Quiz 2 – Fall 1998 Condensed Solution

1. There are 8 possible solutions offered for the first question. If we number them 1-8 from top to bottom then the transfer functions for circuits a-d are: a-3, b-1, c-2 and d-5. The resonant frequency for these RLC circuits is $w_o = \frac{1}{\sqrt{LC}}$. The transfer function for each of the four circuits at the resonant frequency is

   a. $H(jw) = \frac{1/jwC}{R} = \frac{1}{jwRC} = \frac{\sqrt{L}}{jR\sqrt{C}}$

   b. $H(jw) = \frac{jwL}{R} = \frac{j\sqrt{L}}{R\sqrt{C}}$

   c. $H(jw) = 1$ and d. $H(jw) = 0$

   The magnitudes of the first two expressions are equal to $\frac{\sqrt{L}}{R\sqrt{C}}$, while the magnitude of the third is equal to 1 and the last is equal to zero. The phase of the first is -90^o, the second is $+90^o$, the third is zero and the fourth is undefined.

   For the six plots on page 3, the first goes with circuit d since the output goes to zero at the resonant frequency (f = 1/(LC2π)=1.6kHz.), the second goes with circuit a since it is a low pass filter (input = output at low frequency and output is about zero at high frequency), the third goes with circuit c since it is a band pass filter (input = output at the resonant frequency and the output is about zero at high and low frequencies), and the fourth is circuit b since it is a high pass filter (the output = the input at high frequencies and the output is about zero for low frequencies). Before the quiz, the students were informed that only the first four figures were options, since it was too difficult to figure out why the last two could not work.

2. This problem is like the third homework problem. Circuit One is the full-wave rectifier and Circuit Two is a half-wave rectifier. The input and output voltages at the top right go with the half-wave rectifier and the input and output voltages just below them are for the full-wave rectifier.

   For the PSpice plots shown at the bottom of the page, the one at the left is for the full-wave rectifier and the one at the right is for the half-wave rectifier. This should be obvious since they look the most like the corresponding idea voltages. The differences between these plots and the idea plots occur primarily because it takes a finite amount of voltage to turn on a diode. For the half-wave rectifier output shown at the right, there is a difference of about 0.7volt between the peak input voltage and the peak output voltage because there is one diode in this circuit and it requires 0.7 volt to be turned on. For the full-wave rectifier circuit shown at the left, there is a difference of about 1.4volts between the peak input and the peak output voltages because there are two diodes turned on in this circuit when it is at full voltage and each requires 0.7 volt to be turned on.

3. The LR circuit shown in this problem is a low-pass filter because the inductor looks like a short circuit at low frequency and, thus, the input voltage will be equal to the output voltage. The input voltage shown on the next page has an amplitude of 3 volts and a period of 33.3μs. Thus its angular frequency is $\omega=2\pi/33.3\mu s=1.9x10^5$. The phase is zero since the sine wave passes through zero at t = 0. Therefore the input voltage can be written mathematically as $V=3\sin(1.9x10^5 t)$. For the LR circuit, the corner frequency is equal to R/L=4700. Thus the input frequency will be high since it is much larger than the corner frequency. The output of a low-pass filter will be substantially smaller than the input when the frequency is high.

4. The op-amp circuit shown is an inverting amplifier, since the input goes to the terminal marked with a minus sign. The gain of such a configuration is equal to –R2/R1. To have the output equal to 3V for an input of 0.1V, the gain has to be equal to 30 (we are not worried about the minus sign here). Thus, R2 must be about 30k ohms.