ECE 209 – MIDTERM

SPRING 1998 **A.P. FELZER**

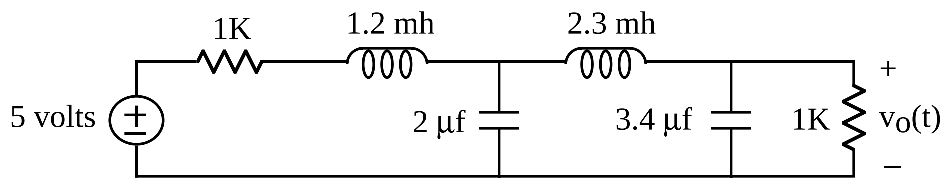
You may consult **your** notes and any books you may have or borrow from the library as well as any computer software or plotting calculators to do the following problems. But you **may not** under any circumstances for any reason talk to any person about the exam except for Felzer. If you **do discuss** this exam or **in any way** make use of the work of others, you will **fail** the course and have a letter put in your file explaining why.

To get a good grade in this exam you must not only get the right answers but also make sure that your solutions are neat, complete, concise, make obvious what each problem is, make obvious how you're solving the problem and make obvious what your answer is. You also need to include drawings of all circuits (including equivalent circuits) as well as appropriate graphs and tables. In addition all equations, graphs and tables must be labeled

Note that it is better to do a problem with brute force than not at all. But it's better to do a problem "simply". Include any pertinent computer printouts. Be sure to start early enough so that you have time to think about and double check your work

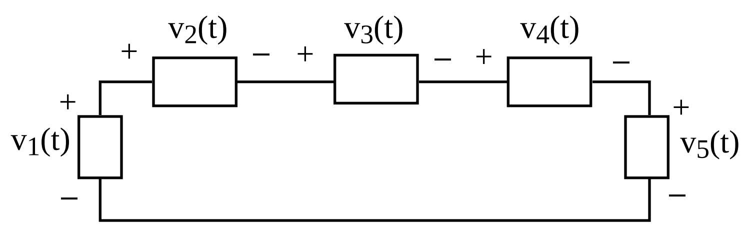
1. Write out the page of notes you would use for this midterm if it was closed book

2. Find the steady state response of the following circuit



Explain how you got your answer

3. Given



Find $v_5(t)$ – as a single cosine – if

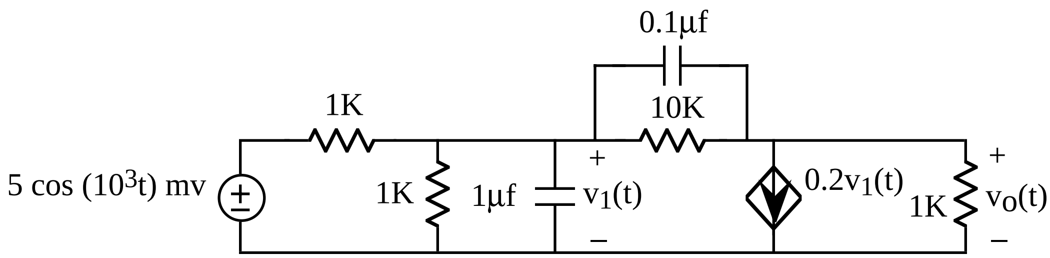
$v_1(t) = 3\cos(100t)$ $v_2(t) = 4\cos(100t - 1.1)$
$v_3(t) = 1.5\cos(100t + 0.5)$ $v_4(t) = 2.5\cos(100t - 0.4)$

4. Find the transfer function $G(j\omega) = V_o(j\omega)/V_{in}$ of a circuit with differential equation

$$\ddot{v}_o + 1.5x10^3\dot{v}_o + 10^6 v_o = 10^3\dot{v}_{in}$$

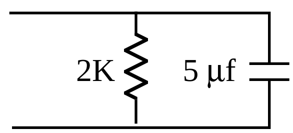
Then use your result to find the steady state response to $v_{in}(t) = 5\cos(1000t - 1.2)$

5. Given the following circuit in the sinusoidal steady state

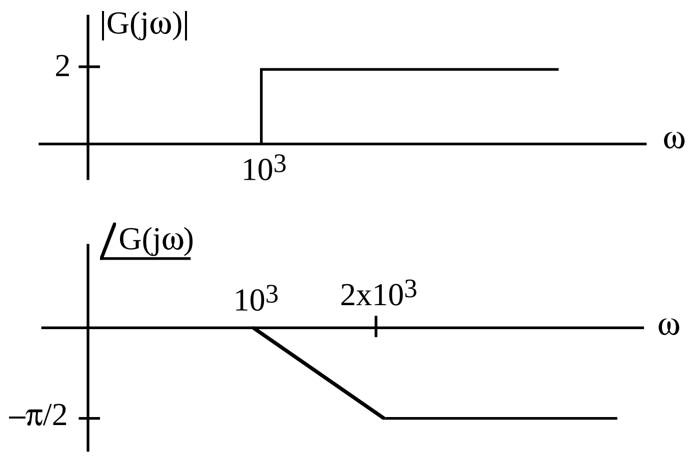


a. Draw the phasor circuit
b. Write the node equations and then put them in matrix form
c. Solve your equations for the steady state $v_o(t)$
d. Verify that SPICE gives the same result

6. Find and sketch the admittance of the following circuit as a function of frequency

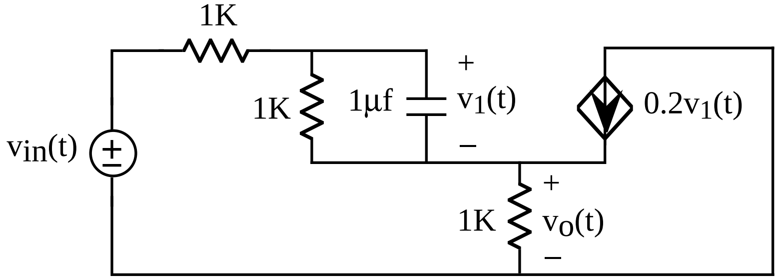


7. Given a circuit N with input $v_{in}(t) = 2\cos(500t) + 3\cos(1500t + 1.3)$ and ideal frequency response $G(j\omega) = V_o(j\omega)/V_{in}$ given by



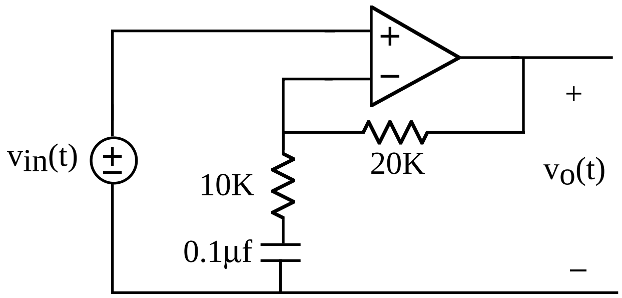
a. Plot $v_{in}(t)$
b. Find and plot $v_o(t)$

8. Given the following circuit



a. Find the transfer function $G(j\omega) = V_o(j\omega)/V_{in}$
b. Make a Bode Plot of the magnitude of the gain of your transfer function
c. Make use of SPICE to obtain a Bode Plot of the gain. Verify that your SPICE results are the same as your plot in part (b)

9. Find the voltage transfer function $G(j\omega) = V_o(j\omega)/V_{in}$ of the following circuit



10. Given a circuit with voltage transfer function given by

$$G(j\omega) = \frac{V_o(j\omega)}{V_{in}} = \frac{j\omega}{2000 + j\omega}$$

a. Plot $|G(j\omega)|$ as a function of ω with ω plotted on a log scale
b. Find the steady state response to $v_{in}(t) = 2\cos(1500t + 1.2)$. Then plot both $v_{in}(t)$ and $v_o(t)$
c. Repeat part (b) for $v_{in}(t) = 2\cos(1500t + 1.2) + 3\cos(3000t - 0.5)$

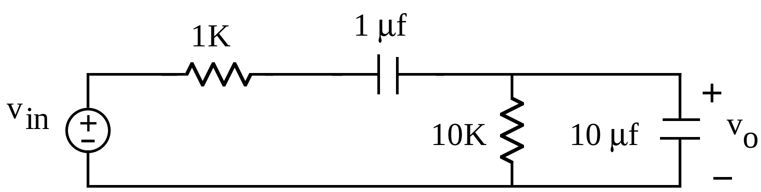
11. Design a first order RC circuit with input $v_{in}(t) = \cos(10^3 t) + 4\cos(10^5 t)$
and output $v_o(t) \approx K\cos(10^5 t + \theta)$ with K as close to 4 as you can make it. Plot the transfer function of your circuit. What is the difference in dB in the gain of your filter at the two frequencies. Make use of SPICE to test your circuit. Do you think it's working. Explain why

12. Analytically find the frequency where

$$G(j\omega) = \frac{j\omega}{j\omega + 2000}$$

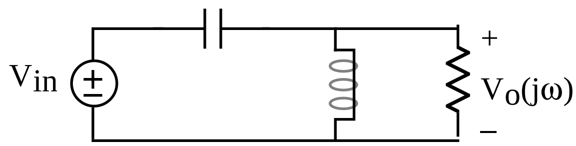
is down 10 dB from its maximum

13. Find the transfer function $G(j\omega) = V_o(j\omega)/V_{in}$ of the following circuit



Sketch $|G(j\omega)|$ as a function of ω with ω plotted on a log scale and then explain in words why the response looks the way it does. Is this a resonant circuit. How do you know

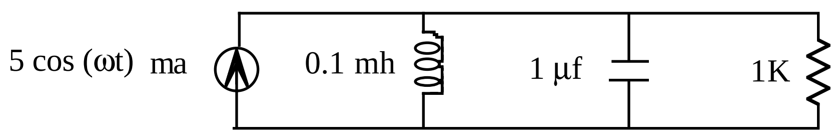
14. Sketch the magnitude of $G(j\omega) = V_o(j\omega)/V_{in}$ for the following circuit



Then explain in words why the response looks the way it does

15. Suppose $v_{in}(t) = \cos(5x10^4 t) + \cos(10^5 t) + \cos(2x10^5 t)$ is the input to a resonance circuit with $\omega_o = 10^5$. Describe how the shape of the output $v_o(t)$ changes as Q_p is increased (without changing ω_o). Make use of graphs of $|G(j\omega)|$ to justify your answer. Plot the corresponding $v_o(t)$'s

16. What is the total energy being stored by the L and C in the following circuit



when the circuit is in resonance. Explain how you got your result

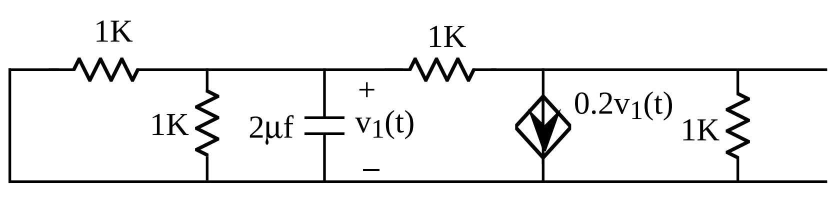
17. Find (any way you want) the frequencies where

$$G(j\omega) = \frac{j\omega 10^6}{(j\omega + 100)(j\omega + 10^5)}$$

is 40 dB down from its maximum

18. Find circuits with equivalent impedances and admittances as follows
    a. Z(j1000) = 2000 + j1000
    b. Z(j1000) = 2000 – j1000
    c. Y(j1000) = 2000 – j1000

19. Find the equivalent impedance $Z(j\omega)$ of the following circuit



and then sketch its magnitude as a function of frequency ω. Describe what happens as ω increases