UNIVERSITY OF WOLLONGONG IN DUBAI

LAB REPORT 3

# INTERNAL RESISTANCE AND ELECTRICAL METERS

**Subject:** PHYS143 (DB123) Physics for Engineers.

**Group Members:**

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# Experiment 1
# Charging a capacitor

## Purpose

The objective of this experiment was to understand how potential difference depends on time across a capacitor in a simple RC series circuit.

## Hypothesis

Knowing about the formulas, it is expected that the voltage would change and this can be detected using a multimeter. Use an ammeter/voltmeter when appropriate.

## Materials used

- Bread board
- Probe wires
- Power supply
- Capacitor
- Multimeter
- Resistor
- Wires
- Power supply wires
- Stopwatch

## Procedures

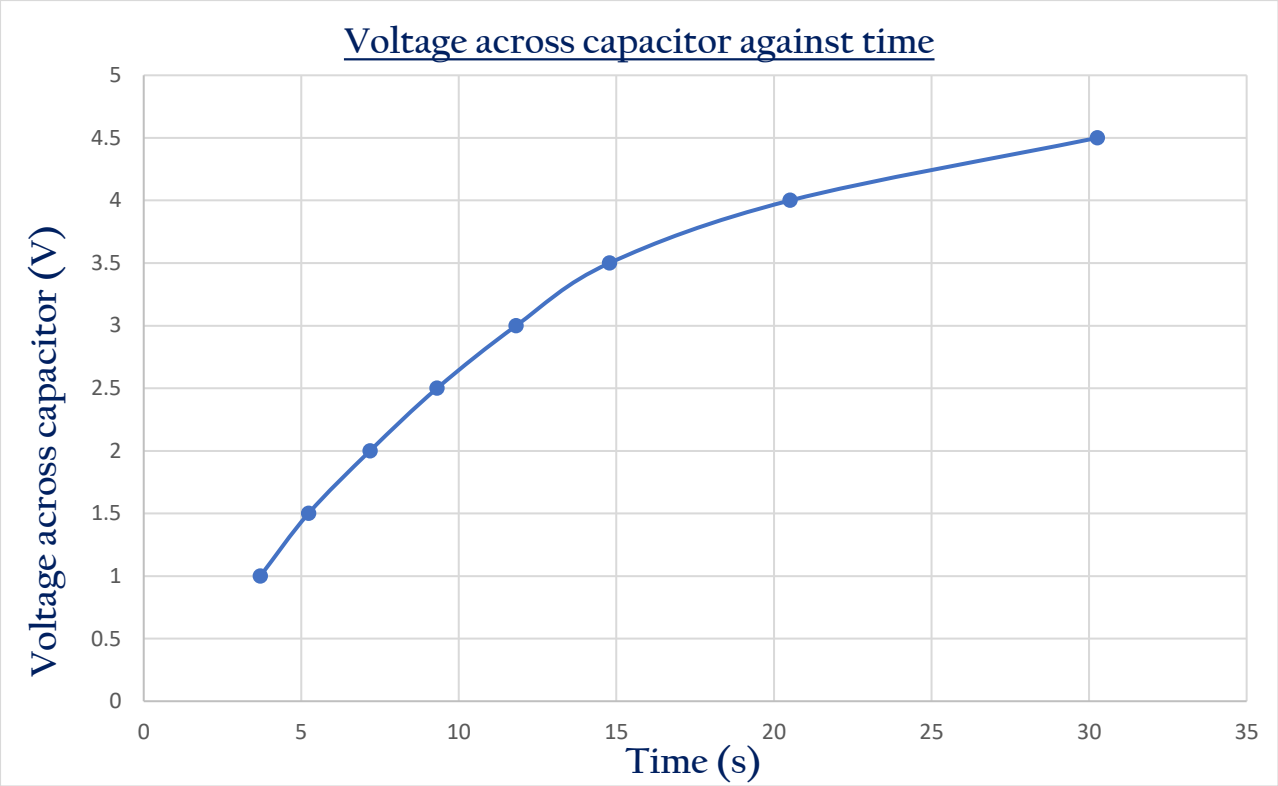
1. A circuit was set up on the bread board which consisted of wires, a resistor, a multimeter.
2. The capacitor was discharged by connecting its ends before connecting it to the bread board.
3. The power supply was connected to the circuit using power supply wires.
4. Measure the resistance of the resistor and set the voltage to 5 V
5. The stopwatch and power supply were both turned on simultaneously to record the time at various voltages after making sure all of the connections were secure.
6. After each reading was taken, the capacitor was discharged and reconnected to the circuit. This was repeated various times for specific values of voltages.

## Data and observations

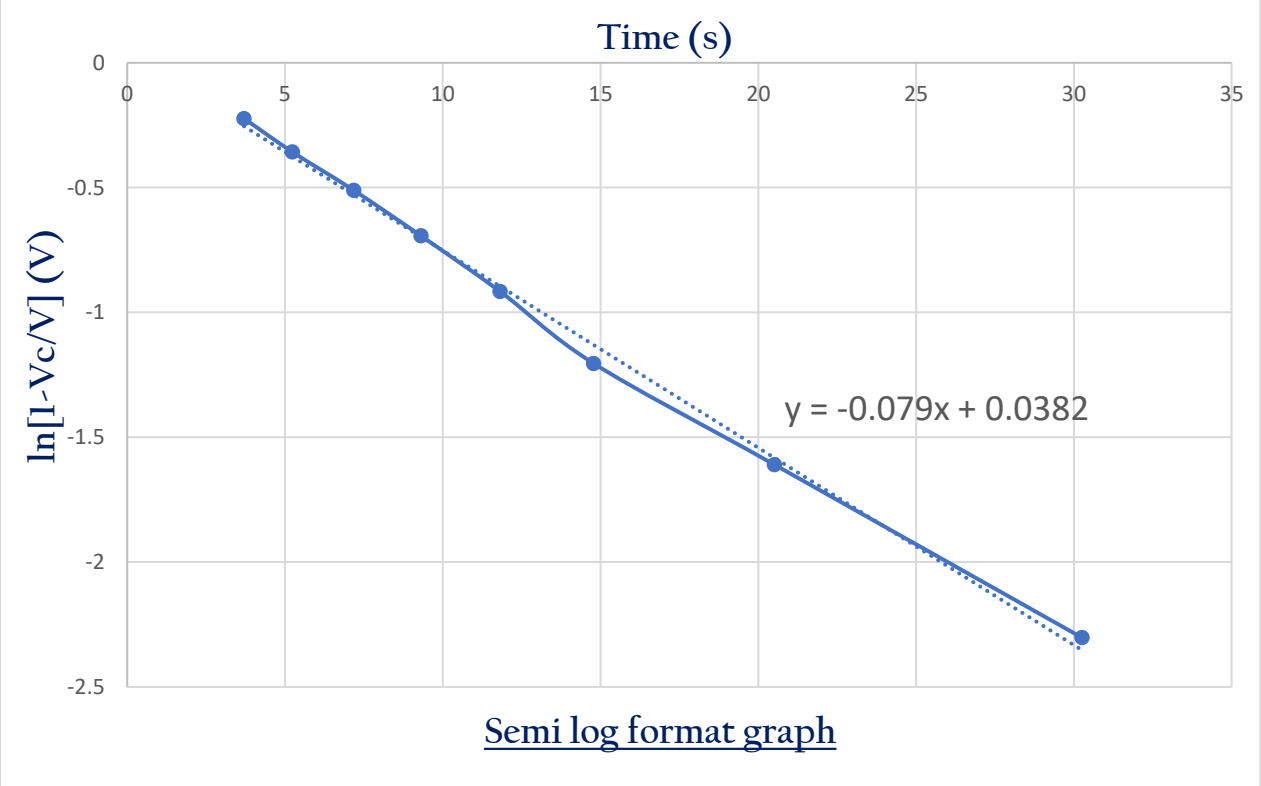
It was observed that the voltage across the capacitor would increase exponentially when time passes by.

| Voltage across the capacitor ($V_c$) | Time (s) |
|---|---|
| 1 | 3.70 |
| 1.5 | 5.23 |
| 2 | 7.18 |
| 2.5 | 9.31 |
| 3 | 11.82 |
| 3.5 | 14.78 |
| 4 | 20.51 |
| 4.5 | 30.26 |

## PLOT 1 (Graph 1)




## PLOT 2 (Graph 2)




Semi log format graph

## Calculations

Measured Resistance of resistor is 11.94kΩ.
$\tau$ = 11940*1000*$10^{-6}$ = RC= 11.94s
V = 5 V

**PLOT 1**

Using graph 1, the time constant can be found for 63.2% of the initial voltage (5V). The voltage at 63.2% is 3.16V and the corresponding time constant off the graph is $\tau$ = 12.7s.
Therefore, C = $\tau$/R = (12.7/11940) *$10^{6}$ = 1064 µF

**PLOT 2**

Since $V_C$ = 3.16 V, Y axis value = -0.9998 V.
Using graph 2, the corresponding time constant value for $V_C$ is 12.63s
Thus C = $\tau$/R = (12.63/11940) *$10^{6}$= 1058 µF
Both of these values are close to the known value of 1000 µF.

## Conclusion

The goal of this experiment was to find how voltage changes with time. A circuit was set up on the bread board and the capacitor was discharge before connecting it to the circuit. The voltage was set to 5V and the resistance of the resistor was measured. Then the stopwatch and power supply were turned on simultaneously to record the time at specific values of the voltage. After every reading, the capacitor was discharged by connecting its positive and negative side to each other. A problem we faced was that our capacitor was faulty and did not exceed a certain amount of voltage.
Some sources of error may include:

- Improper connections of wires
- Improper calibration of multimeter.
- Human error when using a stopwatch.
- The capacitor may not be perfectly discharged during the experiment.

We learnt that voltage decreases exponentially with respect to time and that the rate at which a capacitor charges and discharges in an RC circuit is determined by the time constant, which is $\tau$=RC.

When conducting the experiment, a second time, make sure to have proper connections of everything on the circuit. Make sure that the multimeter is calibrated. Make sure the capacitor is fully discharged before reconnecting it to the circuit.

# Experiment 2
# Ammeter-Voltmeter methods

## Purpose

The experiment compares two methods of measuring resistance using an ammeter and a voltmeter, with the difference being how the ammeter and voltmeter are connected in series and parallel respectively.

## Hypothesis

Because the fixed resistor and voltmeter are parallel to each other, the current recorded by the ammeter is predicted to divide. As a result, the resistance of the unknown resistance may be determined using the proper formulas.

## Materials used

- Bread board
- Probe wires
- Power supply
- Multimeter
- Resistor
- Wires
- Power supply wires
- Decade box/Resistance box

## Procedure

1. A circuit was set up on the bread board which consisted of wires, a resistor, a multimeter.
2. A decade box was connected to the circuit.
3. Make sure that the instructor has scanned the circuit.
4. Record and adjust the decade box for 3 different values of resistance. The current of the resistor was read on the ammeter.
5. To read the voltage across the fixed resistor, the circuit was adjusted to record the voltage (since we used 1 multimeter) and the voltmeter was connected in parallel to the fixed resistor.

## Data

| Decade box setting (Ω) | Voltage (V) | Current (mA) | Resistance (Ω) |
|---|---|---|---|
| 300 | 1.24 | 12.3 | 105.05 |
| 400 | 0.992 | 9.85 | 104.94 |
| 500 | 0.818 | 8.25 | 103.25 |

## Calculations

Resistance of fixed resistor = 100Ω

V= 4.95 V

I = 0.05 A

$I_R$ = 0.048 A

$I_V = I - I_R = 0.05-0.048 = 0.002$ A

$R_V = V/ I_V = 4.95/0.002 = 2475$ Ω

$R=V/ (I - V/R_V)$. Example: $R= 1.24/[(12.3*10^{-3})-1.24/2500] = 105.05$Ω

Average Resistance: (105.05 +104.94+103.25)/3 = 104.41 Ω

% error = (104.41-100)/100 = 4.41%

## Conclusion

In conclusion, the experiment was conducted to measure the resistance of a circuit that included an unknown resistance (R) and a decade box ($R_h$) as a variable resistance. The experiment involved varying the resistance of the decade box 3 times, taking the corresponding readings of the ammeter and voltmeter, for each of the resistances and recording the data in a table. The data was then used to calculate and determine the resistance of the circuit. It also recorded the resistance of the voltmeter for the scale setting used in the data acquisition. Some sources of error may include:

- Improper connections of wires.
- Faulty equipments may give inaccurate results.
- Human error, poor decisions can affect the readings.

We learnt that the current will be divided when the resistor and voltmeter are connected in parallel. We also learnt how voltage, current, and resistor varies when one of them is changed. When attempting the experiment the second time, make sure to take multiple readings of the voltage and current to be accurate. We may also repeat the experiment couple of times as small complications can ruin the results. We would also make sure that the resistance of the fixed resistor is 100Ω.

## Analysis Questions

1) When a capacitor is charged through a resistor by a constant voltage source, what is the voltages across the capacitor and a resistor?

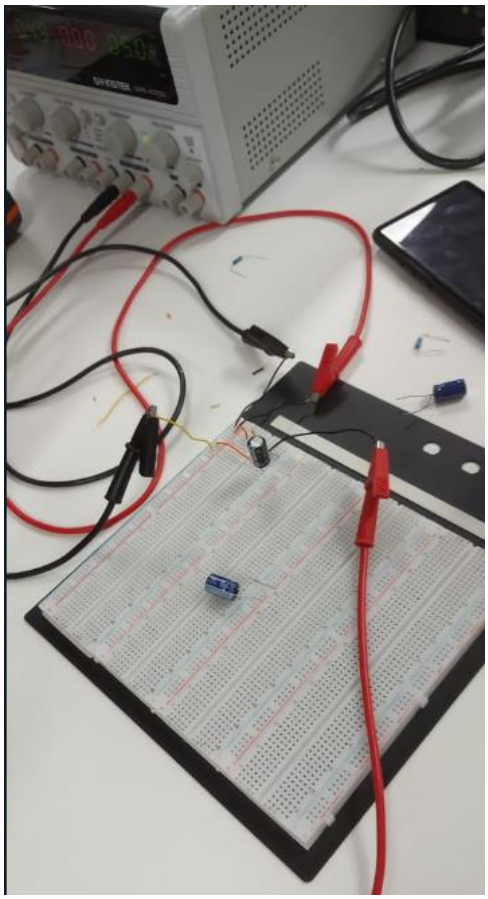
   When the constant voltage (V) source is switched on, the voltage across the resistor is equal to the voltage from the power supply and the voltage of the capacitor is zero. As time passes, the voltage across the capacitor ($V_C$) rises and the voltage across the resistor ($V_C$) falls. $V = V_C + V_R$. After some time, $V_R = 0$ thus the capacitor is fully charged and $V_C = V$.

2) When a capacitor is discharged through a resistor by a constant voltage source what is the voltages across the capacitor and a resistor?

   A constant voltage source discharges a capacitor through a resistor, causing the voltage across the capacitor to decrease while the voltage across the resistance stays constant.

# Pictures

## Experiment 1



## Experiment 2