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NORTH SOUTH UNIVERSITY

Department of Mathematics & Physics

Experimental Physics

PHY-108L 12

Name of the Experiment: Charging and Discharging Characteristics of a Capacitor

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Group Number: E

Date: (i) Experiment Performed: 27 February, 2023

(ii) Report Submitted: 06 March, 2023

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Experiment Name: Charging and Discharging Characteristics of a Capacitor.

Objective:

- To observe charging and discharging characteristics of a capacitor using an oscilloscope.
- To verify the time constant in an RC circuit.
- Usage of Function Generator & Oscilloscope.

Apparatus:

- Breadboard
- Resistor : 1 kΩ
- Capacitor : 0.1 μF
- Function Generator
- Oscilloscope
- wires

Theory:

A capacitor is a passive device that stores energy in it the form of an electric field. It can be charged and discharged through a resistor with the help of a power supply.

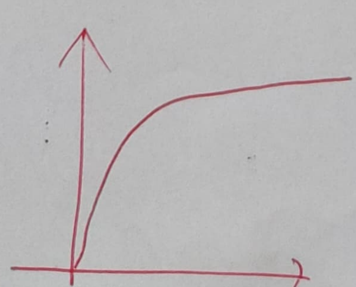
During charging, the voltage across the capacitor increases exponentially with time and is given by the following relation

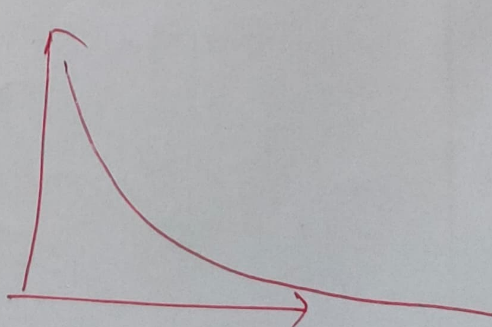
$$V_c(t) = V_0\left(1 - e^{-\frac{t}{RC}}\right)$$

Similarly, a charged capacitor can be discharged through a resistor and the voltage accross the capacitor at any instant can be found by the following relationship

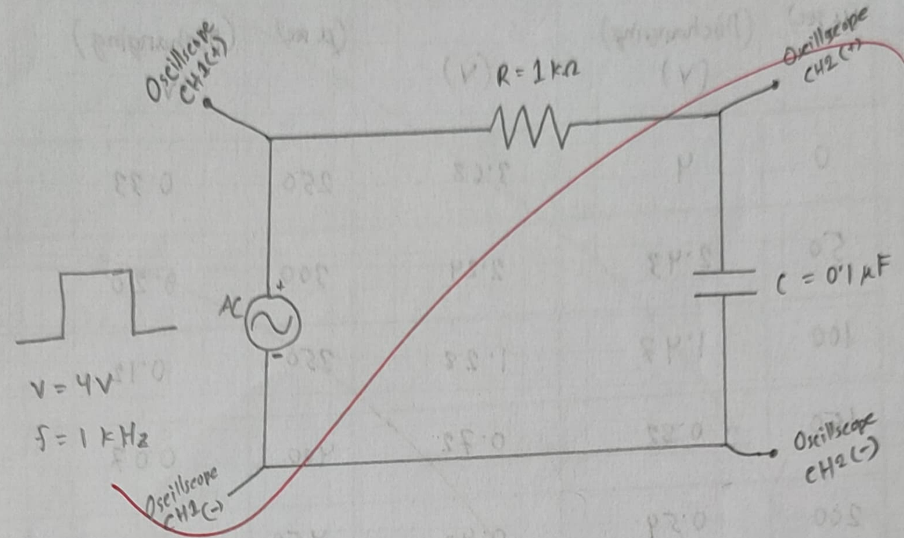
$$V_c(t) = V_0\, e^{-\frac{t}{RC}}$$

Time constant is defined as the time required to charge the capacitor, through the resistor, to 63 percent of full charge; or to discharge it to 37% of its initial voltage.





Circuit Diagram :



Data Table :

Time (μ sec)	Calculated V_c (Charging) (V)	Measured V_c (V)	Time (μ sec)	Calculated V_c (Charging) (V)	Measured V_c (V)
0	0	0.08	250	3.67	3.52
50	1.57	1.52	300	3.80	3.68
100	2.53	2.48	350	3.88	3.76
150	3.11	3.04	400	3.93	3.84
200	3.46	3.36	450	3.96	3.84

Table-1: Time dependent charging characteristic of a capacitor

Time (μ sec)	Calculated V_c (Discharging) (V)	Measured V_c (V)	Time (μ sec)	Calculated V_c (Discharging) (V)	Measured V_c (V)
0	4	3·68	250	0·33	0·24
50	2·43	2·24	300	0·20	0·08
100	1·47	1·28	350	0·12	0·08
150	0·89	0·72	400	0·07	0·08
200	0·54	0·40	450	0·04	0·08

Table 2: Time dependent discharging characteristic of a capacitor.

Calculation:

For charging:

when, $t = 50\,\mu sec$; $V_c = V_0 \left(1 - e^{-t/\tau}\right)$

$= 4\left(1 - e^{\frac{-50}{100}}\right)$

$= 1·57\ V$

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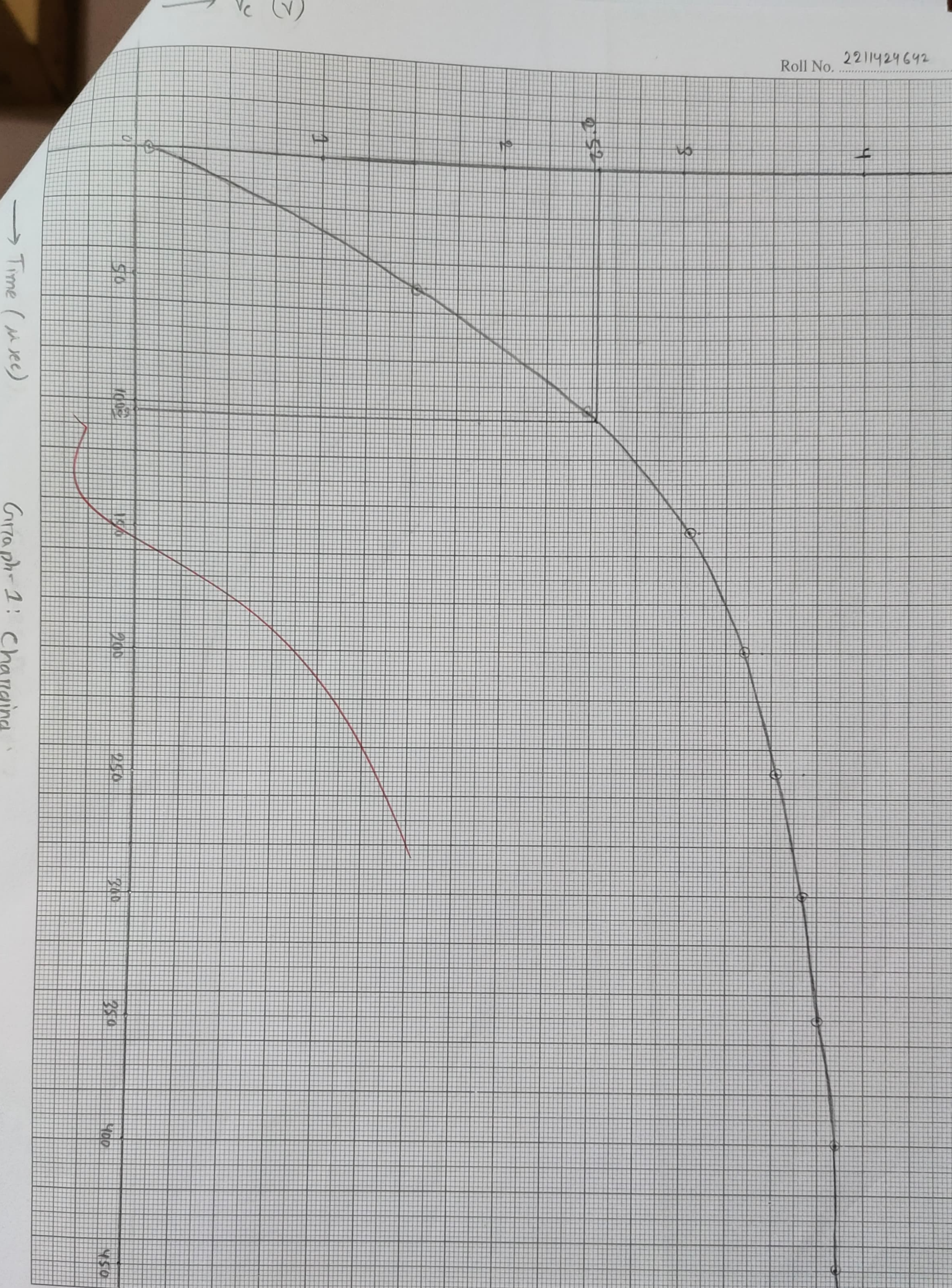
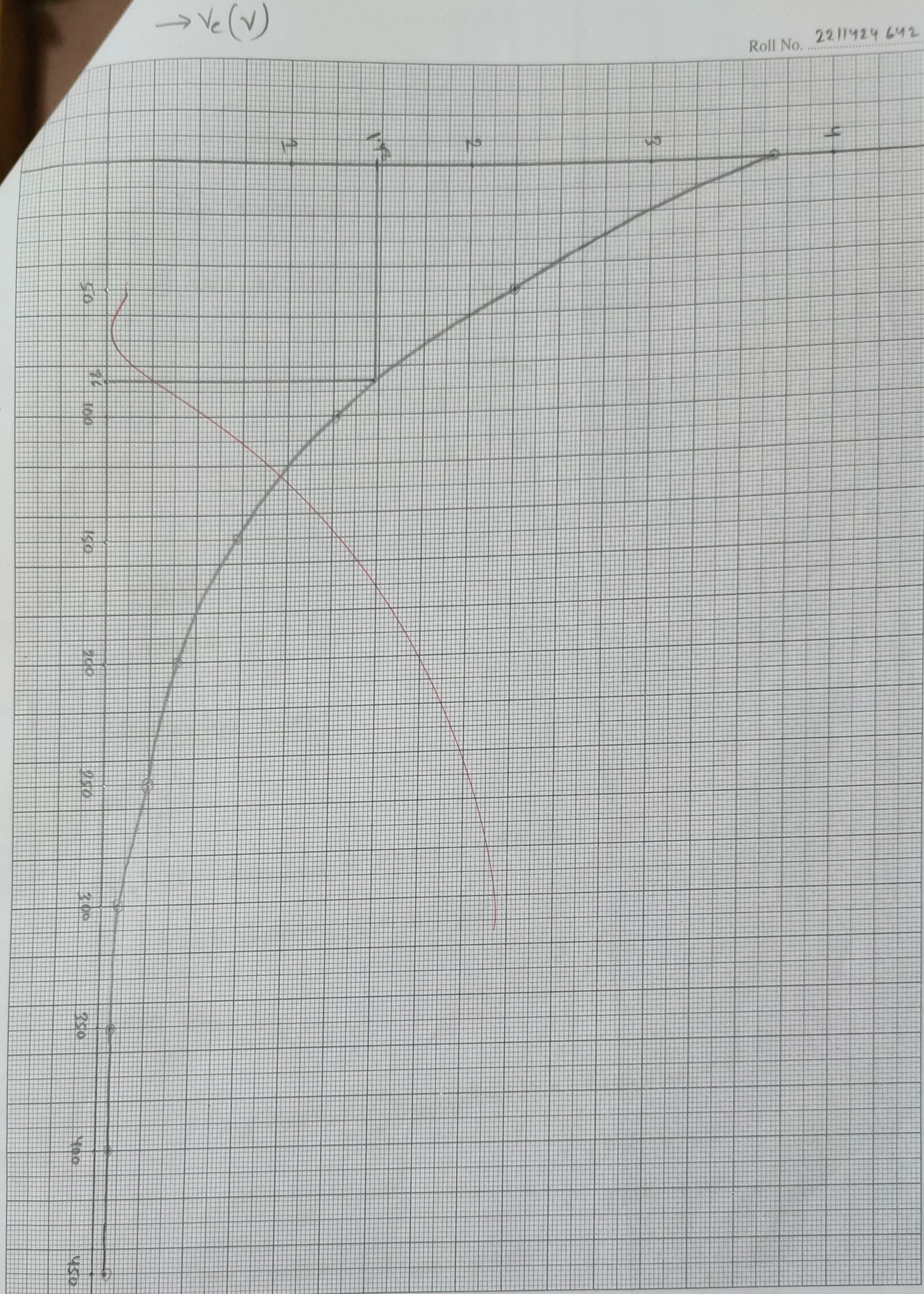


MICRO

N.P. 20 cm x 25 cm

Roll No. 2211424642



Graph-2: Discharging

MICRO
N.P. 20 cm x 25 cm

For discharging:

when $t = 50\ \mu sec$;

$$V_c = V_o\, e^{-t/\tau}$$

$$= 4 \times e^{-50/100}$$

$$= 2.43\ V$$

Graph:

Attached.

Questions and Answer:

1)

$R_{measured} = 0.971\ k\Omega = 971\ \Omega$

Capacitor, $C = 0.1\ \mu F$

For charging,

Time constant (Theoretical): $= R_{measured} \times C$

$= (971 \times 0.1)$

$= 97.1\ \mu sec$

Time constant (From Graph):

when, $t = 1\tau$, $V_c = V_o(1 - e^{-t/\tau}) = V_o \times 0.63$

$= 4 \times 0.63$

$= 2.52\ V$

From the graph,

when $V_c = 2.52\ V$

then, $t = 103\ \mu sec$

$\therefore$ time constant from graph: $103\ \mu sec$

$$\therefore \text{Error} = \left| \frac{\text{Time constant theoretical} - \text{Time constant from graph}}{\text{Time constant theoretical}} \right| \times 100\%$$

$$= \left| \frac{97.1 - 103}{97.1} \right| \times 100\%$$

$$= 6.08\%$$

2|

For discharging,

Time constant theoretical $= 97.1\ \mu sec$

from graph:

when, $t = 1\tau$, $V_c = V_0\ e^{-t/\tau} = 4 \times 0.37$
$= 1.48\ V$

from the graph,

when $V_c = 1.48\ V$

then, $t = 86\ \mu sec$

$\therefore$ time constant from graph: $86\ \mu sec$

$$\therefore \text{Error} = \left| \frac{97.1 - 86}{97.1} \right| \times 100\%$$

$$= 11.43\%$$

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3)

Yes, there is a difference between theoretical and experimental values of time constants, as obtained from the charging and discharging of capacitors. There are about 6.08% of error while charging and 11.43% of error while discharging. It happens because of the supply of voltage. We provided 4 V to the circuit but in the ~~osc~~ oscillscope it was showing that 3.96 V. Because of the wire there are some resistance which caused voltage drop. And also the graph was drawn by best feed line. That's why there are also some error. By combining them we found 6.08% and 11.43% of error respectively for charging and discharging.

4)

As we know,

time constant, $\tau = RC$

that means, $\tau \propto R$

if we decreased the resistors then time constant will also be decreased. That means capacitor will charge very quickly than before also discharge faster than before.

In this experiment,

$R = 1k\Omega$

$C = 0.1\ \mu F$

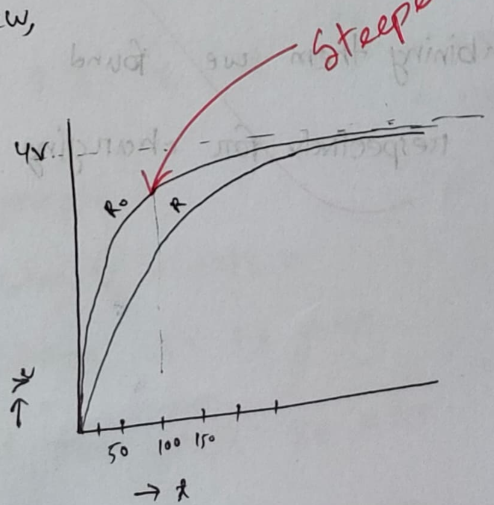
$\therefore \tau = 1000 \times 0.1 = 100\ \mu sec$

if we decreased R to $100\ \Omega$

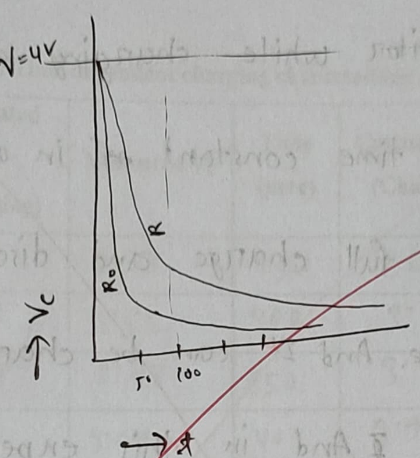
the $\tau_0 = 100 \times 0.1 = 10\ \mu sec$

in Graphical view,

for charging,



for discharging,



Results:

From this experiment, we found that a capacitor can charge 63% with in 1τ (time constant) and also discharge to 37% with in 1τ (time constant). And we found ~~th~~ almost same time constant with some error. We found that our capacitors charge 63% with in 103 μsec and discharge in 37% with in 86 μsec.

Discussion:

From the experiment we learnt about the characteristics of a capacitor while changing and discharging. We also verify the time constant ~~of~~ in an RC circuit. We learn that, for full charge and discharge capacitors need infinity time. And It can be charge 63.2 with in one tim constant. ~~I~~ And in this experiment, we don't face any difficulty. But some time oscillscope showing some abnormal behavior, but we fix it ~~to~~ by ~~th~~ rechecking the wire connection. In short, we learn about the charging and discharging characteristics of a capacitor.

Group-E

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$V_c = V_0 (1 - e^{-t/\tau})$

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