**EE40 Su 2010 Homework #5, due Tuesday 7/20/10 by 2 PM in the Homework box in 240 Cory**

1. The circuit shown in Fig. P3.72 has $i_L(t)$ = 0.1cos(5000t) A. Find $v(t)$, $i_C(t)$, $i(t)$, and the total amount of energy stored in both devices. [Hint: the total energy is constant with respect to time.]

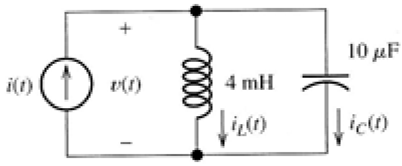
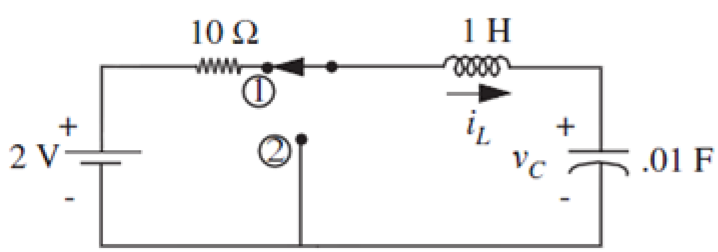



**Figure P3.72**

Hint if you get a weird answer and feel uncomfortable with it, you're probably right: An LC circuit will resonate, even if disconnected from a source

2. PROBLEM 12.6 In the circuit in Figure 12.77, the switch has been in position 1 for all $t < 0$. At $t = 0$, the switch is moved to position 2 (and remains there for $t > 0$). Find and sketch $v_C(t)$ and $i_L(t)$ for $t > 0$.




Hint: I'd recommend doing this one from scratch including solving the ODE. You will need to find $i_L(0)$ and $i_L'(0)$ if you write a 2nd order ODE in $i_L$. Even if you do this problem with a shortcut, I would HIGHLY recommend that you make sure you know how to **quickly** find $i_L(0)$ and $i_L'(0)$ (like by inspection).

3. PROBLEM 15.21

a) Using the "ideal operational amplifier" assumption, that is, infinite gain, infinite input resistance, and zero output resistance, determine the relationship between $v_O(t)$ and $v_I(t)$ in Figure 15.87.

b) If the signal $v_I(t)$ is the rectangular pulse in Figure 15.88, sketch $v_O(t)$ for $t > 0$, assuming that $v_O(0) = 0$.

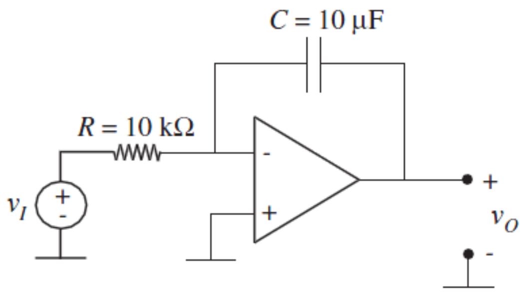



FIGURE 15.87

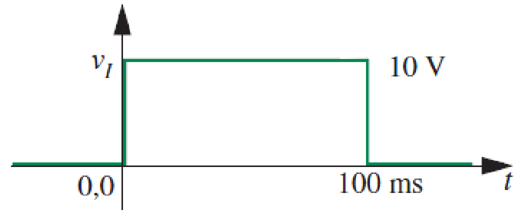



FIGURE 15.88

4. EXERCISE 13.1 Find the magnitude and phase of each of the following expressions:

a) $(8 + j\,7)(5e^{j30^\circ})(e^{-j39^\circ})(0.3 - j\,0.1)$

b) $\dfrac{(8.5 + j\,34)(20e^{-j25^\circ})(60)(\cos(10^\circ) + j\sin(10^\circ))}{(25e^{j20^\circ})(37e^{j23^\circ})}$

c) $(25e^{\,j30^\circ})(10e^{\,j27^\circ})(14 - j\,13)/(1 - j\,2)$

d) $(13e^{\,j30^{(15^\circ + j1.5)}})(6e^{(1-j30^\circ)})$

**-4d is a bit ambiguous and not the most useful problem. Skip it.**

The answer in the back of the book is wrong for part d. Should be in the 2000ish magnitude and 60something degrees range. Note that 30 is exponentiated on the left part of 4d

5. EXERCISE 13.2 Find the real and imaginary parts of the following expressions:

a) $(3 + j\,5)(4e^{j50^\circ})(7e^{-j20^\circ})$

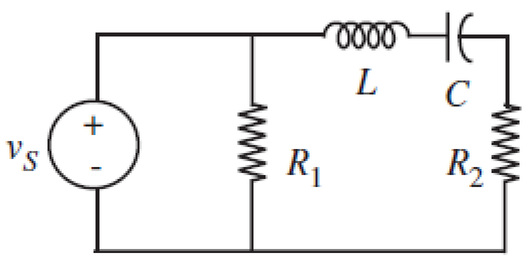
b) $(10e^{j50^\circ})(e^{j20^\circ})$

c) $(10e^{j50^\circ})(e^{j\omega t})$

d) $Ee^{j\omega t}$ where $E = |E|e^{j\Theta}$

6. There is no question 6 (moved to extra questions).

7. EXERCISE 12.4 Is the zero-input response of the circuit in Figure 12.69 under-damped, over-damped, or critically-damped? (Provide some kind of justification for your answer, either a calculation or a sentence of explanation.)




$$L = 1\,\mu H, C = 0.01\mu F, R_1 = R_2 = 15\Omega$$

Reminder: The zero input response is just the response of the circuit when the circuit sources are **set to zero**, but the various elements with memory have some potentially non-zero initial condition. This problem is very easy.

Sources set to zero!

8.

a. What is the phasor representation of the sinusoid $5cos(22t + \pi)$?

i. Write in polar ($Ae^{j\theta}$) form

ii. Write in shorthand polar ($A\angle\theta$) form

iii. Write in rectangular ($a + jb$) form

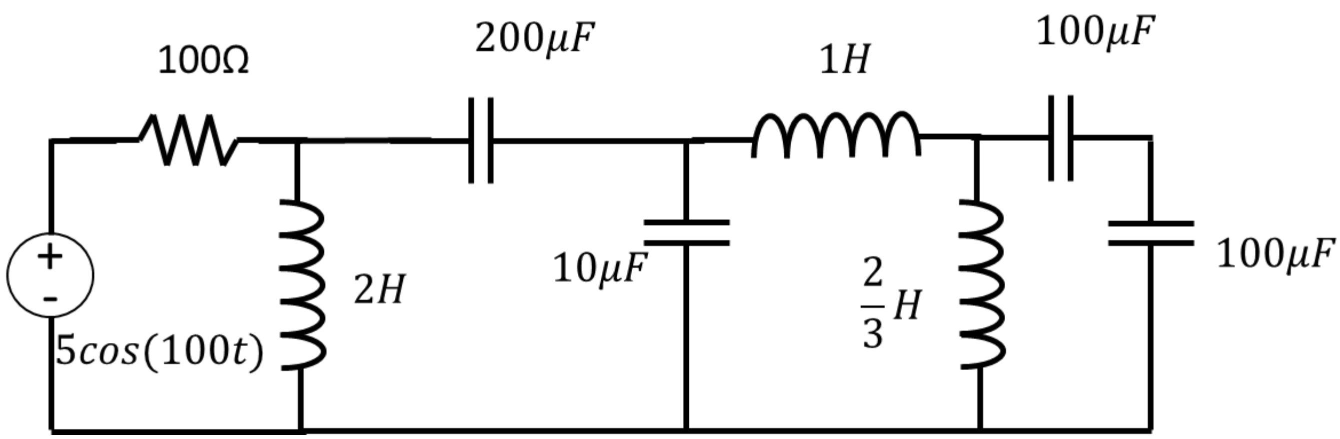
b. If we have a phasor $3 + 2j$ what is the sinusoid represented by this phasor if $\omega = 20$?

Note that if $\theta > \frac{\pi}{2}$ or $\theta < \frac{\pi}{2}$, then we start suffering from ambiguity issues because $\arctan\left(\frac{b}{a}\right)$ isn't a function, but rather a relation, i.e.

arctan(0) $= \{\ldots, -2\pi, -\pi, 0, \pi, 2\pi, \ldots\}$. For this reason, it's a better idea to keep $\theta$ in that range.

This can bite you. If you write the answer to part iii directly, you'll 5+0. If you convert your answer from part ii, you'll get -5+0. Sorry, for all other problems ever, $\theta$ will be less between $-\pi/2$ and $\pi/2$ . I'll talk about this in lecture.

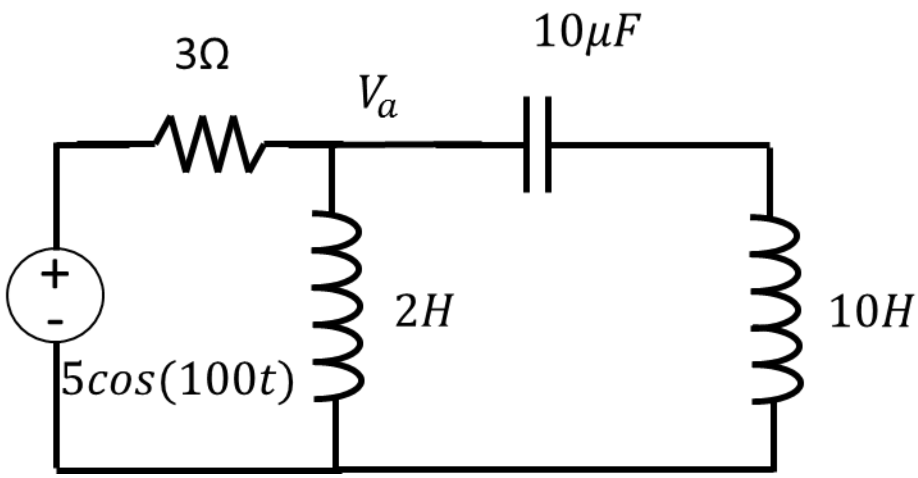
**9.** Consider the following circuit




a. Draw the circuit, but replace all of the components with their equivalent impedance, and replace the source by its phasor representation (its phasor representation is just 5V)
b. Find the equivalent impedance that the source sees. Your numbers should come out nice!! If they're not, work slowly right to left, and the numbers should constantly be nice as you work your way to the left.
c. Find the phasor representation of the total current delivered by the source (this is just the phasor representation of the voltage source divided by the equivalent impedance). Give your answer in polar coordinates.
d. Convert your phasor representation in part c to the particular solution for the current delivered by the voltage source $i_{S,P}(t)$.
e. What is the complete solution $i_S(t)$ in steady state? (Hint, this is really really easy once you have d)
f. Suppose we decreased $\omega$ ($\omega = 100$ in our circuit above). What is the limit of the **steady state** $i_S(t)$ as $\omega$ goes to zero? [Hint it will no longer be a function of time]
g. What is the limit of the impedance of a capacitor as $w \to \infty$? An inductor? A resistor? What is the limit of each as $w \to 0$?
h. Extra **(not for a grade)**: What is the limit of $i_S(t)$ as $\omega$ becomes very large?
i. Extra **(not for a grade):** Write a set of node voltage equations which would allow you to find the homogeneous solution [remove the source first]. You will end up with a lot of

integrals and derivatives in your node voltage equations. Take derivatives to eliminate integrals. Finding the homogenous solution would necessitate solving this giant set of ODEs. Luckily, we usually don't care about this approach to steady state. Sure the first couple of oscillations will be a little off, but eventually the whole circuit will settle into your answer from part d.

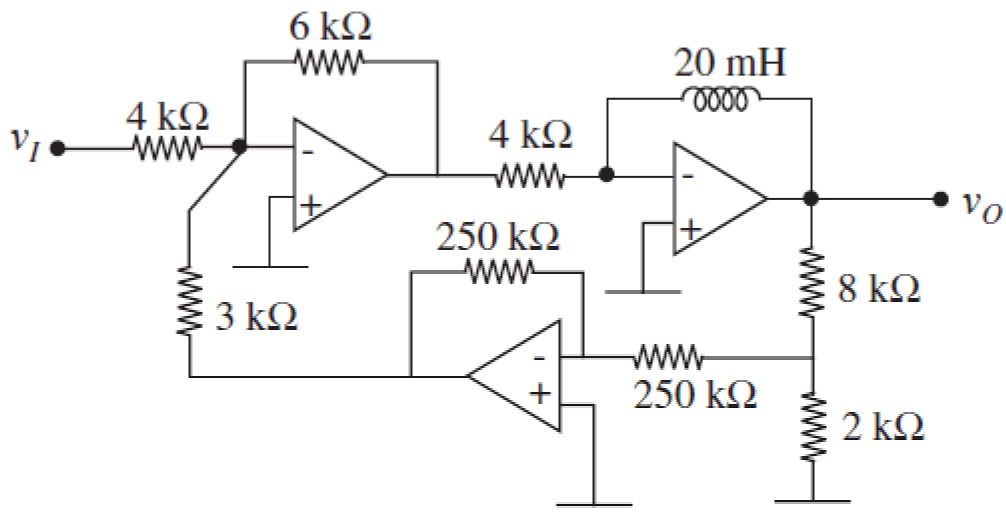
10.




a. Find $V_a(t)$ in steady state – Hint, if two impedances sum to zero, they act like a short
b. If you change $\omega$, your answer will change. Explain why. (This is easy)
c. Are there any frequencies other than $\omega = 100$ for which you get the same answer as in part a? Optional: Draw the output at the + side of the source for any other answers you may get.
d. Extra **(not for a grade)**: Put this circuit into the Falstad circuit simulator and verify your answer to part a. Note that the frequency in the Falstad circuit simulator is not $\omega$, but rather $f$, which is just $\frac{w}{2\pi}$, so you'll have to input $100/2\pi$ as your frequency.

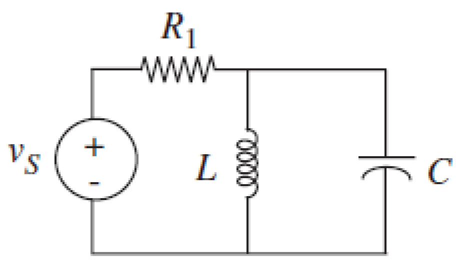
Extra Problems: [not for a grade]

PROBLEM 15.27 What is the differential equation relating to $v_O$ to $v_I$ in the network in Figure 15.98? Assume that the Op Amps are ideal.

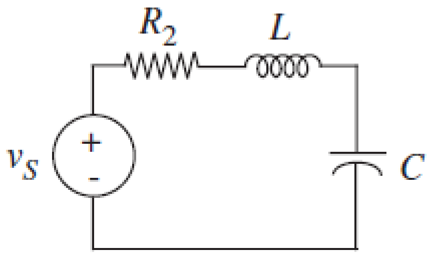



EXERCISE 12.8 Find the roots of the characteristic polynomial (often called the network natural frequencies) in each of the networks in Figure 12.72.

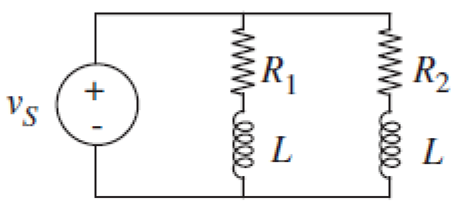
Numerical values: $R_1 = 10\ \Omega$, $L = 10\ \mu\text{H}$, $C = 10\ \mu\text{F}$, $R_2 = 2\ \Omega$.



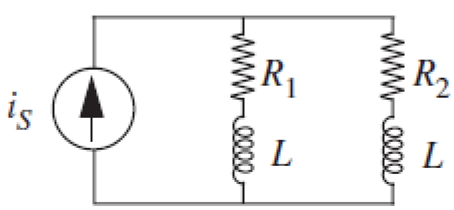

(a)




(b)




(c)




(d)