Duke University

Edmund T. Pratt, Jr. School of Engineering

EGR 224 Spring 2015

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.

Your calculator may only be used as a calculation device, not a memory storage unit. Using a calculator for any purpose other than performing "just-in-time" numerical calculations is a violation of the community standard.

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):
Community Standard (print ACPUB ID):

Problem I: [25 pts.] Basics

The following items get at the "core" of some of the concepts you have learned in the course. Note however that they are *not* related to each other. **Put your final answers in the appropriate spaces below**; you may put work on additional pages.

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

$$v_{\text{a}}(t) = 3\cos(47t) - 8\sin(47t)$$

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

$$i_{\text{b}}(t) = 10\sin(100t - 18^o) + 12\sin(100t + 41^o)$$

(3) A resistor R is in series with a reactive element. At a frequency of 500 rad/s, the impedance of the series combination is found to be 2000-j4000 Ω. Draw the series combination below, including the actual values of the resistor and the reactive element.

(4) Determine the inverse Laplace transform $v(t)$ of:

$$\mathbb{V}(s) = \frac{s+10}{s^2+8s+12}$$

(5) Determine the inverse Laplace transform $i(t)$ of:

$$\mathbb{I}(s) = \frac{s+10}{s^2+8s+17}$$

(6) A system can be modeled with the differential equation:

$$2\frac{d^2y(t)}{dt^2} + 8y(t) = 5\frac{dx(t)}{dt} + 24x(t)$$

Determine:

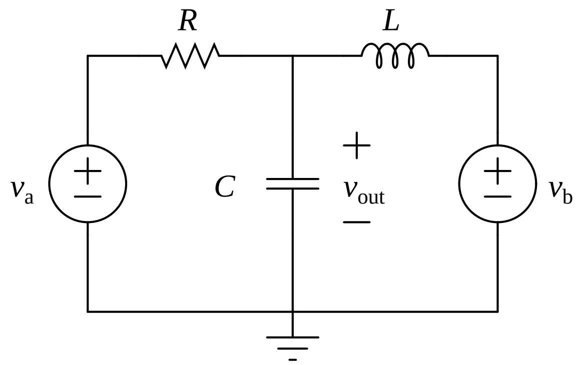
(a) The transfer function for the system, $\mathbb{H}(s) = \frac{\mathbb{Y}(s)}{\mathbb{X}(s)}$

(b) The impulse response for the system, $h(t)$

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

Problem II: [25 `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 v_b is 0 V for this.

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

(3) Assuming

$$v_a(t) = 9\cos(1000t + 42^o) + 3\sin(6000t + 88^o)\text{ V} \qquad R = 200\ \Omega$$
$$v_b(t) = 4 + 7\cos(1000t - 154^o)\text{ V} \qquad L = 100\text{ mH}$$
$$C = 400\text{ nF} = 4 \times 10^{-7}\text{ F}$$

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.

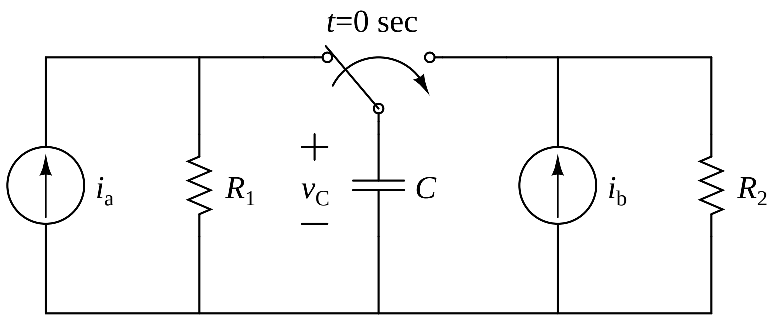
(4) Given the element values above, what kind of filter does $\mathbb{H}_a(j\omega)$ represent? Why do you think that?

(5) Given the element values above, what kind of filter does $\mathbb{H}_b(j\omega)$ represent? Why do you think that?

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

Problem III: [25 pts.] Complete Response

For the circuit below, assume that the switch has been in the left-most position for a very long time before $t = 0$ s. At t=0 s the switch moves to its right-most position.



(1) Assuming that $i_a(t)$ is a constant i_a for all time and that while $i_b(t)$ is *not* a constant it is known to be equal to $i_b(0^+)$ at $t = 0^+$ s, determine the following in terms of the symbolic element and source values; **write your final answer next to the item** - your work can be on extra paper:

(a) $v_C(0^-)$

(b) $i_C(0^-)$

(c) $v_C(0^+)$

(d) $i_C(0^+)$

(2) Assuming the circuit has the following element and source values:

$R_1 = 1\ \text{k}\Omega$	$R_2 = 5\ \text{k}\Omega$	$C = 2\ \mu\text{F}$
$i_a = 6$ mA	$i_b = 14e^{-40t}$ mA	

Determine $v_C(t)$ for $t > 0$ s. **Write your final answer below** - your work can be on extra paper

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

Problem IV: [25 pts.] Design and Analysis

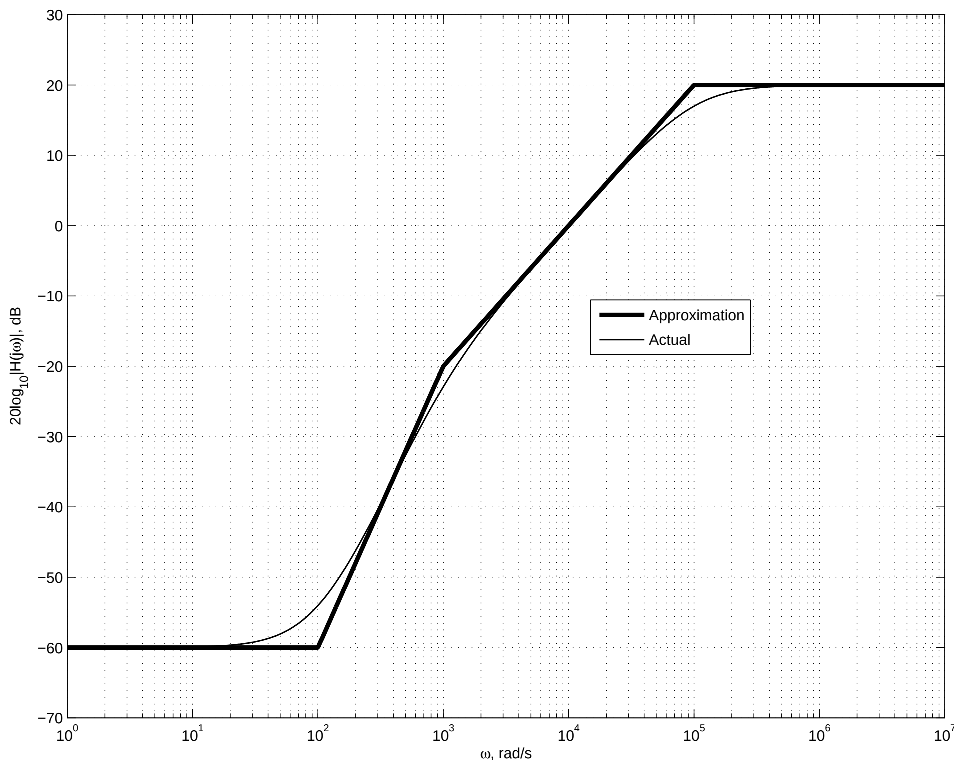
(1) Filter Design:

(a) Determine the transfer function $\mathbb{G}(s)$ for a second-order band-pass filter with a passband gain of 1, a logarithmic center frequency of 4000 rad/s, and a quality of 0.2. Write the transfer function for the band-pass filter using one of the two "standard" forms we discussed in class for band-pass filters.

(b) For this filter, determine the damping ratio, cutoff (half-power) frequencies, linear center frequency, and bandwidth for the filter. Be sure to clearly indicate which value is which and include units when appropriate.

(c) Assuming you have access to a single 20 μF capacitor, along with a generous array of resistors and inductors design a voltage-to-voltage circuit that has the same transfer function as this filter. Be sure to clearly indicate where the output voltage is as well as what the component values are.

(2) Given the following Bode magnitude plot of some transfer function $\mathbb{H}(s)$ (along with its straight line approximation):



(a) Assuming all poles in the system are overdamped, determine the formula for a transfer function $\mathbb{H}(s)$ or $\mathbb{H}(j\omega)$ which is represented in the figure.

(b) What kind of filter is this? Also state why you believe that, *approximately* what the cutoff frequency/frequencies is/are, and what the passband gain is/is.