# College Physics II
# Lab 6: Capacitors

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## Introduction

You will get a feeling for what a capacitor is and you will get practice calculating net capacitance for combinations of capacitors.

**Note:** For both parts of this lab, the one major pitfall is that some parts of the two pieces of foil (with the paper and/or plastic between them) touch each when they should not; this is called "shorting out." You need to be very careful to make sure this does not happen. If your results start to look nonsensical, then you probably have shorted out. What you need to do in that case is to rebuild your capacitor from scratch, trying to be more careful.

## Part 1: Building Capacitors

Construct two different capacitors out of aluminum foil and paper—or plastic wrap, or perhaps wax paper. I will show you how. Make one using a sheet of one substance as the dielectric and another with a sheet of a different substance. Make sure that the area of each capacitor is at least 7 cm by 7 cm; if the area is smaller, the resulting capacitance may be too small to easily measure. When measuring the capacitance, you will need to lay your capacitors out flat: place a book on them, and stand on the book. This ensures that there is no substantial thickness of air between layers. Measure and write down the following for each capacitor:

- The length, $l$, and width, $w$, of one of the aluminum foil "plates,"
- The capacitance $C$, using a faradometer.

- The total thickness of the material between the plates, using a micrometer.

The capacitance $C$ of a capacitor of plate area $A$ and plate separation $d$ is:

$$C = \frac{\kappa \epsilon_0 A}{d}$$

where $\epsilon_0 = 8.85 \times 10^{-12}$ F/m.

Since $A = lw$, you can solve this equation for $\kappa$ in terms of measured quantities and $\epsilon_0$:

$$\kappa = \frac{dC}{\epsilon_0 lw}$$

You should get $\kappa > 1$. Compare your results for $\kappa$ with at least one other lab group.

### To hand in for part 1

- Measurements for $l$, $w$ and $C$ for each of the two capacitors,
- A calculation of $\kappa$ for each material used, such as paper and wax paper. Include equations used and value of $d$ used in each case.
- Comparisons with other lab groups.

## Part 2: Combining Capacitors

Build a third capacitor similar to your first two. Then lay a piece of paper under each of your capacitors (make sure the area of the paper is bigger than the area of either plate), roll up each of your three capacitors into a cylinder, and tape each cylinder so that it doesn't unroll. Re-measure the capacitance of the first two—they will have changed noticeably from when they were being squashed by your book, and measure the capacitance of the third. Draw diagrams for the following combinations of your three capacitors:

- All in parallel,
- All in series,

- Two in parallel, in series with the third,
- Two in series, in parallel with the third.

Measure the total capacitance $C_T$ for each combination using your three capacitors and the faradometer.

Here are three options for how $n$ capacitances add:

1. **Direct addition:**
$$C_T = C_1 + C_2 + \ldots + C_n$$
2. **Square addition:**
$$C_T^2 = C_1^2 + C_2^2 + \ldots + C_n^2$$
3. **Inverse addition:**
$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots + \frac{1}{C_n}$$

Given your data, which option do you think describes the total capacitance for capacitances in series? What option applies to capacitors joined in parallel? Check how your four measured $C_T$'s fit the options you choose.

## To hand in for part 2

- A picture of each of the 4 arrangements, labeling which capacitor is which,
- Your measurement of $C_T$ for each of the 4 arrangements,
- Your decisions on how capacitors add in series and in parallel, with all relevant evidence and calculations.