

Lecture 9 — Dielectrics

Michael Brodskiy

Professor: J. Adams

March 12, 2025

- Capacitance

$$C = \frac{\epsilon_r \epsilon_o A}{d}$$

- ϵ_o represents the permittivity of free space
- ϵ_r is the permittivity of a dielectric material
- A is the cross-sectional area of the plates
- d is the distance between plates
- C represents the effective capacitance
- Add in parallel, divide in series

- Dielectric Strength

- When the electric field in the dielectric reaches a critical value called the dielectric strength, the medium suffers a dielectric breakdown where a large current flows across the plates

- Dielectric Theory

- p is the electric dipole moment (measure of electrostatic effect of opposite charges displaced by a): $p = Qa$
- Power dissipation in a capacitor occurs and is also frequency dependent

- Polarizability

- Polarizability is defined as:

$$p = \alpha E$$

- The induced dipole moment is called the electronic polarizability, α_e

- The electronic polarization may be written as:

$$p_e = \left(\frac{Z^2 e^2}{\beta} \right)$$

- We can find susceptibility as:

$$\chi_e = \frac{1}{\varepsilon_o} N \alpha_e$$

- The two are related through:

$$\varepsilon_r = 1 + \chi_e$$

- Clausius-Mossotti Equation

- Taking:

$$p = \alpha_e E$$

$$P = \chi_e \varepsilon_o E$$

$$\varepsilon_r = 1 + \chi_e$$

- We combine all of the relationships to get:

$$\frac{\varepsilon_r - 1}{\varepsilon_r + 2} = \frac{N \alpha_e}{3 \varepsilon_o}$$