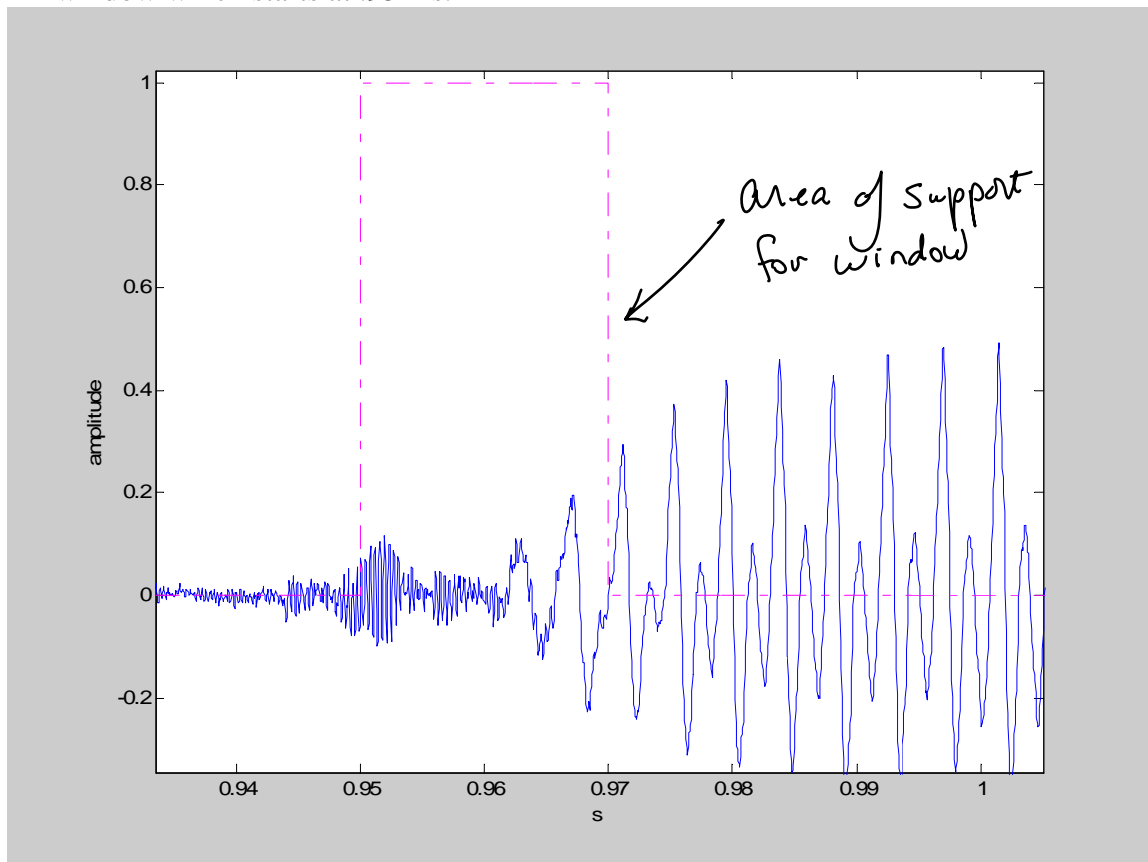
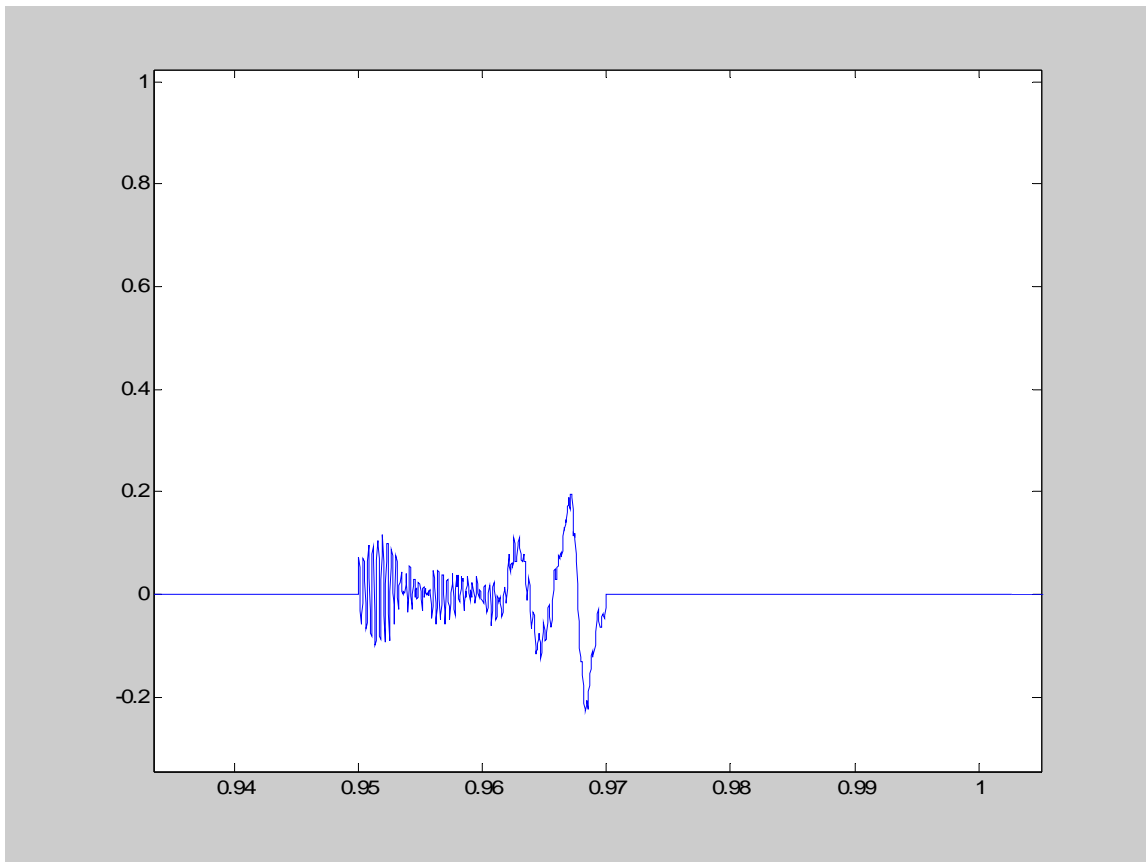


Problem set 3

1. When we extract a segment from a signal to analyze via the short-time discrete Fourier transform (which we will hereafter simply refer to as a Fourier transform or DFT), we are in effect multiplying by a window with 1s in the positions that we wish to analyze and 0s everywhere else. This is called a rectangular window. The figure below shows a speech signal sampled at 22.05 kHz and a 20 ms window which starts at .95 ms.

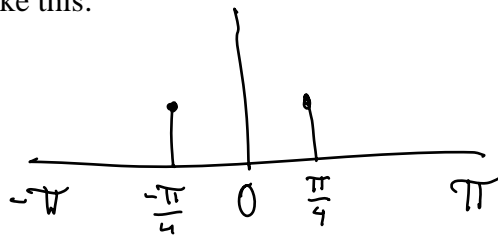


When we multiply, the resultant signal is as follows:

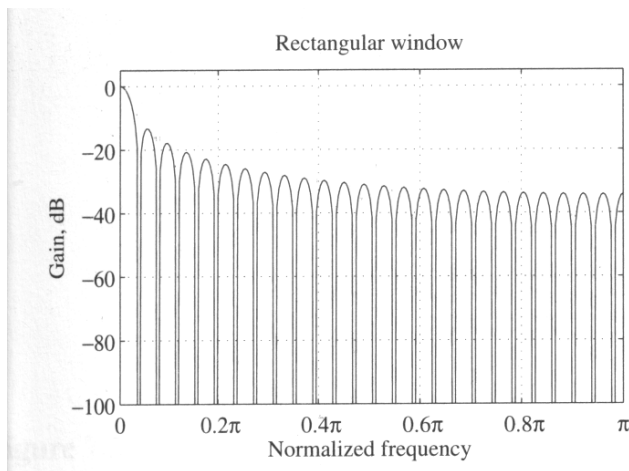


It turns out that multiplication in the time domain is equivalent to convolution in the frequency domain. Therefore, to see how a rectangular window affects the Fourier transform of a signal, you can take its Fourier transform and convolve it with the input signal's spectrum.

To illustrate this, suppose that we wish to consider the effect of the rectangular window on a cosine wave with a normalized frequency of $\frac{\pi}{4}$ Hz. Its Fourier transform looks something like this:



The Fourier transform of the rectangular window is as follows (the negative frequencies are omitted, but remember that they are simply a reflection across the 0 Hz point:



Mitra 2001, p. 453

Sketch the output of the convolution between the two sets of spectra.

- Use wavesurfer to record yourself saying the word “apple” /æ p ah l/ at 16 kHz. A pair of microphones is available for use in lab GMCS 405, and can be checked out from the lab monitor with your RedID for use in the lab. If you do this exercise in the lab, try to use one of the machines in the rear of the room, they have lower voltage CPU cores which generate less noise in the onboard audio. Please remember to turn off the microphones when you are finished.

Open a spectrogram and identify the phoneme boundaries using both the spectrogram and listening through your headphones. Identify the voiced and unvoiced portions as well (do this by looking at the spectrogram, not just looking up whether or not the phonemes are voiced/unvoiced).

Turn in a labeled copy of your spectrogram. (You can copy a picture into Word by holding ALT and pressing the print screen button. This will copy the active window onto the clipboard, and you can paste in the image. Hand-labeling is fine, but regardless of how you generate your labels be sure to show the approximate phone boundaries.)

- Zoom in on the center part of the /æ/ to the point that you can see individual cycles. Showing your work, determine your F0.
- Record 3 phonemes from each manner of consonant and label them. For each one, write the place of articulation and whether the consonant is voiced or unvoiced. Pay attention to patterns that you see in the spectrogram. (You do not need to describe them.)