PHYS605

HOMEWORK 4

DUE WEDNESDAY MARCH 6.

READING:

- See the lab writeups. Make sure you prepare for labs!
- **Practical Electronics:** We will be covering time varying signals and energy storing components: Capacitors and Inductors and how to calculate with them. Relevant parts in the book are listed (bold chapters more important).
    - Chapter 2.23 - Capacitors - 2.23: **5** + 7 + **8** + 10 + 11 + 13
    - Chapter 2.24 - Inductors - 2.24: 4 + **6** + 7 + **9** + 10 + 11 + 16 + 17 + **18**
    - Chapter 2.25 - Modeling Complex Circuits: **2.25**
    - Chapter 2.27 - Circuits with Sinusoidal Sources: 2.27: **2**
    - Chapter 2.33 - Two-Port Networks and Filters: 2.33: **1**

1. SIMULATING CIRCUITS PROBLEMS:

Problem 1 – In your Analog Lab 2, you made a number of different filters and you created Bode plots for them and also a plot of the response to a square wave input signal. In this problem, you need to create a Python notebook with numerical calculations for one of the RC filters that you created in the lab.

Another helpful notebook in making plots from CSV files using Python and the Pandas module is found here:

https://github.com/mholtrop/Phys605/blob/master/Python/Plotting/Plot_from_CSV_data.ipynb

Tasks:

1. [40 points] You will complete a notebook that is already templated for you to create Bode plots for RC (and RL or RLC) circuits. The notebook is on GitHub at:

   https://github.com/mholtrop/Phys605/blob/master/Homework/HW4/RC_Filters_in_Python.ipynb

   Download this RC low-pass notebook to your own computer, so you can run the notebook, i.e. you are not viewing it on GitHub only! Understand what it does for each bit of code. Then follow the steps in the notebook to complete the code.
   - **a.** In the same directory as the notebook, you also want to add the file for image of the filter, which on GitHub is here: https://github.com/mholtrop/Phys605/blob/master/Homework/HW4/rc_filter_circuit.pdf
   - **b.** In the text under the RC Filters header, add your name.
   - **c.** Check that you understand the math that is below that. Is this for an RC lowpass filter? Compare with your homework.

d. Finish **all the steps** in the notebook.

2. [optional] There is another notebook that solves the low-pass filter by finding numerical solutions for the differential equation directly. If you have time, look at the code here: https://github.com/mholtrop/Phys605/blob/master/Python/Signal/Solving_RC_low_pass_with_ODE.ipynb
   [20 bonus points] Submit a notebook that solves the differential equation, like the notebook shown here, but now for a high pass filter.
3. [10 points] The last section in chapter 2 of your book talks about circuit simulators. The most common are "SPICE" simulators, and they are very useful and extensively used by engineers. Electrical engineers often work with complete packages that simulate circuits and also allow them to then create printed circuit boards. For more choices see the course webpages under "Resources" where there is a section on simulations. I choose "partsim.com" for this exercise since it is free.
   Parallel: https://explore.partquest.com/groups/mauriks-workspace/designs/rlc-parallel-network
   Series: https://explore.partquest.com/groups/mauriks-workspace/designs/rlc-series-network
   a. I created two simulations of RLC circuits for you to look at, one is a parallel RLC, the other is a series RLC. Modify them so they have the same values for R L and C as you used in your lab, and then run the simulation. Save the data (hint: Vout) and use it to make Bode plots (hint: *you* need to make it a log-log plot)
   b. Compare the outputs of the two runs and comment on what you observe.
   c. If you want, play with the simulation and learn how these work.
4. [+10 points, optional bonus] There is another notebook for an RLC resonant circuit. This notebook shows you how you can make curves for a sequence of different values all on the same plot. See:
   https://github.com/mholtrop/Phys605/blob/master/Python/Signal/LRC_Network_Analysis.ipynb
   a. Take a good look at this notebook and study it a bit. Note that it uses the symbolic Python module to simplify the math. This module is not quite as good as Mathematica, but it is free, so may be worth looking into.
   b. IF at this point you haven't already spend too much time on these notebooks, modify this one to correspond to your parallel RLC network (this one is in series.)
   c. IF you want to compare with your own data, you will see more significant differences, because the inductor in the lab was not very ideal.