EECS 451 Fall 2013 HW 8
Due November 12

After a genuine attempt to solve the homework problems by yourself, you are free to collaborate with your fellow students to find solutions to the homework problems. Regardless of whether you collaborate with other 451 students, you are required to write your own solutions to hand in. Copying homework solutions from another student or from existing solutions will be considered a violation of the honor code. Finally, if you choose to collaborate, you must include the names of your collaborators on your submitted homework. I haven't figured out yet how to track this, but I do look at it every once in awhile to see who's working with whom.

Please take advantage of the Piazza discussion forum on CTools and the professor's and GSI's office hours. We are all in this together!!! (Seriously)

All HWs will now be worth 50 points. Each problem is worth 10 points.

1. Download and execute the m-file `freqMary.m` from CTools. You will need to load marySong.mat from last week's homework. The goal of this problem is to understand the aliasing you heard by looking at the effect of linear interpolation in frequency domain.

   General overview of m-file:

   $$y[n] \xrightarrow{\text{downsample by } N} y_d[n] \xrightarrow{\text{upsample by } N} y_s[n] \xrightarrow{\text{linear interpolation}} y_i[n]$$

   (a) Complete the m-file. You will need to compute $y_d[n]$ and $y_s[n]$ on lines 34 and 37. You will also need to complete lines 38, 40, 52, and 54. Hint: look at $Y[k]$, but make sure you understand the functions used.

   (b) Describe what is happening to the spectrum of the signal as it is downsampled and then upsampled, i.e. how would you describe $Y_s[k]$ in terms of $Y[k]$?

(c) Describe what happens to the spectrum of the signal during interpolation. How is $Y_i[k]$ related to $Y_s[k]$? Hint: what is the impulse response $h[n]$ for linear interpolation, and what is the general shape of its DFT?

(d) Now change N to 75 and rerun `freqMary.m`. What has changed?

(e) Submit print outs of plots for both $N = 35$ and $N = 75$. Also submit your code.

2. Textbook 8.21

3. Textbook 8.30

4. Textbook 8.67

5. The deterministic crosscorrelation function between two real sequences is defined as

$$c_{xy}[n] = \sum_{m=-\infty}^{\infty} y[m]x[n+m] = \sum_{m=-\infty}^{\infty} y[-m]x[n-m] = y[-n]*x[n] \quad -\infty < n < \infty$$

(a) Show that the DTFT of $c_{xy}[n]$ is $C_{xy}(e^{j\omega}) = X(e^{j\omega})Y^*(e^{j\omega})$.

(b) Suppose that $x[n] = 0$ for $n < 0$ and $n > 99$ and $y[n] = 0$ for $n < 0$ and $n > 49$. The corresponding crosscorrelation function $c_{xy}[n]$ will be nonzero only in a finite-length interval $N_1 \leq n \leq N_2$. What are N_1 and N_2?

(c) Suppose that we wish to compute values of $c_{xy}[n]$ in the interval $0 \leq n \leq 20$ using the following procedure:

(i) Compute $X[k]$, the N-point DFT of $x[n]$

(ii) Compute $Y[k]$, the N-point DFT of $y[n]$

(iii) Compute $C[k] = X[k]Y^*[k]$ for $0 \leq k \leq N-1$

(iv) Compute $c[n]$, the inverse DFT of $C[k]$

What is the *minimum* value of N such that $c[n] = c_{xy}[n]$, $0 \leq n \leq 20$? Explain your reasoning.