ECE 209 – FINAL

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.

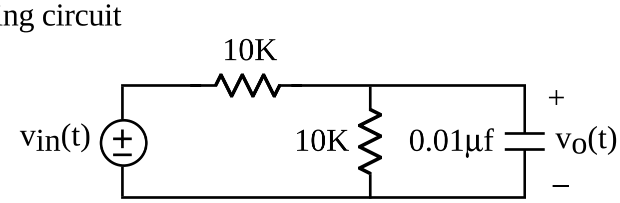
To get a good grade in this exam you must not only get the right answers but also make sure that your solutions are neat, complete, concise, make obvious what each problem is, make obvious how you're solving the problem and make obvious what your answer is. You also need to include drawings of all circuits (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 final if it was closed book

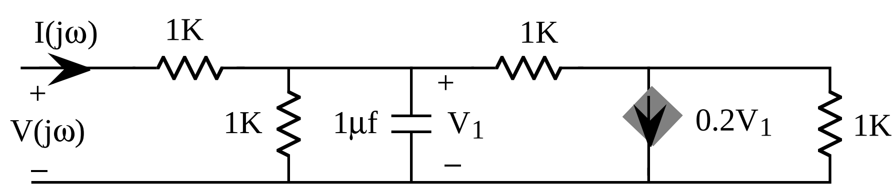
2. Find the steady state response of a linear circuit to the input $v_{in}(t) = 7\cos(10^3t - 1.2)$ if its steady state response to $v_{in}(t) = 5\cos(10^3t + 0.7)$ is $v_o(t) = 3\cos(10^3t - 0.2)$

3. Given the following circuit



   a. Sketch the magnitude $|G(j\omega)| = |V_o(j\omega)/V_{in}|$ of the circuit's voltage gain as a function of frequency on a log scale
   b. Sketch the Bode Plot of $|G(j\omega)|$
   c. What is the 3dB frequency
   d. What would be the maximum and the minimum possible values for the 3dB frequency if the circuit is built with 5% resistors and 10% capacitors
   e. At what frequency f is the gain 15dB down from its maximum value

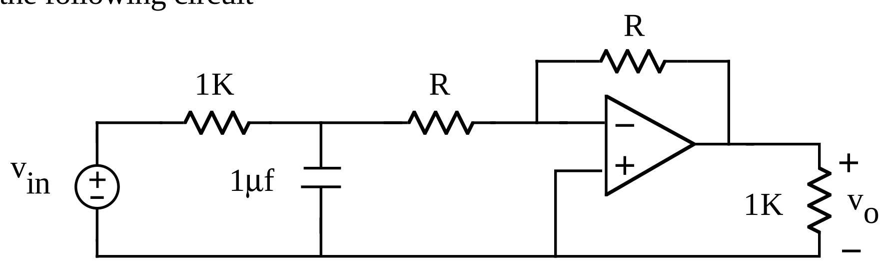
4. Given the following circuit



   a. Obtain an expression for the input impedance $Z(j\omega) = V(j\omega)/I(j\omega)$. Then use your calculator or a computer program to plot $|Z(j\omega)|$ as a function of ω on a log scale. Explain why your result looks the way it does

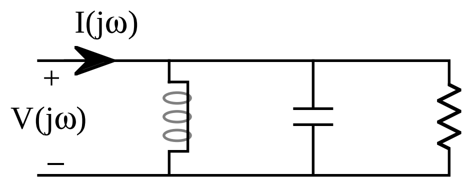
b. Make use of SPICE to get a plot of $|Z(j\omega)|$ as a function of ω on a log scale. Compare your results with those you got in part (a)

5. Given the following circuit



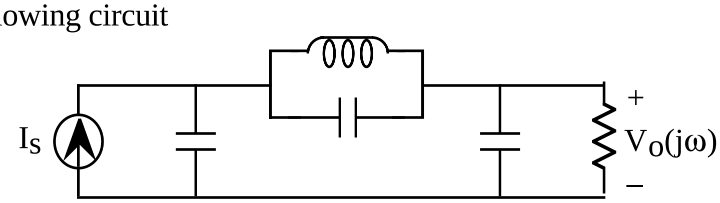
Sketch what $|G(j\omega)| = |V_o(j\omega)/V_{in}|$ looks like as a function of R for a given value of ω. Describe your graph. Explain why it looks the way it does

6. Given the following circuit



Sketch a graph of the magnitude of the admittance $|Y(j\omega)| = |I(j\omega)/V(j\omega)|$ as a function of ω on a log scale. Explain why your graph looks the way it does

7. Given the following circuit



Sketch a graph of the magnitude of the transfer function $|G(j\omega)| = |V_o(j\omega)/I_s|$ as a function of ω on a log scale. Explain why your graph looks the way it does

8. Given the following transfer function

$$G(j\omega) = \frac{2x10^3 j\omega}{(j\omega)^2 + 2x10^3 j\omega + 10^8}$$

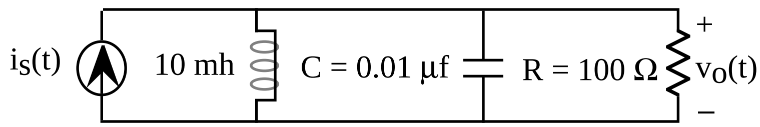
a. Find ω_p and Q_p

b. Sketch $|G(j\omega)|$ as a function of ω on a log scale

c. Make a Bode plot of $|G(j\omega)|$

d. Design a circuit with reasonable circuit element values with transfer function $G(j\omega)$

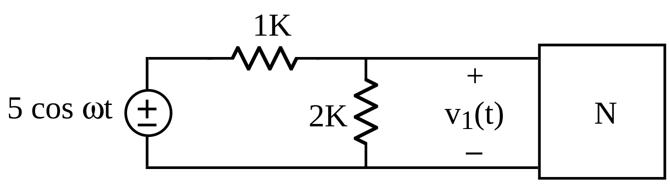
9. A major concern in the design of filters and circuits in general is how sensitive they are – how much their responses are affected by changes in the values of their circuit elements. So – for the following circuit



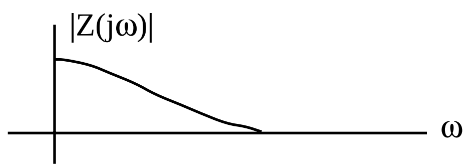
a. Find by what percentages ω_p and Q_p will change if C increases by 10% and R decreases by 5%

b. Will these changes have much affect on $v_o(t)$ when $i_s(t) = \cos 5\text{x}10^4 t + \cos 10^5 t$. Justify your response

10. What will happen to the magnitude of $v_1(t)$ in the following circuit as ω increases

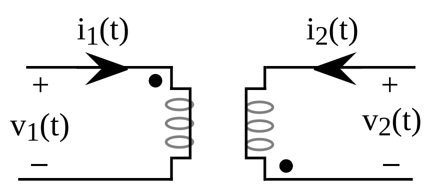


if the equivalent impedance of N varies as a function of frequency as follows



Justify your answer

11. Given the following coupled inductors



for which

$$v_1(t) = 5\,\frac{di_1(t)}{dt} - 3\,\frac{di_2(t)}{dt}$$

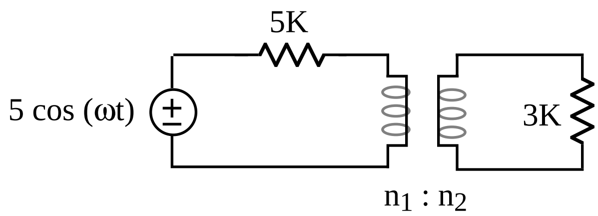
$$v_2(t) = -3\,\frac{di_1(t)}{dt} + 4\,\frac{di_2(t)}{dt}$$

a. Find out and explain why the dots are needed

b. Explain how the dots and reference directions are related to the signs in the equations

c. Find $V_1(j\omega)$ and $V_2(j\omega)$ in terms of $I_1(j\omega)$ and $I_2(j\omega)$

12. Given the following circuit with an ideal transformer



Find values for n_1 and n_2 so maximum power will be transferred to the 3K load

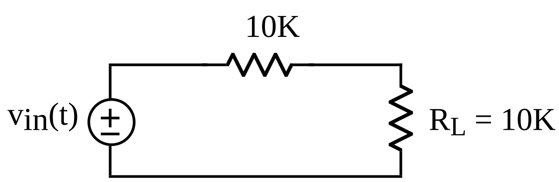
13. Write out an expression for the magnitude of $G(j\omega) = G_1(j\omega)\,G_2(j\omega)\,G_3(j\omega)$ if

$$G_1(j\omega) = \frac{10^4}{(j\omega)^2 + 5\text{x}10^3 j\omega + 10^8}$$

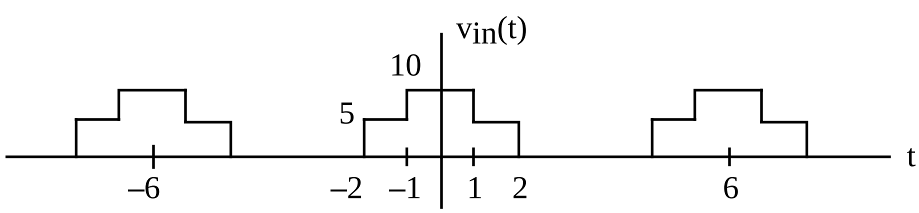
$$G_2(j\omega) = \frac{10^4\,(j\omega)}{(j\omega)^2 + 4\text{x}10^3 j\omega + 10^7}$$

$$G_3(j\omega) = \frac{10^4\,(j\omega)^2}{(j\omega)^2 + 10^3 j\omega + 10^6}$$

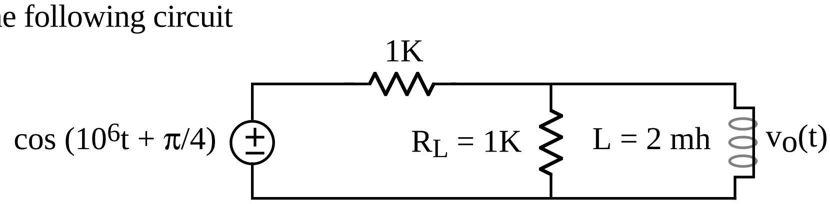
14. Given



Find the average power P_{av} being delivered to R_L by the periodic input

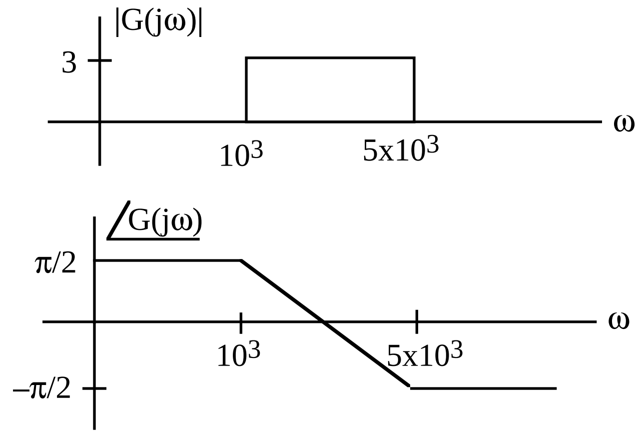


15. Given the following circuit

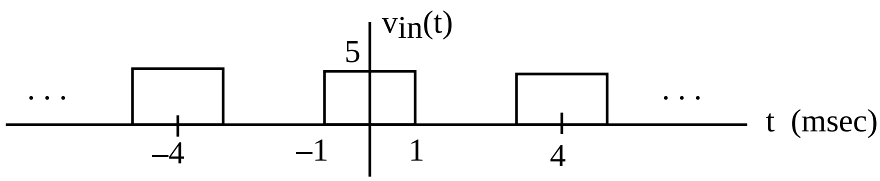


How much energy will be delivered to the parallel RL load in one hour

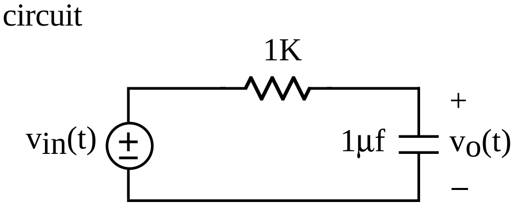
16. Find and plot the steady state response of a circuit N with frequency response



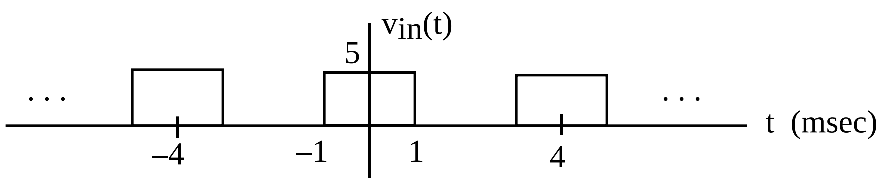
to the pulse train input



17. Given the following circuit

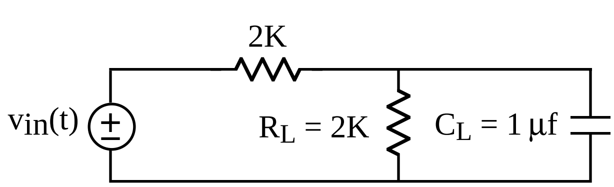


with pulse train input



a. Use SPICE to get a plot of the steady state response of $v_o(t)$
b. Find the response of the circuit to the DC term and the first 5 nonzero harmonics of the input $v_{in}(t)$
c. Plot the response you calculated in part (b)
d. How close are your plots in parts (a) and (c)

18. Get a good estimate for the average power P_{av} that the pulse train in Problem (17) would deliver to the $R_L C_L$ load in the following circuit

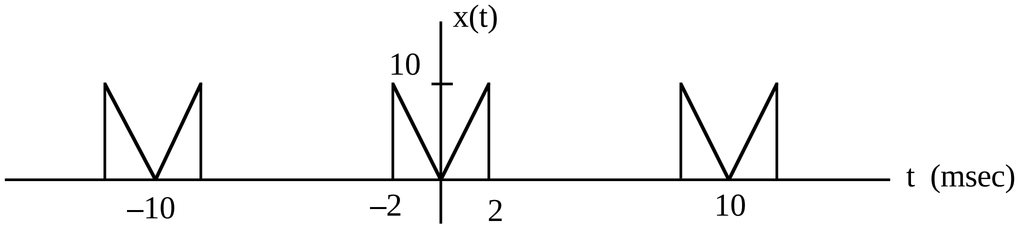


Explain how you got your result

19. Given that

$$x(t) = c_o + \sum_{n=1}^{\infty} c_n \cos(n\omega_o t + \theta_n)$$

is the Fourier Series expansion of the following periodic signal



Sketch each of the following. Explain how you got your results

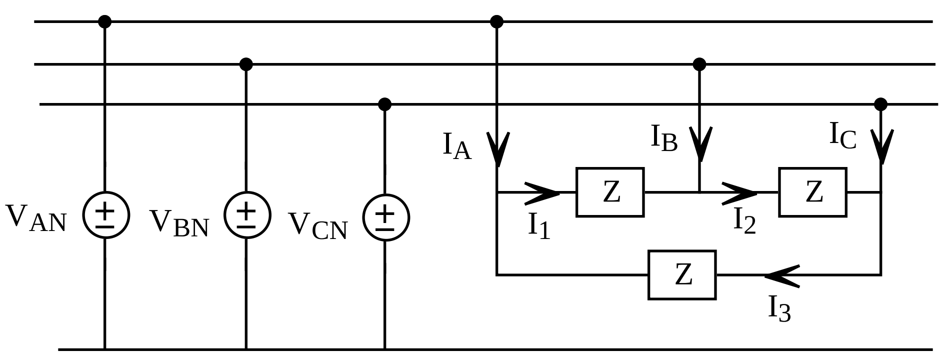
a. $x_1(t) = 2c_o + \sum_{n=1}^{\infty} c_n \cos(n\omega_o t + \theta_n)$

b. $x_2(t) = 2c_o + \sum_{n=1}^{\infty} 2c_n \cos(n\omega_o t + \theta_n)$

c. $x_3(t) = 2c_o + \sum_{n=1}^{\infty} 2c_n \cos(2n\omega_o t + \theta_n)$

20. Design a circuit with input $v_{in}(t) = \cos(5\text{x}10^3 t) + 3\cos(10^5 t) + \cos(8\text{x}10^6 t)$ and output approximately equal to $v_o(t) = K\cos(10^5 t + \theta)$ for some K and θ. Make plots of your circuit's steady state response $v_o(t)$ and the magnitude $|G(j\omega)|$ of your circuit's frequency response. Use reasonable element values

21. Given the following circuit



with $Z = 100 + j100$

$V_{AN} = 1000$, $V_{BN} = 1000\angle -120°$, $V_{CN} = 1000\angle -240°$

Find I_1, I_2, I_3, I_A, I_B, I_C