# PHYS 122L Experiment 8
## Circuits

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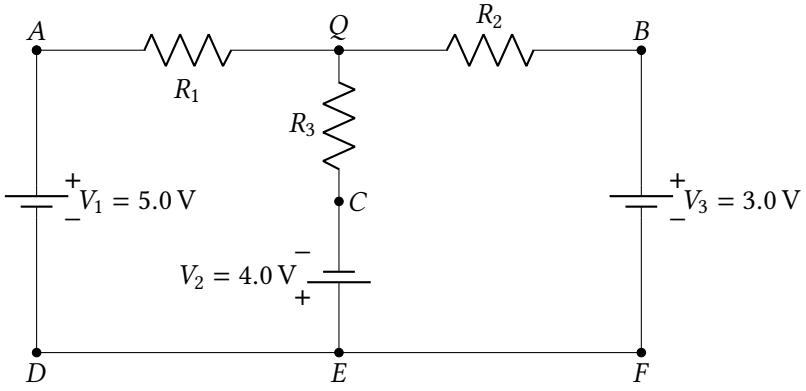
## Part A: Investigation of a multiloop DC circuit

The following measurements will be made on this circuit:




| Resistances | Voltage drops | Current |
|---|---|---|
| $R_1 = 991(0)\ \Omega$ | $V_{R_1} = 5.57(2)\,\text{V}$ | $I_{R_1} = 0.5623\,\text{mA}$ |
| $R_2 = 2162(5)\ \Omega$ | $V_{R_2} = 3.55(8)\,\text{V}$ | $I_{R_2} = 0.1645\,\text{mA}$ |
| $R_3 = 482(2)\ \Omega$ | $V_{R_3} = -3.50(4)\,\text{V}$ | $I_{R_3} = -0.7267\,\text{mA}$ |

Summing the currents calculated above, we get that $\sum I = 0.0001\,\text{mA}$, which is very close to zero. This confirms Kirchoff's current law.

For the left loop:
$V_{AQ} = 5.57(3)\,\text{V}$
$V_{QC} = 3.50(4)\,\text{V}$
$V_{CE} = -3.99(8)\,\text{V}$
$V_{DA} = -5.08(2)\,\text{V}$
$\sum V = -0.003\,\text{V}$

For the right loop:
$V_{QB} = -3.55(8)\,\text{V}$
$V_{BF} = 3.06(7)\,\text{V}$
$V_{EC} = 3.99(8)\,\text{V}$
$V_{CQ} = -3.50(4)\,\text{V}$
$\sum V = 0.003\,\text{V}$

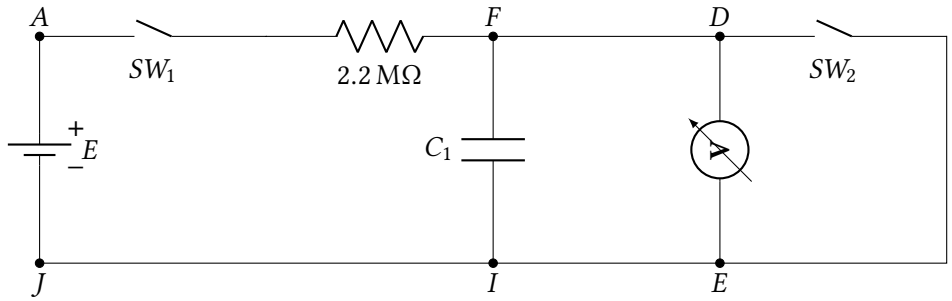
For the outer loop:
$V_{AQ} = 5.57(3)\,\text{V}$
$V_{QB} = -3.55(8)\,\text{V}$
$V_{BF} = 3.06(7)\,\text{V}$
$V_{DA} = -5.08(3)\,\text{V}$
$\sum V = -0.001\,\text{V}$

For all three loops, $\sum V \approx 0$. This confirms Kirchoff's voltage law.

# Part B: Charge and discharge of a capacitor

## Charge of a capacitor

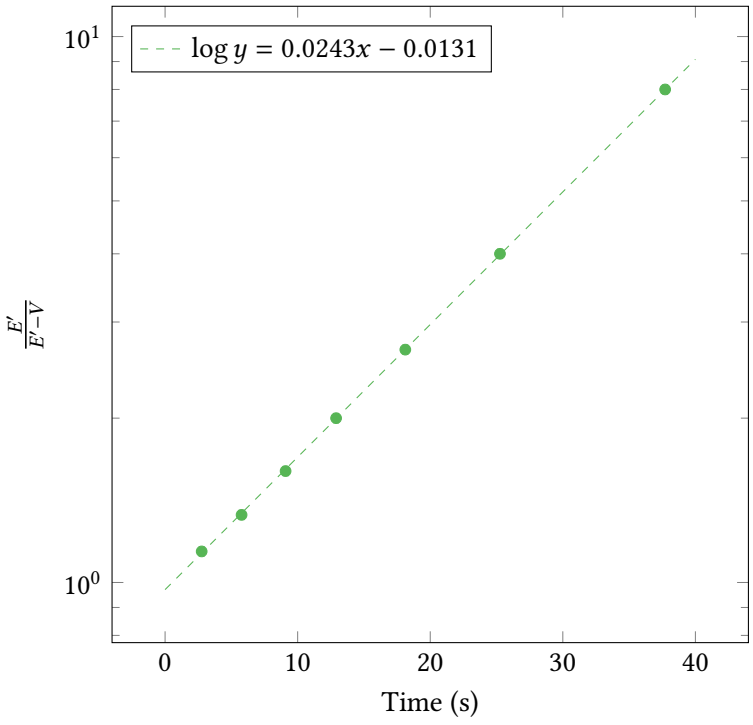
The following measurements will be made on this circuit:




*All time values have an uncertainty of* ±0.01 s.

| Voltage (V) | Time (s) | | | Average time (s) | $\frac{E'}{E'-V}$ |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | | |
| 0.5 | 2.85 | 2.82 | 2.61 | 2.76 | 1.14 |
| 1.0 | 5.59 | 5.92 | 5.79 | 5.77 | 1.33 |
| 1.5 | 9.09 | 8.97 | 9.21 | 9.09 | 1.60 |
| 2.0 | 13.06 | 12.95 | 12.68 | 12.90 | 2.00 |
| 2.5 | 18.14 | 18.15 | 18.09 | 18.12 | 2.67 |
| 3.0 | 25.10 | 25.36 | 25.33 | 25.26 | 4.00 |
| 3.5 | 37.98 | 37.49 | 37.70 | 37.72 | 8.00 |

Plotting $\frac{E'}{E'-V}$ vs. $t$ on a semi-log graph, we get:



Notes about the above graph:

- The error bars are too small to be shown.
- The dashed line is a regression of the data.

The slope of the line is $m = 0.0243$. Using this, we can calculate $C_1$:

$$m = \frac{\log e}{R'C_1} \tag{1}$$

$$\frac{1}{C_1} = \frac{mR'}{\log e} \tag{2}$$

$$C_1 = \frac{\log e}{mR'} \tag{3}$$

To calculate $R'$:

$$R' \equiv \frac{R_M}{R_M + R} \cdot R \tag{4}$$

$$= \frac{10.5\,\text{M}\Omega}{10.5\,\text{M}\Omega + 2.2\,\text{M}\Omega} \cdot 2.2\,\text{M}\Omega \tag{5}$$

$$= 1.82\,\text{M}\Omega \tag{6}$$

$$= 1.82 \times 10^6\ \Omega \tag{7}$$

Plugging this back into Equation 3:

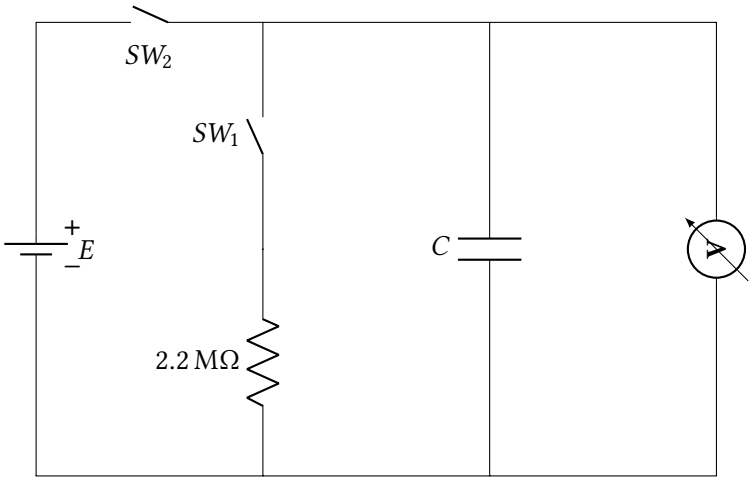
$$C_1 = \frac{\log e}{(0.0243\,\text{s}^{-1})(1.82 \times 10^6\ \Omega)} \tag{8}$$

$$= 9.82\,\text{s}\,\Omega^{-1} \tag{9}$$

$$= 9.82\,\text{F} \tag{10}$$

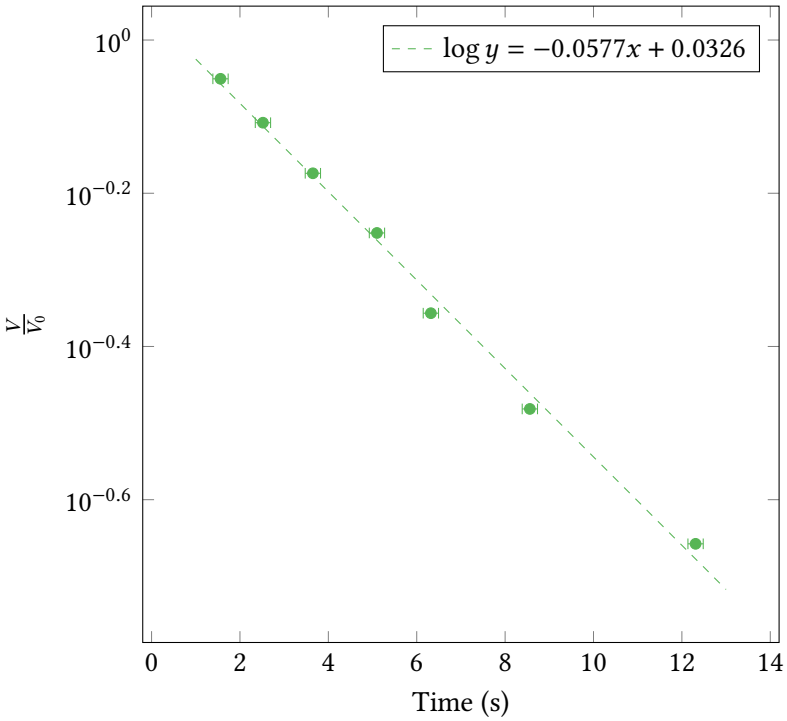
## Discharge of a capacitor

The following measurements will be made on this circuit:



| Voltage (V) | $\frac{V}{V_0}$ | Time (s) |
|---|---|---|
| 4.00 | 0.89 | 1.56 |
| 3.50 | 0.78 | 2.52 |
| 3.00 | 0.67 | 3.65 |
| 2.50 | 0.56 | 5.10 |
| 2.00 | 0.44 | 6.32 |
| 1.50 | 0.33 | 8.56 |
| 1.00 | 0.22 | 12.31 |

Plotting $\frac{V}{V_0}$ vs. time on a semi-log graph:




The slope of the dashed regression line is $m = -0.0577$. Using this, we can calculate $C_2$:

$$m = \frac{\log e}{R'C_2} \tag{11}$$

$$\frac{1}{C_2} = \frac{mR'}{\log e} \tag{12}$$

$$C_2 = \frac{\log e}{mR'} \tag{13}$$

$$= \frac{\log e}{(-0.0577\,\mathrm{s}^{-1})(1.82 \times 10^6\,\Omega)} \tag{14}$$

$$= -4.14\,\Omega\,\mathrm{s}^{-1} \tag{15}$$

$$= -4.14\,\mathrm{F} \tag{16}$$

## Part C: Capacitors in series and parallel

[incomplete]