$$\vec{E} = \frac{1}{4\pi\epsilon_0}\cdot\frac{Q}{r^2}\,\hat{r} \quad \text{along } \vec{OP}$$

NOTE The Electric field vector ($\vec{E}$) around a +ve charge are directed radially outwards.

Electric field Intensity Due to Gp. of Charge.

$\vec{E}$ due to gp of point charges is equal to vector sum of Electric field intensities due to individual charges at same pt.

Same as superposition principle,

i.e. $\vec{E} = \vec{E}_1 + \vec{E}_2 + \dots + \vec{E}_n$

$$\boxed{\vec{E} = \frac{1}{4\pi\epsilon_0}\sum_{i=1}^{n}\frac{Q_i}{r_i^2}\hat{r}_i} \quad \text{--- (1)}$$

Where $Q_1, Q_2, Q_3 \dots$ are the charges located at positions $\vec{r}_1, \vec{r}_2, \vec{r}_3$ from the test charge q_0.

In terms of position vectors.

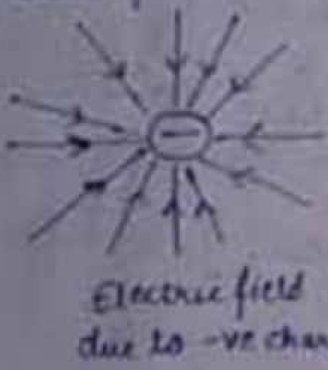
$$\vec{E} = \frac{1}{4\pi\epsilon_0}\cdot\frac{Q}{r_{12}^2}\hat{r}_{12} = \frac{1}{4\pi\epsilon_0}\cdot\frac{Q}{r_{12}^3}\cdot\vec{r}_{12}$$

$$\boxed{\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{Q}{|\vec{r}_2 - \vec{r}_1|^3}(\vec{r}_2 - \vec{r}_1)}$$

5. ELECTRIC FIELD LINES.

It is defined as a path either straight or curved such that tangent to it at any pt. gives the direction of Electric field intensity at that point

Electric field due to +ve charge.

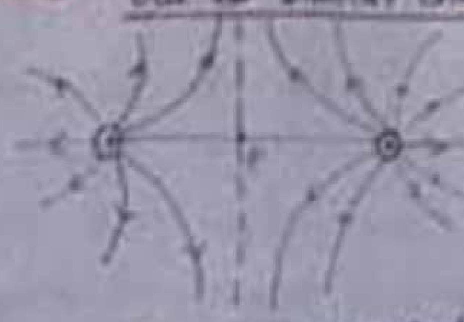


Electric field due to -ve charge.

AB is electric field line

• $\vec{E}_M$ & $\vec{E}_N$ are $\vec{E}$ at pt. M & N

Due to Opposite Charge SATYAKUL CLASSES Due to Similar Charge ⑦



Here P is the neutral point, where electric field is Zero

Here P is the neutral point

5 b) PROPERTIES OF ELECTRIC FIELD LINES

Electric field lines are discontinuous curves. They starts from +ve charge & end at -ve charge.

No Electric field lines exists inside the charged body.

Tangent to the electric field lines at any pt gives the direction of $\vec{E}$ at that pt.

No two electric field lines of force can intersect each other.

The electric field lines are always normal the surface of conductor.

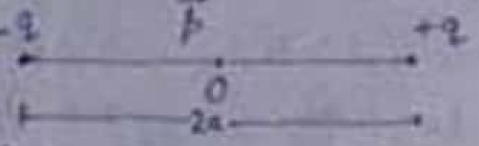
The electric field lines contract longitudinally due to attraction b/w unlike charges.

Electric field lines exert a lateral pressure due to repulsion of like charges.

6. ELECTRIC DIPOLE

An electric dipole consists of a pair of equal & opposite pt charges separated by some small distance.

where $+q$ & $-q$ are equal & opposite charges separated by a distance $2a$ forms an Electric Dipole.



DIPOLE MOMENT

It is the measure of strength of electric dipole.

Defined as the product of magnitude of either charge and the distance b/w the charges. Denoted by $\vec{p}$. It is a Vector quantity directed from -ve to +ve charge. given by,

$$\boxed{\vec{p} = q \times (2a)}$$

Units are C-m.

NOTE **IDEAL DIPOLE** :- If the charges ±q becomes larger & larger & the separation 2a becomes smaller & smaller, then the dipole is called as Ideal Dipole.

- Net Charge of an Ideal electric dipole is Zero.
- If centre of mass of +ve charge coincides with centre of mass of -ve charge the molecule behaves non-polar. as $(2a \approx 0)$

6 a) ELECTRIC FIELD INTENSITY ON AXIAL LINE OF DIPOLE

Consider an electric dipole having charges -q & +q located at a distance 2a apart.
Let P be the point on axial line of dipole where we have to calculate electric field intensity such that OP = r, where O is the mid-of dipole.

Here if $\vec{E}_1$ is the electric field intensity at P due to -q charge at A then

$$|\vec{E}_1| = \frac{1}{4\pi\epsilon_0}\cdot\frac{q}{AP^2} \Rightarrow \boxed{\vec{E} = \frac{1}{4\pi\epsilon_0}\cdot\frac{q}{(r+a)^2}} \text{ Along } \vec{PA} \quad — (1)$$

Again if $\vec{E}_2$ is the electric field intensity at P due to +q charge at B then,

$$|\vec{E}_2| = \frac{1}{4\pi\epsilon_0}\cdot\frac{q}{(BP)^2} \Rightarrow \boxed{\vec{E} = \frac{1}{4\pi\epsilon_0}\cdot\frac{q}{(r-a)^2}} \text{ Along } \vec{BP} \quad — (2)$$

As $\vec{E}_1$ & $\vec{E}_2$ are collinear vectors acting in opposite directions. Since $|\vec{E}_2| > |\vec{E}_1|$. So resultant electric field intensity at P due to dipole is given by difference of two i.e.

$$|\vec{E}| = |\vec{E}_2| - |\vec{E}_1|$$

$$|\vec{E}| = \frac{1}{4\pi\epsilon_0}\cdot\frac{q}{(r-a)^2} - \frac{1}{4\pi\epsilon_0}\cdot\frac{q}{(r+a)^2}$$

$$= \frac{q}{4\pi\epsilon_0}\left[\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2}\right]$$

$$= \frac{q}{4\pi\epsilon_0}\left[\frac{(r+a)^2 - (r-a)^2}{(r-a)^2(r+a)^2}\right]$$

$$E = \frac{q}{4\pi\epsilon_0}\left[\frac{r^2 + a^2 + 2ar - r^2 - a^2 + 2ar}{(r-a)^2(r+a)^2}\right]$$

$$E = \frac{q}{4\pi\epsilon_0}\left[\frac{4ar}{(r^2-a^2)^2}\right] \quad \& \text{ As } p = q \times 2a$$

$$\boxed{|\vec{E}| = \frac{1}{4\pi\epsilon_0}\,\frac{|\vec{p}|\cdot 2r}{(r^2-a^2)^2}}$$ Required $\vec{E}$ acting along $\overrightarrow{BP}$

If the dipole is short i.e. $2a << r$ then

$$|\vec{E}| = \frac{|\vec{p}|\cdot 2r}{4\pi\epsilon_0 (r^2-0)^2}$$

$$\boxed{|\vec{E}| = \frac{2|\vec{p}|}{4\pi\epsilon_0\, r^3}}$$

...ak :- $E \propto \frac{1}{\ldots}$