



# LECTURE 5

Introductory Lecture on Section B  
-Dielectric Materials



# Topics to be covered

- Behaviour of dielectric materials in static electric field
- Dipole Moments
- Polarization

## Introduction Dielectrics

These are the materials having electric dipole moment permanently. Dipole: A dipole is an entity in which equal positive and negative charges are separated by a small distance.

**DIPOLE moment** : The product of magnitude of either of the charges and separation distance b/w them is called Dipole moment.

$\mu_e = q \cdot x$  [ coul – m ]  $+q -q$  X All dielectrics are electrical insulators and they are mainly used to store electrical energy.

It stores with minimum dissipation power). Since, the e- are bound to their parent molecules & hence, there is no free charge .

Ex: Mica, glass, plastic, water & polar molecules...

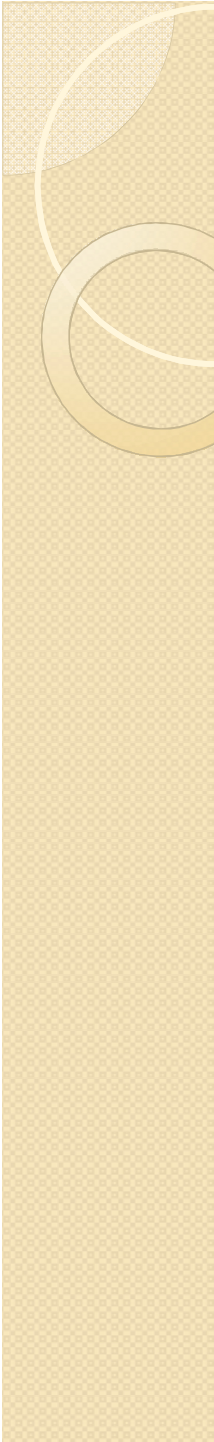
## Important terms in dielectrics

### 1) Electric intensity or electric field strength

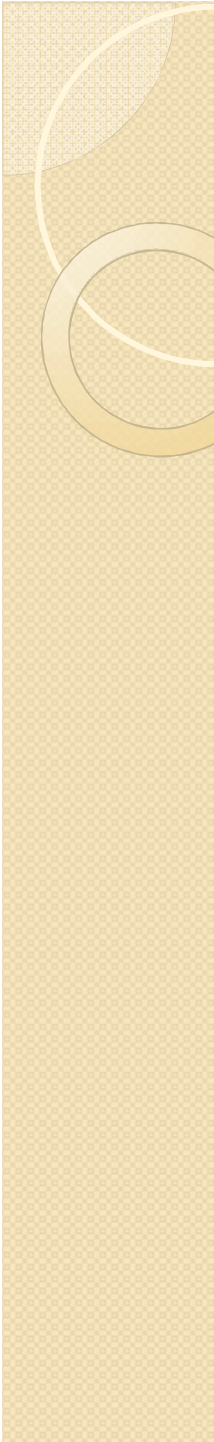
Def:- The force per unit charge “dq” is known as electric field strength (E). Where “dq” is point charge , E is electric field, F is force applied on point charge “dq”.  $E = F/dq = Q / 4\pi\epsilon r^2$  where “ $\epsilon$ ” is permittivity.

What is permittivity?

It is a measure of resistance that is encountered when forming an electric field in a medium. “ In simple words permittivity is a measure of how an electric field effects and is effected by a dielectric medium”.

- 
- a)  $\epsilon$  (permittivity of medium):- How much electric field generated per unit charge in that medium.
- b)  $\epsilon_0$  (permittivity of space) :- The electric field generated in vacuum. It is constant value  $\epsilon_0 = 8.85 \times 10^{-12}$  F/m. Imp points:
- 1) More electric flux exist in a medium with a high permittivity(because of polarization).
  - 2) Permittivity is directly related to “ Susceptibility” which is a measure of how easily a dielectric polarize in a response of an electric field. “

permittivity relates to a materials ability to transmit an electric field”  $\epsilon = \epsilon_r \cdot \epsilon_0 = (1 + \chi) \epsilon_0$  Relative permittivity Susceptibility



Electric Flux density or Electric displacement Vector:  
The electric flux density or electric displacement vector “D” is the number of flux line’s crossing a surface normal to the lines, divided by the surface area.

$D = Q / 4\pi r^2$  where ,  $4\pi r^2$  is the surface area of the sphere of radius “r”.

Dielectric Parameters :a) Dielectric constant( $\epsilon_r$ ):- It is defined as the ratio of permittivity of medium( $\epsilon$ ) to the permittivity of free space( $\epsilon_0$ ).  $\epsilon_r = \epsilon / \epsilon_0$  b) Electric dipole moment ( $\mu$ ):- The product of magnitude of charges & distance of separation is known as electric dipole moment ( $\mu$  ).  $\mu = Q.r$

Electric Polarization :- The process of producing electric dipoles by an electric field is called polarization in dielectrics.

“ In simple words polarization  $P$  is defined as the dipole moment per unit volume averaged over the volume of a cell”  $P = \mu / \text{volume}$

Polarizability :- When a dielectric material is placed in an electric field, the displacement of electric charge gives rise to the creation of dipole in the material .

The polarization  $P$  of an elementary particle is directly proportional to the electric field strength  $E$ .  $P \propto E$   $P = \alpha E$   
 $\alpha \rightarrow$  polarizability constant The unit of “ $\alpha$ ” is  $\text{Fm}^2$