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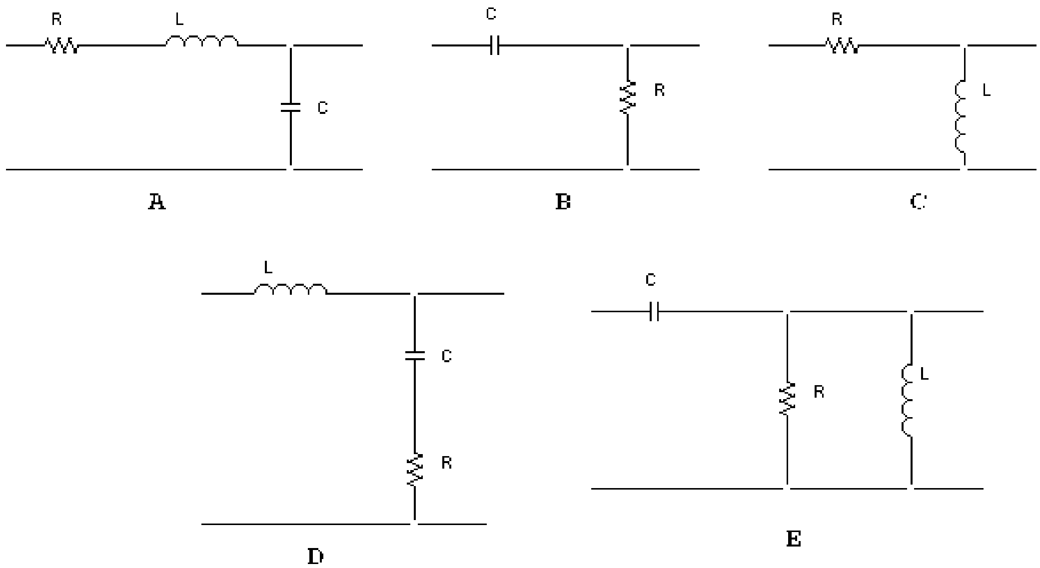
1. RLC, RL and RC Circuits (25 points)

Shown below are 5 circuits. Assume the input voltage (V_{in}) is applied across the left-most terminals and the output voltage (V_{out}) is measures across the rightmost terminals (1 point each).



Given below are several possible expressions for generic transfer functions for such circuits. Indicate which circuit goes with which function.

$$\frac{j\omega L}{R + j\omega L + \frac{1}{j\omega C}}$$

$$\frac{R}{R + \frac{1}{j\omega C}}$$

$$\frac{R + \frac{1}{j\omega C}}{R + j\omega L + \frac{1}{j\omega C}}$$

$$\frac{j\omega C + \frac{1}{j\omega L}}{R + j\omega C + \frac{1}{j\omega L}}$$

$$\frac{\frac{1}{j\omega C}}{R + j\omega L + \frac{1}{j\omega C}}$$

$$\frac{R}{R + j\omega L}$$

$$\frac{j\omega L}{R + j\omega L}$$

$$\frac{R + j\omega L}{R + j\omega L + \frac{1}{j\omega C}}$$

$$\frac{\frac{R}{j\omega RC + 1}}{j\omega L + \frac{R}{j\omega RC + 1}}$$

$$\frac{R}{R + j\omega L + \frac{1}{j\omega C}}$$

$$\frac{\frac{1}{j\omega C}}{R + \frac{1}{j\omega C}}$$

$$\frac{j\omega L + \frac{1}{j\omega C}}{R + j\omega L + \frac{1}{j\omega C}}$$

$$\frac{\frac{j\omega LR}{R + j\omega L}}{\frac{1}{j\omega C} + \frac{j\omega LR}{R + j\omega L}}$$

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Find the resonant frequency ω_0 for the RLC circuits and the corner frequency ω_c for the other circuits. That is, write the general expression for each frequency (1 point each).

A.

B.

C.

D.

E.

Determine the complex transfer function for each of the five circuits at the resonant frequency. (1 point each) Be sure your answer is given in terms of R, L, and/or C and does not contain ω. This may seem like an obvious comment, but we want to make sure you have the simplest possible expression. Identify the magnitude and the phase of the transfer function at this frequency. (1 point for each magnitude, 1 point for each phase)

A. $V_{out}/V_{in} = H(j\omega_0) =$

$|H(j\omega_0)| =$

$\angle H(j\omega_0) =$

B. $V_{out}/V_{in} = H(j\omega_c) =$

$|H(j\omega_c)| =$

$\angle H(j\omega_c) =$

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C. $V_{out}/V_{in} = H(j\omega_c) =$

$|H(j\omega_c)| =$

$\angle H(j\omega_c) =$

D. $V_{out}/V_{in} = H(j\omega_0) =$

$|H(j\omega_0)| =$

$\angle H(j\omega_0) =$

E. $V_{out}/V_{in} = H(j\omega_0) =$

$|H(j\omega_0)| =$

$\angle H(j\omega_0) =$

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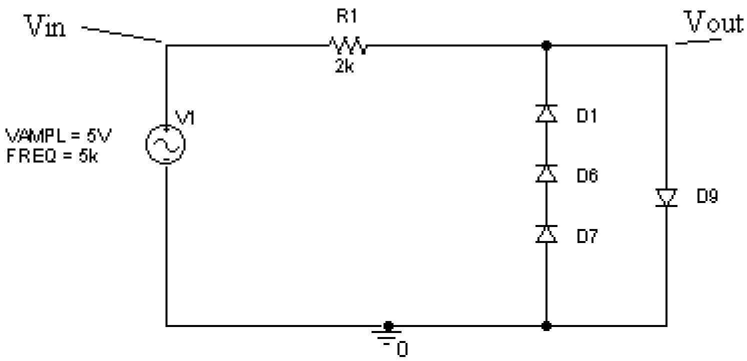
2. Diodes (25 points)

In the figure below, each of the diodes turns on at between 0.6 volts and R=2k.



1. Give the voltage at Vout for each of the following values of the input voltage, Vin (2 points each).

a. Vin = 5 Volts

b. Vin = 2 Volt

c. Vin = 1Volts

d. Vin = 0.4 Volts

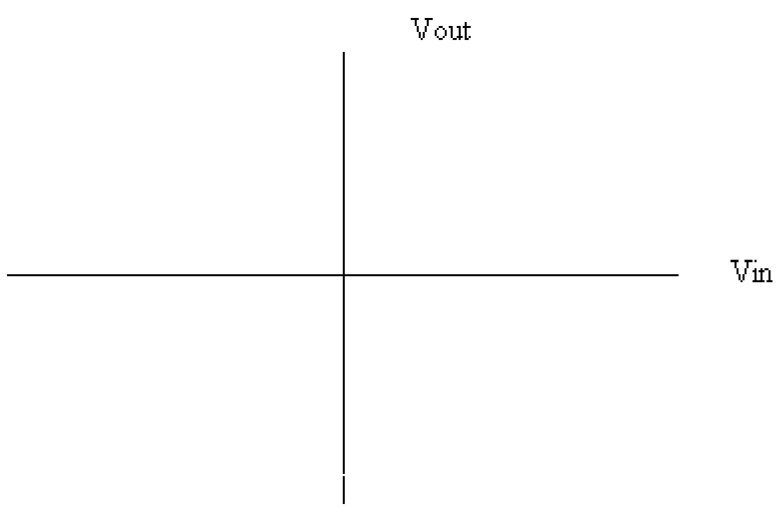
e. Vin = 0 Volts

f. Vin = -0.4 Volts

g. Vin = -1 Volt

h. Vin = -2 Volt

2. Use the above data to plot Vout vs Vin for the range –5 <=Vin <= +5 (4 points)



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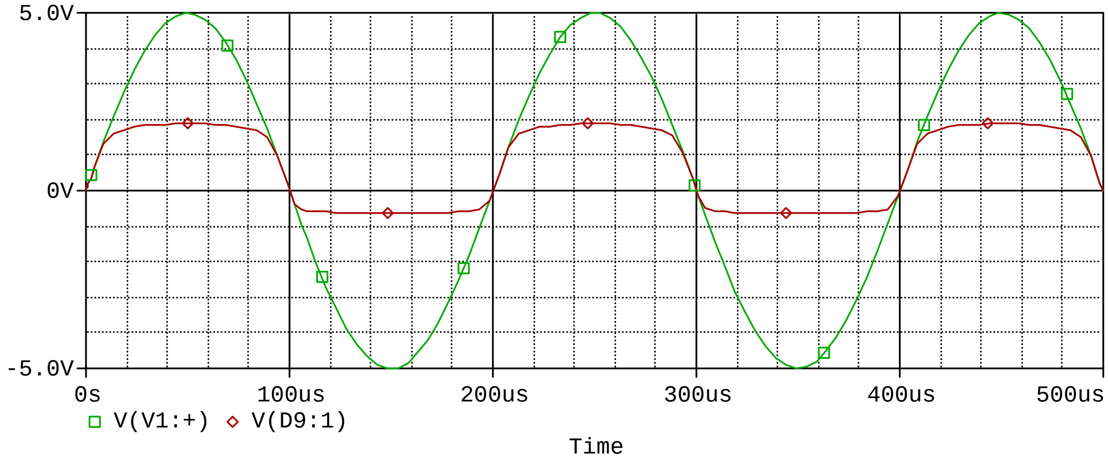
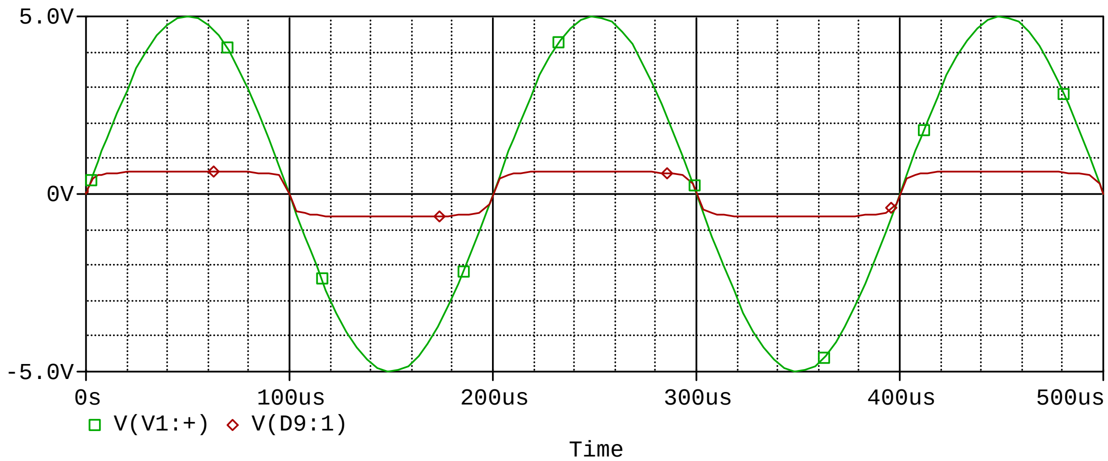
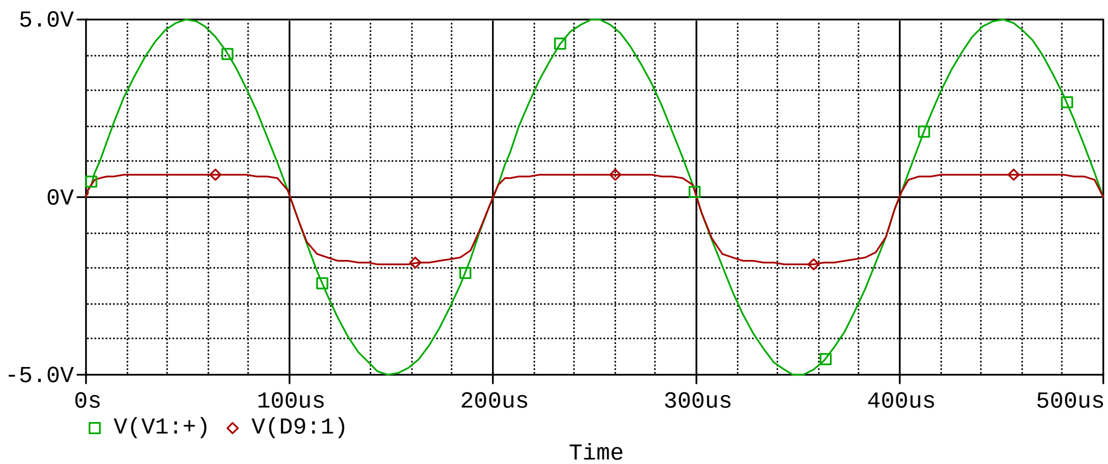
3. Which of the plots below represents Vout for this circuit (5 points)?







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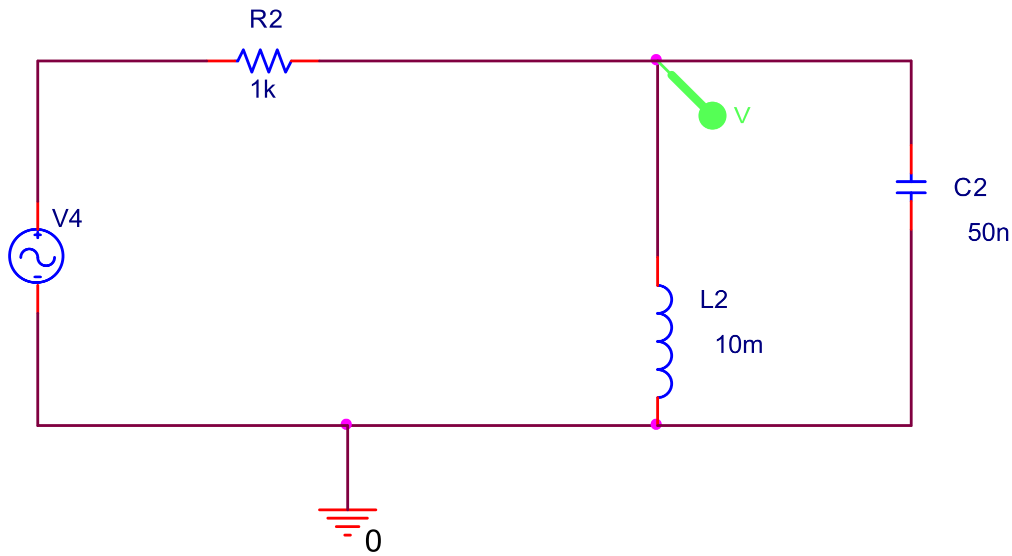
3. Filters (25 points)

The following circuit consists of a sinusoidal source, an inductor, a capacitor and a resistor.



If v_{in} is the sinusoidal source (including the 50 ohm internal impedance) and v_{out} is the voltage across the inductor, is this configuration a high pass filter, a low pass filter, a band pass filter or a band reject filter? Explain your answer.

The source is a sinusoidal voltage with some amplitude and frequency. The source voltage, as a function of time, is shown on the next page. Write out the mathematical expression for this voltage function in the form $v_{in} = v_0\sin(\omega t+\phi_0)$. Be sure that you give values for v_0, ω, and ϕ_0.

v_0 =

ω =

ϕ_0 =

v_{in} =

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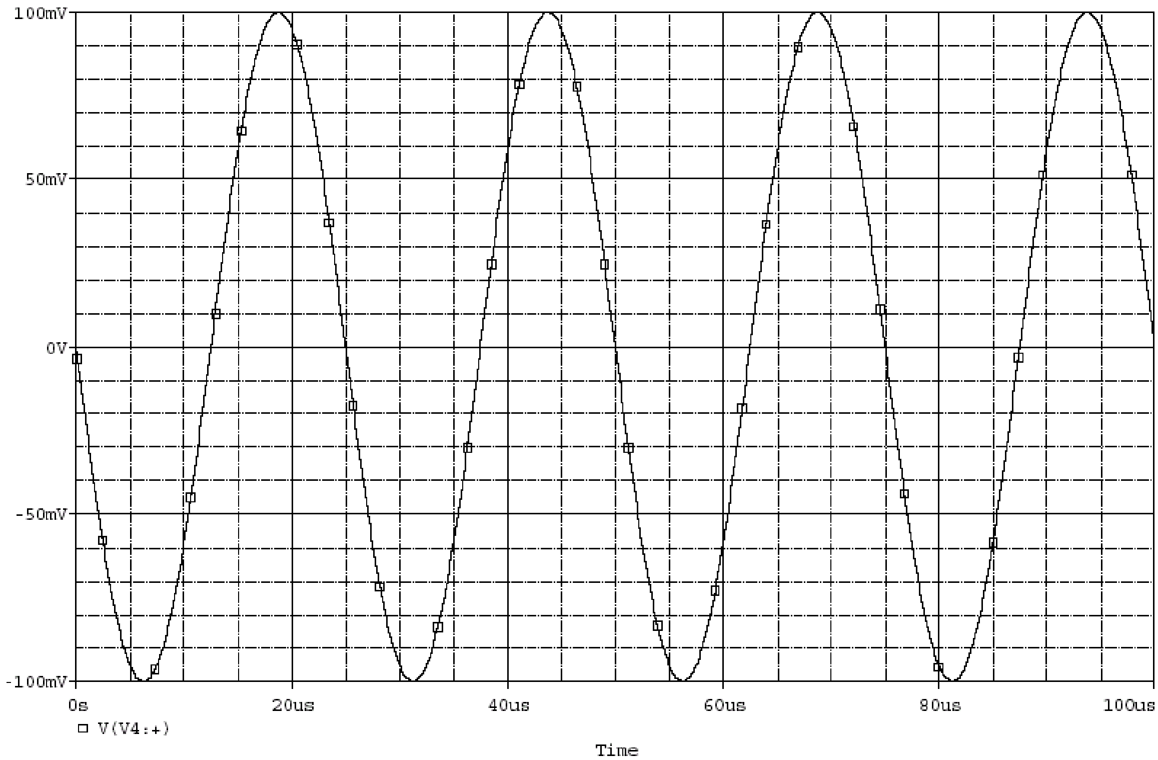

Now that you have determined the magnitude, frequency and phase of the input voltage, you should have some idea of what will happen at the output. From your knowledge of the corner or resonant frequency of this circuit, will the output voltage be about the same as the input, substantially smaller or substantially larger than the input? Explain your answer.

Very roughly sketch the magnitude of the transfer function for this circuit as a function of frequency. You only need to show the general shape of the magnitude, not the phase. Indicate on the graph where the resonance frequency is. Please give a numerical value.

Question 4 Op-Amps (25 points)

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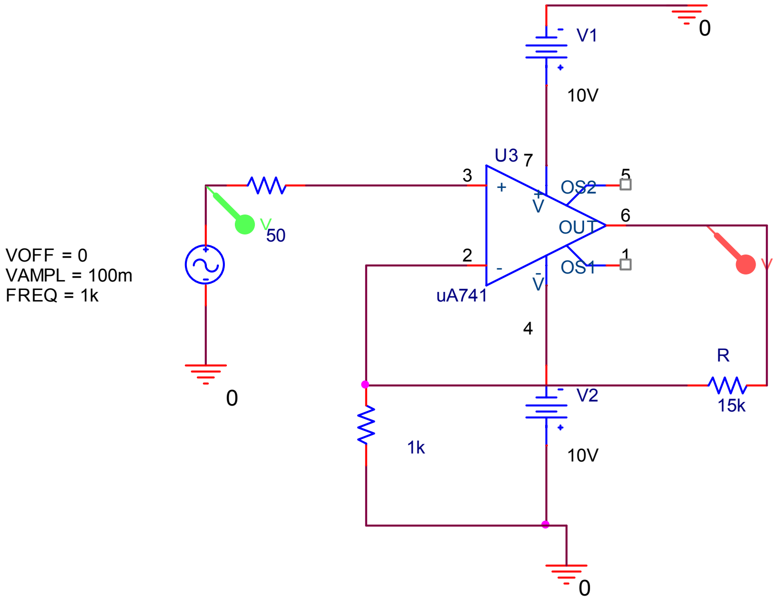

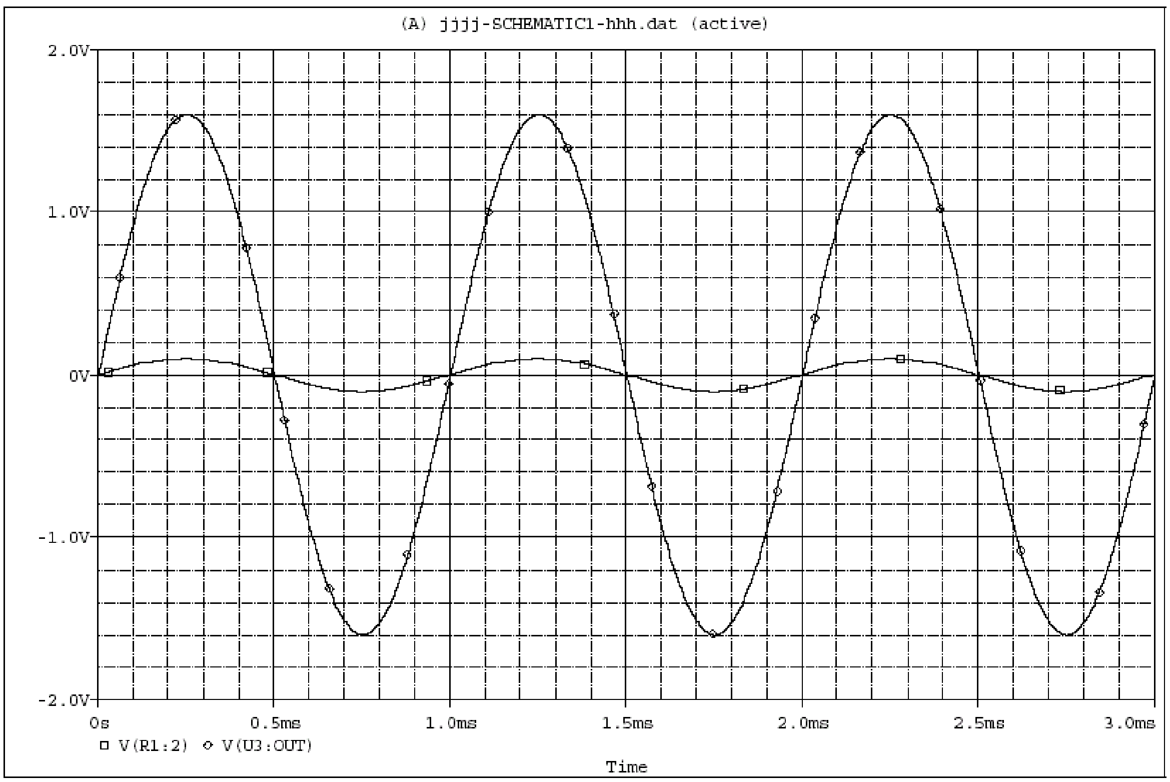

Above is a figure of an Op Amp Circuit and its input and output voltage as seen in Pspice.

a) Is this an Inverting, Non inverting, or Differential Op Amp?

b) Calculate the resistance R to produce the PSPICE Graph above.

c) What is the Maximum amount of voltage that can *ever* be read at the Output of the Circuit?