This should add up to 100 points. I came up with a few results to help you out.

Lab 9
Data Table 1. Derived Transfer functions

This was a *LOT* of work. I sent the final results for |H(jw)| and /_H(jw) to everyone in the class. It took Mike G and I about 2 hours to derive the transfer functions due to all the potential for making small errors.

10 points
They are supposed to attach their calculations and this should be what the grade for this is based upon. I would probably not spend a lot of time on grading the transfer function since we gave them the solution.

This is the transfer function I got for the bandpass filter.

$$\frac{Vout}{Vin} = \frac{w^2*R1*C1(R1*C1+R2*C2)+jw*R1*C1*(1-w^2*R1*C1*R2*C2)^2}{(1-w^2*R1*C1*R2*C2)^2+w^2*(R1*C1+R2*C2)^2}$$

R1 and C1 are the input components; R2 and C2 are the output components. The phase angle goes from +90 degrees for very low frequencies to -90 degrees at very high frequencies. The peak output occurs at 4643 Hz

This is the transfer function I got for the active lowpass filter.

$$\frac{Vout}{Vin} = -\frac{R2}{R1} * \frac{1-jw*R2*C}{1+w^2*R2^2*C^2}$$

where R1 is the sum of the input resistances and R2 is in parallel with the capacitor C across the op-amp.

Data Table 2. Buffered Band Pass Filter Characteristics
This was primarily recording the data - 11 data points.

15 points

Mike G pointed out that some students might be measuring t1 and t2 backwards. This is a result of confusion in the instructions and is not a big deal, but it may make the phase graphs appear flipped.

Data Table 3. First Order Low Pass Filter Characteristics
Same comments. 8 data points.
10 points

Data Table 4. Second Order Active Low Pass Filter Characteristics
Same comments. 8 data points.
10 points

Data Table 5. Notch Filter Characteristics.
This was only magnitude measurements. 17 measurements.
10 points

Questions
1. For the buffered and op-amp buffered bandpass filters, plot both 20log10|H(jw)| and Df(jw) as functions of log10w. You can use the graph below for this. Determine the cutoff* frequencies from your plot and compare them with calculated values from the equations that you obtained in Data Table 1.

wLO (calculated) = ___________ wLO (measured) = ________
wHI (calculated) = ___________ wHI (measured) = ________

15 points
There are a number of ways you can calculate the 3-db break points. You can do it analytically and solve for the point at which the imaginary part of the denominator is 1 - this corresponds to a denominator of 1+j which will reduce the magnitude by 1/sqrt(2), or 3db. The easier way is to simply plot the result. The results for EWB are shown below.

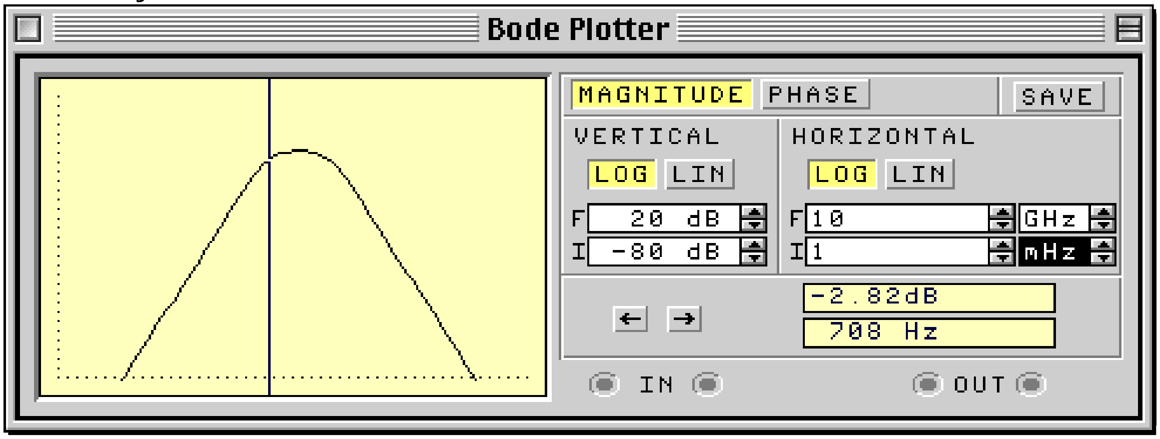
wLO (calculated) = _708 HZ __
wHI (calculated) = _34.7 KHZ ___

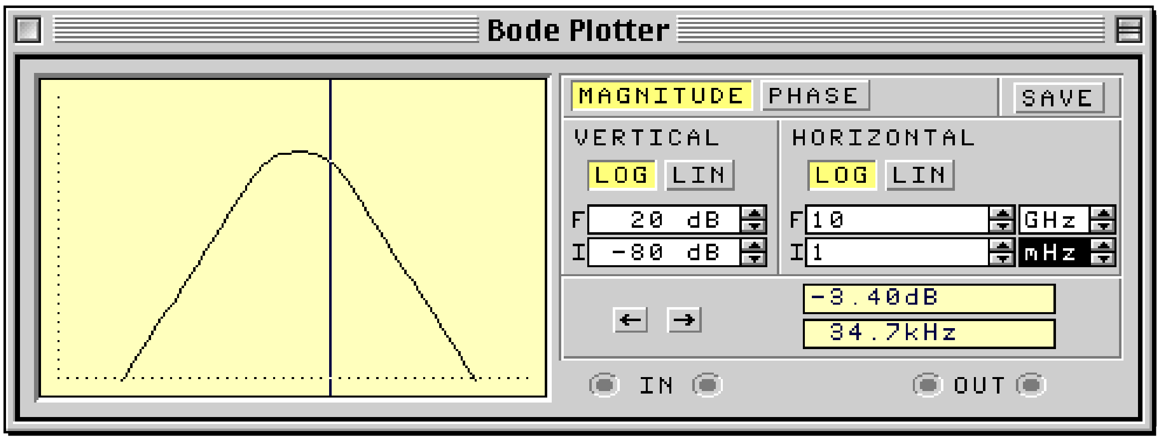
However, I also did it more analytically in Excel and got:

wLO (calculated) = 679.18 Hz
wHI (calculated) = 31.741 kHz

Discuss the differences between your calculated and measured cutoff frequencies.

5 points. This is easy. Capacitors have tolerances of up to ±20% or more so this will be the major source of error.





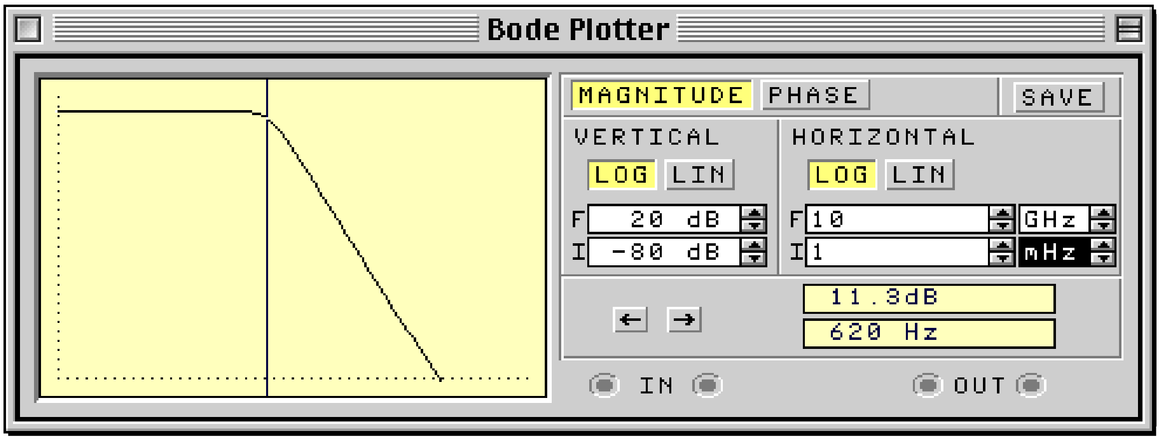
2. Plot your data for log10|H(jw)| and Df (jw) for the first and second order active low pass filters as functions of log10w. Use the graph provided below for this. Draw best fit asymptotic (straight line) approximations for each of the two gain curves. This simply means that you should use a straight edge and draw a good fit to the passband and stop band parts of your frequency response curve. From your plots determine the cutoff frequencies and the slopes (this is also called the roll-off) for the two curves. Note the we are not interested in any slight slope in the passband; we are only interested in the slope in the stop band.

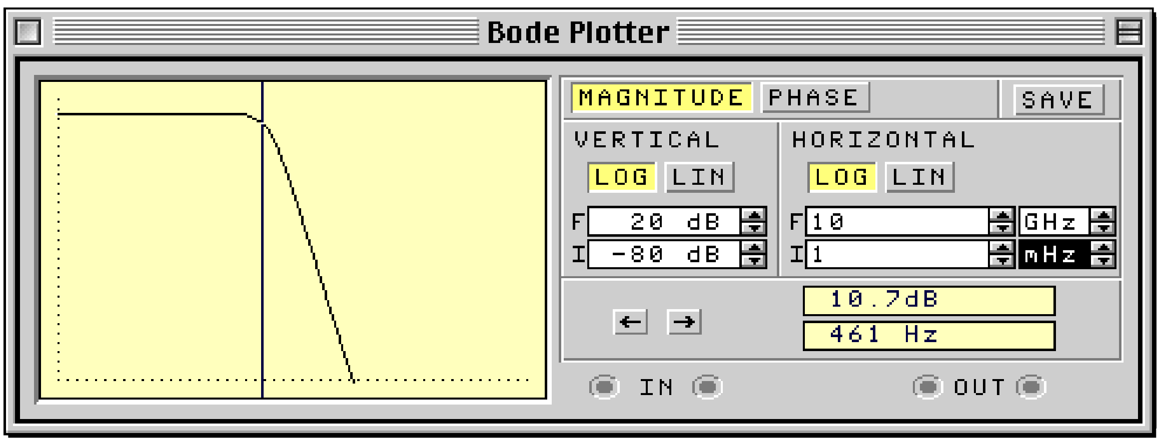
1st order low-pass:
wcutoff = ___________ slope =___________ dB/decade
2nd order low-pass:
wcutoff = ___________ slope =___________ dB/decade

Discuss the differences between the performance of the two filters.

15 points

The measured cutoff for the two filters is slightly different. The first-order is about 620 Hz and the second order is about 500 Hz. This is due to the faster roll-off the the second order. Since a decade is a factor of 10 you can see that the second order rolls off twice as fast as the first order filter. The first order is -10dB per decade; the second order is -20 db/decade.





3. Plot 20log10|jw)| as a function of log10w for the notch filter. Use the graph provided below for this.

What are the notch frequency and the maximum attenuation that you obtained with your circuit? The maximum attenuation would be the ratio of the output to input voltage computed at the notch frequency. Note that this should be computed in decibels.

fnotch = __________Hz   Max attenuation = __________dB

10 points

I got a notch at about 72 Hz of -52db from an EWB simulation. Note that the actual attenuation is really only about -42 db since the response of the filter is about -10 db away from the notch.