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,

$$Q = C\Delta V_C \qquad \text{Eq. 1}$$

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 (μF = 10^{-6} F). For a parallel-plate capacitor with separation d and area A, the capacitance is

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

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.

1. Prior to recording the video, the capacitor plates were discharged.
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).