PHYS605

HOMEWORK 3

DUE WEDNESDAY FEB 28.

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. CALCULATING CIRCUIT PROBLEMS:

Problem 1 – [20 points] For the two filter functions in Figures 1 and 2 on the right, compute the transfer functions, G(ω). Explain what the output looks like for each circuit when Vin is DC (constant voltage), and when Vin is a sine wave with a very high frequency.

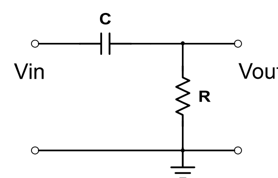

Figure 2, High pass filter.

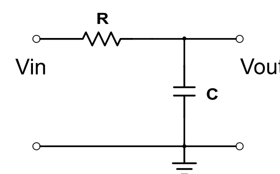

Figure 1, Low pass filter

Problem 2 – [40 points] You sometimes want to have an AC coupled circuit that does NOT act like a high pass filter. This can be accomplished by carefully compensating the series resistor and capacitor with an additional set of series resistor and capacitor, as is done with the circuit on the right.

Show algebraically that for the condition $C_1R_1 = C_2R_2$ this circuit behaves like a voltage divider for *all* frequencies. In other words, that the transfer function can be written as:

a) $G = \frac{R_2}{R_1+R_2}$ b) $G = \frac{C_1}{C_1+C_2}$

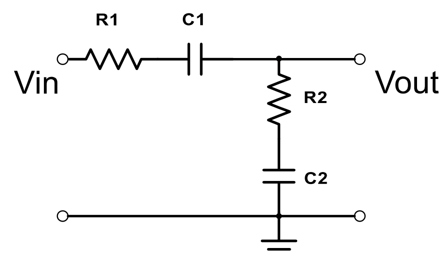

Figure 3 - Circuit for problem 2

Problem 3 - Band pass filter.

[40 points] Consider the circuit on the right, which is that of a band-pass filter, with the characteristic frequency $\omega_{RC}=1/R_1C_1$. If you choose $C_2=C_1/\alpha$ and $R_2=\alpha R_1$, then the gain of this **filter at $\boldsymbol{\omega_{RC}}$** is:

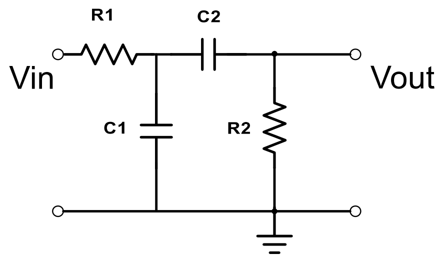

Figure 4 - Circuit for problems 3

$$G=\frac{\alpha}{2\alpha+1}$$

a) Verify that this equation is correct.
b) What is the input impedance at $\boldsymbol{\omega_{RC}}$?
c) What is the output impedance at $\boldsymbol{\omega_{RC}}$?
d) Describe in words what you would expect this circuit to do if $C_2=C_1$=C=100nF and $R_2=R_1$=R=10kΩ, i.e the value of α = 1. If you think you have the tools (see HW4 to get the tools) you may add a plot of the response of this circuit versus frequency (i.e. a Bode plot), but this much detail is not needed to answer this question. You can sketch the response you expect by hand.