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NORTH SOUTH UNIVERSITY

Department of Mathematics & Physics

Experimental Physics

PHY-108L.8

Name of the Experiment: **RL SERIES CIRCUIT**

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Serial No: **21**

Group Member's Name: (i) **Mortaza Morshed** ID: **2212697643**

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Date: (i) Experiment Performed: 04/09/2023

(ii) Report Submitted: 11/09/2023

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Experiment 5: RL SERIES CIRCUIT

1. Objective:

1) To observe the rise and decay characteristic of an inductor using an oscilloscope.
2) To verify the time constant of an RL circuit.

2. Background:

An inductor is a passive electronic component that stores energy in the form of a magnetic field. In its simplest form, an inductor consists of a wire loop or coil. If a source emf is introduced in a circuit containing an inductor and a resistor, an induced emf ($\mathcal{E}_L$) will be observed across the inductor while there is a change in the current (like switch 'on' or 'off'), written below:

$$\mathcal{E}_L = -L\frac{di}{dt} \tag{1}$$

It follows the **Faraday's law of induction**. The "minus" sign in the equation 1 indicates that $\mathcal{E}_L$ is opposes the change in current, explained by the **Lenz's Law**.

In this experiment we will observe the decay (positive to zero and negative to zero) of voltage across the inductor in an exponential fashion, like we observed in the *RC* circuit experiment. However, there is no such terms as "charging" and "discharging" in an inductor.

If a constant emf V_O is introduced in a circuit containing *R* and *L*, when the current rises exponentially to $\frac{V_O}{R}$, and because of this change the voltage across the inductor will decay exponentially (positive to zero) (see equation 1), written as,

$$V_L(t) = V_O e^{-t/\tau}. \tag{2}$$

36.8% 1 time

63.2% 2 time cons

Where τ_L is the inductive time constant of the inductor measured in terms of second, given by

$$\tau = L/R. \tag{3}$$

1×10^{4} L (...) (H)

$\tau = 1.02 \times 10^{-4}$ L

Similarly, if the constant emf V_O is withdrawn, current decays exponentially and the voltage across the inductor also decay exponentially (negative to zero), written as,

$$V_L(t) = -V_O e^{-t/\tau}. \tag{4}$$

In figure 2 both current and voltage waveforms are given schematically with respect to time.

Here the inductive time constant, τ is the time required to decay the inductor, through the resistor, 37% of its initial voltage.

For this experiment we will use the circuit in figure 1.

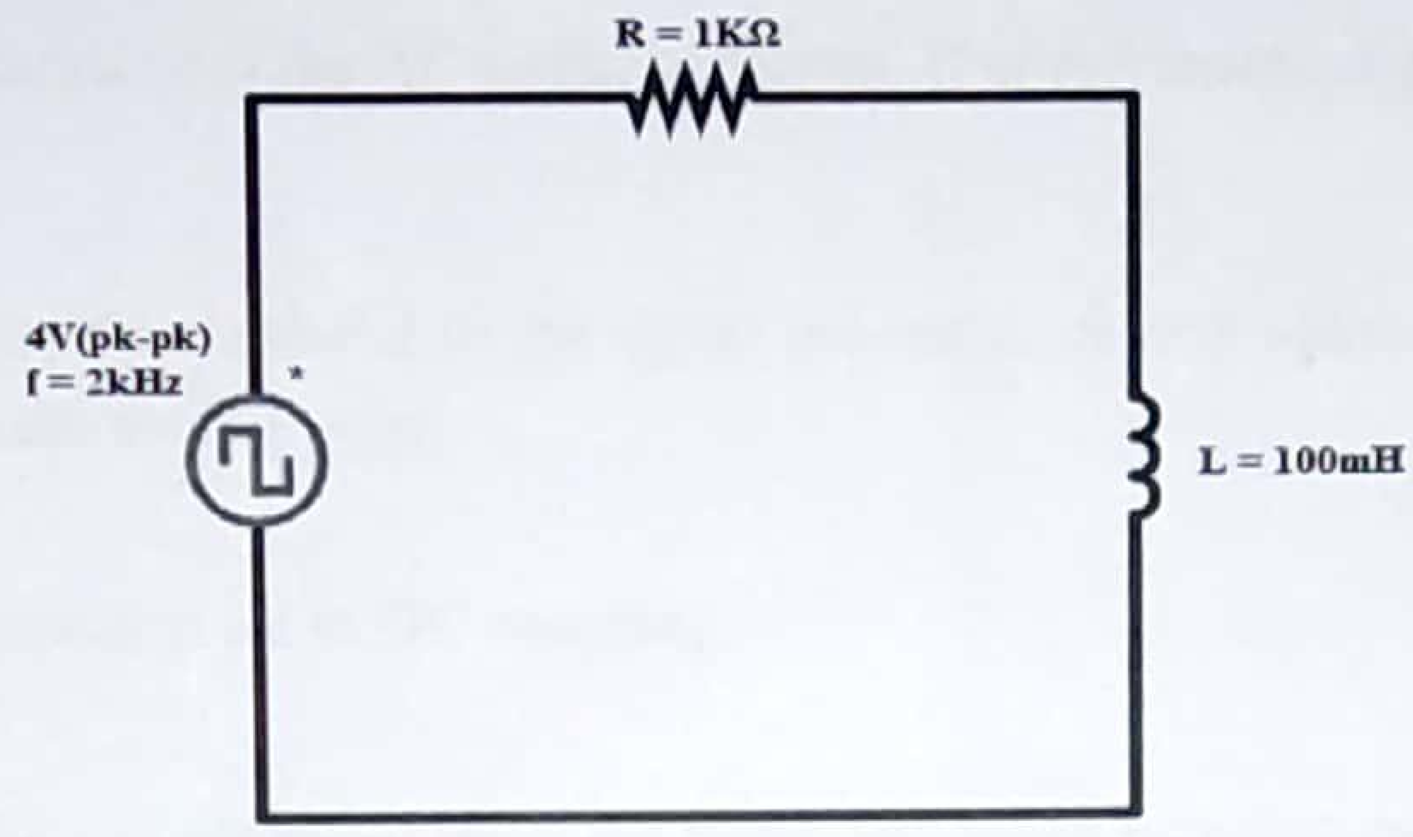


Figure 1: RL Series Circuit

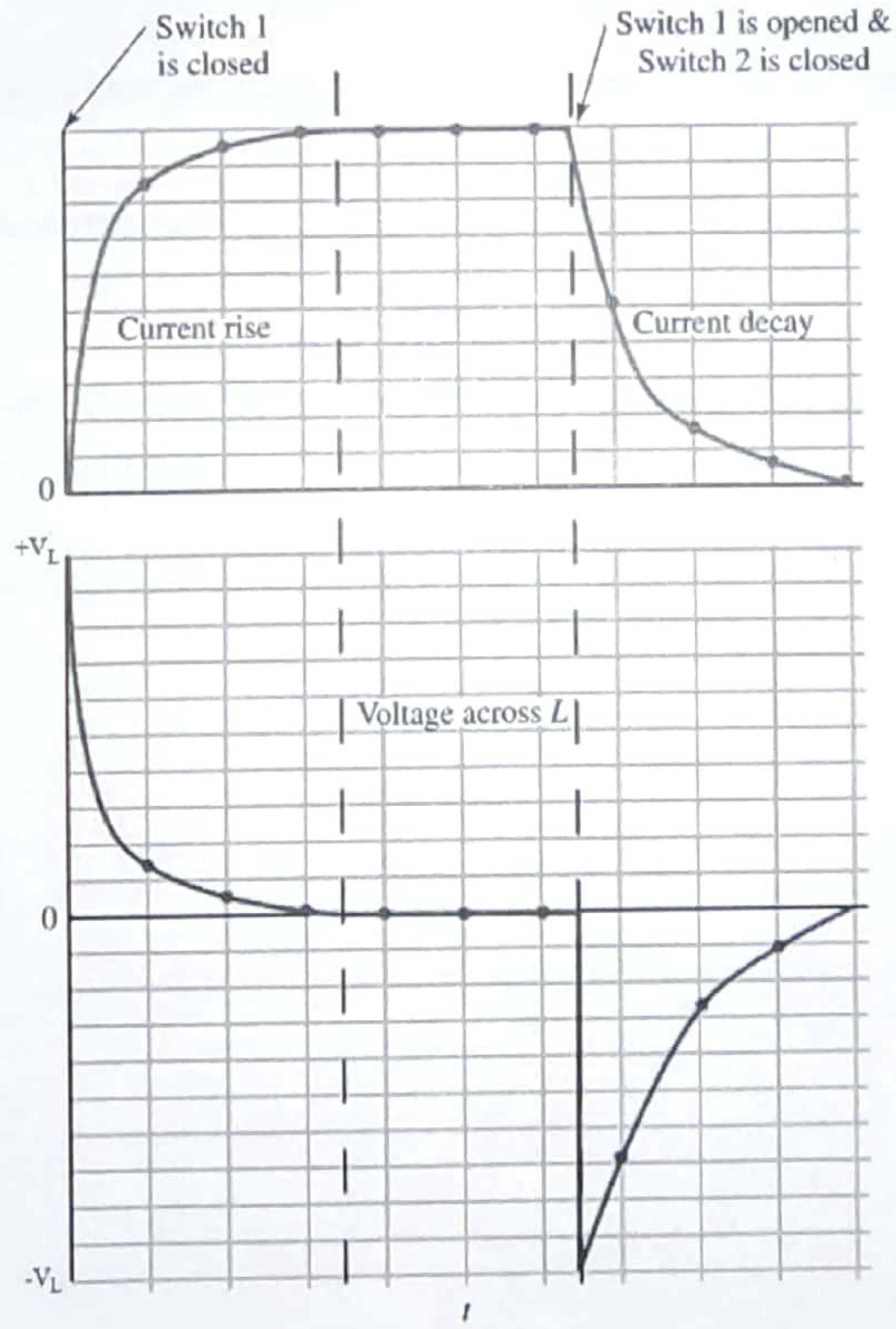


Figure 2: Current and voltage waveform with respect to time

3. Procedures and Observations:

a) Measure the value of the resistor, $R_{measured}$=

b) Connect R and L in series with the AC signal generator. (For reference, please see the circuit given above in figure 1).

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 signal and make sure that the amplitude is set to $4V_{p\text{-}p}$ and the frequency to 2 kHz with 50% duty cycle.

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

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

h) Measure the voltage across the inductor at 20 μs (approximately) interval and record the data in the following table.

i) For calculation of inductor voltage during decay, measure the maximum inductor voltage during charging and use it as V_o in Eqn. 1.

j) Measure the inductor voltage and record in the following table.

Lab Report:

Date: 04.09.23	
Name of the Students and IDs	(1) Shakil Ahmed 2221453042
	(2) Morteza Morshed 2212697643
	(3) Sdfayat Ibrahim 2131174642

Data Tables:

Table 1: Time dependent for the voltage decay **(positive to zero)** of an inductor

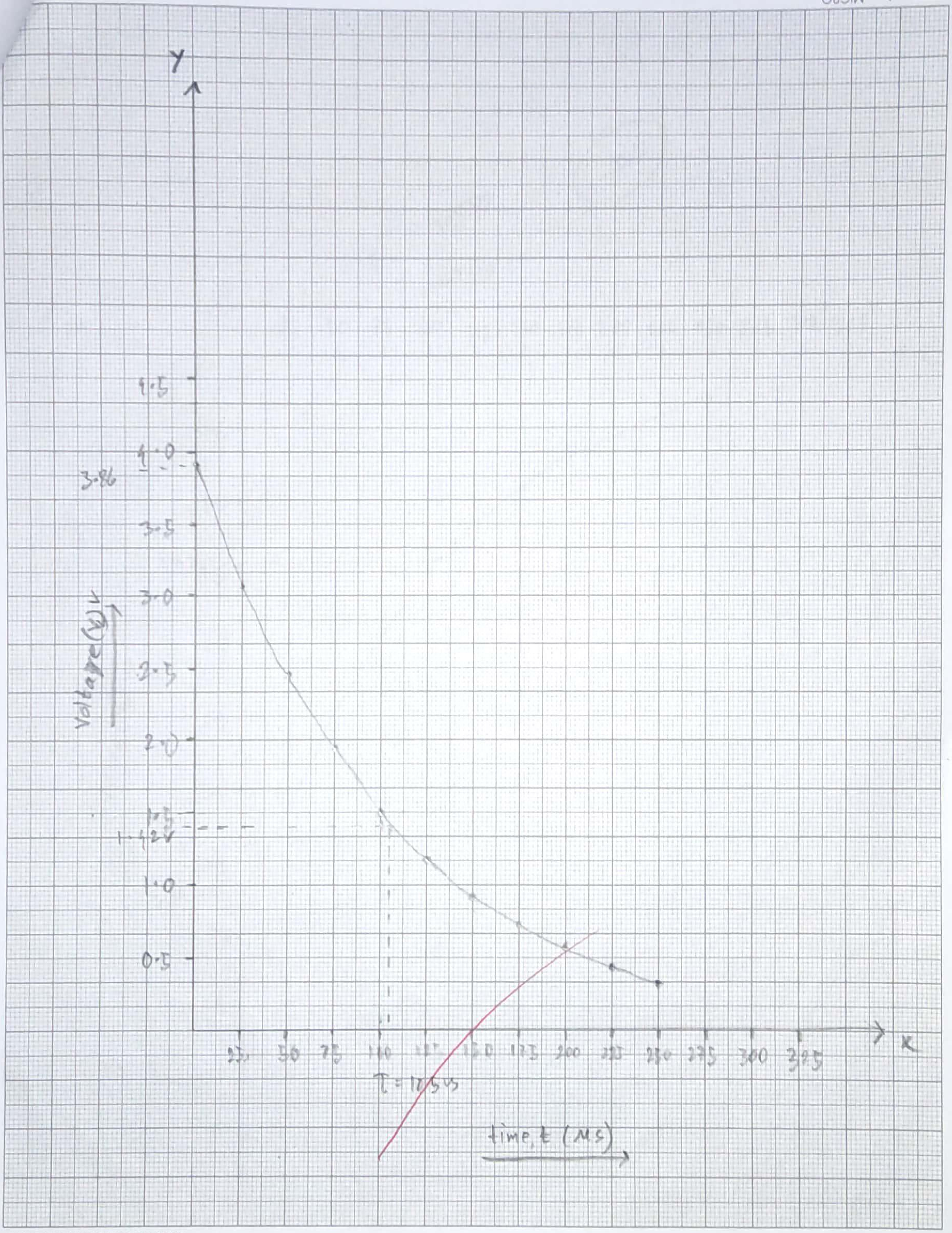
Time (µs)	Calculated V_L (positive to zero)	Measured V_L	Time (µs)	Calculated V_L (positive to zero)	Measured V_L
0	4 V	3.86 V	175 µs	0.71 V	960 mV
25 µs	3.13 V	3.06 V	200 µs	0.56 V	860 mV
50 µs	2.45 V	2.46 V	225 µs	0.44 V	740 mV
75 µs	1.91 V	1.90 V	250 µs	0.34 V	680 mV
100 µs	1.5 V	1.60 V	275 µs		
125 µs	1.17 V	1.34 V	300 µs		
150 µs	0.91 V	1.1 V	325 µ		

Table 2: Time dependent for the voltage decay **(negative to zero)** of an inductor

Time (µs)	Calculated V_L (negative to zero)	Measured V_L	Time (µs)	Calculated V_L (negative to zero)	Measured V_L
0	-4	-3.86	175 µs	- 0.71	-2.26
25 µs	-3.13	-3.18	200 µs	- 0.56	-1.88
50 µs	- 2.45	-3.19	225 µs	- 0.44	-1.48
75 µs	- 1.91	-3.60	250 µs	- 0.34	-82 mV
100 µs	- 1.5	- 2.9	275 µs		
125 µs	- 1.17	- 2.74	300 µs		
150 µs	- 0.91	- 2.58	325 µs		

MICRO

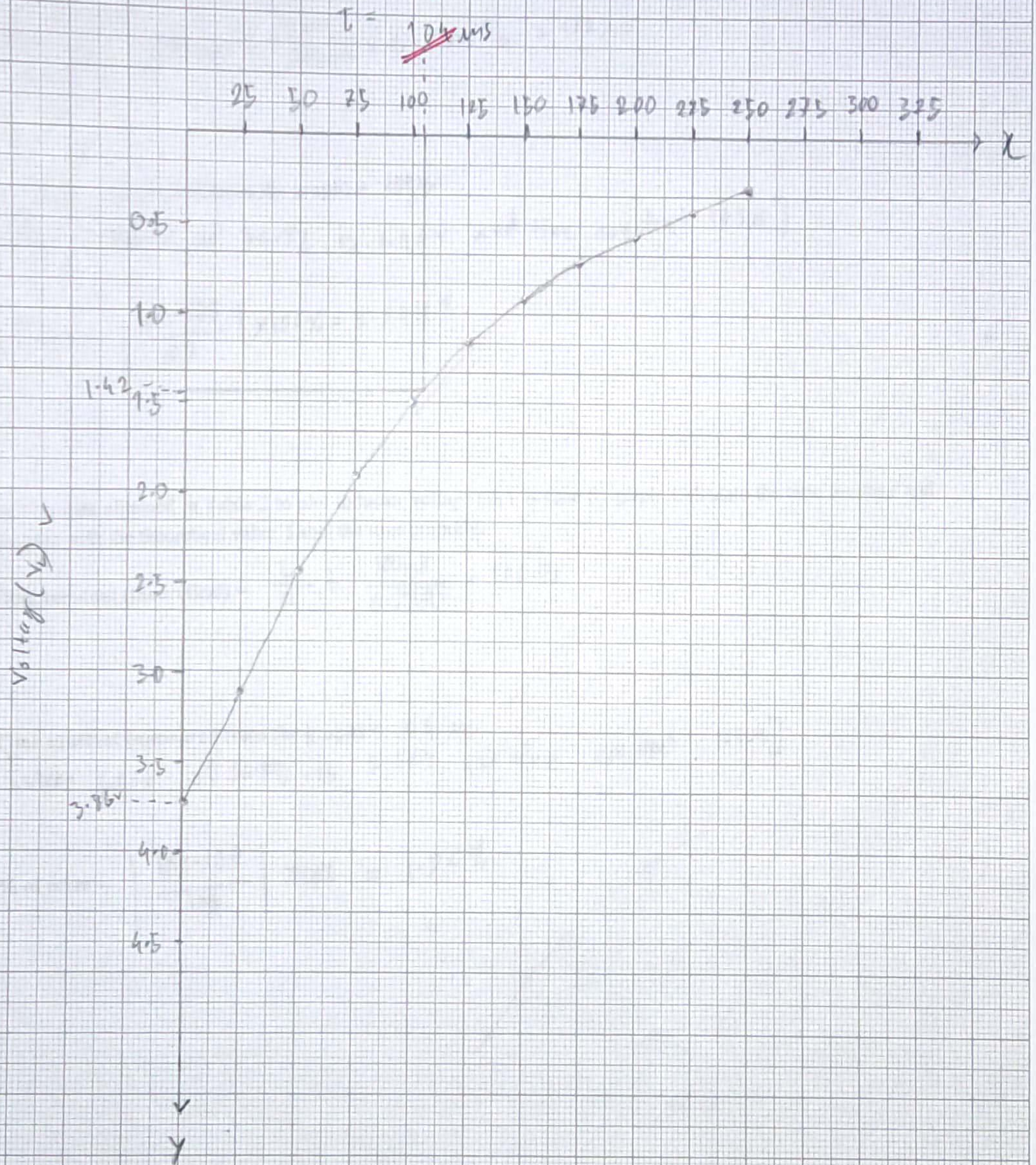
20 cm x 25



Roll No.

-0.5

105 µs



τ = ~~104~~ µs
25 50 75 100 125 150 175 200 225 250 275 300 325
X
0.5
1.0
1.42
1.5
2.0
2.5
3.0
3.5
3.86
4.0
4.5
Voltage (V)
Y

Tasks and Questions:

#1: Use data obtained in Table 1 to plot inductor voltage (V_L) vs time (t) graph. Calculate the time constant and compare with the theoretical value. Label the axes properly.

Time constant (theoretical) = $\frac{L}{R} = \frac{100mH}{0.98k\Omega} = 1.02 \times 10^{-4} s = 102 \mu s$

Time constant (measured from the graph) = 105 μs

where 3.86 v of 36.8% is 1.42V and time constant 105μs]

% of error = $\left| \frac{102-105}{102} \right| \times 100\% = 2.9411\%$

#2: Use data obtained in Table 2 to plot inductor voltage (V_L) vs time (t) graph. Calculate the time constant and compare with the theoretical value. Label the axes properly.

Time constant (theoretical) = $\frac{L}{R} = \frac{100mH}{0.98k\Omega} = 102 \mu s$

Time constant (measured from the graph) = 104 μs

[where 3.86V of 36.8% is 1.42V and time constant 104μs]

% of error = $\left| \frac{102-104}{102} \right| \times 100\% = 1.96\%$

Results: For table 1, where $R = 0.98k\Omega$ $\cdot \tau = 1.02 \times 10^{-4} s$

for 100μs, calculated $V_L = V_s e^{-t/\tau} = 4 \times e^{\frac{-100 \times 10^{-6}}{1.02 \times 10^{-4}}} = 1.5V$

Fo table 2, where $R = 0.98k\Omega$, $\tau = 1.02 \times 10^{-4} s$

for 50μs, calculated $V_L = -4 \times e^{\frac{50 \times 10^{-6}}{1.02 \times 10^{-4}}} = -2.45V$

Discussion:

This lab was about, RL series circuit, for this lab we used wire, breadboard, Ac signal generator, osciloscope, inductor, resistor, then we contructed the circuit. After construtivity the circuit, following the procedure we measured value of V_L to for time status from 0 to 325 for both ~~negative~~ positive to zero and negative to zero of an inductor. Our measured values followed theoritical concept, Thus our experiment got varified

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Lab Report:

Date: 04.09.2023	
Name of the Students and IDs	(1) Shakil Ahmed 2221453042
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	(3) Safayat Ibrahim 2131174642

Data Tables:

R = 0.98 kΩ

Table 1: Time dependent for the voltage decay **(positive to zero)** of an inductor

Time (µs)	**Calculated V_L (positive to zero)**	**Measured V_L**	**Time (µs)**	**Calculated V_L (positive to zero)**	**Measured V_L**
0	4 V	3.86 V	175 ms	0.71 V	960 mV
25 ms	3.13 V	3.06	200 ms	0.56 V	860 mV
50 ms	2.45 V	2.46	225 ms	0.44 V	740 mV
75 ms	1.91 V	1.96	250 ms	0.34 V	680 mV
100 ms	1.5 V	1.60	275 ms		
125 ms	1.17 V	1.34	300 ms		
150 ms	0.91 V	1.10	325 ms		

Mahadul
04.09.23

Table 2: Time dependent for the voltage decay **(negative to zero)** of an inductor

Time (µs)	Calculated V_L (negative to zero)	Measured V_L	Time (µs)	Calculated V_L (negative to zero)	Measured V_L
0	-4 V	-3.86 v	175 µs	-0.71 v	-2.26 v
25 µs	-3.13 v	-3.18 v	200 µs	-0.56 v	-1.88 v
50 µs	-2.45 v	-3.12 v	225 µs	-0.44 v	-1.42 v
75 µs	-1.91 v	-3.00 v	250 µs	-0.34 v	-82 mV
100 µs	-1.5 v	-2.90 v	275 µs		
125 µs	-1.17 v	-2.74 v	300 µs		
150 µs	-0.91 v	-2.58 v	325 µs		

Mehadul
04.09.23