Capacitance Due Tuesday

$$\underline{26.7},\ \underline{26.21},\ 26.11,\ 26.37,\ 26.59,\ 26.67, \tag{1}$$

$$27.3,\ 27.15,\ 27.39 \tag{2}$$

The underlined problems should be turned in for grading.

- For two conductors with have charge Q on either conductor, the potential difference between them is ΔV, and the capacitance is the proportionality constant

$$C\Delta V = Q \tag{3}$$

- The capacitance for various charged objects can be computed by distributing the charge, computing the electric field, the potential difference between the charged objects, and finally comparing Q and ΔV. The result depends only on the geometry

  1. For two plates of area A and separation d the capacitance is

  $$C = \epsilon_o \frac{A}{d} \tag{4}$$

  2. For a coaxial cable of length L with inner radius a and outer radius b the Capacitance is

  $$C = \frac{L}{2k_e \ln(b/a)} \tag{5}$$

  with $k_e = 1/(4\pi\epsilon_o)$

  3. For a sphere of radius R with the second sphereical conductor at infinity

  $$C = 4\pi\epsilon_o R \tag{6}$$

- For capacitors in parallel the equivalent capacitance of the circuit is

$$C_{\text{eq}} = C_1 + C_2 + C_3 + \ldots \tag{7}$$

For capacitors in series the equivalent capacitance of the circuit

$$\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots \tag{8}$$

- Energy is stored in a capacitor as charged is transfered from one side to another. At the end of this process the energy is

$$U = \frac{1}{2}C(\Delta V)^2 = \frac{Q^2}{2C} \tag{9}$$

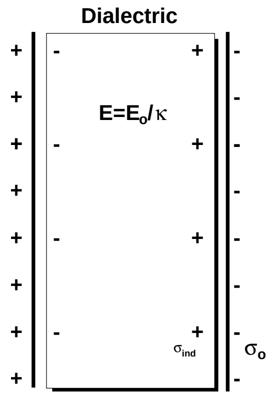
This energy is stored in the electric field in between the plates. The energy per unit volume is proportional to the electric field squared

$$\frac{U}{\text{Vol}} = \frac{1}{2}\epsilon_o E^2 \tag{10}$$

- When a dialectric is placed between two charged slabs, the electric field inside the slabs E is less than it would have been in vacuum E_o.

$$E = \frac{E_o}{\kappa} \tag{11}$$

The electric field is decreased because there is an induced surface charge σ_{ind} on the dialectric material.



σ_{ind} can be related to charge density on the plates σ_o and the dialectric constant κ.

$$\sigma_{\text{ind}} = \left(1 - \frac{1}{\kappa}\right)\sigma_o \tag{12}$$

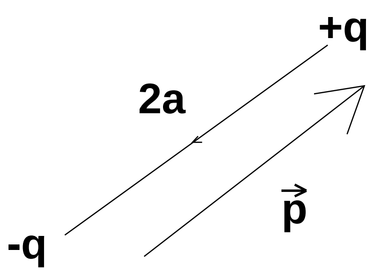
When a dialectric is introduced the capacitance C is increased to what it would have been without the dialectric C_o

$$C = \kappa C_o \tag{13}$$

- An the electric dipole moment is

$$p \equiv 2aq \tag{14}$$

and points from the negative to the postive charge as shown below



When a dipole is placed into an electric field it will try to rotate its dipole moment in the direction of the field. There is no net force but there is a net torque.

$$\tau = \mathbf{p} \times \mathbf{E} \tag{15}$$

The potential energy of a dipole in an external field is

$$U = -\mathbf{p} \cdot \mathbf{E} \tag{16}$$

The potential energy is smallest when the dipole is aligned with the field.