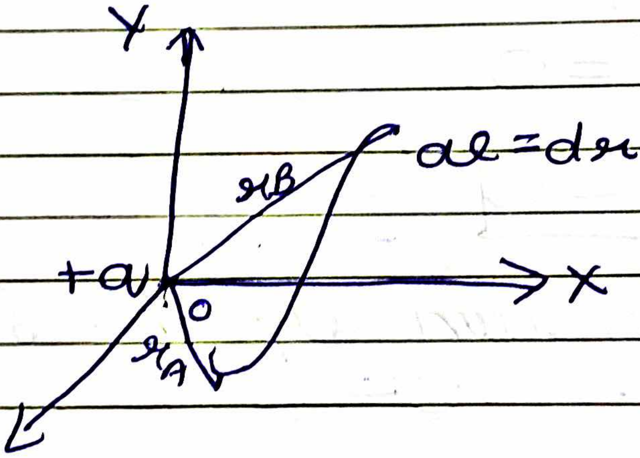
Unit - 5

Chapter - 2

Curl of Electrostatic Feild :

Consider a line element dl which is at a distance of r_A and r_B from the charge q situated at the origon.



Than the line integral of the Electric feild from A to B is given by

$$= \int_A^B E \cdot dl \quad -(1)$$

Now, we know that

$$E = \frac{q}{4\pi\epsilon_0 r^2} \quad -(2)$$

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Put (2) in (1).

$$= \int_{A}^{B} \frac{q}{4\pi\epsilon_0 r^2}\, dr.$$

$$= \int_{r_A}^{r_B} \frac{q}{4\pi\epsilon_0 r^2}\, dr$$

Line int of Elec. field $= \frac{q}{4\pi\epsilon_0} \int_{r_A}^{r_B} \frac{1}{r^2}\, dr.$

$$= \frac{q}{4\pi\epsilon_0} \left| \frac{-1}{r} \right|_{r_A}^{r_B}.$$

$$= \frac{q}{4\pi\epsilon_0} \left[\frac{1}{r_A} - \frac{1}{r_B} \right]$$

If $r_A = r_B$.

$$\boxed{\int_{A}^{B} \vec{E} \cdot d\vec{l} = \frac{q}{4\pi\epsilon_0} (0) = 0} \quad -(3)$$

Stokes Theorem:

$$\int_{l} A \cdot dl = \int_{S} (\vec{\nabla} \times \vec{A})\, ds \quad -(4)$$

~~If~~ $\vec{\nabla} \times \vec{A} =$ curl of A.

Put ④ in ①

$$= \int_S (\vec{\nabla} \times \vec{E})\, ds \quad -⑤$$

Put ⑤ in ③.

$$\int_S E \cdot dl = \int_S (\vec{\nabla} \times \vec{E})\, ds$$

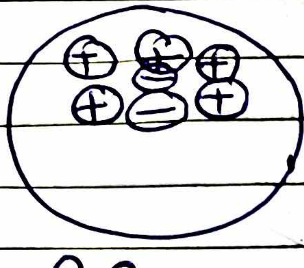
$$(\vec{\nabla} \times \vec{E})\, ds = 0$$

$$\boxed{\vec{\nabla} \times \vec{E} = 0}$$

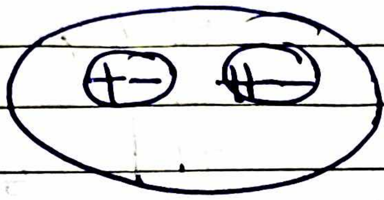
Curl of E = 0.

Dilectrics

These are the materials which can't transmit electricity by ~~pself~~ itself.



Polar

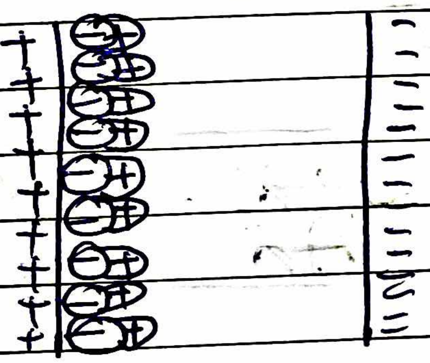


Di-polar

Two equal and opposite charges are seperated by some distance is known as electric dipole.

$$\boxed{p = q \cdot 2r}$$

Polarisation of Dielectrics



$$\boxed{\vec{P} = \epsilon_0 \alpha \vec{E}}$$

$$\boxed{\vec{P} = n\vec{p}}$$

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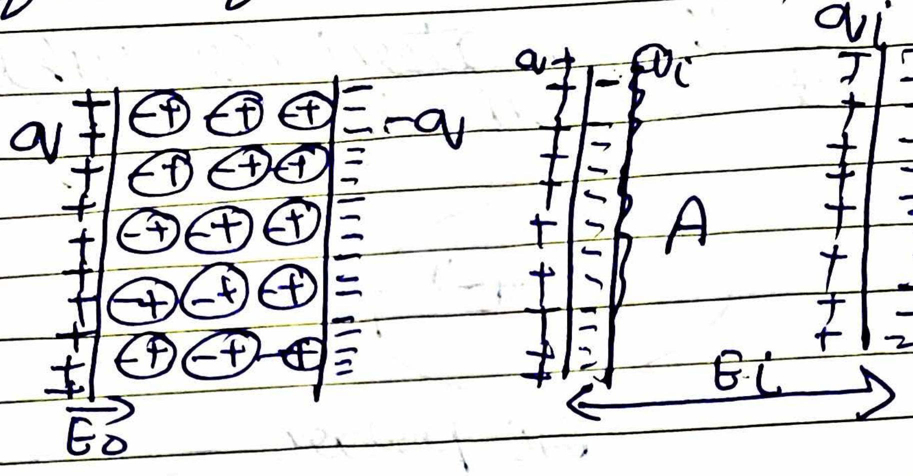
Effect of electric field on Dilectric-



Resultant Electric Feild:

$$E = E_0 - E_i$$

$$\boxed{E = \frac{E_0}{K}}$$

$$\sigma = \frac{q}{A}$$

$$\sigma_i = \frac{q_i}{A}$$

$$\boxed{\vec{P} = \frac{p}{\text{volume}} = \frac{q_i d}{A d} = \frac{q_i}{A} = \sigma_i}$$

$$P \propto E$$

$$\boxed{P = \epsilon_0 \chi \vec{E}}$$

χ = Dilectric suceptibility.

$$\boxed{E_0 = \frac{\sigma}{\epsilon_0}} \quad \boxed{E_i = \frac{\sigma_i}{\epsilon_0}}$$

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$$E = \frac{\sigma}{\epsilon_0} - \frac{\sigma_i}{\epsilon_0}$$

$$E = E_0 - \frac{\sigma_i}{\epsilon_0}$$

$$E = E_0 - \frac{P}{\epsilon_0}$$

$$E = E_0 - \frac{\cancel{\epsilon_0} \chi E_0}{\cancel{\epsilon_0}}$$

$$E = E_0 - \chi E_0$$

$$E = E_0(1-\chi)$$

$$\cancel{\frac{E}{E_0} = (1-\chi)}$$

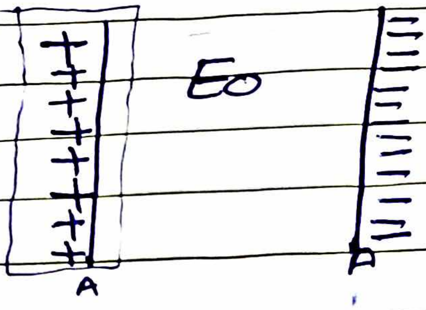
$$\cancel{\frac{1}{K} = 1-\chi}$$

$$E_0 = E + \chi E$$

$$\frac{E_0}{E} = 1+\chi$$

$$\boxed{K = 1+\chi}$$

Gauss Law in Dilectrics:



Acc. to Gauss Law.

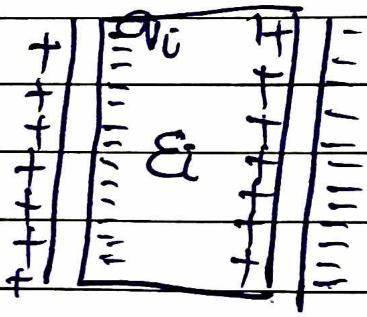
$$\cancel{\vec{E_0} = q}$$

$$\int \vec{E_0}\cdot \hat{n}\, ds = \frac{q}{\epsilon_0}$$

$$E_0 \int ds = \frac{q}{\epsilon_0}$$

$$E_0 A = \frac{q}{\epsilon_0}$$

$$E_0 = \frac{q}{\epsilon_0 A} \quad \text{—(1)}$$



$$E = E_0 - E_i$$

$$\int \vec{E}\cdot \hat{n}\, ds = \frac{(q - q_i)}{\epsilon_0} \text{ —(}$$

$$EA = \frac{(q - q_i)}{\epsilon_0}$$

$$E\cancel{A} = \frac{(q - q_i)}{\epsilon_0 A}$$

$$E = \frac{q}{\epsilon_0 A} - \frac{q_i}{A\epsilon_0} \quad — (2)$$

$$E = \frac{E_0}{K} \quad — (3)$$

Put (3) in (1)

$$E = \frac{q}{\epsilon_0 K} \quad — (4)$$

Put (4) in (2)

$$\frac{q}{\cancel{A\epsilon_0}K} = \frac{q}{\cancel{\epsilon_0 A}} - \frac{q_i}{\cancel{A\epsilon_0}}$$

$$\frac{q}{K} = (q - q_i) \quad — (5)$$

Comparing (5) & (6)

$$\int \vec{E}\cdot n\,ds = \frac{q}{K\epsilon_0}$$

$$\boxed{K\int \vec{E}\cdot \hat{n}\,ds = \frac{q}{\epsilon_0}}$$

\# Electric Displacement Vector:

$$\frac{q}{\epsilon_0 A} = E + \frac{q_i}{\epsilon_0 A}$$

$$\frac{q_i}{A} = P$$

$$\frac{q}{\epsilon_0 A} = E + \frac{P}{\epsilon_0}$$

$$\frac{q}{A} = \epsilon_0 E + P$$

$$\frac{q}{A} = D$$

$$\boxed{D = \epsilon_0 E + P}$$

X————X