Duke University

Edmund T. Pratt, Jr. School of Engineering

BME 153L.1 Spring 2009

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 Judicial 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 Judicial 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.

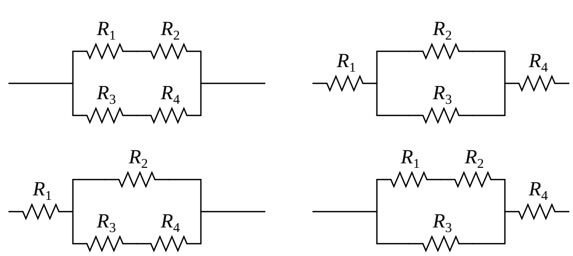
Make sure that your name *and* NET ID are *clearly* written at the top of *every* page, just in case problem parts come loose in the shuffle. Make sure that the work you are submitting for an answer is clearly marked as such. Finally, when turning in the test, individually staple all the work for each 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 impedances in parallel and do not need to expand that construction (unless you are required to get a numerical answer). Be clear with your use of parentheses, however; simply writing something like

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

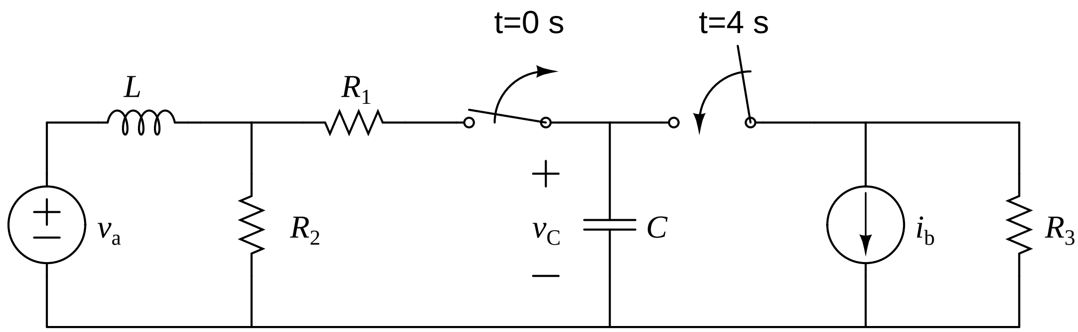
is too vague since it could refer to any of the four combinations below:



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

Problem I: [25 pts.] Switched Circuits I

Given the following circuit:



note that the left switch opens at time t=0 s and, four seconds later, the right switch closes.

(a) Determine the values below symbolically:

- $i_C(0^+)$
- $v_C(0^+)$
- $i_C(4^+)$
- $v_C(4^+)$
- $i_C(\infty)$
- $v_C(\infty)$

(b) Assuming $v_a = 10$ V, $i_b = 250\ \mu$A, $L = 8$ mH, $C = 100\ \mu$F, $R_1 = 1$ kΩ, $R_2 = 2$ kΩ, and $R_3 = 20$ kΩ, give an expression for $v_C(t)$ for $t > 0$ s. *Accurately* sketch the voltage across the capacitor for the first 10 seconds after the left switch is opened.

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

Problem II: [25 pts.] Filter Design

(1) Design a voltage-to-voltage bandpass filter with a maximum gain of 1 at the resonant frequency that has half-power frequencies at ω=250 rad/s and ω=25000 rad/s. Unfortunately, the only capacitors you can find in the lab are 4.7 μF, but you have adjustable resistors and inductors at your disposal. As part of the design, specify the value of the resistor and the inductor as well as the filter's:

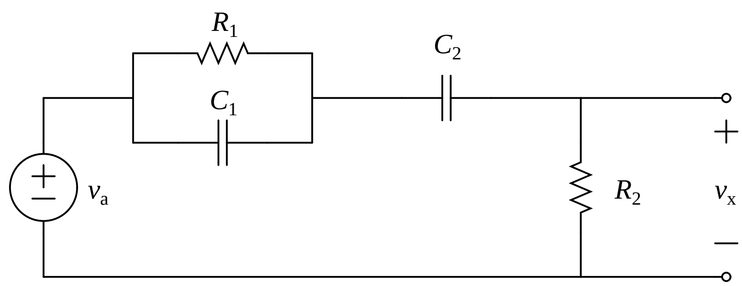
(a) Bandwidth
(b) Damping ratio
(c) Linear center frequency
(d) Natural frequency
(e) Quality factor

(2) Make an accurate sketch of the Bode magnitude plot for the filter. Be sure to clearly label the axes. Your plot must extend at least two decades beyond the half-power frequencies in either direction.

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

Problem III: [25 pts.] Transfer Functions

Given the following circuit:



and assuming the values for the passive elements are known,

(a) Find an expression for the following transfer function:

$$\mathbb{G}(j\omega) = \frac{\mathbb{V}_{\text{x}}(j\omega)}{\mathbb{V}_{\text{a}}(j\omega)}$$

(b) What kind of filter do you think $\mathbb{G}(j\omega)$ represents? Why do you think that?

(c) Assuming

$$R_1 = 100\ \text{k}\Omega \qquad R_2 = 20\ \text{k}\Omega$$
$$C_1 = 100\ \mu\text{F} \qquad C_2 = 100\ \mu\text{F}$$

and

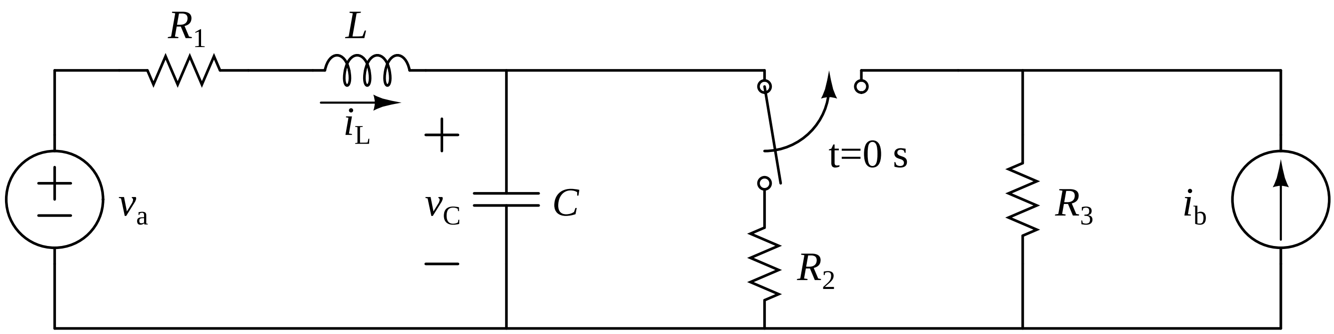
$$v_{\text{a}}(t) = 3 + 2\cos(2t + 15°) - 4\sin(10t - 35°)\ \text{V}$$

find an expression for the steady-state voltage across the resistor, $v_{\text{x}}(t)$.

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

Problem IV: [25 pts.] Switched Circuits II

Given the following circuit:



and assuming that the values for the passive elements as well as sources v_a and i_b are known

(1) Assuming v_a and i_b are constant values for a long time before $t = 0$ s, determine

- $i_L(0^-)$
- $v_L(0^-)$
- $i_C(0^-)$
- $v_C(0^-)$
- $i_L(0^+)$
- $v_L(0^+)$
- $i_C(0^+)$
- $v_C(0^+)$

(2) Determine (but do not solve) a differential equation for the inductor current $i_L(t)$ in terms of the passive element values and the sources $v_a(t)$ and $i_b(t)$ for $t > 0$ s. Note that $v_C(t)$ *cannot* be a part of the final answer.