

REPORT

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Exp. Name :	Charging and Discharging the Capacitor
Experiment Goals :	Examining the time-dependent change in current during the charging and discharging the capacitor and determining the time constant.

1. Record your experimental results in tables for charging and discharging processes of the capacitor. (10 point)
2. Using your experimental data, **plot current (I) - time (T) graphs** for each case. Obtain the time constant from each graph separately. (20 point) **You do not have four graphs; you have two graphs. You will not draw the charge-time graph.**
3. **Interpret the graphs you have drawn.** Describe the expected graphical models and explain why they should exhibit such behavior. If your graphs deviate from the expected models, provide possible explanations for these discrepancies. (10 point)
4. Now, obtain the time constant using the values of circuit elements that you applied to your circuit. (10 point)
5. Explain the meaning of time constant (τ). (10 point)

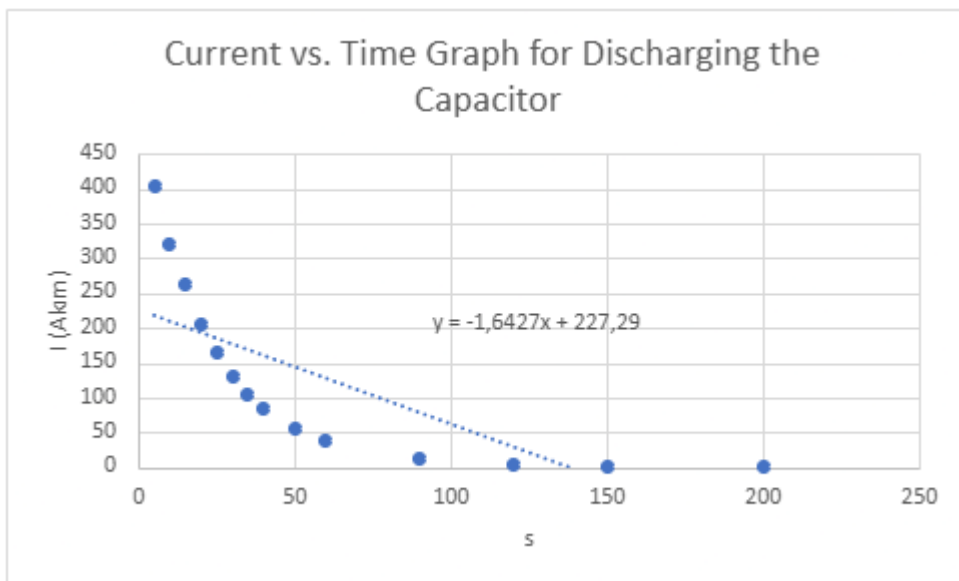
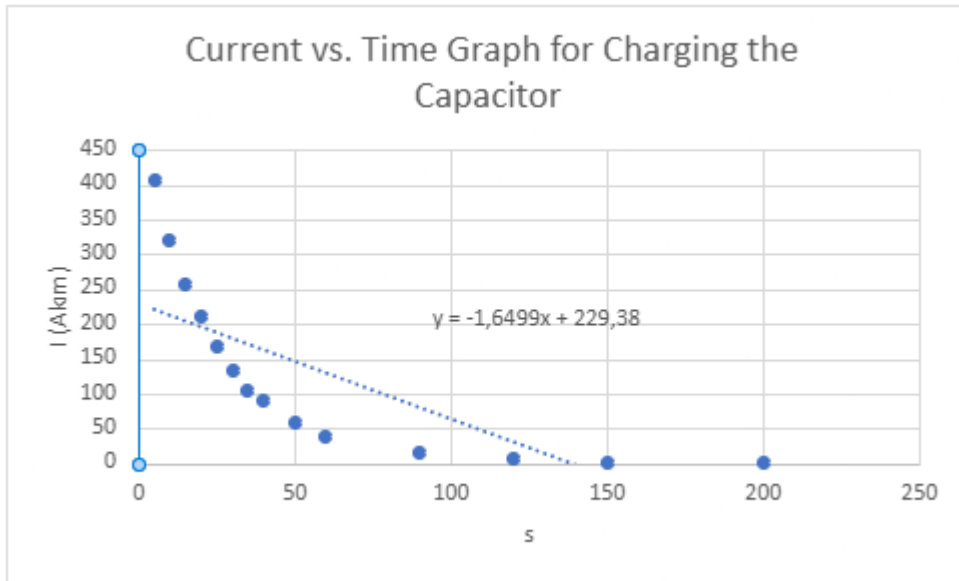
1. **Table 2.1.** Charging the Capacitor.

$C = 10\mu F$		$R = 10k\Omega$	
t		I	
5s		407	
10s		321	
15s		257	
20s		210	
25s		167	
30s		133	
35s		105	
40s		90	
50s		58	
60s		39	
90s		14	
120s		6	
150s		2	
200s		0	

Table 2.2. Discharging the Capacitor.

$C = \mu F$		$R = k\Omega$	
t		I	
5s		403	
10s		320	
15s		261	
20s		206	
25s		165	
30s		130	
35s		105	
40s		85	
50s		56	
60s		38	
90s		11	
120s		3,7	
150s		1,4	
200s		0	

2.



3. Expected Graphical Models

The expected model for both charging and discharging processes is an **exponential decay** described by the equation $I(t) = I_0 e^{-\frac{t}{\tau}}$. In this model, the current starts at a maximum value (I_0) at $t = 0$. and decreases over time.

Why They Exhibit Such Behavior:

- **Charging:** As the capacitor fills, its opposing voltage increases, which reduces the voltage across the resistor and forces the current to drop.

- **Discharging:** The capacitor's stored voltage acts as the source; as it depletes, the voltage and the resulting current both fall toward zero.

Discrepancies and Possible Explanations:

- **Component Tolerance:** The real R and C values may vary from their labeled nominal values.
- **Internal Resistance:** The internal resistance of the multimeter and connecting wires can influence the decay rate.
- **Measurement Timing:** Minor human errors in syncing the stopwatch with the multimeter readings can cause data shifts.

4. Theoretical Calculation of the Time Constant

The theoretical time constant (τ) is calculated using the following formula:

$$\tau = R \times C$$

Given values

- **Resistance (R):** $10k\Omega = 10 \times 10^3\Omega$
- **Capacitance (C):** $10\mu F = 10 \times 10^{-6}F$

Calculation:

$$\tau = (10 \times 10^3) \times (10 \times 10^{-6})$$

$$\tau = 100 \times 10^{-3}$$

$$\tau = 0.1 \text{ second}$$

In your experimental data, the current reaches zero around 200 seconds, which suggests a much larger time constant (around 22-23 seconds). If your instructor asks about this difference, you can mention that the actual components used in the lab likely had different values than the $10k\Omega$ and $10\mu F$ labels shown in the table header, or that a larger resistor was used to slow down the process for easier data collection.

5. The Meaning of the Time Constant (τ)

The time constant, denoted by the Greek letter tau (τ), is a fundamental parameter that characterizes the response time of an RC (Resistor-Capacitor) circuit. It represents the time required for the circuit's response to reach a specific percentage of its final or initial state.

- **Physical Meaning:** In a charging or discharging circuit, the time constant is the time it takes for the current (or voltage) to drop to approximately **36.8% ($1/e$)** of its initial value. Conversely, in a charging circuit, it is the time required for the capacitor to reach approximately **63.2%** of its maximum charge.
- **Rate of Response:** The value of τ determines how quickly a circuit reacts to changes. A small time constant indicates a very fast response (the capacitor charges or discharges quickly), while a large time constant indicates a slow response.
- **Steady State:** Mathematically, a capacitor is considered to be fully charged or fully discharged after a period of approximately **5τ** . At this point, the current has effectively reached zero, and the circuit enters a steady state.