AMERICAN INTERNATIONAL UNIVERSITY–BANGLADESH (AIUB)

FACULTY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICS

PHYSICS LAB 1

Summer 2020-2021

Section: J | Group: 06

LAB REPORT ON

To determine the time constant of an RC circuit.

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Submitted By

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1. AHMED FARHAN AMIN	21-44804-1	Theory, Calculation & Graph.
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3. M.A.R.M SOUROV	20-43647-2	Theory & Procedure.
4. G.M ALVI SIDDIQUE	20-43659-2	Experimental Data & Discussion.
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Theory:

A capacitor is a device that stores electrical energy in an electric field. It is a passive electronic component with two terminals. The effect of a capacitor is known as capacitance. Capacitors are used in timing circuit in many devices. The time that the dome lights inside a car stay on after turning off the cars ignition at night is one example of how a capacitor can be used to maintain the lighting long enough to remove the key and collect things before exiting. The values we use to characterize these kinds of circuits is given by the time constant defined as: $\tau = RC$, where R is the circuit resistance and C is the capacitance. In this lab, we will observe the charging and discharging of a capacitor and determine the time constant of a RC circuit.

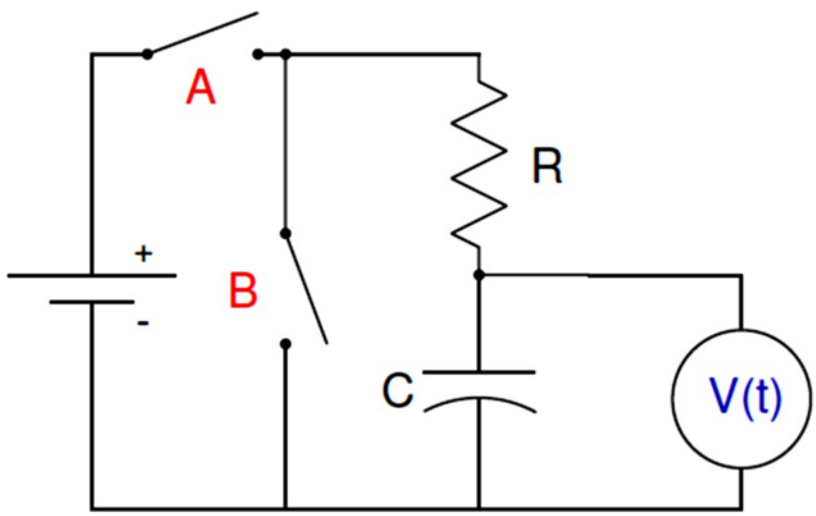

Figure 6.1: *Circuit for RC charge-discharge measurement where V(t) is the potential difference across the capacitor as a function of time.*

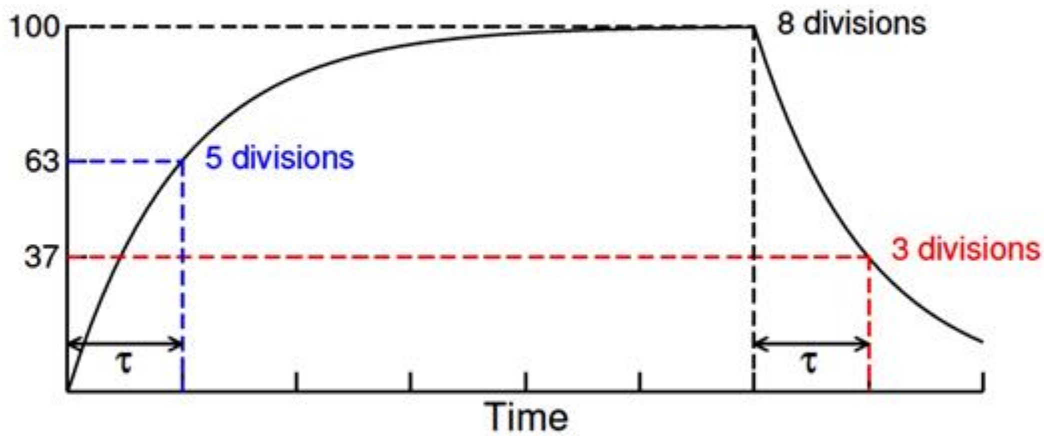

Figure 6.2: *Potential difference across a capacitor in an RC circuit as a function of time.*

The time constant can be determined by observing either the charging and the discharging process of the capacitor as the Fig. 6.2 shows. For the charging process, τ is the time for V(t) to reach 63% of its final value. For the discharging process, τ is the time for V(t) to fall 63% from its initial value.

In the RC circuit in fig. 6.1, if at t = 0 switch A is closed (switch B remains open) charges will begin to build up in the capacitor. These charges do not accumulate within the capacitor instantaneously due to the resistance provided by the resistor. The potential difference across the capacitor for this process can be expressed as,

$$\boldsymbol{V(t)} = \boldsymbol{Vm}\ (\mathbf{1} - \boldsymbol{e}{-}\boldsymbol{t/\tau}\ ) \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

where Vm is the maximum potential difference across the capacitor. After a sufficiently long time (much larger than time constant), if switch A is open while switch B is closed, the capacitor will discharge all its accumulated charges. The potential difference across the capacitor can be expressed as,

$$\boldsymbol{V(t)} = \boldsymbol{Vm}\ \boldsymbol{e}{-}\boldsymbol{t/\tau} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

For charging, Eq. 1 can be written as,

$$\boldsymbol{ln}\ [\mathbf{1} - \boldsymbol{V}(\boldsymbol{t})/\ \boldsymbol{Vm}] = (-\ \mathbf{1}/\boldsymbol{\tau})\ \boldsymbol{t} \ \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Comparing Eq. 3 with y = mx and plotting a graph of "$\boldsymbol{ln}\ [\mathbf{1} - \boldsymbol{V}(\boldsymbol{t})/\boldsymbol{Vm}]\ \boldsymbol{vs}\ \boldsymbol{t}$" we get the value as $\tau = -\ 1/m$, where m is the slope of the graph.

On the other hand, for discharging, Eq. 2 can be written as,

$$\boldsymbol{ln}\ \boldsymbol{V}(\boldsymbol{t}) = (-\ \mathbf{1}/\boldsymbol{\tau}\ )\ \boldsymbol{t} + \boldsymbol{lnVm} \ \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Comparing Eq. 4 with y = mx + c and plotting a graph of "$\boldsymbol{ln}\ \boldsymbol{V}(\boldsymbol{t})\ \boldsymbol{vs}\ \boldsymbol{t}$ " we get the value of τ as, $\tau = -\ 1/m$.

Apparatus

1. Power supply
2. Circuit board
3. Resistor
4. Capacitor
5. Multi meter
6. Stopwatch
7. Connecting wires

Procedure

1.An RC circuit was constructed on the circuit board according to the given circuit shown in theory.

2. A sufficient voltage was applied from the power supply. The charging of the capacitor was observed and the voltage differences across the capacitor with time was noted.

3. After that the power supply was disconnected from the circuit. The discharging of the capacitor with time was observed. The voltage difference across the capacitor with time was also noted.

Experimental Data:

- In the experiment, resistance, R = 47 KΩ and capacitance, C = 2200 μF.
- Maximum potential difference, V_m = 6.8 Volts.

Time (seconds)	Charging capacitor		Discharging capacitor	
	V (t) (Volts)	$ln\left[1 - \frac{V(t)}{V_m}\right]$	V (t) (Volts)	ln V(t)
0	0	0	6.8	1.9169
30	4.6	-1.1285	4.92	1.5933
60	5.02	-1.3403	3.94	1.3712
90	5.35	-1.5454	3.37	1.2149
120	5.61	-1.7430	2.90	1.0647
150	5.84	-1.9577	2.10	0.7419
180	6.03	-2.1783	1.73	0.5481
210	6.16	-2.3632	1.42	0.3507
240	6.27	-2.5518	1.19	0.1740
270	6.37	-2.7609	0.98	-0.0202
300	6.48	-3.0564	0.83	-0.1863
330	6.54	-3.2640	0.69	-0.3711
360	6.60	-3.5264	0.58	-0.5447
390	6.64	-3.7495	0.49	-0.7133
420	6.64	-3.7495	0.41	-0.8916
450	6.70	-4.2195	0.34	-1.0788
480	6.72	-4.4427	0.30	-1.2040
510	6.74	-4.7303	0.25	-1.3863
540	6.75	-4.9127	0.21	-1.5606
570	6.77	-5.4235	0.18	-1.7148
600	6.78	-5.8289	0.16	-1.8326
630	6.78	-5.8289	0.14	-1.9661
660	6.79	-6.5221	0.12	-2.1203
690	6.79	-6.5221	0.10	-2.3026

Analysis and Calculation:

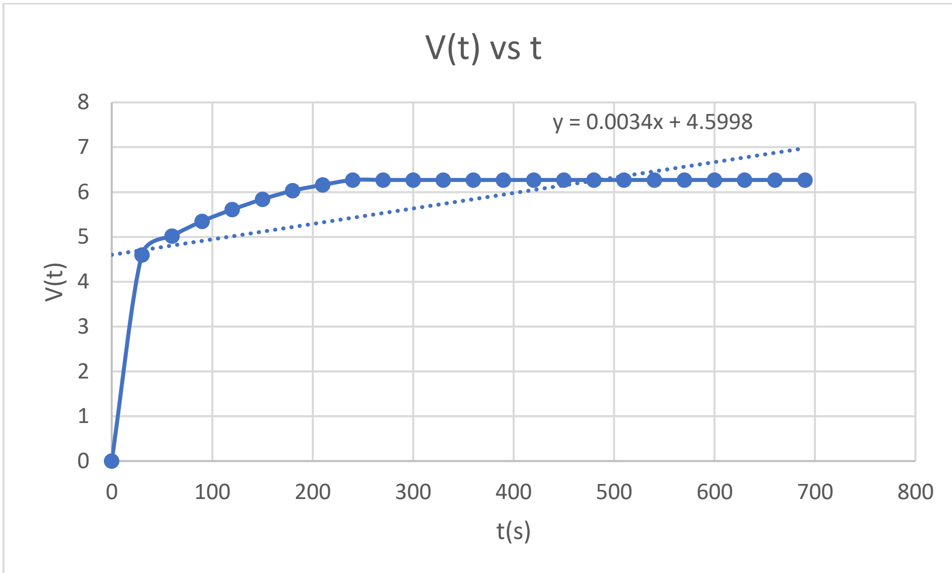

Fig1: Charging Capacitor.

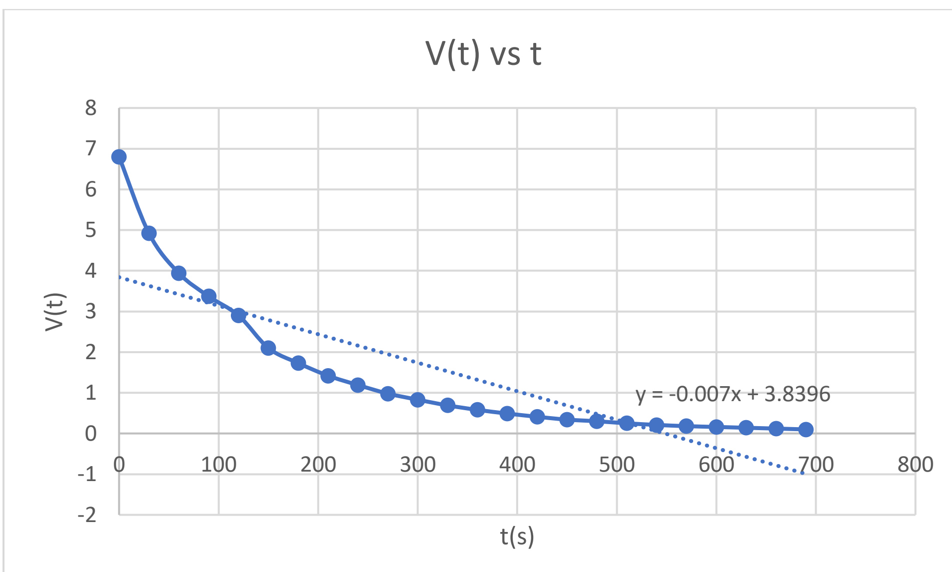

Fig2: Discharging Capacitor.

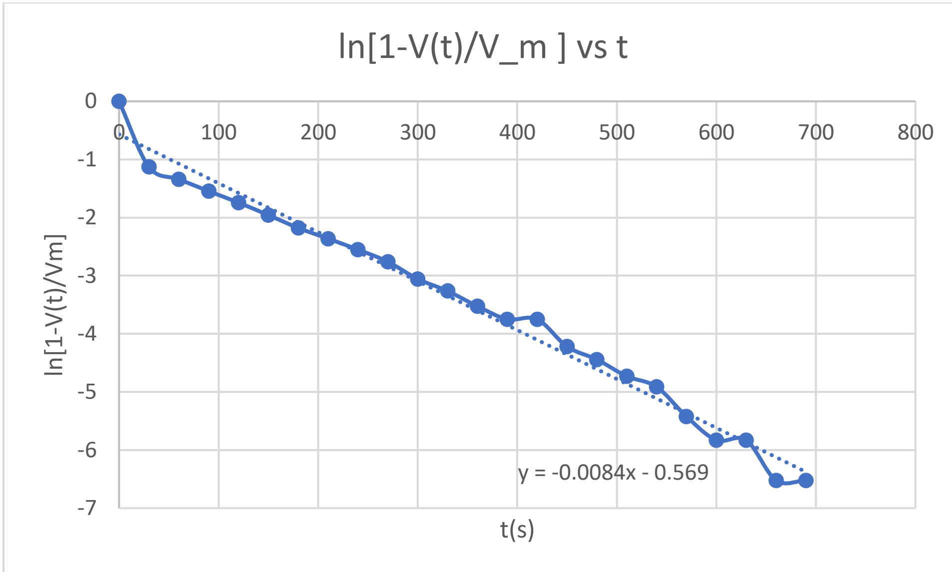

Fig3: Charging graph "$\boldsymbol{ln}\ [\mathbf{1}-(\boldsymbol{V(t)}/\boldsymbol{V}_{\mathrm{m}})]\ \boldsymbol{vs}\ \boldsymbol{t}$"

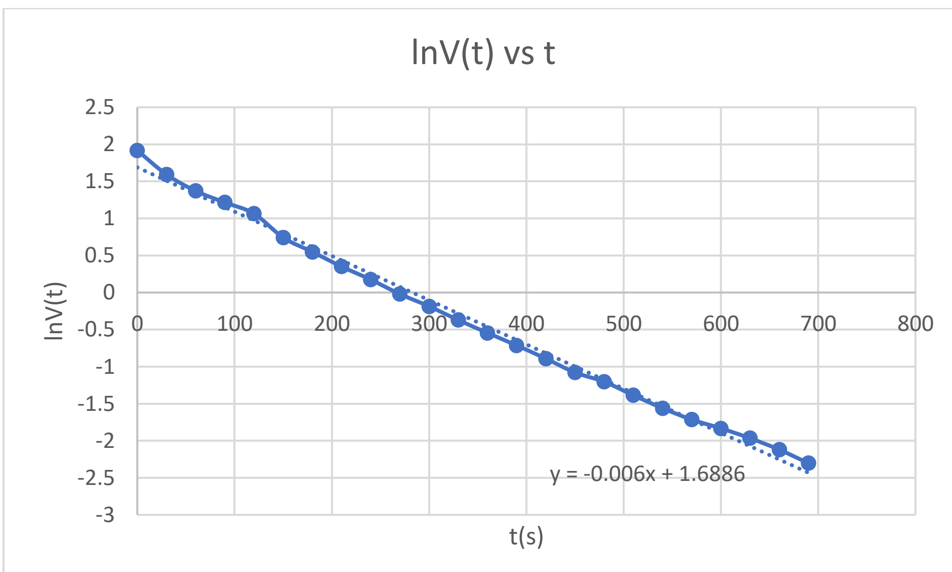

Fig4: Discharging graph " $\boldsymbol{nV(t) vs\ t}$"

For the graph 3, slate $\tau = -1/m$ = 119.0476

For the graph 4, slate $\tau = -1/m$ = 166.667

Result:

<table>
<tr><td colspan="2">From the graphs</td><td rowspan="2">Estimated Values of τ (=RC) in seconds</td><td>Comments</td></tr>
<tr><td>Process</td><td>Values of τ in seconds</td><td rowspan="3">The value of τ in charging discharging are different</td></tr>
<tr><td>Charging</td><td>119.0476</td><td rowspan="2">103.4</td></tr>
<tr><td>Discharging</td><td>166.667</td></tr>
</table>

Discussion:

1. We need to construct the circuit on a circuit board. Then we connect 2 wires with the positive and negative terminal of power supply.

2. The positive terminal relates to the resistor and capacitor with negative terminal of power supply.

3. Then we connect a multimeter across the capacitor to measure the voltage difference

4. We measure voltage and time for charging for data collection.

5. We then supply 5 volts from the power supply. We turn on the power supply and start stopwatch together.

6. At starting we determine the voltmeter reading which we get from the multimeter from 0.

7. Then every 15 seconds we note the multimeter reading.

8. We stop the stopwatch after taking sufficient data and then reset it.

9. Then we switch on the power supply and start the timer again.

10. At starting we note the multimeter at maximum and then again after 15 seconds interval we note the voltmeter reading and stop the stopwatch at 0.

References

For further understanding you may go through the following resources:

- **Fundamental of Physics (10th Edition):** Capacitor (Chapter 25, page 717-721), RC circuit (Chapter 27, page 788-791).

    - **Video Links:**
        - https://www.youtube.com/watch?v=f_MZNsEqyQw
        - (4) 22 - Circuits - Time constant of an RC circuit - YouTube