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NORTH SOUTH UNIVERSITY

Department of Mathematics & Physics

Experimental Physics

PHY-108L

Name of the Experiment: ~~Ohm's Law~~ charging and Discharging charactis of a capacitor

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(ii) Report Submitted: 21.08.2023

Lab Report:

Date: 14.08.2023	
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Data Tables:

Table 1: Time dependent charging characteristic of a capacitor

Time (µsec)	Calculated V_C (Charging)	Measured V_C	Time (µsec)	Calculated V_C (Charging)	Measured V_C
0 µs	0 V	0 V	250 µs	3.687 V	3.52 V
50 µs	1.598 V	1.68 V	300 µs	3.812 V	3.64 V
100 µs	2.558 V	2.52 V	350 µs	3.887 V	3.72 V
150 µs	3.134 V	3.06 V	400 µs	3.930 V	3.78 V
200 µs	3.48 V	3.4 V	450 µs	3.959 V	3.84 V

Table 2: Time dependent discharging characteristic of a capacitor

Time (µsec)	Calculated V_C (Discharging)	Measured V_C	Time (µsec)	Calculated V_C (Discharging)	Measured V_C
0 µs	3.84 V	3.84 V	250 µs	0.289 V	0.3 V
50 µs	2.305 V	2.3 V	300 µs	0.179 V	0.16 V
100 µs	1.38 V	1.36 V	350 µs	0.1 V	0.1 V
150 µs	0.83 V	0.84 V	400 µs	0.06 V	0.04 V
200 µs	0.49 V	0.5 V	450 µs	0.03 V	0.02 V

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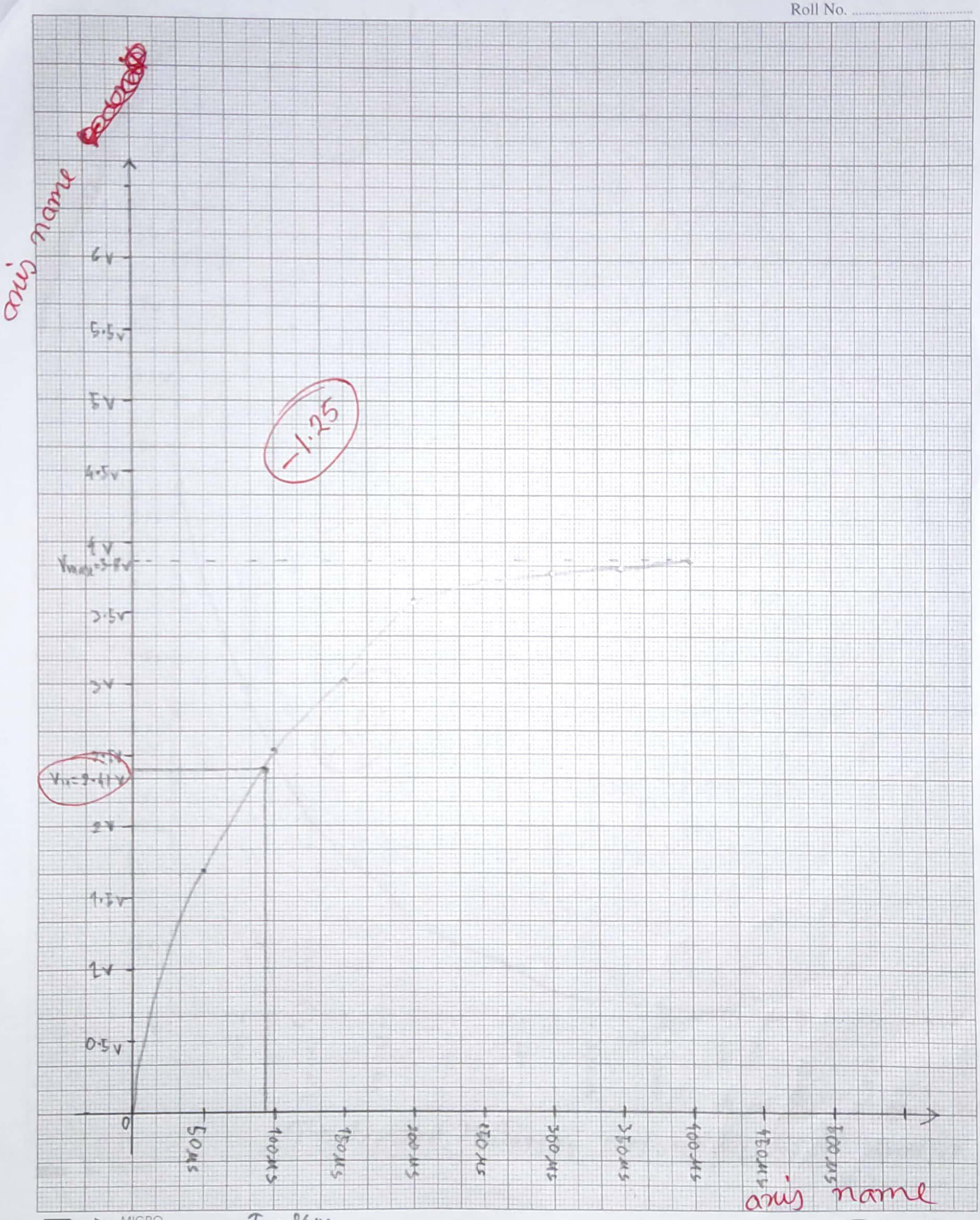

MICRO

τ = 94μs

Time dependent charging of a capacitor

N.P. 20 cm x 25 cm

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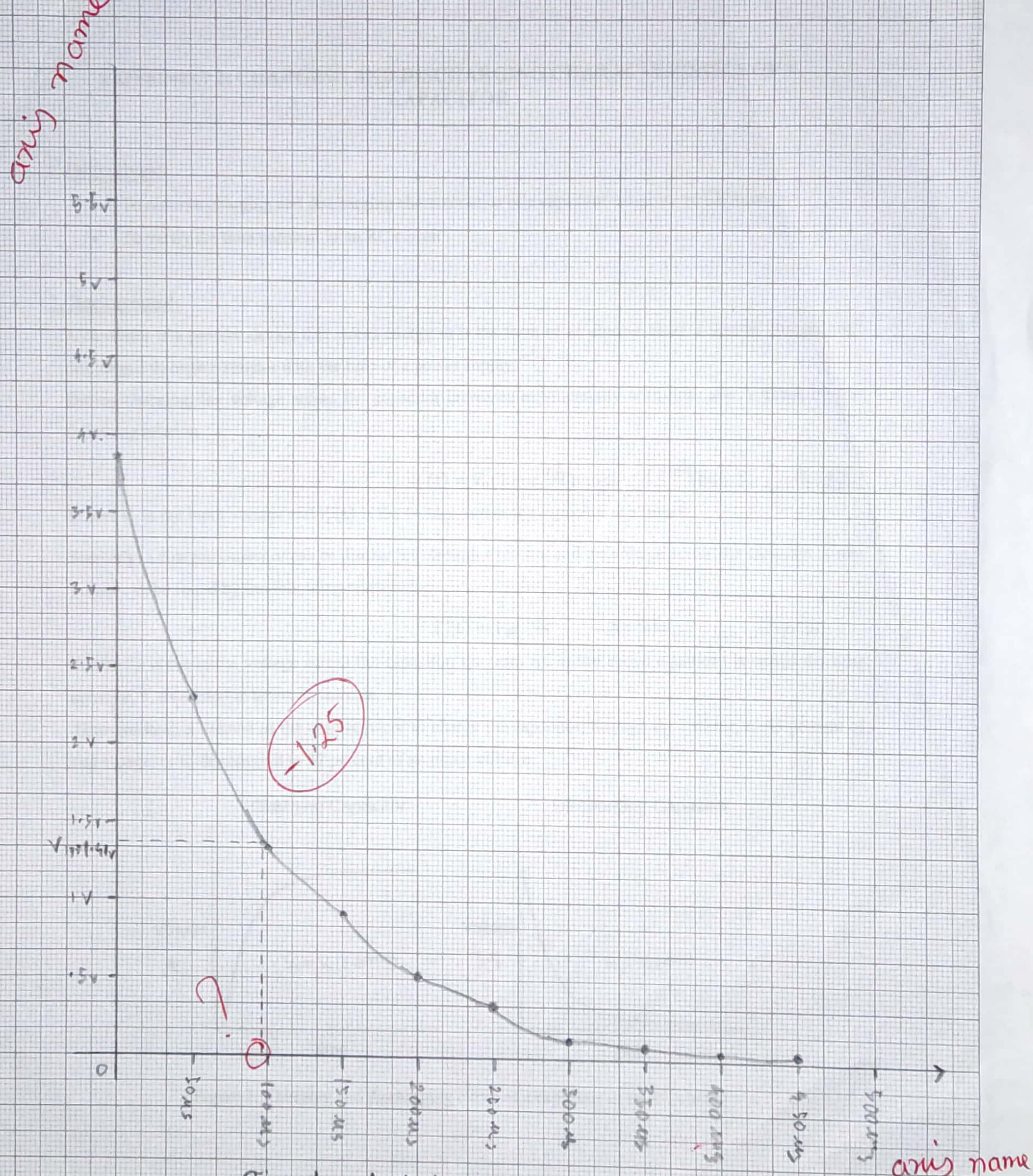


Time dependent discharging charasteristic of a capacitor

MICRO

N.P. 20 cm x 25 cm

EXPERIMENT 2: CHARGING AND DISCHARGING CHARACTERISTICS OF A CAPACITOR

1. Objectives:

- To observe charging and discharging characteristics of a capacitor using an oscilloscope
- To verify the time constant in an RC circuit

2. Background:

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

$$V_c(t) = V_0(1 - e^{-\frac{t}{RC}}) \quad t = RC \quad \text{(Eqn. 1)} \quad 6.3.2\%$$

Where V_0 is the input voltage and $V_c(t)$ is the voltage across the capacitor at a time t.

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

$$V_c(t) = V_0 e^{-\frac{t}{RC}} \quad 0.36 \quad \text{(Eqn. 2)}$$

Where V_0 is the initial voltage across the capacitor, the term RC is the above equations is called the time constant, τ, measured in terms of seconds.

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 percent of its initial voltage.

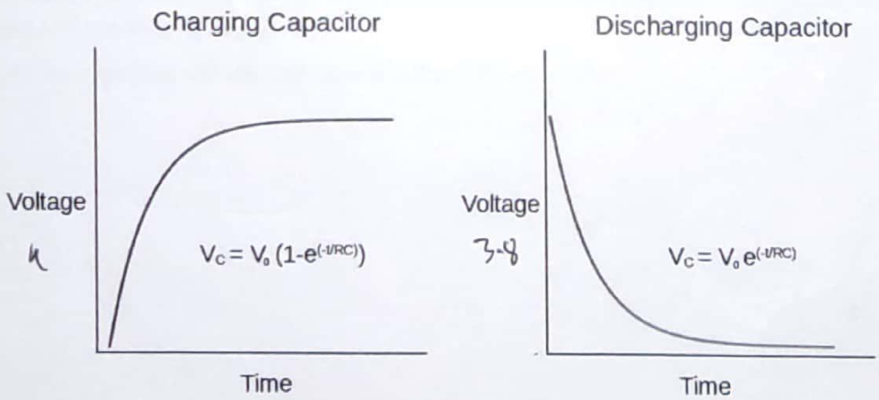


Figure 1: Charging and discharging curve of a capacitor in an RC circuit

0·98 kΩ

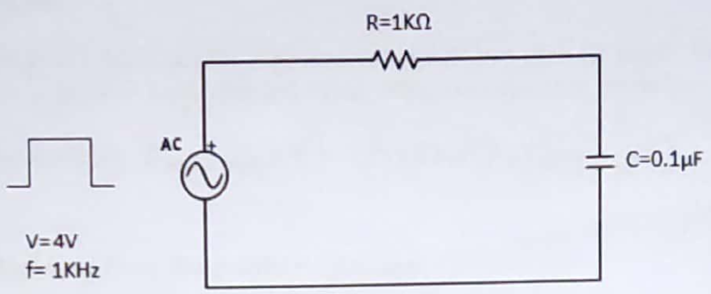


Figure 2: Circuit Diagram for charging and discharging

3. Procedures and Observations:

a. Assume that the capacitor is fully discharged. Measure the value of the resistor, $R_{measured} = 0{\cdot}98 \times 10^{3}$

b. Connect R and C in series with the AC signal generator. (For reference, please see the circuit given above in figure 2).

c. Connect the oscilloscope's channel 1 to the signal generator, choose square wave as an input signal and observe the signal on the oscilloscope.

d. Make sure that the channel is set to **DC coupling**.

e. Measure the amplitude and period of the input pulse and make sure that the amplitude is set to $4V_{p-p}$ Amp and the time period to 1msec with 50% duty cycle.

f. Use the offset knob to raise the signal by 2 V so that the base of the signal is set at 0 V.

g. Connect the oscilloscope's channel 2 across the capacitor and observe the output.

h. Measure the voltage across the capacitor every 50 μsec (approximately) and record the data in the following table.

i. For calculation of capacitor voltage during discharging, measure the maximum capacitor voltage during charging and use it as V_0 in Eqn. 2.

j. Measure the capacitor voltage and record in the following table.

Table+Q

Tasks and Questions:

#1: Use data obtained in Table 1 to **plot** capacitor voltage (V_c) vs time (t) graph. From the graph, calculate the time constant and compare it to the theoretical value. Also, label the axes properly.

Time constant (Theoretical): $R_{measured} \times C =$ $(0.98\times10^{3})\times(0.1\times10^{-6}) = 98\,\mu s$

Time constant (Measured from the graph) = $94\,\mu s$

% of Error = $\left|\frac{98\mu s - 94\mu s}{98\mu s}\right| \times 100\% = 4.081\%$

#2: Use the data obtained in **Table 2** to plot capacitor voltage (V_c) vs time (t) graph. From the above graph, determine the time constant and compare it to the theoretical value. Also, label the axes properly.

Time constant (Theoretical): $R_{measured} \times C =$ $(0.98\times10^{3})\times(0.1\times10^{-6}) = 98\mu s$

Time constant (Measured from the graph) = $96\,\mu s$

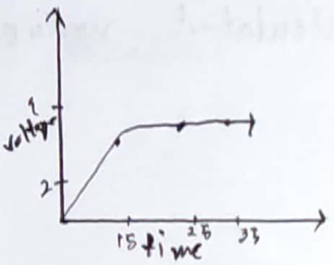
% of Error = $\left|\frac{98\mu s - 96\mu s}{98\mu s}\right| \times 100\% = 2.04\%$ ✓

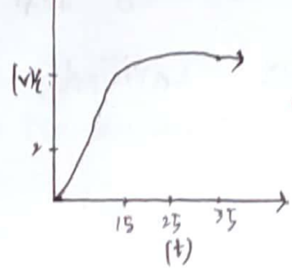
#3: Did you notice any difference between theoretical and experimental values of time constants, as obtained from the charging and discharging of capacitors? If any, Explain.

Yes, we did noticed difference between theoritical and experimental values of the time constants as obtained from the charging and discharging of capacitors.
The wires we used to perform the experiment has their internal resistance which creates variation. We do not measure this external resistance while doing this calcutation. Also the room temparature and human error is the cause of variation. In this theoritical and experimental values of time constants.

#4: What will happen to the charging curve if the resistance is decreased to 100Ω.

If the resistance is decreased to 100Ω the capacitor will ~~ret~~ charged up fast.
The charging curve will do left shift. It will lower level of ~~th~~ we will get higher value of (v). The curve will become constant faster than the 1kΩ curve because the capacitor will get fully charged faster. The curve will get compressed.





Results:

charging: for $T = 350\,\mu s$

$$V_s(t) = V_0\left(1-e^{-\frac{t}{RC}}\right) = 4\left(1-e^{\left(-\frac{350\times10^{-6}}{0.98\times10^{3}\times0.1\times10^{-6}}\right)}\right) = 3.887\ \text{v}$$

Discharging: For $T = 50\,\mu s$

$$V_C(t) = V_0 e^{-\frac{t}{RC}} = 3.84\, e^{\left(-\frac{50\times10^{-6}}{0.98\times10^{3}\times0.1\times10^{-6}}\right)} = 2.305\ \text{v}$$

~~**Discussion:**~~

Charging time constant (Theoretical) $= R_{mea} \times C = 0.98\times10^{3}\times0.1\times10^{-6}$

$\tau = 98\,\mu s$ and time constant form graph $= 94\,\mu s$

$$\%\text{of Error} = \left|\frac{98\,\mu s - 94\,\mu s}{98\,\mu s}\right|\times 100\% = 4.08\%$$

Discharging time constant (Theoretical) $= R_{mea} \times C = 0.98\times10^{3}\times0.1\times10^{-6}$

$\tau = 98\,\mu s$ and time constant form graph $= 96\,\mu s$

$$\%\ \text{Error} = \left|\frac{98\,\mu s - 96\,\mu s}{98\,\mu s}\right|\times 100\% = 2.04\%$$

Discussion: Our lab was about charging and discharging for a capacitor, to conduct this experiment we used capacitor (0.1μ ..., Resistor (0.98 kΩ), AC signal generator, Oscilloscope, Breadboard, wire, Then w placed our resistor and capicitor in the breadboard. Then, we connected R and C in series with the AC signal generator, set squere wave as an input signal. We measured voltage accross the capacitor every 50 μsec and record the data. Then we calculated Vc. Our measured value was close to our calculated value, Thus our experiement got varified.