Duke University
Edmund T. Pratt, Jr. School of Engineering

EGR 119 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.

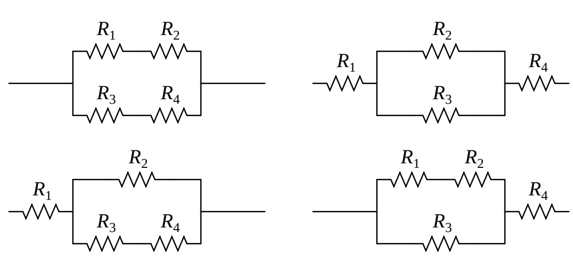
Make sure that your name *and* NET ID are *clearly* written at the top of *every* page, just in case problem parts come loose in the shuffle. Make sure that the work you are submitting for an answer is clearly marked as such. Finally, when turning in the test, individually staple all the work for each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

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

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



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

Problem I: [20 pts.] Filter Design

The data acquisition systems in the lab can properly capture frequencies up to about 12500 Hz; anything above that will cause aliasing which - as you heard in EGR 53 - is bad. To get around that, design two different voltage-to-voltage low-pass filters that will reduce (by at least half) the power of the signal components oscillating faster than 10 kHz.

(1) Design a filter using two components with a 20 dB/dec dropoff after 10 kHz.

(2) Design a filter using three components with a 40 dB/dec dropoff after 10 kHz.

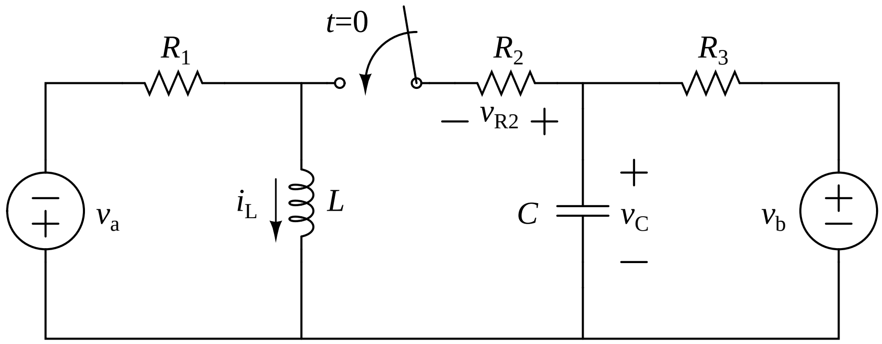
Assume the only resistors you can find in the lab are 1 kΩ, but that you have access to inductors and capacitors of any size you need. In either case, components oscillating more slowly than 10 kHz must *not* be attenuated by more than 6 dB while components oscillating more quickly than 10 kHz must be attenuated by at least 3 dB.

In addition to drawing your circuit, clearly labeling the input and output terminals as well as the component values, sketch a straight-line Bode approximation of the magnitude of the filter. Be sure to properly label the axes.

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

Problem II: [20 pts.] Switched Circuit

Given the following circuit:



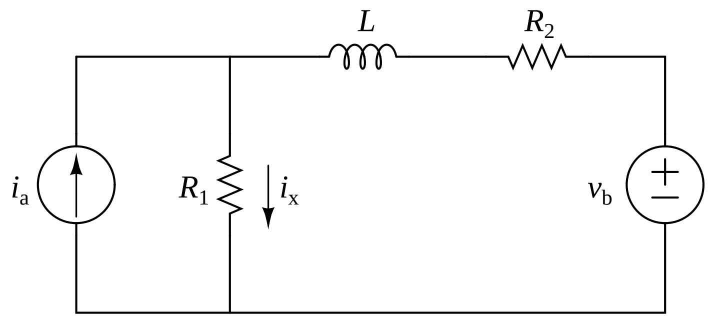
and using passive sign convention to determine the direction of the unlabeled variable, determine the following (fifteen) values at the given times assuming v_a and v_b are constant and that the switch has been open for a very long time before $t = 0$.

	i_L	v_L	i_C	v_C	v_{R_2}
$t = 0^-$					
$t = 0^+$					
$t = \infty$					

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

Problem III: [30 pts.] RL Circuit

Given the following circuit:



and assuming that the values for the passive elements and the values for sources i_a and v_b are known,

(a) Assuming v_b is turned off, determine the transfer function between the current source and the current through resistor R_1, which is labeled i_x in the drawing:

$$\mathbb{G}_a(j\omega) = \frac{\mathbb{I}_x(j\omega)}{\mathbb{I}_a(j\omega)}$$

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

(c) Assuming i_a is turned off, determine the transfer function between the voltage source and the current through resistor R_1:

$$\mathbb{Y}_b(j\omega) = \frac{\mathbb{I}_x(j\omega)}{\mathbb{V}_b(j\omega)}$$

(d) What kind of filter does $\mathbb{Y}_b(j\omega)$ represent? Why do you think that?

(e) Assuming the sources are known functions of time, determine, but do not solve, a differential equation for the unknown current. The current $i_x(t)$ should be the only unknown remaining in your answer.

(f) Assuming the circuit has been in place for a relatively long time with:

$$i_a = 5 + 2\cos(10000t + 25^o) \text{ mA} \qquad\qquad v_b = 3\sin(5000t - 15^o) \text{ V}$$

and $R_1 = 9$ kΩ, $R_2 = 3$ kΩ $L = 4$ H, solve for $i_x(t)$.

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

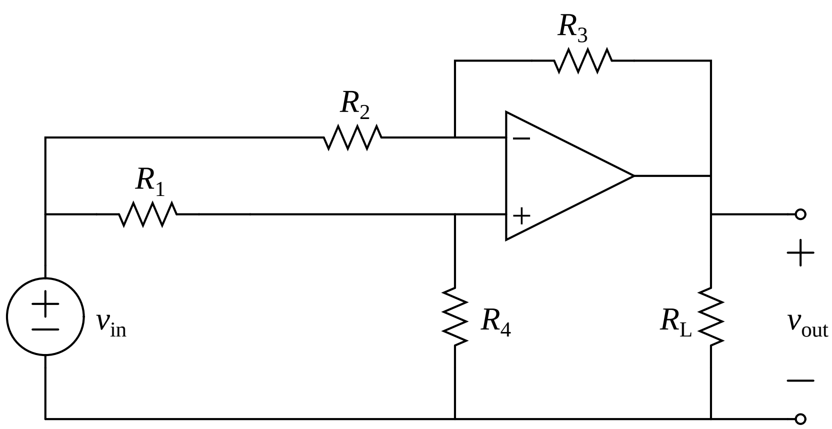
Problem IV: [30 pts.] Operational Amplifiers

(1) Design a circuit that has the relationship:

$$v_{\text{out}}(t) = -\frac{1}{4} v_{\text{in}}(t)$$

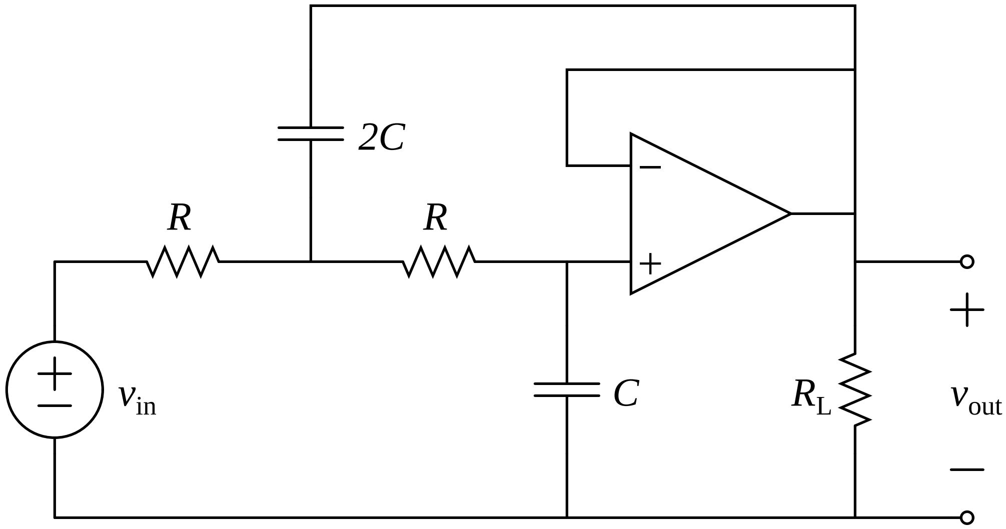
and does not require any power to be delivered by the source. Note that if you use ideal operational amplifier assumptions, your component values must support such an assumption for the LM741 op-amps we discussed in class (i.e. $A \approx 2e5$, $r_{\text{i}} \approx 2$ MΩ, and $r_{\text{o}} \approx 75$ Ω).

(2) Given the following circuit with an ideal operational amplifier:



and assuming the values for the resistive elements are known, find an expression for $v_{\text{out}}(t)$ as a function of $v_{\text{in}}(t)$ and the resistors.

(3) Given the following circuit with an ideal operational amplifier:



and assuming the values for the resistive elements are known, find an expression for the transfer function

$$\mathbb{G}_1 = \frac{\mathbb{V}_{\text{out}}(j\omega)}{\mathbb{V}_{\text{in}}(j\omega)}$$

Note: Label the circuit and set up the equations clearly, then solve if you have time.