Student's Name: ________________________________ Student's Name: ________________________________

Lab day & time: ____________________ Date: ___________________

Alternating Current Circuits (E6B) - Data Sheets

Write all results on the data sheets in ink.

Activity 1: Time Constant for RL Circuits *(1.5 p.)*

1.2. Read the exact value of the DC voltage V (should be close to 4.50 V) and the maximum value of the current I_{max} .

V = ________________ (   ) I_{max} = ________________ (   )

Use Ohm's law to calculate the resistance (R) of the coil and the 10.0 Ω resistor connected in series.

$R = R_{total} = R_{resistor} + R_{coil}$ = ________________ (   ) $R_{resistor}$ = 10.0 (Ω)

The resistance of the coil attached to the "RLC Circuit" board.

R_{coil} = ________________ (   )

1.4. To select points that computer needs for the fit click anywhere on the "Current in the Coil" graph to make it active and use the "Highlight range of points" tool . The fitting parameter *"B"* for the coil and 10.0 Ω resistor connected in series.

"B" = ______________ (   ) $I(t) = A * \exp(-Bt)$

What is the unit for the fitting parameter *"B"*?

Print the graph for 10.0 Ω resistor and label it "Time constant #1".

The time constant τ for the RL circuit τ_1 = ______________ (   ) = L_1/R_{total}

1.5. The inductance of the coil attached to the RLC board L_1 = ______________ (   )

1.6. Calculate the potential energy PE_{ind} stored in the coil's magnetic field when the current is running through the coil and 10.0 Ω resistor (before the external voltage is turned off). Use equation (5) and the average value of the coil inductance L_{AV}. The current I_{max} was measured in step 1.2.

PE_{ind} = ________________ (   )

1.7. Calculate the resistance R in the RL circuit.

$R_{resistor}$ = 33.0 (Ω) $R = R_{total} = R_{resistor} + R_{coil}$ = ________________ (   )

1.8. The fitting parameter $"B"$ = ______________ (   )

The time constant τ for the RL circuit τ_2 = ______________ (   ) = L_2/R_{total}

The inductance of the coil attached to the RLC board L_2 = ______________ (   )

Should the value of inductance L_2 be similar to the inductance measured using the RL circuit with 10.0 Ω resistor (L_1)? ____

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1.9. Calculate the average value of the coil inductance L_{AV}.

$L_{AV} = (L_1 + L_2)/2$ = ______________ (   )

1.10. Calculate the potential energy PE_{ind} stored in the coil's magnetic field when the current is running through the coil and 33.0 Ω resistor (before the external voltage is turned off). Use equation (5) and the average value of the coil inductance L_{AV}. The current I_{max} was measured in step 1.2.

$$PE_{ind} = \frac{1}{2} L_{AV} I_{max}^2 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \text{ (J)}$$

Activity 2: Impedance as a Function of Frequency for RL Circuits *(1 p.)*

The RL circuit includes now:

- $R_{resistor}$ = 10.0 Ω;
- a coil with inductance L_{AV} and resistance R_{coil} (measured in the previous Activity);
- no capacitors.

2.1. Calculate the resistance R in the RL circuit. Use the value of the coil resistance R_{coil} from Activity 1.

$R_{resistor}$ = 10.0 (Ω) $R = R_{resistor} + R_{coil}$ = ________________ (   )

2.3. Use equation (10) to describe what would be the expected change in the impedance Z when the frequency f increases. You need to analyze parts of the equation and explain how they contribute to the conclusion, which could be: an *increase of the impedance* or a *decrease of the impedance*.

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2.4. Read and record the amplitude of current - "Maximum Current" and the amplitude of voltage - "Maximum Voltage" (this should be very close to 4.5 V). Calculate the measured value of the impedance Z using Eq. (8).

Frequency f (Hz)	Voltage Amplitude V_{max} (V)	Current Amplitude I_{max} (A)	Measured Impedance Z (Ω)
100			
200			
300			
400			
500			
600			
800			
1000			

2.5. Change the frequency f to the next value in the table and repeat measurements.

Activity 3: Impedance as a Function of Frequency for RC Circuits *(1 p.)*

The RC circuit includes now:

- $R_{resistor}$ = 33.0 Ω;
- no coil; Inductance: L = 0 (H)
- C = 100 μF capacitor.

3.1. Calculate the resistance R in the RC circuit.

$R = R_{resistor}$ = 33.0 (Ω) (no coil in the circuit)

Capacitance: C = 100 (μF)

Inductance: L = 0 (H) - the coil is bypassed with a jumper cable

3.3. Use equation (13) to describe what would be the expected change in the impedance Z when the frequency f increases. You need to analyze parts of the equation and explain how they contribute to the conclusion, which could be: an *increase of the impedance* or a *decrease of the impedance*.

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3.4. Read and record the amplitude of current - “Maximum Current” and the amplitude of voltage - “Maximum Voltage” (this should be very close to 5.0 V). Calculate the measured value of the impedance Z using Eq. (8).

Frequency f (Hz)	Voltage Amplitude V_{max} (V)	Current Amplitude I_{max} (A)	Measured Impedance Z (Ω)
10			
20			
30			
40			
50			
60			
80			

100			
150			
200			

Activity 4: Resonance in RLC Circuits *(1 p.)*

This time the RLC circuit includes:

- no external resistors;
- a coil with inductance L_{AV} and resistance R_{coil};
- $C = 100\ \mu F$ capacitor.

4.1. **Remove** the "bypass" wire connecting terminals **A** and **B**. Calculate the resistance R in the single-loop RLC circuit. Move the wire from terminal **D** to terminal **A** on the board.

$R_{resistor} = 0\ (\Omega)$ $R = R_{coil} =$ _______________ ( ) (no external resistors) R_{coil} was measured in Activity 1.

Capacitance: $C = 100\ (\mu F)$ Inductance: $L = L_{AV} =$ _______________ ( )

4.3. Read and record the amplitude of current - "Maximum Current" and the amplitude of voltage - "Maximum Voltage" (this should be very close to 1.50 V). Calculate the measured value of the impedance Z using Eq. (8).

Frequency f (Hz)	Voltage Amplitude V_{max} (V)	Current Amplitude I_{max} (A)	Measured Impedance Z (Ω)
100			
120			
140			
160			
170			
180			

190			
200			
220			
240			
260			
280			

4.4. Change the frequency f to the next value (120 Hz) and repeat measurements and calculations listed in step 4.3.

4.5. <u>Prepare a graph</u> of the measured impedance Z versus the frequency f. **Print** the graph and attach it to your lab report. Find the frequency that corresponds to the minimum impedance, i.e., find the resonance frequency f_{res}.

f_{res} = _______________ (   )

4.6. Calculate the theoretical value of the resonance frequency f_0 according to Eq. (17).

f_0 = _______________ (   )

Calculate the percent difference between the measured resonance frequency f_{res} and the theoretical resonance frequency f_0.

$$\frac{|f_{res} - f_0|}{f_0} \times 100\% =$$ _______________ (%)

4.7. Disconnect all wires from the "RLC Circuit" board.

Complete the lab report and return it to the lab TA.