EECS 40, Fall 2006
Prof. Chang-Hasnain
Midterm #2

October 25, 2006
Total Time Allotted: 50 minutes
Total Points: 100 / Bonus: 10 pts

1. This is a closed book exam. However, you are allowed to bring one page (8.5" x 11"),
single-sided notes PLUS your 1-page notes from midterm 1.
2. No electronic devices, i.e. calculators, cell phones, computers, etc.
3. Slide rules are allowed.
4. SHOW all the steps on the exam. **Answers without steps will be given only a small percentage of credits.** Partial credits will be given if you have proper steps but no final answers.
5. **Remember to put down units.** Points will be taken off for answers without units.

Last (Family) Name:_____________________________________________________________________

First Name:____________________________________________________________________________

Student ID:_________________________________ Discussion Session:________________________

Signature:______________________________________________________________________________

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1. [16 points] Parallel and Series Complex Impedance

a) [8 pts] What is the complex impedance $Z_1$?

\[ \begin{array}{cc}
\text{C1} & \\
Z_1 & \text{L1} \\
& \text{R1} \\
\end{array} \]

b) [8 pts] What is the complex impedance $Z_2$?

\[ \begin{array}{cc}
\text{C2} & \\
& \text{R2} \\
Z_2 & \text{L2} \\
\end{array} \]
2. [54 points] Bode Plots:

(a) [10 points] For the above circuit, show $H(f) = \frac{1}{1 + j\frac{f}{f_2}} \times \frac{1}{1 - j\frac{f}{f_1}}$

Express $f_1$ and $f_2$ in terms of $R$, $L$, $C$. (Hint: Remember $\omega = 2\pi f$)

(b) [6 points] Now let $R = 1k\Omega$, $L = 0.16\,mH$, $C = 0.16\,\mu F$, what are $f_1$ and $f_2$? Remember to put down units.
(c) [22 pt] Bode Magnitude Plot. You must put down all the steps leading to your results. 
*Hint:* You may consider $f_1 \ll f_2$

[4 points] Write down the expression for $y = 10 \log |H(f)|^2$

[4 points] As frequency goes to a very small value, what is the slope of $y$ as a function of $\log f$?

[4 points] As frequency goes to a very large value, what is the slope of $y$ as a function of $\log f$?

[4 points] What is $y$, $f_1 \ll f \ll f_2$?

[2 points] What is $y$ at $f_1$?
[2 points] What is $y$ at $f_2$?

[2 points] What filter is this?

**Bonus [5 points]** If the input $|V_{in}| = 1$ V and the frequency is 1 MHz, what is the output $|V_{out}|$?

**Bonus [5 points]** If the input $|V_{in}| = 1$ V and the frequency is 10 MHz, what is the output $|V_{out}|$?

(d) [16 pt total] Bode Phase Plot. You must put down all the steps leading to your results. Hint: You may consider $f_1 \ll f_2$.

[4 points] Write down the expression for $\angle H(f)$

[4 points] What does the value of $\angle H(f)$ approaches to as $f \to 0$?
[4 points] What does the value of $\angle H(f)$ approaches to as $f \to \infty$?

[2 points] What is $\angle H(f)$ at $f = f_1$?

[2 points] What is $\angle \hat{H}(f)$ at $f = f_2$?
3. [30 points] Second-order Circuits:

Assume the switch has been to the left for a long time before switching to the right at $t = 0$.

(a) Find the following values: [18 points] (Hint: What is $v_c(t)$ in terms of $v_C(t)$?)

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<thead>
<tr>
<th>$i_C(0^+)$ =</th>
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<tbody>
<tr>
<td>$v_C(0^+)$ =</td>
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<tr>
<td>$v_C(\infty)$ =</td>
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<tr>
<td>$v_o(0^+)$ =</td>
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<td>$v_o(\infty)$ =</td>
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<td>$\frac{d}{dt}i_C(0^+)$ =</td>
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<td>$\frac{d}{dt}v_o(0^+)$ =</td>
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(b) [6 points] Write the differential equation in terms of $v_c$.

(c) [6 points] What are the values of the natural frequency ($\omega_n$) and the damping ratio ($\zeta$)?