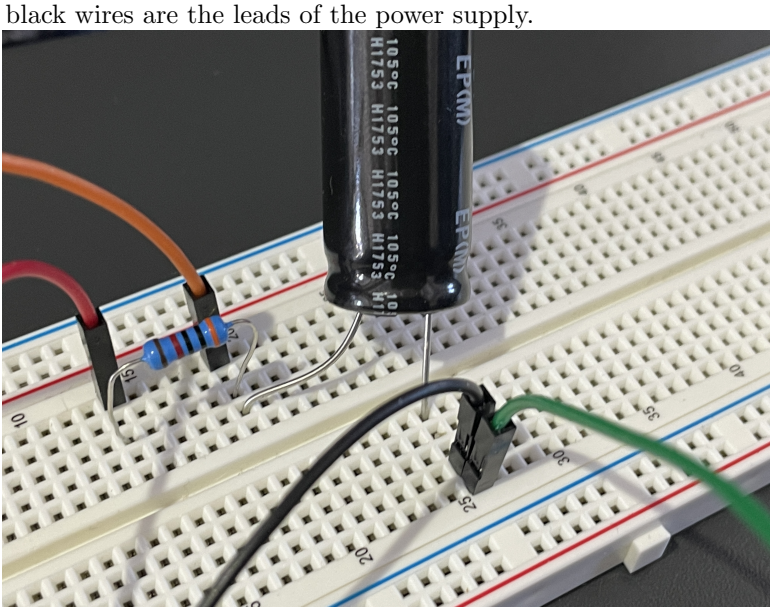
§ 1 Introduction

In this lab we will explore the response of a capacitor and resistor in series to a sudden change in a supply voltage.

§ 2 Setup

Build the circuit below, except the orange and green jumpers. The red and black wires are the leads of the power supply.



▷ Question 1

Draw the circuit digram for this circuit. The large black cylinder is a capacitor.

§ 3 Data Measurement and Recording

1) Add the orange and green jumpers which are connected to the red and black leads of the DMM. Connect the red and black leads to the DMM to measure voltage. Which voltage are you measuring?
2) Set up the the camera so that it can see the display of the DMM and the stop watch. We will be recording for 6 minutes, so set the camera to time-laps if that is available.
3) Plug in the power supply, and turn the dial of the DMM to voltage. If you turn the knob of the power supply the response in the voltage read on the DMM will be sluggish because it will take some time to charge the capacitor. Charge the capacitor to between 5 and 6 volts.
4) Once the voltage has reached about 5 volts, start the camera and the stop watch, then suddenly turn up the power supply. Is is not critical how far you turn the knob on the power supply, but do it in one motion. Put a finger in front of the camera when you are done changing the supply so that later when you look at the video there will be a mark of that moment.
5) Now wait for five minutes while the circuit reaches equilibrium with the new setting of the power supply.
6) When the five minutes are up. Stop recording and reset the stop watch to zero. Then start recording a second video and start the stop watch. This time suddenly turn down the voltage on the power supply. Wait another five minutes and then stop the video. Turn off the DMM and unplug the power supply.

§ 4 Data Entry and Graphing

Now view the first video. Note the time t_0 on the stop watch when you indicated the voltage had been set. Record the time and voltage for the following set of times. Starting with a measurement of the voltage at t_0 then,

- 6 more measurements about 5 seconds apart,
- 6 more measurements about 10 seconds apart,
- 12 more measurements about 20 seconds apart,

Enter the data into a file `up.csv` as before record the voltage value in the first column, the minutes in the second column and the seconds in the third column. Get the application for this lab [macOS, MSwin] and use it to make a graph with your data file `up.csv`. In the application set the start time to t_0 to the value for your recording.

Repeat with the second video, creating a file called `down.csv` and making the associated graph.

§ 5 Analysis

Theory predicts that the voltage on the capacitor will be

$$V_C = V_\infty - (V_0 - V_\infty)e^{-t/\tau}$$

where $\tau = RC$ and V_0 is the voltage on the capacitor at time $t = 0$ and V_∞ is final voltage the capacitor would reach if you waited a long time.

The application graphed your data but also picked the values of τ, V_0 and V_∞ that made the above function fit your data as well as possible.

▷ Question 2
Does the theory fit your data?

▷ Question 3
Compare the value of τ from the graph with the value of RC using the values of the resistor and capacitor in your circuit. Note that there is a capacitance printed on the capacitor but this is only an estimate, the actual value can be $\pm 20\%$, so calculate RC with both extremes of C.