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

EGR 119 Spring 2008

Test I

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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 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 for Problem Sections

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.

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.

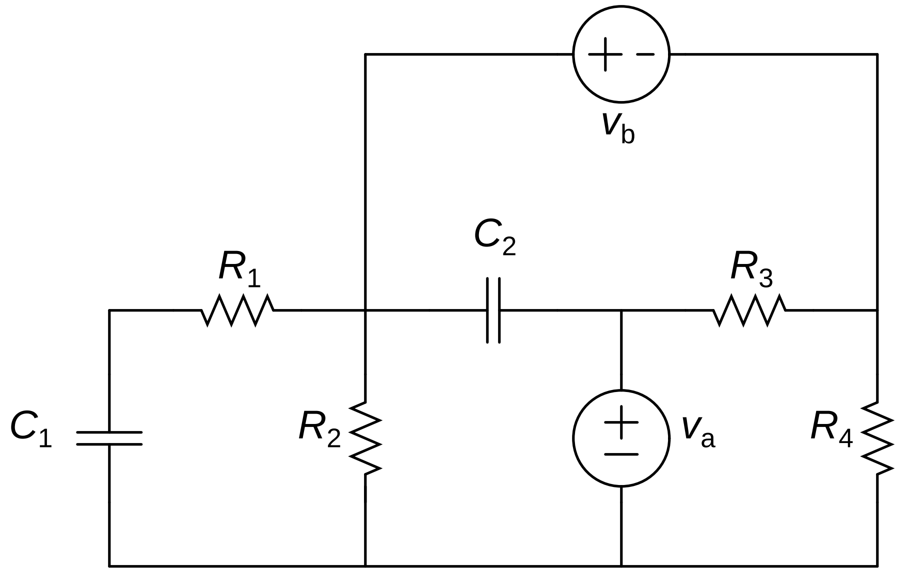
Note that there may be people taking the test after you, so you are not allowed to talk about the test until I send along the OK. This includes talking about the specific problem types, how long it took you, how hard you thought it was - really anything. Please maintain the integrity of this test.

[1]This test is brought to you by the letters $\mathbb{H}$ and $\mathcal{S}$ and the number $\Re\{e^{j\pi/4}\}$.

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

Problem I: [20 pts.] Node Voltage Method

Given the following circuit:



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

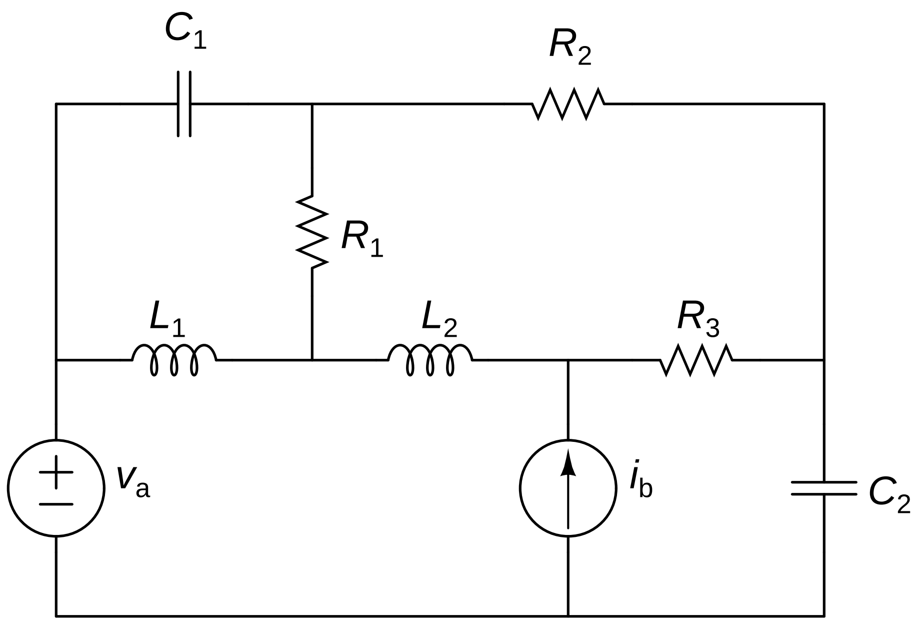
(a) *Clearly* demonstrate the use of the Node Voltage Method in labeling unknowns for the circuit and in determining coupled ordinary differential equations that could be used to solve for the capacitor voltages. However you choose to solve this section, your answer to this part must be in the time domain.

(b) Assuming both $v_a(t)$ and $v_b(t)$ are constants and the circuit has been in place for a very long time, find an expression for the voltage across capacitor C_1. Be sure to clearly label this voltage on your circuit diagram.

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

Problem II: [20 pts.] Mesh Current Method

Given the following circuit:



and assuming that the values for the passive elements as well as sources v_a and i_b are known, first redraw the circuit in the frequency domain, specifically using Laplace transforms. *Note* clearly use symbols that indicate you are in the frequency domain; for example $I(s)$ or I versus $i(t)$ or i. Then,

(a) *Clearly* demonstrate the use of the Mesh Current Method in labeling unknowns for the circuit and in determining equations that could be used to solve for the Laplace transforms of the mesh currents as functions of the element values and the Laplace transforms of the sources.

(b) Using the unknowns you have labeled above, as well as any known values (or their Laplace transforms), give an expression for the Laplace transform of the voltage drop across L_2, $\mathbb{V}_{L_2}(s)$. You can pick which way you are calculating the voltage drop, so clearly indicate the polarities of your voltage drop on the circuit diagram.

Name (please print):
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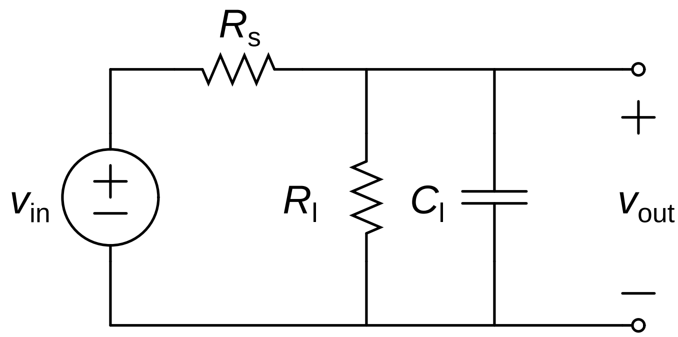
Problem III: [20 pts.] Filters I

Given the following circuit:



and assuming that the values for the passive elements are known,

(a) Determine a symbolic expression for the transfer function $\mathbb{H}(j\omega)$ between the input voltage and the output voltage in terms of the element values R_s, R_l, and C_l.

(b) Determine a symbolic expression for the magnitude of the transfer function, $H(j\omega)$, in terms of the element values R_s, R_l, and C_l.

(c) What kind of filter is this? Why do you think that?

(d) Assuming R_s =1 kΩ, R_l =2 kΩ, and C_l =30 μF, what is the maximum value of $H(j\omega)$ and at what frequency does it occur?

(e) Assuming R_s =1 kΩ, R_l =2 kΩ, and C_l =30 μF, what is the bandwidth of the filter? Be sure to include units.

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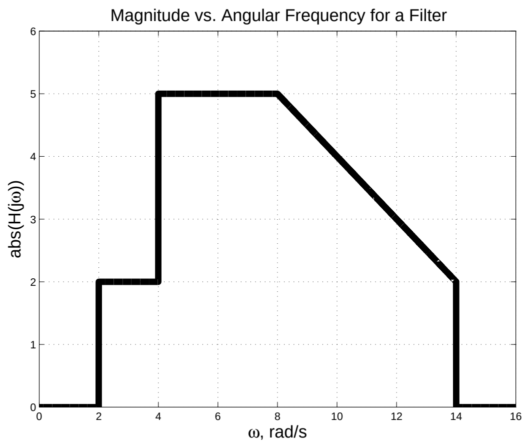
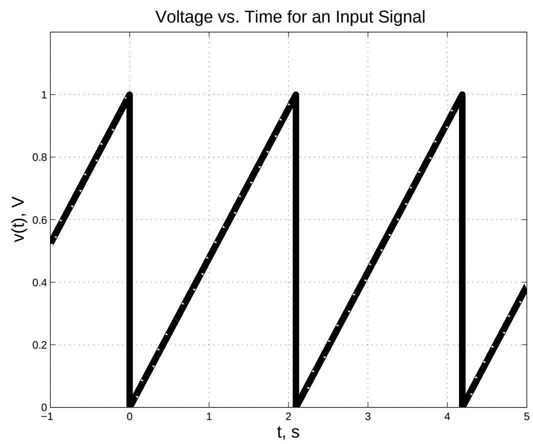
Problem IV: [20 pts.] Filters II

An idealized filter is modeled where the angle of the transfer function is 0 for all frequencies and the amplitude of the transfer function is given in the left-hand figure below. A sawtooth wave which has a period of $\frac{2}{3}\pi$ and is 1 V peak-to-peak is the input to the system and is graphed in the right-hand figure below.





(a) What kind of filter is this?

(b) What is the bandwidth of the filter?

(c) The sawtooth wave has trigonometric Fourier series coefficients of:

$$A_{\mathrm{n}} = 0 \qquad B_{\mathrm{n}} = -\frac{1}{n\pi} \qquad C_0 = \frac{1}{2}$$

If this sawtooth wave is applied as the input to the filter, determine an expression (as a function of time) for the output of the filter.

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Problem V: [20 pts.] Laplace Transforms

A linear, time-invariant system SYS:

$$x(t) \xrightarrow{\text{SYS}} y(t)$$

has a step response of:

$$s_r(t) = e^{-3t} \sin(4t)\, u(t)$$

(a) What is the Laplace transform of the step response, $\mathcal{S}_r(s) = \mathcal{UL}\{s_r(t)\}$?

(b) What is the Laplace transform of the impulse response, $\mathcal{H}(s) = \mathcal{UL}\{h(t)\}$?

(c) If an input signal:

$$x_1(t) = \left(e^{-t} - e^{-2t}\right) u(t)$$

is applied to the input, what is the Laplace transform of the output, $\mathcal{Y}_1(s) = \mathcal{UL}\{y_1(t)\}$?

(d) If an input signal:

$$x_2(t) = u(t) - u(t-2)$$

is applied to the input, what is the output, $y_2(t)$?