Introduction:

The goals of this assignment are:

- Using the matlab functions "filter" and "freqz" to implement and understand pre-emphasis
- Identifying vowel formant frequencies from an FFT-based spectral estimation
- Using the matlab function "corr" to estimate the pitch period

I) Pre-Emphasis:

There are several useful functions in the signal processing toolbox within matlab. We will use the functions "filter" and "freqz" for pre-emphasis. At the matlab prompt, type: help filter and help freqz for an explanation of how to use these functions.

Pre-emphasis is commonly used as the first (digital) processing stage in many speech processing systems. It is defined as: \( y[n] = x[n] - ax[n-1] \), where \( a \) is a coefficient between 0 and 1, that is usually set close to 1.

To see the frequency response of a pre-emphasis filter, type: freqz([1 -0.8],1);. By default, the matlab function freqz, plots a graph of the frequency response (magnitude and phase) for a polynomial in \( Z \), which describes a difference equation. The first vector ([1 -0.8]) describes the numerator of the polynomial in \( Z \) (the feed-forward terms), and the second vector (1), describes the denominator (the feed-back terms).

Experiment with the \( a \) term. Move it closer to 1, change its value to zero, and change its sign (e.g. [1 0.85]).

Load the speech data into matlab by typing: load_in. This loads three vectors into matlab for further analysis:

female_sentence
female_a
male_a

Apply a pre-emphasis filter to the female_sentence by typing:

\[
out = \text{filter}([1 -0.8],1,\text{female_sentence});
\]

Compare the two sounds by typing:
soundsc(female_sentence,8000);
soundsc(out,8000);

Finally, we will use the FFT to analyze the effect of pre-emphasis. View the spectral estimate of the female /a/ by typing: \texttt{zpfft(female\_a,8000,10)}; This routine plots the log magnitude of the 10x oversampled FFT of a sequence with a sampling rate of 8000 samples/second. Then view the output of the pre-emphasis filter by typing:

\texttt{figure(2);
zpfft(filter([1 -0.8],1,female\_a),8000,10);}

Questions:
1) Sketch the three pole-zero plots for $a = 0.8, 0.5, -0.8$. Label each by its difference equation, and classify each as low-pass, or high-pass.

2) Describe the effect of pre-emphasis on the sound of the female sentence, and on the spectral representation of the female\_a vector.

II) Formant Frequency Identification:
View the spectral estimate of the male /a/ by typing:

\texttt{zpfft(male\_a,8000,10)};

The graph will be written to Figure 2. The prominent peaks of the spectrum are the resonant frequencies of the vowel. These resonant frequencies are called formant frequencies.

Question:
3) Determine the approximate frequencies for the first three formants (F1, F2, F3) for the male /a/. (You may want to double-click on the top of Figure 3 to re-draw it using the entire screen.)

III) Autocorrelation computation for the pitch period estimate
Questions:

4) Compute the autocorrelation of male\_a and female\_a and plot them. You can use the Matlab function \texttt{xcorr}.

5) What does the first autocorrelation coefficient correspond to?

6) Estimate the pitch period of both male and female speakers from the autocorrelation.

7) What do you observe and why?