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Lab 5: Capacitors

Name:

PES 216 Report

Lab Station:

Objective

The purpose of this lab was to determine how to measure the capacitance of a capacitor and how capacitors function in series and parallel in a circuit according to Kirchhoff's Rules.

Data and Calculations

Part A – Measuring Capacitance:

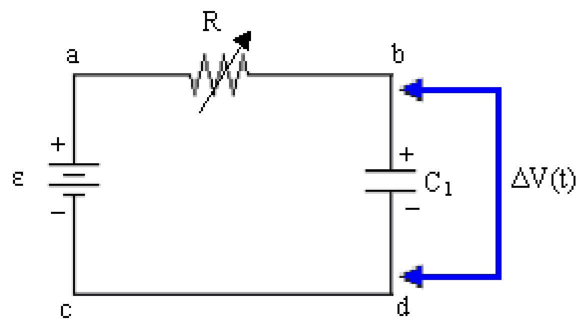
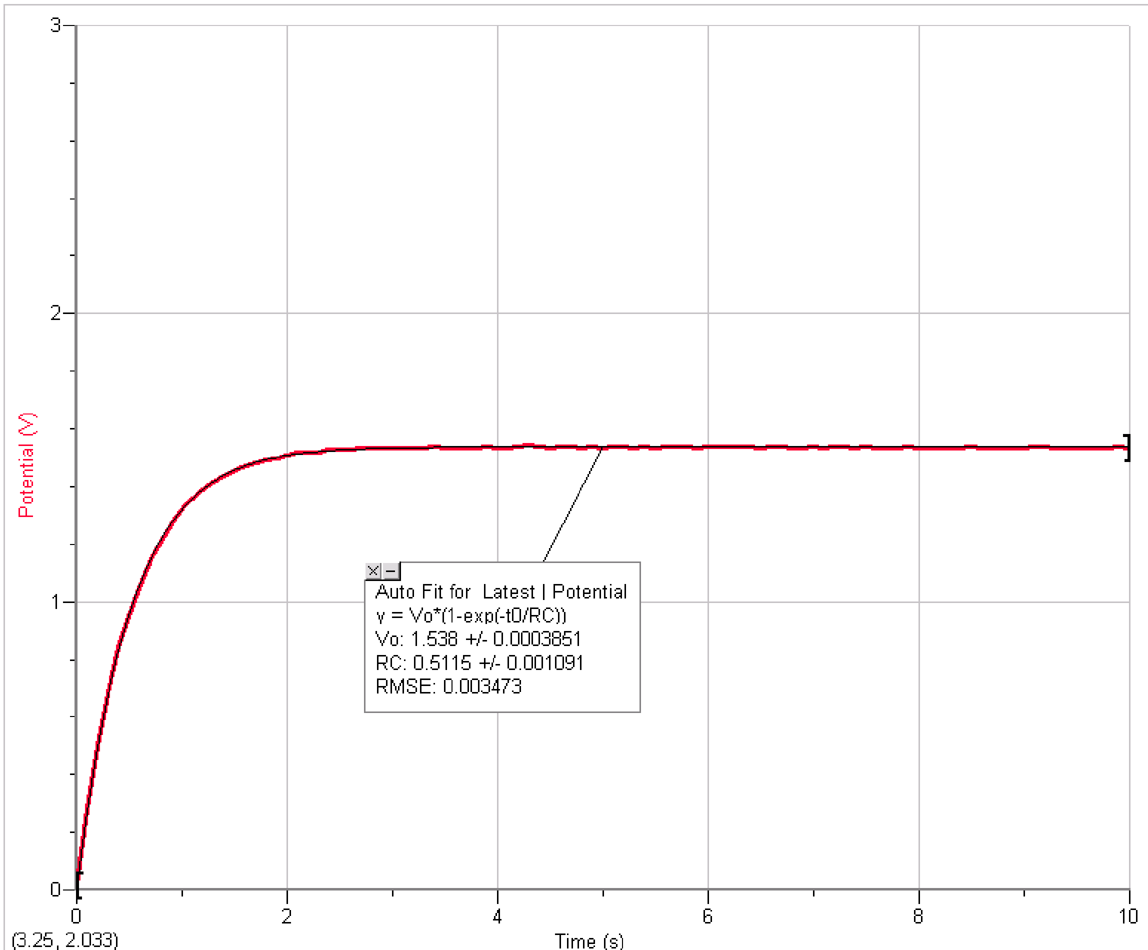


Figure 1: Schematic of the RC circuit built to measure the actual capacitance of provided capacitors.

Part B1 – Big Red Capacitor:



We used Logger Pro to provide a best-fit line for the data captured during the charging of the capacitor.

$$'Potential' = V_o * (1 - \exp(-t0 / RC))$$

Vo [volts]	RC [sec]
1.538 +/- 0.0003851	0.5115 +/- 0.001091

During the experiment it was noted that the resistance substitution box used in the circuit was set to the following resistance:

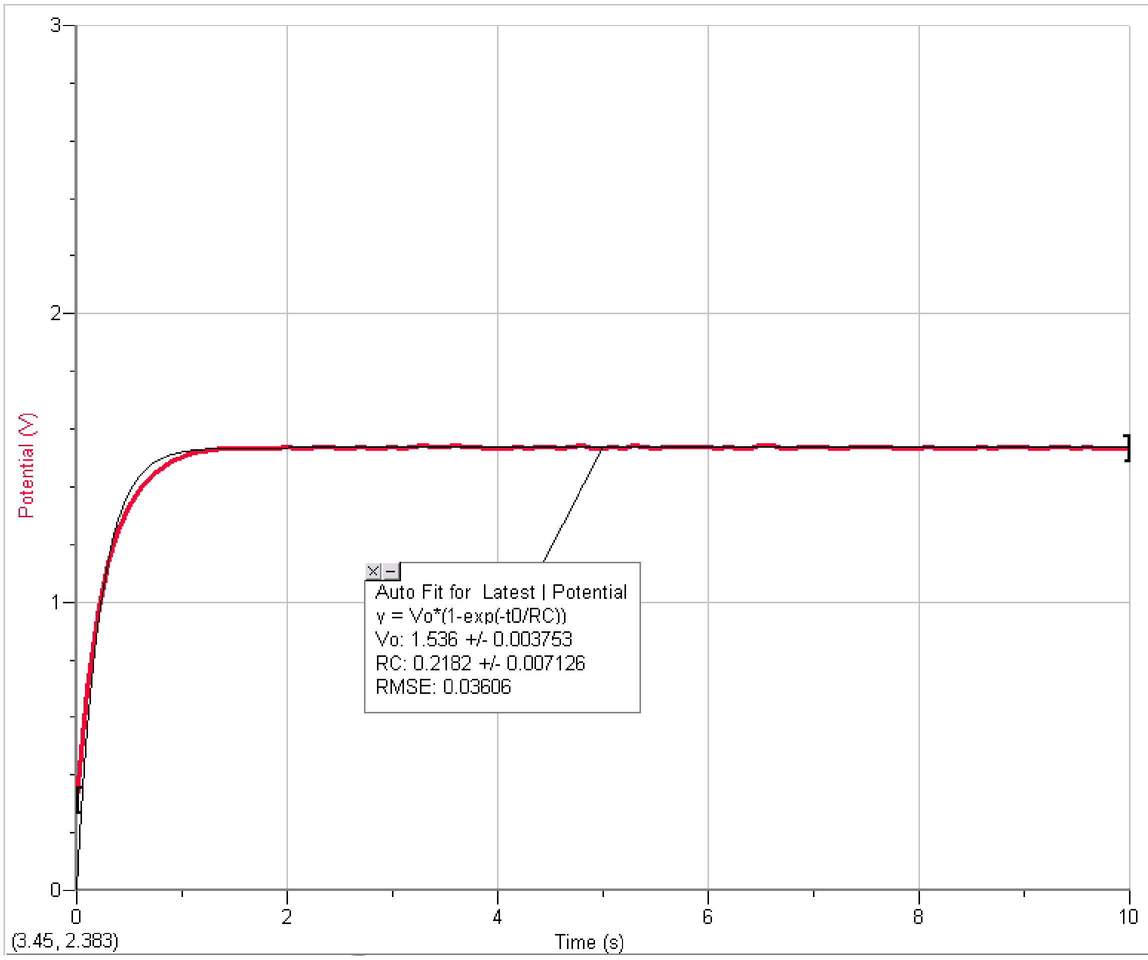
Resistance [ohms]
400 MΩ

$$C = \frac{0.5115\,\text{sec}}{400000\,\Omega} = 1.27875\ \mu F$$

$$\% - difference = \frac{C_{Theory} - C_{Measured}}{C_{Theory}} \times 100\%$$

$$\% - difference = \frac{1.00\,\mu F - 1.27875\,\mu F}{1.00\,\mu F} \times 100\% = 27.875\%$$

Part B2 – Small Orange Capacitor:



We used Logger Pro to provide a best-fit line for the data captured during the charging of the capacitor.

$$'Potential' = V_o * (1 - \exp(-t0 / RC))$$

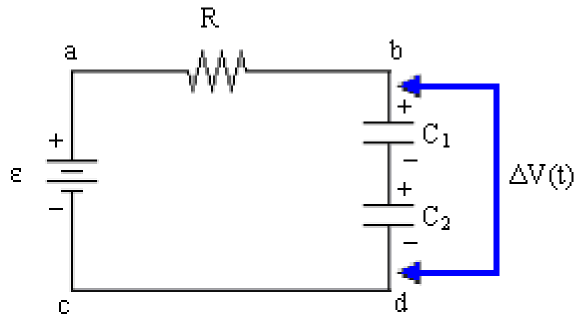
Vo [volts]	RC [sec]
1.538 +/- 0.0003851	0.2182 +/- 0.007126

Resistance [ohms]
400 MΩ

$$C = \frac{0.2182\,\text{sec}}{400000\,\Omega} = 0.5455\ \mu F$$

$$\% - difference = \frac{0.56\,\mu F - 0.5455\,\mu F}{0.56\,\mu F} \times 100\% = 2.589\%$$

Part B – Capacitors in Series and Parallel:

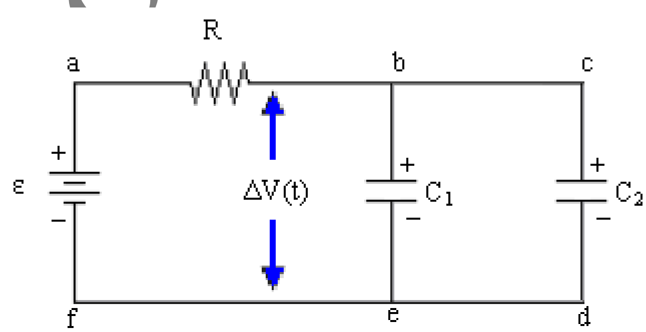


$$\textbf{Series: } C_T = \left[\frac{1}{C_1} + \frac{1}{C_2}\right]^{-1}$$

Using the values from Part A that we measure, theoretically the total capacitance for the two capacitors in series should be:

$$C_T = \left[\frac{1}{1.27875\,\mu F} + \frac{1}{0.5455\,\mu F}\right]^{-1}$$

$$\boxed{C_T = 0.3824\,\mu F}$$



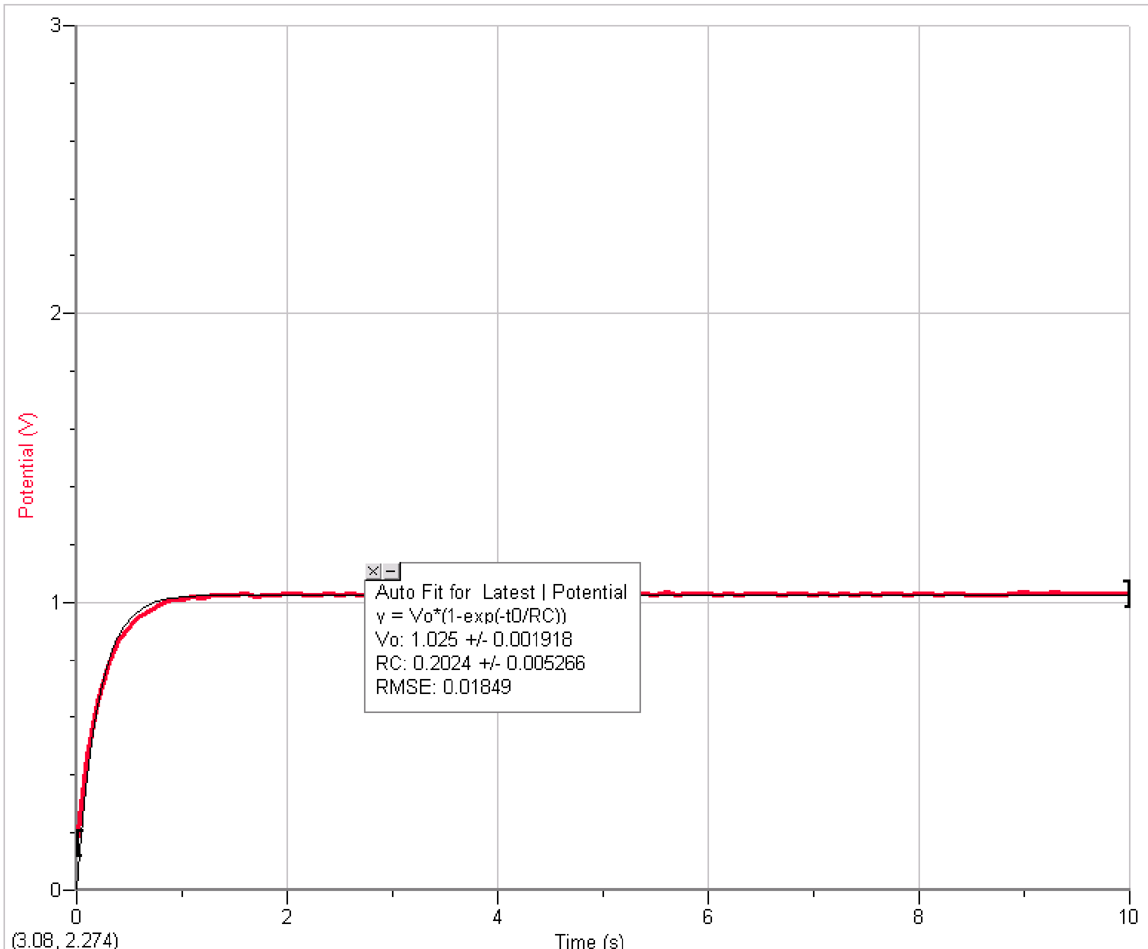
$$\textbf{Parallel: } C_T = C_1 + C_2$$

Using the values from Part A that we measure, theoretically the total capacitance for the two capacitors in parallel should be:

$$C_T = 1.27875\,\mu F + 0.5455\,\mu F$$

$$\boxed{C_T = 1.82425\,\mu F}$$

Part B1 – Capacitors in Series:



We used Logger Pro to provide a best-fit line for the data captured during the charging of the capacitor.

$$'Potential' = V_o * (1 - \exp(-t0 / RC))$$

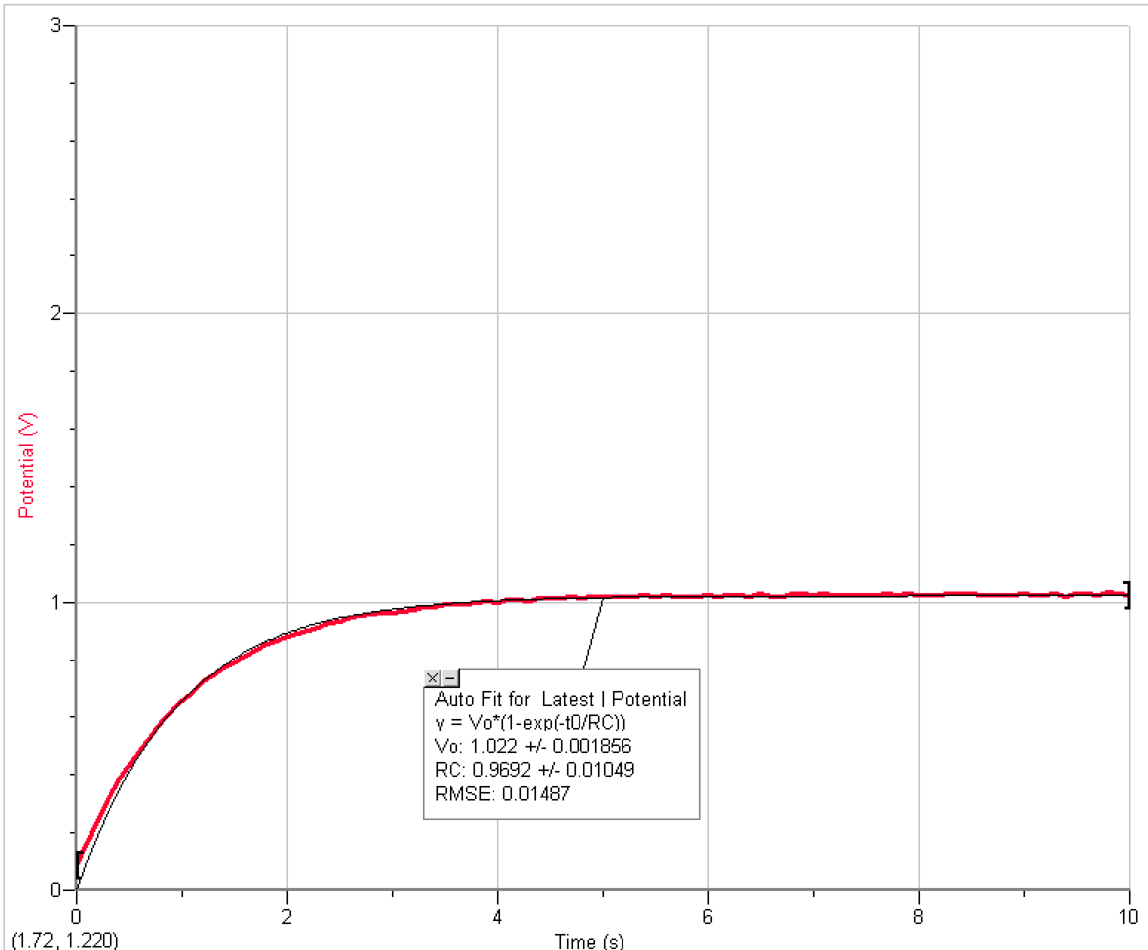
Vo [volts]	RC [sec]
1.025 +/- 0.0001918	0.2024 +/- 0.005266

Resistance [ohms]
530 MΩ

$$C = \frac{0.2024\,\text{sec}}{530000\,\Omega} = 0.38189\ \mu F$$

$$\% - difference = \frac{0.3824\,\mu F - 0.38189\,\mu F}{0.3824\,\mu F} \times 100\% = 0.133\%$$

Part B2 – Capacitors in Parallel:



We used Logger Pro to provide a best-fit line for the data captured during the charging of the capacitor.

$$'Potential' = V_o * (1 - \exp(-t0/RC))$$

Vo [volts]	RC [sec]
1.022 +/- 0.001856	0.9692 +/- 0.01049

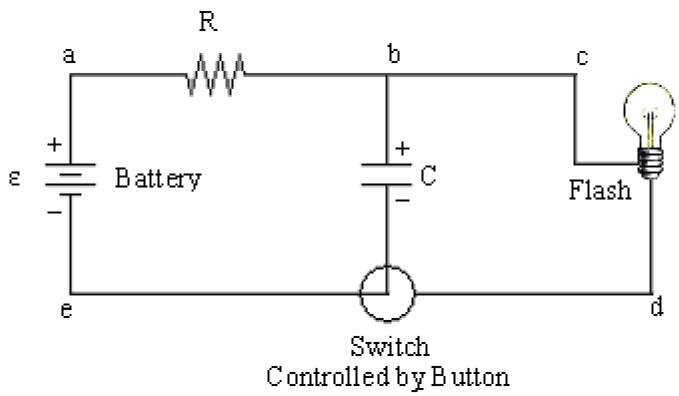
Resistance [ohms]
530 MΩ

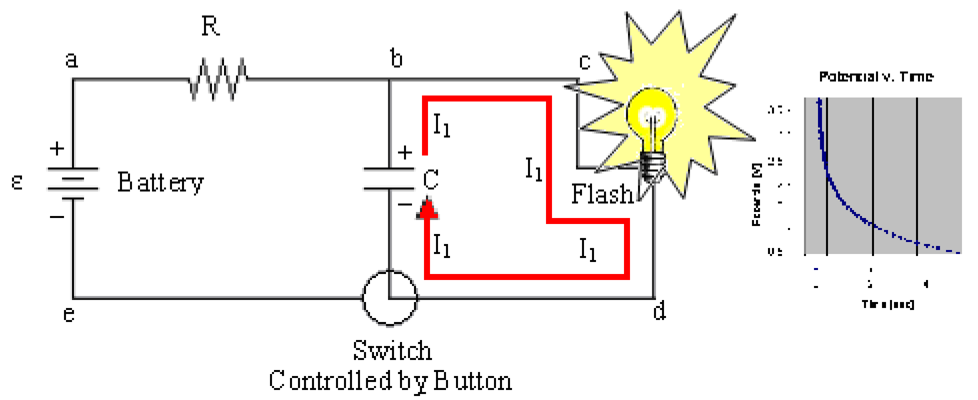
$$C = \frac{0.9692\,\text{sec}}{530000\,\Omega} = 1.8287\ \mu F$$

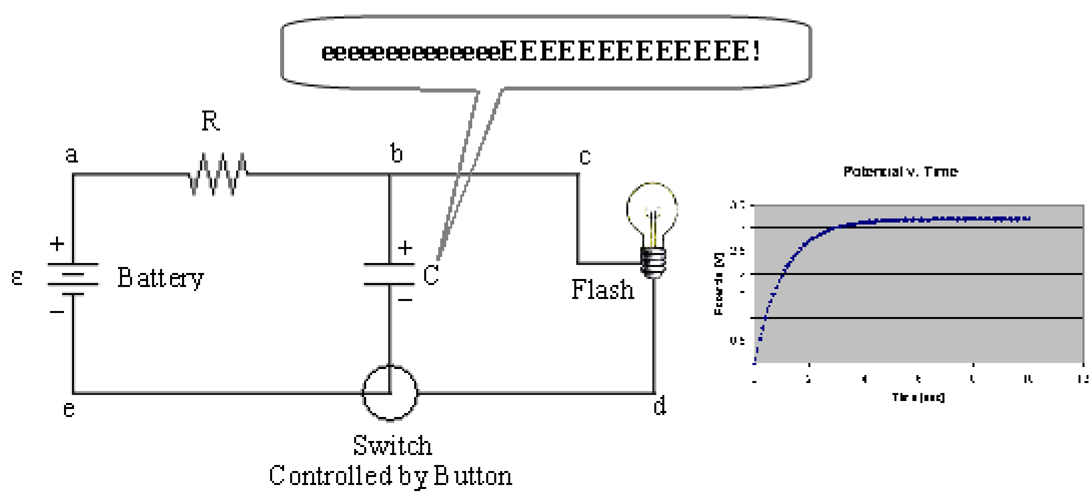
$$\% - difference = \frac{1.82425\,\mu F - 1.8287\,\mu F}{1.82425\,\mu F} \times 100\% = 2.439\%$$

Conclusion

Here is an example of a "real world" occurrence of charging/discharging a capacitor. This explains the high-pitched noise (that starts with a low tone and increases to a high tone) you hear after you trigger the flash on a camera.







You write the details. ← Include your answer here. Use complete sentences!!!!

** NOTE: There are several components of error which could significantly modify the results of this experiment. Some of these are listed below:

- Heat
- Age
- Humidity
- Short circuit
- Fuse
- Bad power supply (recall we used the DMM to attempt to alleviate this problem.)
- Bad connections (in protoboard)
- Insulation
- Length of wire and Gauge accuracy of wire (copper)
- Bad power supply (recall we used the DMM to attempt to alleviate this problem.)
- Buckling, bending, etc… of wire
- Elemental components/material makeup of the wire
- ??

It is recommended that you take these and explain the "***why***" part of each for your results and conclusions sections – and possibly what could have been done (if anything) to minimize the effects of these errors.