BIOL 708L/NACS 728B Lab #5
Fall 2011

**Fourier Transforms in MATLAB Part II**

Like last week, the main goal of this lab is to make signals in Matlab and see what their Fourier Transform looks like. Make sure you understand what's going on with the signals at each step.

For these problems, the number of points $N$ may vary. For every $N$, define $n$ to be a ***column*** vector that starts from zero and runs for $N$ points (though for all graphs in the time domain, $n$ will still run along the horizontal axis). Make another column array of points corresponding to the Fourier frequency. Call it $f$, and it should takes values from 0 to (just less than) 1, should be $N$ points long, starting at 0, in steps of $1/N$. Note that last week this was called $fk$, but now we are de-emphasizing $k$. **In all plots in the frequency domain, make sure you put *f* (not "*k*") along the horizontal axis.**

1) *Different sinusoidal signals with the same frequency and same N.*

   Let the single oscillation frequency $f_A$ be 1/8 (last week there were several). Let $N$ be 32.

   a) Define the cosine signal: `sigc = cos(2*pi*fA*n)`. Open up a figure and graph the following (using `stem()` or `bar()`) in 5 subplots: `sigc` itself, the real part of its Fourier transform, the imaginary part of its Fourier transform, the magnitude of its Fourier transform, the phase of its Fourier transform.
   b) Of the real part, imaginary part and magnitude of the Fourier transform, which components are non-zero? What frequencies do they correspond to? What are their values? How are they related to $f_A$?
   c) For the phase of the Fourier transform we need only examine the components whose magnitude is non-zero. Why? What is the phase of those components? Knowing the phase and the magnitude of those components, calculate the full value of the Fourier transform at those points. Does it agree with what the actual value of the Fourier transform should at those points? With the real and imaginary parts of the Fourier transform at those points?
   d) Repeat (a)-(c) for the sine signal: `sigs = sin(2*pi*fA*n)`. Are the components of the Fourier transform whose magnitude is non-zero the same as for the cosine signal? Why or why not?
   e) Repeat (a)-(c) for the complex exponential signal: `sige = exp(j*2*pi*fA*n)`. In this case, since the signal is complex, use 6 subplots, and in the first two plot the real and imaginary components respectively. Verify that the real and imaginary parts of the signal are correct (e.g. how do they compare to the cosine and sine signals above?) Are the components of the Fourier transform whose magnitude is non-zero the same as for the cosine and sine signals? Why or why not? How do the magnitudes of those points compare?

2) *Sinusoidal signals with the same frequency* ***and different N.***

   Let the frequency $f_A$ be 1/8.

   a) Let $N = 16$. Define the cosine signal: `sigc = cos(2*pi*fA*n)`. Open up a figure and graph the following (using `stem()` or `bar()`) in 3 subplots: `sigc`, the real part of its Fourier transform, the real part of its Fourier transform divided by $N$. Because we are looking at the (symmetric) cosine signal, all information about the Fourier transform is contained in the real part of the Fourier transform

b) What are the maximum and minimum values of the signal? of the real part of its Fourier transform? of the real part of its Fourier transform divided by $N$?

c) Which components of the real part of its Fourier transform are non-zero? What frequencies do they correspond to? How are they related to $f_A$?

d) Repeat (a)-(c) for $N = 32$. Which answers remain the same?

e) Repeat (a)-(c) for $N = 64$. Which answers remain the same?