3.1: Background Material

Text References

- networks of capacitors

The Equipment

There are a number of things one needs to know about the equipment in order to navigate this lab without mishaps.

Safety and Good Habits

The first thing to remember is that the main purpose of a capacitor electrical component is to store electrical energy, often so that it can be discharged quickly. While the capacitors you are using do not boast of large capacitances, nor will we charge them using a high voltage, it is a good idea to get in the habit of never (intentionally or accidentally) completing a circuit involving yourself and the two leads of a capacitor. (This includes when you *think* it is uncharged.) When you are done using a capacitor (i.e. between experiments) it is good practice to discharge it completely by connecting a wire across is. This not only removes any possible shock danger, but also gives you a capacitor whose state of charge you know about for the next experiment.

Polarity of Capacitors

The capacitors you will be using in this lab contain an electrolyte. This particular design of capacitor has a "polarity", which means that it only charges properly in one direction – you need to connect a specific lead of the capacitor to the (+) side of a charging battery, and the other lead to the (–) side. Connecting them backward not only causes them to function improperly, but in extreme cases can ruin the component. You will use capacitors connected to a plastic component board, and their leads are colored red (positive) and black (negative). When connected to a battery, the signs of the capacitor leads need to be matched to those of the battery (positive-to-positive, negative-to-negative). You will also use some loose capacitors, and the polarity of those is determined by the length of the wires protruding from them – the ***longer of the two leads is the positive one***.

Figure 3.1.1 – Component Board

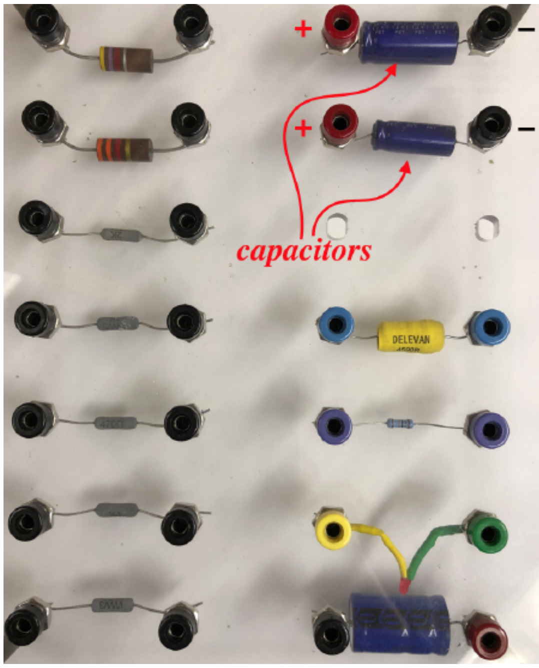
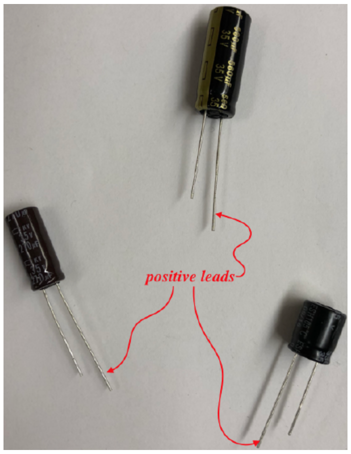


Figure 3.1.2 – Loose Capacitors



The "Battery"

The device you will be using for a battery doesn't look like any battery you have seen before (the wire coming from it that plugs into an outlet is a dead giveaway). While it is clearly drawing electrical energy from the outlet, this nevertheless behaves exactly like a battery – it provides a fixed voltage for circuits. And it has the added bonus that it doesn't run down and end up in a landfill. While the voltage is supposed to be 9 volts, it will not be precisely this, and as usual, you will want to do a pre-experiment calibration check by measuring the true voltage directly with the multimeter.

The Multimeter

We will be measuring DC voltages in the 0-20 volt range, so the setting to use on the multimeter is, unsurprisingly, DC 20V. The two ports where you plug the probe wires are the black "COM", and the red "$V\Omega Hz$".

Figure 3.1.3 – Multimeter

Measuring Capacitance

This lab involves testing what we have learned about capacitance, and using this knowledge to compute unknown capacitance. The "obvious" way to measure the capacitance of a component is to put a known voltage across it, then measure the charge that accumulates, and compute the ratio $C = \frac{Q}{V}$. The problem with this plan is that while we have a multimeter to measure voltage, we don't have a device to measure charge on a capacitor plate. So instead what we will do is use what we know to measure *relative* capacitance, and then is this to compare an unknown capacitance with a known one. For example, if we know that two capacitors possess equal charge (how do we assure this?), and we happen to know the voltages across each of them (measured by a multimeter), then we can compute the ratio of their capacitances:

$$Q = C_1 V_1 \qquad Q = C_2 V_2 \quad \Rightarrow \quad \frac{C_1}{C_2} = \frac{V_2}{V_1} \tag{3.1.1}$$

So if we know one of the capacitances, we also know the other.