# MAS 160/510 Problem Set 1

Due in class Thursday February 16, 2012

1. Perdiodicity

   Determine the fundamental period of each of the following signals;

   (a) $x_a(t) = cos(5\pi t)$

   (b) $x_a(t) = 8cos(4t + \frac{\pi}{12})$

   (c) $x[n] = cos(0.03\pi n)$

   (d) $x[n] = cos(5\pi n) + cos(\frac{4}{5}\pi n)$

2. Sampling

   (a) Let $T_s$, the sampling period for a continuous time signal, be 3/2 and let $x(t) = cos(2\pi t)$. Sketch $x[n] = x(nT)$ for $n = 0, 1, ..., 8$.

   (b) Let $T_s = 1/3$ and let $x(t) = cos(2\pi t)$. Sketch $x[n] = x(nT)$ for $n = 0, 1, ..., 8$.

3. Review of Complex Numbers (*DSP First* problems at the end of Appendix A)

   (a) A.3(b)

   (b) A.4(a)-(e)

   (c) A.5(e), (f), (i)

   (d) A.8

4. **Matlab: Introduction** Once you have Matlab installed, these steps will guide you through the Matlab exercises (Note the "%" symbol indicates a comment and the text following needs not be entered).

   (a) In the Matlab Command Window, type:

   ```
   x = [1:1:150]; % sets up the domain
   yCarrier = cos(pi*x/5); % create a sinusoid to act as a carrier
   plot(x,yCarrier); % and plot it
   ySignal = rand(size(yCarrier)); % create a signal to be transmitted
   plot(x,ySignal); % and plot that too
   ySum = yCarrier + ySignal; % create an average signal
   yDiff = yCarrier - ySignal; % create a difference signal
   ```

   (b) Using only linear combinations of the `ySum` and `yDiff` signals, recover the `ySignal` and plot it.

   The following MATLAB exercises (found in Appendix C of the *DSP First* text) should be treated as walkthrough tutorials to important concepts. You can ignore any references to *instructor verification* or a *lab report*. We will specify which items we would like turned in as part of the homework. However, it would be diffcult to do only the parts that are to be turned in (i.e. it would be unwise to skip steps in the lab).

5. ***DSP FIRST* Lab 1**

   Items to be turned in:

   (a) The `expand` function from C.1.2.6.
   (b) The `replacez` function from C.1.2.7.
   (c) Plots specified in C.1.3.1.

6. ***DSP FIRST* Lab 2**

   Items to be turned in:

   (a) The `sumcos` function from C.2.2.2.
   (b) Plots specified in C.2.3.2.
   (c) Plots and answers to questions specified in C.2.4.

7. **Additional problem (for MAS.510): Listening to Sinusoids**

   We have seen many examples of sinusoids where amplitude, frequency, and phase remain constant. However, these parameters can be varied, often with interesting and surprising results. In this problem, you will use MATLAB to explore these possibilities.

   Start with a basic sinusoid of the following form:

$$x(t) = A(t)sin(f \cdot 2\pi t + g(t)) \tag{1}$$

   (a) In MATLAB, use the equation above to create a 500 Hz tone of constant amplitude ($A(t) = 1$) and constant phase ($g(t) = 0$) lasting two seconds. Then alter its frequency so that it rises linearly from 500 Hz to 2500 Hz. Listen to the resulting signal using the MATLAB function sound. Plot enough of the signal so that the change in frequency is visible. This signal is called a *chirp*. (Note: use the sound command at the Matlab prompt. And when you are selecting a sampling rate try to use 7500 Hz, and see if your results sound better.

   (b) Start again with the 500Hz tone. This time, vary the *amplitude* using the following equation:

$$A(t) = sin(N2\pi t) \tag{2}$$

   Keep the phase constant (i.e. $g(t) = 0$). Vary $N$ with a few values from 1 to 500 and listen to the result. How does the sound change with different values of $N$? Plot enough of the signal so that the change to the signal is apparent.

   (c) Return to the constant amplitude signal ($A(t) = 1$). This time change the phase to be the following:

$$g(t) = cos(M2\pi t) \tag{3}$$

   Try several values of $M$ between 10 and 700 and listen to the result. How does the sound change with different values of $M$? Plot enough of the signal so that the change in the signal is apparent.

   (d) Oftentimes, the modifications themselves contain the signal of interest, while the original sinusoid becomes what is called the *carrier signal*, with frequency f. The changes applied in parts (b) and (c) are called *Amplitude Modulation* (AM) and *Frequency Modulation* (FM), respectively. Where else have you heard these terms? Give some examples of your favorite values of $f$.