Lab: Capacitance spacing dependence, Dielectric (virtual)

Objective(s)

- To measure the dependence of capacitance on the plate separation for a parallel plate capacitor.
- Observe the effect of inserting a dielectric material between capacitor plates.

Fundamentals

The energy associated with an electric field can be stored by placing charges (+Q, -Q) on a pair of flat conductive plates narrowly separated by an insulator (a dielectric such as air, plastic, or paper). We call this arrangement a **capacitor**, named because of its storage capacity. When each conducting plate is connected to opposite sides of a voltage source, the net charge on each plate increases until the electric potential difference, ΔV , across the plates is the same as the voltage source. The amount of accumulated charge, Q, depends on the potential difference ΔV across its plates and on the capacitance, C,

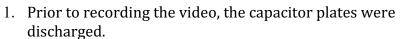
$$Q = C\Delta V_C$$
 Eq. 1

The capacitance C depends on the specific geometry (area and spacing) of the capacitor with standard units of Coulomb/Volt = F(arad). Since one Coulomb is a lot of charge, a Farad is also large. Typical capacitances range from picofarads (pF = 10^{-12} F) to microfarads (μ F = 10^{-6} F). For a parallel-plate capacitor with separation d and area A, the capacitance is

$$C = \frac{\varepsilon_0 A}{d} = \varepsilon_0 A \frac{1}{d}$$
 Eq. 2

Experiment

The video (*CapChangeSpacing*) shows plate separation, *d*, changing a while the meter measures capacitance, *C*. Similar to Figure 1. The **diameter** of a plate is 17.7 cm.



- 2. Use the video to "measure" the capacitance, *C* (in pF) for these separations *d* (in mm): 2, 5, 10, 15, 20, 30, 40.
- 3. Plot the capacitance, *C* (vertical axis) vs. the separation *d* (horizontal axis). Now (using Excel or Desmos or...) fit the data to a power law.
- **Q1**: Why is this reasonable? (see Eq. 2)
- **Q2**: What do you get for the power law exponent? Compare with what you expect, see Eq. 2.
- **Q3**: What do you get for the prefactor? Compare with what you expect, see Eq. 2. If the exponent and/or the prefactor do *not* agree with expectations, can you suggest why? Hint: Compare our model of a parallel plate capacitor with the one actually used.
- 4. The video (*CapDielectric*) shows plate spacing about 1 cm, observed the capacitance. A notebook (with paper pages) is inserted between the plates, almost filling the space between them. Observe how the capacitance changes after you insert the paper (dielectric material).

