Duke University

Edmund T. Pratt, Jr. School of Engineering

EGR 119 Spring 2012

Test II

Michael R. Gustafson II

Name (please print)____

In keeping with the Community Standard, I have neither provided nor received any assistance on this test. I understand if it is later determined that I gave or received assistance, I will be brought before the Undergraduate Conduct Board and, if found responsible for academic dishonesty or academic contempt, fail the class. I also understand that I am not allowed to speak to anyone except the instructor about any aspect of this test until the instructor announces it is allowed. I understand if it is later determined that I did speak to another person about the test before the instructor said it was allowed, I will be brought before the Undergraduate Conduct Board and, if found responsible for academic dishonesty or academic contempt, fail the class.

Signature:____

Instructions

First - please turn **off** any cell phones or other annoyance-producing devices. Vibrate mode is not enough - your device needs to be in a mode where it will make no sounds during the course of the test, including the vibrate buzz or those acknowledging receipt of a text or voicemail.

Please be sure to put each problem on its own page or pages - do *not* write answers to more than one problem on any piece of paper and do not use the back of a problem for work on a *different* problem. You will be turning in each of the problems independently. This cover page should be stapled to the front of Problem 1.

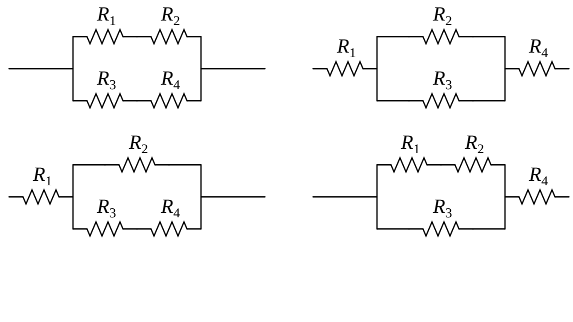
Make sure that your name *and* NET ID are *clearly* written at the top of *every* page, just in case problem parts come loose in the shuffle. Make sure that the work you are submitting for an answer is clearly marked as such. Finally, when turning in the test, individually staple all the work for each problem and place each problem's work in the appropriate folder.

Note that there may be people taking the test after you, so you are not allowed to talk about the test - even to people outside of this class - until I send along the OK. This includes talking about the specific problem types, how long it took you, how hard you thought it was - really anything. Please maintain the integrity of this test.

You may use the $\|$ symbol for resistances in parallel and do not need to expand that construction. Be clear with your use of parentheses, however; simply writing something like

$$R_{\text{eq}} = R_1 + R_2 \parallel R_3 + R_4$$

is too vague since it could refer to any of the four combinations below:



Name (please print):
Community Standard (print ACPUB ID):

Problem I: [25 pts.] Pauly D's sister Bo

You are given a circuit to analyze and have properly come up with a transfer function for it of:

$$\mathbb{H}(s) = \frac{\mathbb{Y}(s)}{\mathbb{X}(s)} \frac{10s(s+1000)}{(s+10)(s+10000)}$$

(1) Sketch a straight-line approximation for the magnitude portion of the Bode plot. Be sure to label the axes, including numerical values, along with all slopes and critical frequencies.

(2) Based on this and any other information at your disposal, what kind of filter do you believe this to be? Why do you believe that? You must provide some reasonable explanation in order to receive credit for this part.

(3) *Approximately* what is/are the cutoff frequency/ies for this filter? How did you come to that conclusion? Describe the process you used or reference the Bode diagram.

(4) Given the transfer function, find a differential equation that relates $y(t)$ and its derivatives to $x(t)$ and its derivatives.

(5) Determine the step response of this circuit.

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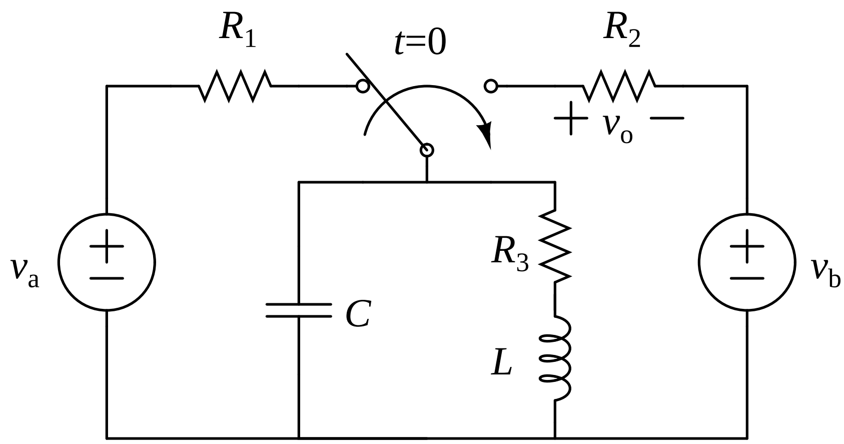
Problem II: [25 pts.] The more things change...

Given the following circuit:



and assuming that

$$v_a(t) = 10 \text{ V} \qquad\qquad v_b(t) = 5 + 12\sin(10t + 30°) \text{ V}$$

$$R_1 = 1 \text{ k}\Omega \qquad R_2 = 2 \text{ k}\Omega \qquad R_3 = 5 \text{ k}\Omega \qquad C = 100\ \mu\text{F} \qquad L = 8 \text{ mH}$$

and the switch has been in its left-hand position for a very long time before being flipped to the right at time 0:

(1) What are the currents through each reactive element at time $t = 0^-$? Be sure to label them on the circuit above and give your answer relative to the direction of your label.

(2) What are the voltages across each reactive element at time $t = 0^-$? Be sure to label them on the circuit above using the passive sign convention based on your current labels.

(3) What are the currents through each reactive element at time $t = 0^+$?

(4) What are the voltages across each reactive element at time $t = 0^+$?

(5) Assuming the switch remains in the right-hand position for a very long time, determine an expression for the output voltage $v_o(t)$ once the circuit reaches AC steady state.

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Problem III: [25 pts.] Filters[1]

(1) Determine the transfer function for a first-order low-pass filter with a maximum gain of 25 and a cutoff frequency of 1000 Hz. Then, using only 100 μF capacitors, one of the LM 324 chips used in lab (which is to say up to four operational amplifiers), and any reasonably sized resistors you need, design a voltage-to-voltage circuit that has this transfer function *and* which draws no current from the input voltage. Also answer this question: what does "reasonably sized resistors" mean and why?

(2) Determine the transfer function for a second-order band-pass filter with a logarithmic center frequency of 5000 Hz, a quality of 0.25, and a pass-band gain of 0.1. For this filter:

(a) Determine the damping ratio, linear center frequency, bandwidth, and cutoff frequencies for the filter. Be sure to clearly indicate which value is which and include units when appropriate.

(b) Write the transfer function for the band-pass filter using one of the two "standard" forms we discussed in class for band-pass filters.

(c) Sketch a Bode plot of the magnitude using straight-line approximations. Be sure to label the axes, including numerical values, along with all slopes and critical frequencies. Also indicate corner frequencies.

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[1] I decided "You(r signal) Shall Not Pass!" might not have been the best idea for a joke here...especially if you haven't read/seen Lord of the Rings.

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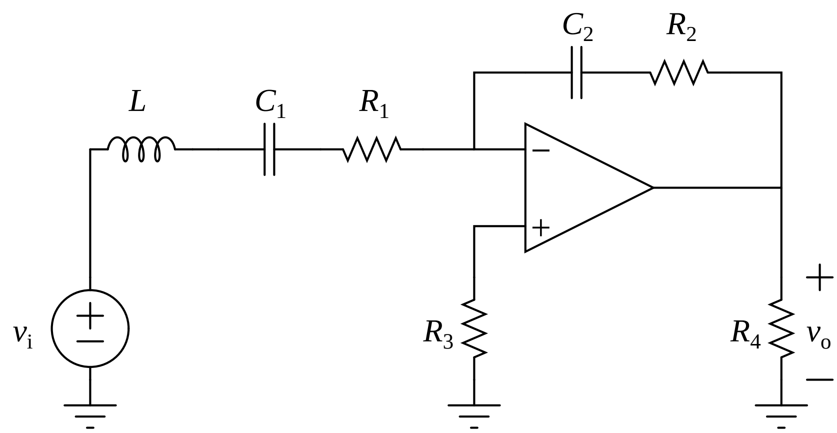
Problem IV: [25 pts.] Livin' la Vida Laplace

Given the following circuit:



and assuming

$R_1 = 6$ kΩ $\quad R_2 = 5$ kΩ $\quad R_3 = 4$ kΩ $\quad R_4 = 10$ kΩ

$C_1 = 100$ pF $= 100 \cdot 10^{-12}$ F $\quad C_2 = 125$ pF $= 125 \cdot 10^{-12}$ F $\quad L = 1$ mH

(1) Determine the transfer function:

$$\mathbb{H}(s) = \frac{\mathbb{V}_o(s)}{\mathbb{V}_i(s)}$$

(2) Determine the impulse response of the circuit, $h(t)$.