GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL of ELECTRICAL and COMPUTER ENGINEERING

ECE 2025 Spring 2011
Problem Set #3

Assigned: 28-Jan-11
Due Date: Week of 7-Feb-11

Quiz #1 will be held in lecture on Friday 4-Feb-2011. It will cover material from Chapter 2, as represented in Problem Sets #1 and #2.
Closed book, calculators permitted, and one hand-written formula sheet ($8\frac{1}{2}'' \times 11''$**, both sides)**

Reading: In *SP First*, Chapter 3: *Spectrum Representation,* Sections 3-1, 3-2 and 3-3.

The *SP First* Toolbox for MATLAB has been posted on **`t-square`** under the "Lab Assignments" link. You can install it to get some useful functions and GUIs for manipulating complex numbers. The direct link to the toolbox is: `http://users.ece.gatech.edu/mcclella/SPFirst/Updates/SPFirstMATLAB.html`

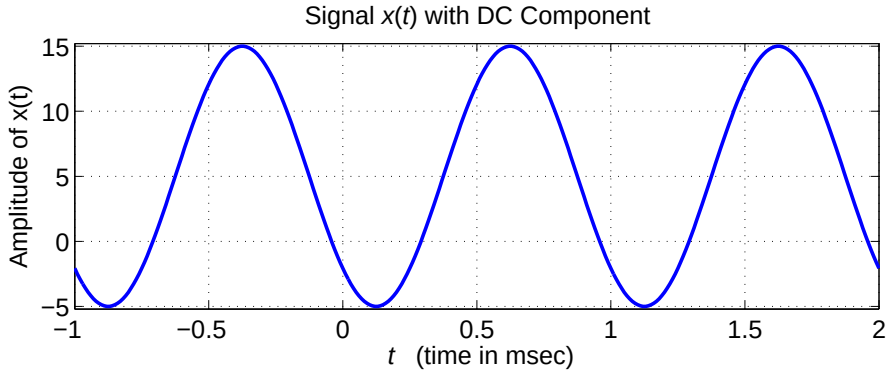
The web site for the course uses **`t-square`**: `https://t-square.gatech.edu`
$\Longrightarrow$ Please check **`t-square`** daily. All official course announcements will be posted there.

ONLY the **STARRED** problems should be turned in for grading; a random subset of these will be graded.

Some of the problems have solutions that are similar to those found on the SP-First CD-ROM.

Your homework is due in recitation at the beginning of class. After the beginning of your assigned recitation time, the homework is considered late and will be given a zero.
$\Longrightarrow$ For the week of 7-Feb, students in the **Monday recitations** should turn in HW #3 on Wed. (9-Feb-2011) at their lab time.

PROBLEM 3.1*:



The above signal $x(t)$ consists of a DC component plus a cosine signal. The terminology *DC component* means a component that is constant versus time.

(a) What is the frequency of the DC component? What is the frequency of the cosine component?

(b) Write an equation for the signal $x(t)$. You should be able to determine numerical values for all the amplitudes, frequencies, and phases in your equation by inspection of the above graph.

(c) Plot the two-sided spectrum of the signal $x(t)$. Show the complex amplitudes for each positive and negative frequency component contained in $x(t)$.

PROBLEM 3.2:
In AM radio, the transmitted signal is voice (or music) mixed with a *carrier signal.* The carrier is a sinusoid at the assigned broadcast frequency of the AM station. For example, WCNN in Atlanta has a *carrier frequency* of 680 kHz. If we use the notation $v(t)$ to denote the voice/music signal, then the actual transmitted signal for WCNN might be:

$$x(t) = (v(t) + A)\cos(2\pi(680 \times 10^3)t)$$

where A is a constant.
Note: The constant A is introduced to make the AM receiver design easier, in which case A must be chosen so that $(A + v(t))$ is positive.

(a) Voice-band signals tend to contain frequencies less than 4000 Hz (4 kHz). Suppose that $v(t)$ is a 3000 Hz sinusoid, $v(t) = \cos(2\pi(3000)t + 0.3\pi)$. Draw the spectrum for $v(t)$.

(b) Now draw the spectrum for $x(t)$, assuming a carrier at 680 kHz (with zero phase). Use $v(t)$ from part (a) and assume that $A = 1.5$. *Hint: Substitute for $v(t)$ and expand $x(t)$ into a sum of cosine terms of three different frequencies.*

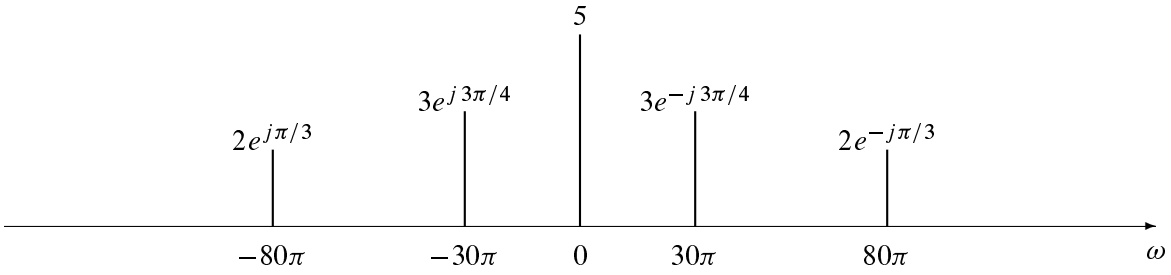
PROBLEM 3.3*:
The two-sided spectrum of a signal $x(t)$ is given in the following table:

Frequency (rad/sec)	Complex Amplitude
$-\omega_2$	$8e^{-j\pi/3}$
-80π	X_{-1}
0	B
ω_1	$\sqrt{2} + j\sqrt{2}$
100π	X_2

(a) If $x(t)$ is a *real* signal, determine the numerical values of the parameters: X_{-1}, X_2, ω_1 and ω_2.

(b) Write an expression for $x(t)$ involving only real numbers and cosine functions.

PROBLEM 3.4*:
A real signal $x(t)$ has the following two-sided spectrum:



(a) Write an equation for $x(t)$ as a sum of cosines.

(b) Plot the spectrum of the signal $y(t) = x(t - 0.01)$.

PROBLEM 3.5*:
Signal Processing First, Chapter **3**, Problem **19**, page 69–70.