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

ECE 110 Fall 2014

Test II

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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.

Name (please print):
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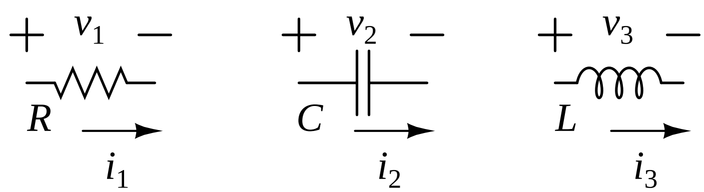
Problem I: [20 *pts.*] The Basics

(1) Write the equations that relate the current to the voltage for the following three elements:



(2) For the reactive elements above, write the equation for the energy stored in each element:

(3) Circle the appropriate entries in the sentence below:

> The (voltage drop across / current through) a capacitor and the
> (voltage drop across / current through) an inductor must be continuous.

(4) Clearly using phasors, simplify the following signal into a single cosine:

$$v_{\mathrm{a}}(t) = 7\cos(50t) - 3\sin(50t)$$

(5) Clearly using phasors, simplify the following signal into a single cosine:

$$i_{\mathrm{b}}(t) = 18\cos(550t + 36^o) - 10\sin(550t - 122^o)$$

(6) Assuming you have some voltage signal v_{a} that you want to measure, but you want to make sure that you are not requiring the signal's source to deliver any power. Draw a circuit below that has an output voltage equal to v_{a} but that draws no current from the signal source:

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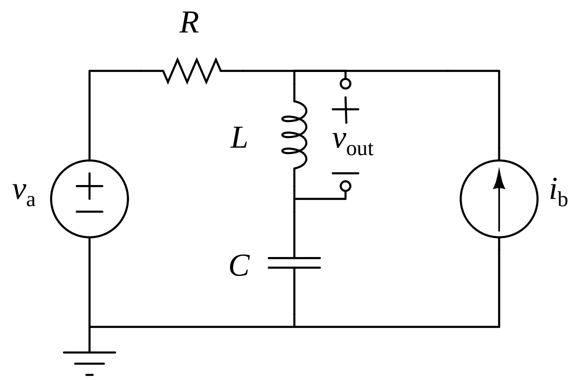
Problem II: [20 *pts.*] Frequency and Steady-State Analysis

Given the following circuit:



(1) Determine a transfer function $\mathbb{H}_a(j\omega)$ between source v_a and output v_{out}. You should assume i_b is 0 A for this.

(2) Determine a transfer function $\mathbb{H}_b(j\omega)$ between source i_b and output v_{out}. You should assume v_a is 0 V for this.

(3) Assuming

$$v_a(t) = 14\cos(8000t + 8^o) + 7\sin(35000t + 24^o) \text{ V}$$
$$i_b(t) = 3 + 2\cos(8000t - 15^o) \text{ mA}$$

$$R = 4 \text{ k}\Omega$$
$$L = 300 \text{ mH}$$
$$C = 10 \text{ nF} = 10 \times 10^{-9} \text{ F}$$

and further assuming the circuit has been place for a very long time prior to $t = t_0$ sec, determine an expression in the time domain for the voltage $v_{out}(t)$ for $t > t_0$ sec.

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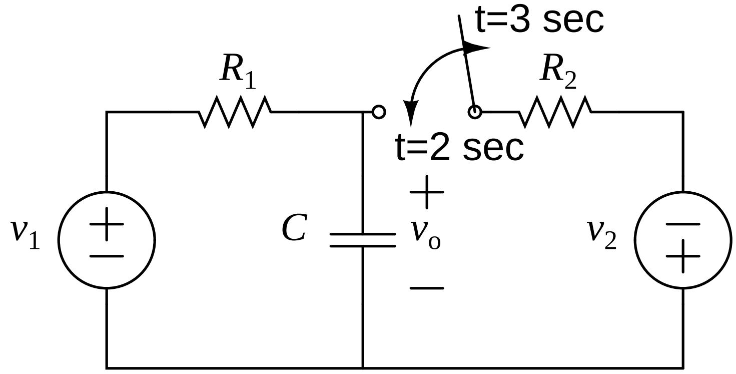
Problem III: [20 *pts.*] Switched Circuit

Given the following circuit:



where the switch has been *open* for a very long time before t =2 sec and:

$v_1 = 10$ V $\qquad v_2 = 15$ V $\qquad R_1 = 5$ kΩ $\qquad R_2 = 2$ kΩ $\qquad C = 350\mu$F

Determine and accurately sketch expressions for the capacitor voltage for all times $0 \leq t \leq 5$ sec. Note that the switch closes at time 2 sec and then opens again at time 3 sec. On the sketch, be sure to clearly indicate time constants and how you approximated slopes at various locations.

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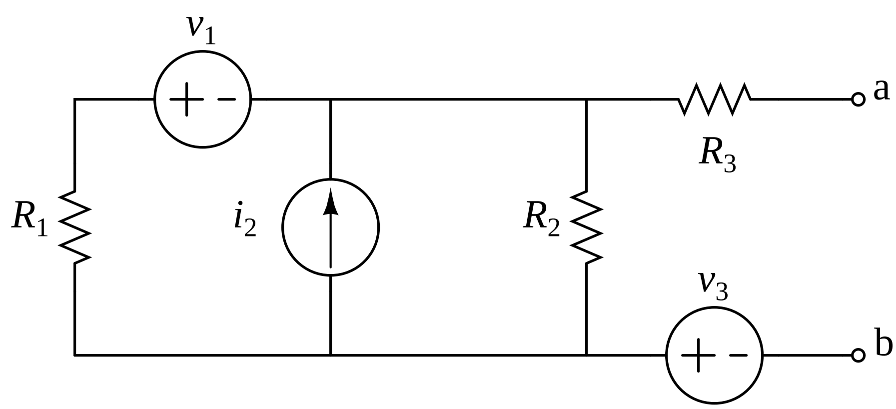
Problem IV: [20 *pts.*] Thévenin-Norton Equivalents

Given the following circuit:



(1) Clearly determine the values of and draw the Thévenin equivalent for the circuit as seen from terminals a and b.

(2) Clearly determine the values of and draw the Norton equivalent for the circuit as seen from terminals a and b.

(3) If a load resistor R_L were placed between the terminals a and b, what value of this resistor would maximize the power transferred to that load? What is the value of the power transferred to that load?

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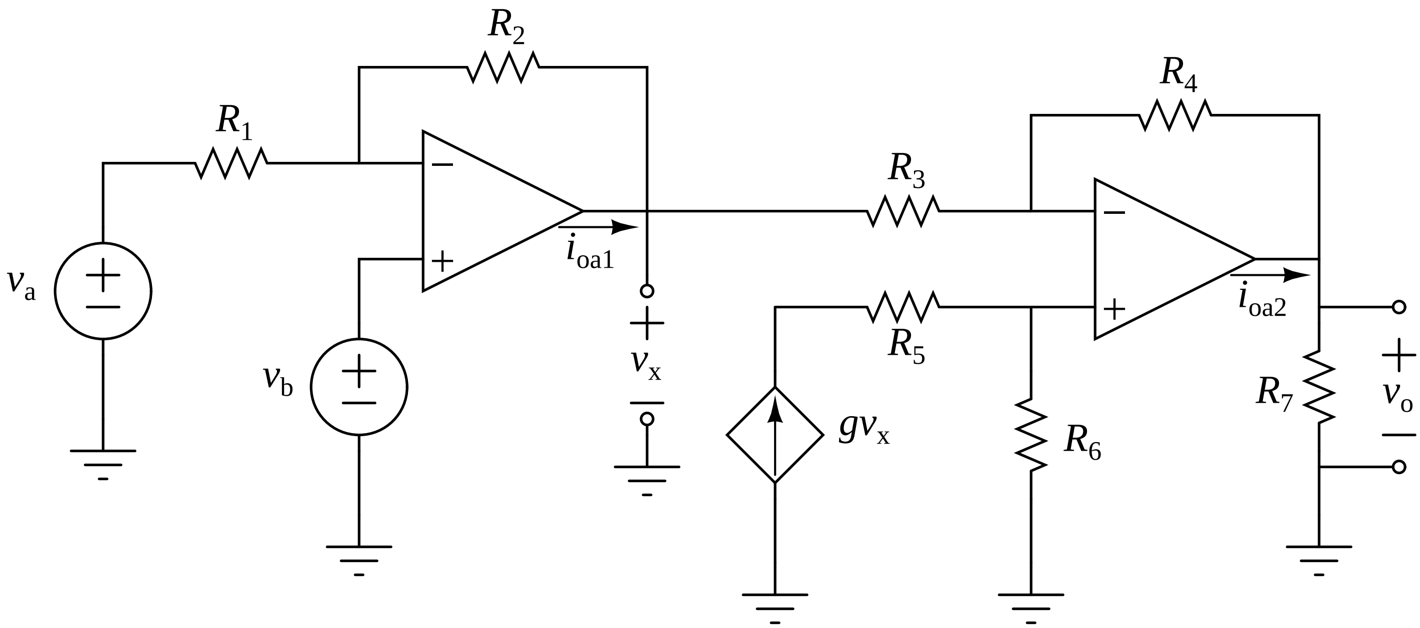
Problem V: [20 *pts.*] Operational Amplifiers

Given the following circuit:



and assuming ideal operational amplifiers:

(1) Clearly determine expressions for v_x and v_o in terms of the known source (v_a, v_b), resistor (R_1 through R_7), and controlled source gain (g) values. *Note:* once you have solved for a previously unknown value in terms of known values, you may use that value as if it were known.

(2) Assuming you have found v_x and v_o correctly, solve for:

(a) The power delivered by each of the three sources, and
(b) The output current from each operational amplifier.

in terms of the known values (which now include v_x and v_o).