Pre-Lab Report

Lab section:

Name & Surname:

Table #:

***Before the Lab* complete this page YOURSELF! Hand it in *in the first 5 min*. of the session PERSONALLY!**

You MUST justify your answers and show all steps. NO COPYCAT answers, or NO credits!

Please read the relevant presentation on PHYS LAB Website.

In this experiment various series circuits are going to be connected; RC, RL, RLC. Phasor diagrams are going to be drawn for each case.

Q1. Give the definition of the following concepts. You may give examples, show plots etc.

a) Resistance:

b) Reactance:

(Cont'd on the next page!)

c) Phasor diagram:

d) What is the unit of reactance?

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***Complete this report YOURSELF except DATA taking parts! Use a pencil for plots only and a pen for the rest!* Show your work clearly, NO COPYCAT analysis allowed, or NO credits!**

OBJECTIVE : To study the alternating current circuits.

THEORY : To study the alternating current circuits.

$$V(t) = V_p \sin(2\pi ft) \quad (1)$$

where Vp is the peak voltage and f is the frequency of the power supply. When we connect various circuit elements to an alternating current source, we can determine the current through the circuit by Ohm's Law. The current through a resistor, a capacitor, and an inductor will be given by:

$$I_R = \frac{V_p}{R}\sin(2\pi ft) \quad (2a)$$

$$I_C = C\frac{d\left(V_p \sin(2\pi ft)\right)}{dt} = V_p 2\pi fC \sin(2\pi ft + 90^o) \quad (2b)$$

$$I_L = \frac{1}{L}\int V_p \sin(2\pi ft)dt = \frac{V_p}{2\pi fL}\sin(2\pi ft - 90^o) \quad (2c)$$

Hence the current through a resistor is in phase with the voltage across it; the current through a capacitor leads the voltage by 90°; and the current through an inductor lags the voltage by 90°.

Because of these differences in the phases, analyzing alternating current circuits involving different types of circuit elements is somewhat tricky and not as simple as the DC circuits. We can solve this problem by using either complex algebra or the phasor method which are similar to each other.

In the complex algebra method we define reactances for each element:

$$X_R = R \qquad X_C = \frac{1}{i2\pi fC} \qquad X_L = i2\pi fL \quad (3)$$

and treat the voltage and the current as real numbers. Then the circuit analysis for the alternating currents turns into a form similar to the DC circuits. Of course, the reactances contain all the information relevant to the alternating current circuit, that is, the frequency and the phases in the form of the imaginary numbers. Solutions will include both real and imaginary parts. As you know, we can also represent the complex numbers as pairs of numbers on a Cartesian coordinate system where the horizontal axis corresponds to the real and the vertical axis corresponds to the imaginary part. Phasor method simply uses the graphical representation of the complex numbers. In this experiment we will be using the phasor method.

RC Circuit:

When you connect a capacitor and a resistor in series to an alternating voltage source, the phase of the current through the capacitor will be 90° ahead of the voltage. If we were to take the current as our reference for the phase, then the voltage across the capacitor will be 90° behind the current hence the voltage across the resistor. The total voltage across the RC series combination will be equal to the applied voltage:

$$V_{app} = \sqrt{\left(V_R^2 + V_C^2\right)} \tag{4}$$

RL Circuit:

When you connect an inductor and a resistor in series to an alternating voltage source, the current through the inductor will be 90° behind the voltage. If we were to take the current as our reference for the phase, then the voltage across the inductor will be 90° ahead of the current hence the voltage across the resistor. The total voltage across the RL series combination will be equal to the applied voltage:

$$V_{app} = \sqrt{V_R^2 + V_L^2} \tag{5}$$

However, the inductor also has some internal resistance, RL. Because of its internal resistance, the voltage across the inductor will not be exactly 90° ahead but at an angle calculated from:

$$\tan\theta = \frac{2\pi f L}{R_L} \tag{6}$$

We should also modify Equation (5) accordingly:

$$V_{app} = I\sqrt{\left(R + R_L\right)^2 + X_L^2} \tag{7}$$

RLC Circuit:

When you connect an inductor, a capacitor, and a resistor in series to an alternating voltage source, the current through the inductor and the capacitor will be 90° behind and ahead of the voltage, respectively. If we were to take the current as our reference for the phase, then the voltage across the inductor and the capacitor will be 90° ahead of and behind the current (hence the voltage across the resistor), respectively. The total voltage across the RLC series combination will be equal to the applied voltage:

$$V_{app} = \sqrt{(V_L - V_C)^2 + V_R^2} \quad (8)$$

Because of its internal resistance, RL, the voltage across the inductor will not be exactly 90° ahead but at an angle calculated from:

$$\tan\theta = \frac{2\pi f L}{R_L} \quad (9)$$

We should also modify Equation (8) accordingly:

$$V_{app} = I\sqrt{(R + R_L)^2 + (X_L - X_C)^2} = IZ \quad (10)$$

where the total impedance of the RLC circuit is given by

$$Z = \sqrt{(R + R_L)^2 + (X_L - X_C)^2} \quad (11)$$

Now the phase difference between the current and the voltage is more complex and given by:

$$\tan\Phi = \frac{(X_L - X_C)}{R_{total}} \quad (12)$$

This Φ angle is the angle between the applied voltage and the resulting current phasors. It determines the total average power used in an RLC circuit:

$$\overline{P} = V_{rms} I_{rms} \cos\Phi \quad (13)$$

We should remind that the values measured by instruments like voltmeters, ammeters, etc. are root-mean-squared values and not the peak values. You can determine the peak values using an oscilloscope.

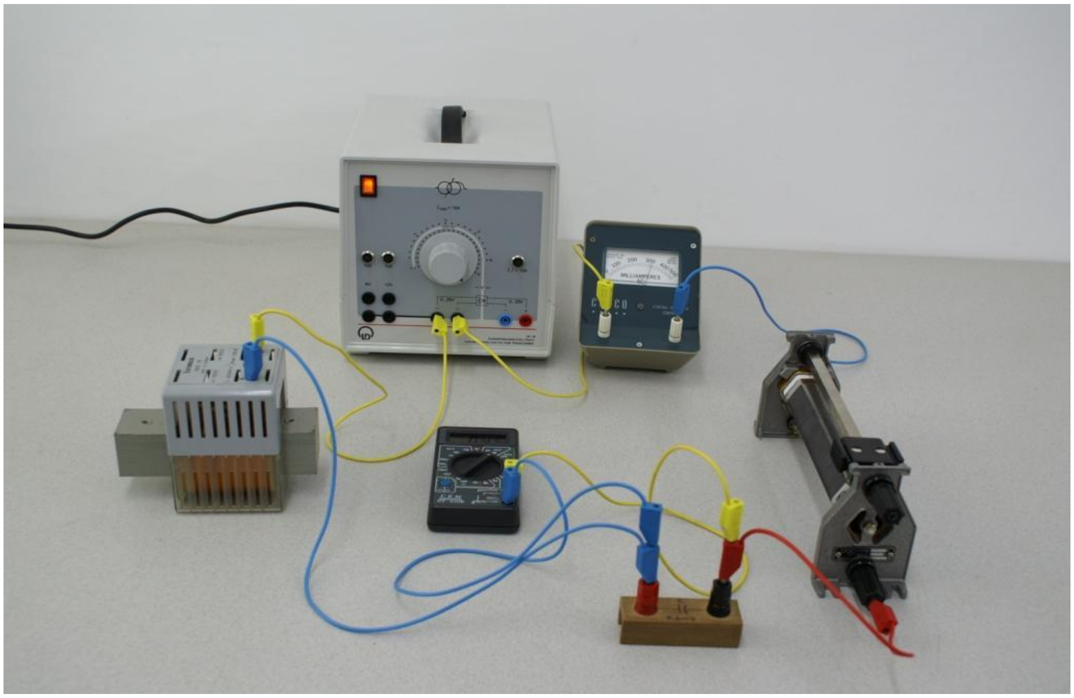
APPARATUS : Inductor with an iron block inside, resistance box, capacitor, AC voltmeter and ammeter, 24-V AC power supply.

PROCEDURE :

1. Use the two fixed ends of the rheostat as a resistor. Use 24 V, 50 Hz output of the power supply as your AC source.
2. Construct an RC circuit and measure the voltage across each element. Then draw the phasor diagram by taking the current (i.e. the voltage across the resistor) as the reference.
3. Then draw two circles with radii equal to VC and Vapp from each end of the phasor corresponding to the voltage across the resistor. Phasors for VC and Vapp will meet each other at the point where the circles intersect. Determine the angle between

VC and VR.

4. Repeat the previous step by constructing an RL circuit this time. Determine the internal resistance of the inductor by measuring the current through the circuit and the horizontal component of VL from your phasor diagram.



5. Repeat the previous step by constructing an RLC circuit this time. Again measure the current value through the circuit. You should draw the phasor diagram in this case by assuming that VC is 90° behind VR (or perpendicular in the negative direction).

6. Then draw two circles centered at the beginning of the phasor for VR and the tip of the phasor for VC with radii equal to Vapp and VL, respectively. Draw Vapp and VL phasors from the centers of the circles to the intersection point.

7. Using the current value and the internal resistance of the inductor determined in the previous step, determine the capacitive and inductive reactances first and then calculate the value of the capacitor and the inductor.

8. Finally determine the phase angle [illegible]and the average power dissipated in the RLC circuit.

PART – 1: RC CIRCUIT

Draw the RC circuit diagram

Description / Notation	Value & Unit	# of Significant Figures
Potential difference across the resistance V_R =	....	....
Potential difference across the capacitor V_C =	....	....
Applied potential V_{app} =	....	....

6 **Draw Phasor Diagram of the RC Circuit:**

Angle between V_C and V_R = ...

PART – 2: RL CIRCUIT

Draw the RL circuit diagram:

Description / Notation		Value & Unit	# of Significant Figures
Current in the circuit I	=	. . . .	. . . .
Potential difference across the resistance V_R	=	. . . .	. . . .
Potential difference across the inductor V_L	=	. . . .	. . . .
Applied potential V_{app}	=	. . . .	. . . .

Draw Phasor Diagram of the RL Circuit on the next page and show the results below:

Description / Symbol		Value / Calculation	Result
Potential difference due to the internal resistance of the inductor Vr_L	=	. . . .	. . . .
Internal resistance of the inductor r_L	=	. . . .	. . . .

8 **Draw Phasor Diagram of the RL Circuit:**

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PART – 3: RLC CIRCUIT

Draw the RLC circuit diagram:

Description / Notation		**Value & Unit**	**# of Significant Figures**
Current in the circuit I	=	. . . .	. . . .
Potential difference across the resistance V_R	=	. . . .	. . . .
Potential difference across the inductor V_L	=	. . . .	. . . .
Potential difference across the capacitor V_C	=	. . . .	. . . .
Applied potential V_{app}	=	. . . .	. . . .

10 **Draw Phasor Diagram of the RLC Circuit:**

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Description / Symbol	Value / Calculation (show step by step)	Result
Capacitive reactance X_C =	. . . .	. . . .
Value of the capacitor C =	. . . .	. . . .
Inductive reactance X_L =	. . . .	. . . .
Value of the inductor L =	. . . .	. . . .
Internal resistance of the inductor r_L =	. . . .	. . . .
Total resistance R_{tot} =	. . . .	. . . .

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Description / Symbol			Value / Calculation (show step by step)	Result
Impedance	Z	=	. . . .	. . . .
			. . . .	
Phase angle	φ	=	. . . .	. . . .
			. . . .	
Average dissipated power	P	=	. . . .	. . . .
			. . . .	

QUESTION

If the angle between VC and VR is different from 90°, what could the because reason be?

Consult to the resources for this experiment from PHYS LAB Website:

PHYL202 Intro **Presentation #2** **PHYL202 Lab Book**