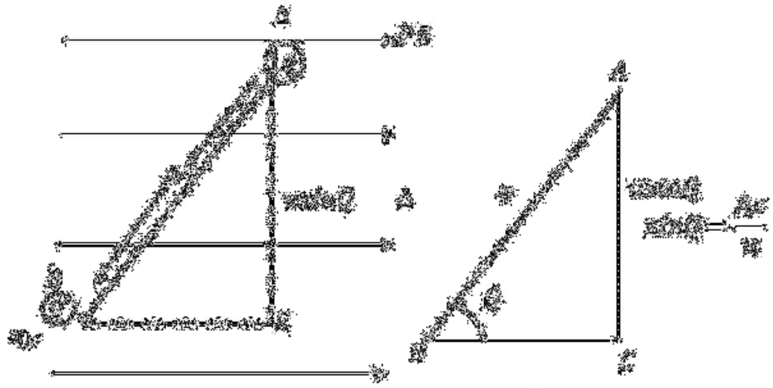
Its direction is from negative to positive

$$o \rightarrow Point\ of\ reference.$$

Torque on an electric dipole in a uniform electric field

Suppose an electric dipole (AB) is placed in a uniform electric field (E) dipole makes an angle 'θ' with the direction of electric field.

Charge '+q' experiences a force 'qE' in the direction of electric field and negative charge experiences in the opposite direction of electric field these forces produced a torque on the dipole.



$$\tau = force \times perpendicular\ distance$$

$$\tau = qE \times 2lsin\theta$$

$$\tau = q \times 2lEsin\theta$$

$$\tau = PEsin\theta$$

$$\vec{\tau} = \vec{P} \times \vec{E}$$

$$\vec{\tau} = PEsin\theta\hat{n}$$

Unit → N x mt [ML^2T^{-2}]

If θ is 0^0 , τ *is minimum*

If θ is 90^0 , τ *is maximum*

Electric field intensity due to an electric dipole in axial position or Endon positive

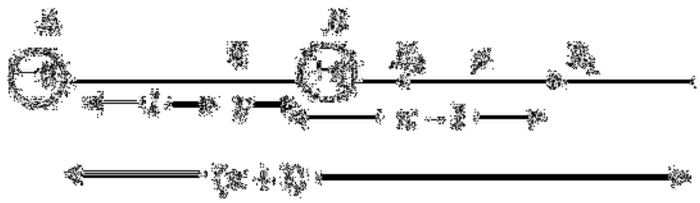
Suppose an electric dipole AB consisting of charges '-q' and '+q' having the distance 2*l* between them, there is a point 'P' at the axial position of the dipole at which we have to determine the EFI.

$$E.F.I\ due\ to\ positive\ E_1 = \frac{1}{4\pi E_0}\frac{q}{(r-l)^2}$$

$$E.F.I\ due\ to\ negative\ E_2 = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{(r+2)^2}$$

$$Net\ field\ intensity$$

$$E = E_1 - E_2$$



$$E = \frac{1}{4\pi E_0}q\left\{\frac{1}{(r-2)^2} - \frac{1}{(r+2)^2}\right\}$$

$$E = \frac{1}{4\pi E_0}\cdot q\left\{\frac{(r+2)^2-(r-l)^2}{(r-l)^2\,(r+l)^2}\right\}$$

$$E = \frac{1}{4\pi E_0}\cdot\frac{q\times 4rl}{(r^2-l^2)^2}$$

$$E = \frac{1}{4\pi\varepsilon_0}\,\frac{q\times 4rl}{(r^2-l^2)^2}$$

$$E = \frac{1}{4\pi\varepsilon_0}\,\frac{q\times 2l.2r}{(r^2-l^2)^2}$$

$$r \ggg> l$$

$$r^2 \ggg> l$$

Which means $l \to 0$

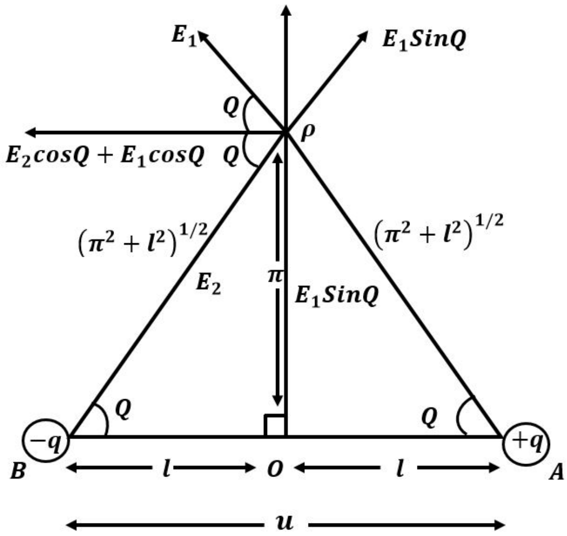
$$E = \frac{.1}{4\pi\varepsilon_0}\cdot\frac{p\times 2r}{r^{43}}$$

$$\boxed{E = \frac{1}{4\pi E_0}\cdot\frac{2p}{r^3}}$$

$$At\ axial\ position$$

The direction of resultant E.F. along the direction of electric dipole moment.

Electric field intensity due to an electric dipole at equilateral position or perpendicular position



$$\left|\vec{E_1}\right| = \left|\vec{E}_2\right| = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{(r^2 + l^2)}$$

Net E.F.I. Along axis

$$Ey = E_1 sin\theta - E_2 \sin\theta$$

$$\boxed{E_y = 0}$$

Net E.F.I. along $x - axis$

$$E_X = E_1\ cos\theta + E_2\ Cos\ \theta$$

$$E_2 = E_2$$

$$E_X = 2E\cos\theta$$

$$\boxed{E_X = 2.\frac{1}{4\pi\epsilon_0}.\frac{q}{(r^2 + l^2)}\ cos\theta}$$

In $\Delta O\ AP$.

$$Cos\theta = \frac{l}{(r^2 + l^2)^{\frac{1}{2}}}$$

$$E_X = \frac{1}{4\pi\epsilon_0}\frac{2q}{(r^2 + l^2)}.\frac{l}{(r^2 + l^2)^{\frac{1}{2}}}$$

$$\boxed{E_X = \frac{1}{4\pi\epsilon_0}.\frac{P}{r^3}}$$

$$At\ equitorial\ position$$

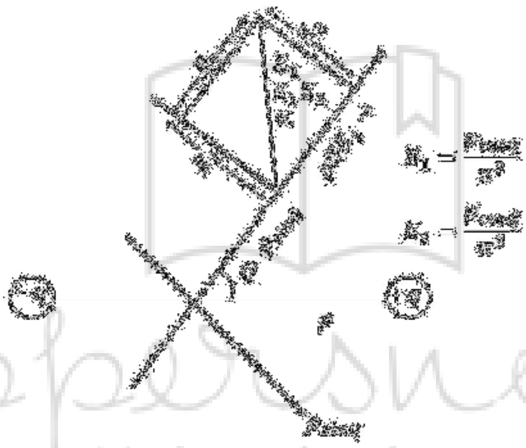
$$\vec{E} = \vec{E}_X + \vec{E}_4$$

$$\boxed{\vec{E} = \frac{1}{4\pi\epsilon_0} . \frac{P}{r^3}}$$

$$\{\overrightarrow{E_y} = 0\}$$

The direction of resultant E.F. opposite to the direction of electric displacement.

EFI due to an electric dipole at any point



$$E^2 = E_1^2 + E_2^2$$

$$E^2 = \left(\frac{2pcos\theta}{r^3}\right) + \left(\frac{P\ sin\theta}{r^3}\right)^2$$

$$E^2 = \left(\frac{P}{r^3}\right)^2\ \{4\ cos^2\theta + sin^2\theta\}$$

$$E^2 = \left(\frac{p}{r^3}\right)^2 \{3\ cos^2\ \theta + cos^2\theta + sin^2\theta\}$$

$$E^2 = \left(\frac{p}{r}\right)^2\ \{3\ cos^2\theta + 1\}$$

$$\boxed{E = \frac{p}{r^3}\ (3\ cos^2\theta + 1)^{1/2}}$$

In Cgs System ;

$$\frac{1}{4\pi\varepsilon_0} = 1\ in\ C.G.S$$

$$or$$

$$E = \frac{1}{4\pi\epsilon_0}.\frac{2p}{r^3}$$

For equatorial Position $\theta = 90^0$

$$\boxed{E = \frac{1}{4\pi\varepsilon_0}.\frac{P}{r^3}}$$

Direction :-

$$tan \propto = \frac{E_2}{E_1} = \frac{\cancel{p}\ sin\theta/\cancel{r^3}}{2\cancel{P}cos\theta/\cancel{r^3}}$$

$$\boxed{tan \propto = \frac{1}{2}\tan\theta}$$

Area vector

The area taken in perpendicular direction of given area is called area vector.

Electric flux

It is the measurement of number of electric force of line passes through the given area it is called electric flux.

It is equal to the scalar product of electric field intensity and area vector.

$$\emptyset E = \vec{E}.\vec{A} = \frac{N\,m^2}{C}$$

$$\emptyset E = \vec{E}.\overrightarrow{dA} = [ML^3T^{-3}A^{-1}]$$

$$\emptyset E = \int \vec{E}.\overrightarrow{dA}$$

$$\boxed{\emptyset E = \int E.dA\,cos\theta}$$

If θ < 90^0, $\emptyset_E$ is positive EFI comes out from given area.

If θ>90^0, $\emptyset_E$ is negative EFI enter in given area.

Ifθ = 90^0, $\emptyset_E$ = 0

Gauss Theorem

It states that the total electric flux passing through the given area is equal to the $1/\epsilon_0$ times of enclosed charge.

$$d\emptyset_E = \frac{1}{\epsilon_0}\sum q$$

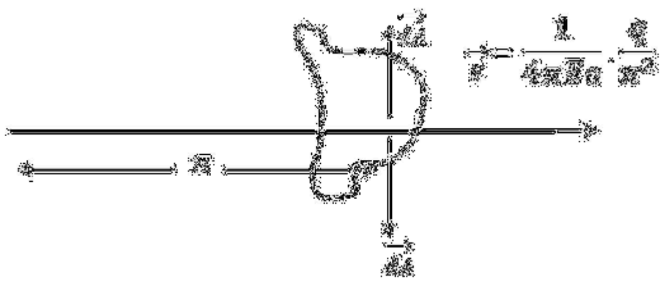
$$\int \vec{E}.d\vec{A} = \frac{1}{\epsilon_0}\sum q$$

Deduction of Gauss theorem from coulomb law

Suppose a point charge q is placed at a point a there is a point P at a distance r from O at this point the electric field intensity due to charge q is given by,

$$\epsilon = \frac{1}{4\pi\ \epsilon_0}\frac{q}{r^3}$$

Let there is a small area dA and its perpendicular d$\vec{A}$. It means the direction of electric field intensity is same hence [$\theta = 0$]



$$\emptyset E = \int \vec{E}.\overrightarrow{dA}$$

$$\emptyset E = \int E.dAcos\theta$$

$$\emptyset E = \int E.dA\ \ \{\theta = 0^0\}$$

$$\emptyset E = \int EdA \ \{Gaussion\ surface\}$$

$$\emptyset E = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r^2} \cdot 4\pi r^2$$

$$\boxed{\emptyset E = \frac{q}{E_0}}$$

Deduction of coulomb law from Gauss theorem

$$\emptyset E = \frac{q}{\in_0}$$

$$\int \vec{E} . \overrightarrow{dA} = \frac{q}{\in_0}$$

$$\theta = 0^0$$

$$E \int dA = \frac{q}{\in_0}$$

$$E . 4\pi r^2 = \frac{q}{\epsilon_0}$$

$$\boxed{E = \frac{q}{\in_0} \cdot \frac{1}{4\pi r^2}}$$

$$E = \frac{E}{q_0}$$

$$F = Eq_0$$

$$F = q_0 \ \frac{1}{4\pi r^2} \cdot \frac{q}{\epsilon_0}$$

$$\boxed{F = \frac{1}{4\pi\epsilon_0} \cdot \frac{q \ q_0}{r^2}}$$

Electric field intensity due to line charge

Suppose a line charge '*l*' and having a charge q and linear charge density ƛ there is a point P at a distance r from the line charge at which we have to determine the electric field intensity