Practice Work 2

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Do all of your calculations using Mathematica. The Mathematica notebook is your report so:

- Write your name, number of the excersice work, and returning date at the beginning of the notebook.
- Use sections and subsections to organize your report.
- Tell what you are doing in your own words (comment your calculations)
- Do not refer previous results like %n (define symbols).
- Write your notebook so that it could be evaluated/calculated straight from the beginning to the end without errors.

Return your report by email: kloo@paju.oulu.fi or kloo@oulu.fi

A Pinch of Theory: RLC-circuits

RCL circuit consists of three components: resistor, capasitor and coil. The Voltage drop in a particular component is

$$U_R = RI(t) \qquad U_L = L\frac{dI(t)}{dt} \qquad U_C = \frac{1}{C}\int I(t)dt,$$

where R is the resistance of the resistor, C in the capacitance of the capacitor and L is the inductance of the coil. From the Kirchhoff's law follows that those voltage drops cancel out the voltage fed into the circuit. That leads to the equation

$$U(t) = L\frac{dI(t)}{dt} + RI(t) + \frac{1}{C}\int I(t)dt \tag{1}$$

If we differentiate the previous with respect to time, we get out of the integral and we get the differential equation which describes the current: j

$$\frac{dU(t)}{dt} = L\frac{d^2I(t)}{dt^2} + R\frac{dI(t)}{dt} + \frac{1}{C}I(t) \tag{2}$$

Lost Measurements

You have again spent a glorious evening in the physics lab doing some current measurements. Circuits you have explored consisted of a resistor, a capasitor or a coil or some combination of them. You look at your watch and notice that it's 7 p.m and you are starving. If you hurry, you could get a burger from Wokki-Paja. So you forget to write down the resistance, capacitance and inductance of the components used.

On next day you scratch your head when noticing that those components cannot be found again. You put your faith in analysis of the data you measured. On top of it all you can'tt find all measured data, but the first three measurements (`data1.txt, data2.txt, data3.txt`).

Luckily you have written down something;

$$\text{Alternating voltage} \rightarrow U(t) = U_0 \sin(\omega t)$$

and

$$U_0 = 6\text{V} \qquad f = 50\text{Hz} \qquad \omega = 2\pi f$$

You start to form a strategy to find the values of the components and the result is following to-do –list

1. By exploring the differential equation (2), find out how every component affect to the current. Deduce which component have been present in the measurements (`ht2_data1.txt, ht2_data2.txt, ht2_data3.txt`).

   note: There is "enough" data in the files and the frequency of the AC is quite high, so it would be convenient to look some small set of the data (from the begin) and of course in the beginning of the measurement $i(0) = 0$ *and* $i'(0) = 0$.

2. Determine the resistance, capacitance and inductance from the data by fitting a function of proper form into it. Plot the fit-functions and data.

3. By using the values determined in the previuos ex, solve and plot the current (from (1) or (2) in the following situations. Circuit consist only (no voltage source):

   a) coil + capacitor

   b) resistor + capacitor

   c) resistor + coil

   connected in series and the initial current is $I(0) = 0.1$ A

4. Explain what is the resonant frequency of the RLC-circuit. Calculate it for the circuit of measured components connected in series.