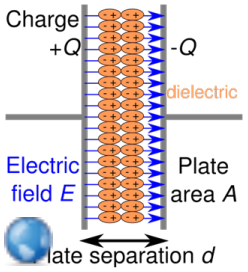
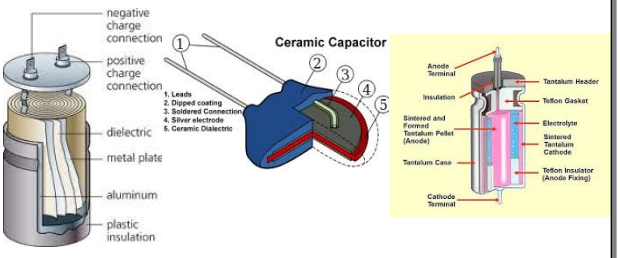
3.B.3 - Dielectrics



Dielectrics

Dielectric materials placed between a capacitor's plates serve several purposes:

1. Insulate the two plates from contact,
2. Allow flexible plates to be rolled into a cylinder,
3. Increase charge storage capacity of capacitor.

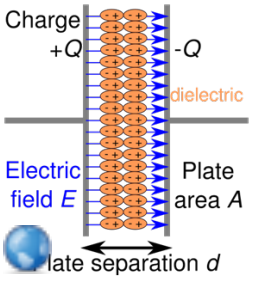


How Dielectrics Work

Dielectric molecules are polarizable: they reorient in the direction of the electric field, changing the electron distribution in the material.

This sets up miniature E fields that counter that of the plates.

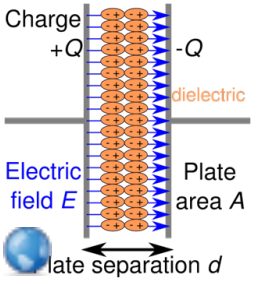
The energy needed to realign molecules and electron clouds increases overall energy storage of the capacitor.



How Dielectrics Work

All of the reoriented and induced dipoles in the dielectric allow for more charges to be stored on the capacitor plates.

More charges = greater capacitance.



Dielectric Calculations

The dielectric constant of a material (κ) is a ratio:

$$\kappa = \frac{C}{C_0}$$

C = capacitance with dielectric material
C_0 = capacitance without material

Review: capacitor equation:

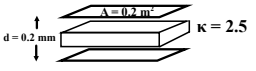
$$C = \kappa \varepsilon_0 \frac{A}{d}$$

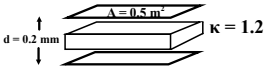
κ = dielectric constant
ε_0 = permittivity of free space (8.85E -12 $C^2/N \cdot m^2$)
A = one plate's area (m^2)
d = plate separation (m)

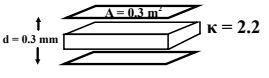
AP Equation

Capacitor Comparison Example

Rank the following capacitors from least to greatest in terms of capacitance:

A 

B 

C 

C, A, B

Use:

$$C = \kappa \varepsilon_0 \frac{A}{d}$$

Voltage of a Capacitor

If a voltage is applied to (and then disconnected from) a capacitor with no dielectric material, the voltage across the capacitor equals the battery's (capacitor demo).

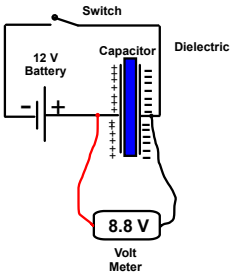
If a dielectric material is then placed between the plates of the capacitor, the voltage reading drops.

Some of the capacitor's potential is used to realign the molecules of the dielectric.

κ is also a voltage ratio:

$\kappa = \frac{V_0}{V}$	V_0 = without the dielectric V = voltage with dielectric

Voltage Drop of a Capacitor Example



Dielectric

Voltage Before: **12.0 V** Vs. Voltage After: **8.8 V**

Now: if the original capacitance was 13.6 mF, what's the new capacitance?

$$13.6\,mF \bullet \frac{12.0\,V}{8.8\,V} = 18.5\,mF$$

Homework

3.B.3 Problems.
Due: Next Class.