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.

Q1. If you apply Kirchhoff's law to the circuit you will get the following relation:

$$L\frac{d^2q}{dt^2} + R\frac{dq}{dt} + \frac{q}{C} = V_{app}(t)$$

Convince yourself by inserting $q(t) = q_0 A\, e^{-Rt/2L}\sin(\omega_0 t + \delta)$ with $\omega_0 = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$ is a solution to this equation. **Show your calculations below explicitly or no credits!**

(2nd Question is on the next page!)

Q2. Show dimension analysis for Inductance L, Capacitance C and Resistance R clearly. **Show your calculations below <u>explicitly or no credits</u>!**

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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 oscillations of potential difference across a charged capacitor in series with a resistor and an inductor.

THEORY : In a series RLC circuit, the Kirchoff's loop rule results in the following:

$$L\frac{di}{dt}+Ri+\frac{q}{C}=V_{app}(t) \qquad \text{or} \qquad L\frac{d^2q}{dt^2}+R\frac{dq}{dt}+\frac{q}{C}=V_{app}(t)$$

since I = dq/dt. This is an equation for a damped oscillator driven by a time dependent voltage source or a signal generator. There are three different combinations of R, L, and C values where we can get specific solutions to this equation for a square wave signal as the applied voltage.

Underdamped:

If the values satisfy the following conditions, the circuit will be underdamped:

$$\frac{R^2C}{4L}<1$$

Then the solution will be:

$$q(t)=q_o A e^{(-Rt/2L)}\sin(\omega_o t+\delta)$$

and the voltage across the capacitor will be:

$$V_C(t)=V_o B e^{(-Rt/2L)}\sin(\omega_o t+\delta),$$

where V_0 is the voltage when the square wave is at the maximum value and δ is the phase. ω_0 is given by:

$$\omega_o=\sqrt{\frac{1}{LC}-\frac{R^2}{4L^2}}$$

Oscillations decay exponentially with a time constant 2L/R. Signals reach their half values in:

$$t_{1/2}=\frac{2L}{R}\ln 2$$

which we can call half-life of the signals.

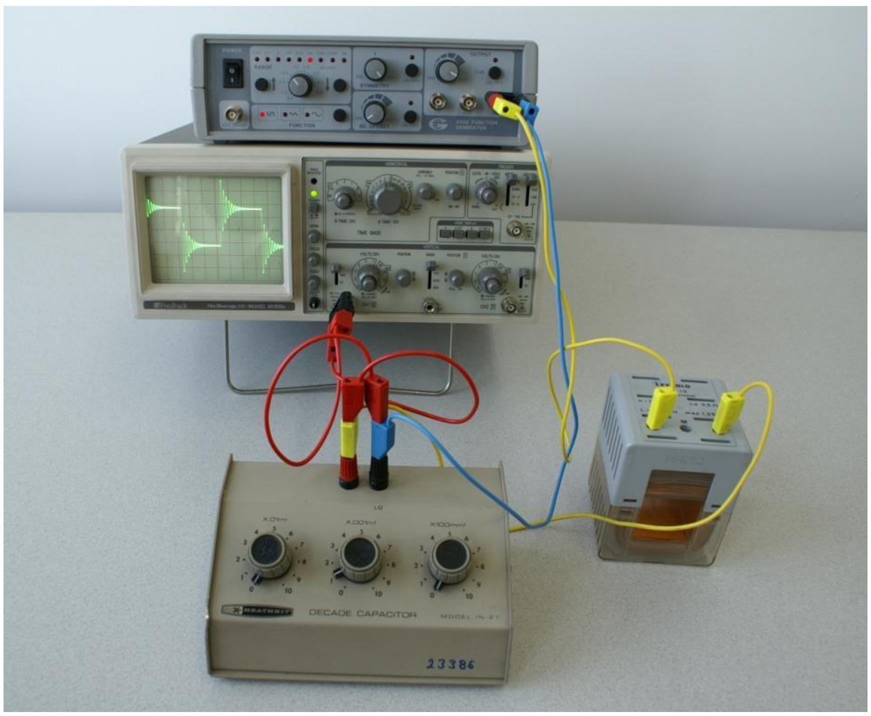
Critically Damped:

If $\frac{R^2C}{4L} = 1$, the circuit is critically damped. As you see from the equation for ω_0 above, the frequency of the oscillations is zero which means there is only an exponential decay.

Overdamped:

If, $\frac{R^2C}{4L} > 1$ the circuit is overdamped. The frequency of the oscillations, ω_0, is an imaginary number which means there is only an exponential decay similar to the Critically Damped Case.

APPARATUS : Capacitance and resistance boxes, inductor with an iron block, oscillator, oscilloscope.



PROCEDURE :

- Connect the circuit by using the A-E terminals of the 1000 turn coil for the inductor and 0.001µF capacitor, turn on the oscilloscope and make the initial adjustments. Internal resistance of the square wave generator and the coil resistance will be the total resistance in the circuit.
- Adjust the square wave frequency and the sweep frequency of the oscilloscope so that

one complete cycle of decaying oscillations cover the whole screen of the oscilloscope. Record the value of the sweep frequency in your report.

- Choose two peaks at least 5-6 cm far from each other and count the number of the complete cycles in this chosen range l. Determine the length of one complete cycle, period, and the frequency of the decaying oscillations.
- Measure the half-life of the decaying oscillations.
- Using the half-life equation, calculate the inductance L of the coil in millihenries and calculate the frequency of oscillations by using this value.

$$t_{1/2} = \frac{2L}{R} \ln 2$$

$$f_o = \frac{1}{2\pi}\left[\frac{1}{LC} - \frac{R^2}{4L^2}\right]^{1/2}$$

- When a piece of iron is inserted into a coil, a large change occurs in the inductance of the coil. With the iron fully inserted, determine the new value of the inductance.

CIRCUIT DIAGRAM

Draw the circuit diagram

DATA & CALCULATIONS

Description / Notation			Value & Unit	# of Significant Figures
Capacitance	C	=	. . . .	. . . .
Resistance	R	=	. . . .	. . . .
Frequency of the Square Wave Generator	f_{SWG}	=	. . . .	. . . .

Description / Notation			Value & Unit	# of Significant Figures
[TIME / DIV] Dial of the Oscilloscope <u>without</u> Iron Block		=	. . . .	. . . .
[TIME / DIV] Dial of the Oscilloscope <u>with</u> Iron Block		=	. . . .	. . . .
Length between the chosen peaks	ℓ	=	. . . .	. . . .
Number of complete Cycles in ℓ	n	=	. . . .	. . . .

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DATA & CALCULATIONS

WITHOUT IRON BLOCK INSIDE THE INDUCTOR

Description / Symbol		Value / Calculations (show each step)	Result
Half-Life	$t_{1/2}$ (cm) =	....	....
Half-Life	$t_{1/2}$(sec) =	....	....
Inductance of the coil	L_1 =	....	....
Wavelength	λ =	....	....
Period of the Oscillations	T =	....	....
Frequency of the Oscillations	$f_{measured}$ =	....	....
Frequency of the Oscillations	$f_{calculated}$ =	....	....

% Error for f:

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WITH IRON BLOCK INSIDE THE INDUCTOR

Description / Symbol		Value / Calculations (show each step)	Result
Half-Life	$t_{1/2}$ (cm) =	. . . .	. . . .
Half-Life	$t_{1/2}$(sec) =	. . . .	. . . .
Inductance of the coil	L_2 =	. . . .	. . . .
		. . . .	

QUESTION

What is the reason for the difference you observe when you insert the iron block inside the inductor?

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

PHYL202 Intro

Presentation #1

PHYL202 Lab Book