GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL of ELECTRICAL and COMPUTER ENGINEERING

EE 2200 Spring 1999
Problem Set #2

Assigned: 9 April 1999
Due Date: 16 April 1999 (FRIDAY)

Reading: In *DSP First*, Appendix A on *Complex Numbers*, pp. 378–398; and Ch. 2 on *Sinusoids*, pp. 9–43.

The web site: `http://webct.ece.gatech.edu/SCRIPT/SPR99EE2200/scripts/serve_home`
All official course announcements will be posted to the "Bulletin Board." Please check it very often (daily).

ALL of the **STARRED** problems will have to be turned in for grading.

Some of the problems have solutions that can be found on the CD-ROM. Next week a solution will be posted to the web. After NOON on Friday, the homework is considered late and will be given a zero.

PROBLEM 2.1*:

Simplify the following and give the answer in polar form. Make a plot of the vectors involved in the complex addition.

(a) $z_a = e^{-j(3\pi/4)} + \sqrt{2}\,e^{j(3\pi/4)}$

(b) $z_b = \sqrt{3}e^{j(5\pi/3)} + \sqrt{3}e^{j\pi/3} - 1$

(c) In addition, write the MATLAB statements that will perform the addition and also display the magnitude and phase of the result. Consult `help` on the DSP-First functions: `zprint`, `zvect`, etc. Use these to check your hand calculations in parts (a) and (b).

PROBLEM 2.2*:

Simplify the following and give the answer as a single sinusoid. Draw the vector diagram of the complex amplitudes (phasors) to show how you obtained the answer.

(a) $x_a(t) = \sqrt{2}\cos(2\pi t + 3\pi/4) - \cos(2\pi t + \pi/4)$

(b) $x_b(t) = \cos(11t + 17\pi) + \sqrt{3}\cos(11t + \pi/3) + \sqrt{3}\cos(11t - \pi/3)$

(c) $x_c(t) = \cos(\pi t + 3\pi/4) + \cos(\pi t + 5\pi/4) + \cos(\pi t - \pi/4) + 2\cos(\pi t + \pi/4)$

PROBLEM 2.3:

Some miscellaneous complex number problems:

(a) Evaluate the complex number $z = \dfrac{j^{-1} - j^{-2}}{j^{-3} + j^{-4}}$.

(b) The following set defines a curve in the complex plane (i.e., the 2-D plane): $\{z : |z - j| = 2\}$. Draw a sketch of this curve.

(c) The following set defines a curve in the complex plane (i.e., the 2-D plane): $\{z : \Im m\{z\} = \pi\}$. Draw a sketch of this curve.

PROBLEM 2.4*:

Suppose that you have two sinusoids: $x_1(t) = 4\cos(77t - \pi)$ and $x_2(t) = 4\cos(77t + 3\pi/2)$

(a) Determine the complex amplitudes for both sinusoids, and plot these as vectors in a two-dimensional plane. Let Z_1 denote the complex ampltiude of $x_1(t)$ and Z_2 be the complex ampltiude of $x_2(t)$.

(b) Find a complex-valued signal $z_3(t)$ such that the sum signal, $x_3(t) = x_1(t) + x_2(t)$, is $x_3(t) = \Re e\{z_3(t)\}$.

(c) Calculate the product: $Z_p = Z_1 Z_2$, and plot the result as a vector. Use Z_1 and Z_2 from part (a).

(d) Explain why the product signal $x_p(t) = x_1(t) \cdot x_2(t)$ *cannot* be obtained by multiplying the complex amplitudes. (You may not have to find the product signal.)

PROBLEM 2.5*:

Suppose that MATLAB is used to plot a sinusoidal signal. The following MATLAB code generates the signal and makes the plot. Draw a sketch of the plot that will be done by MATLAB. Determine the period of the sinusoid and label the period on your plot.

```
dt = 0.1;
tt = -10 : dt : 20;
Fo = 0.08;
Z = 3 + 3i;
xx = real( Z*exp( 2j*pi*Fo*tt ) );
%
plot( tt, xx ),   grid
title( 'SECTION of a SINUSOID' ),    xlabel('TIME   (sec)')
```

PROBLEM 2.6*:

When two sinusoids are summed, the amplitude of the result might be larger or smaller than either. Suppose that the two sinsoids are $x_1(t) = 5\cos(11t - \frac{1}{2}\pi)$ and $x_2(t) = M\cos(11t + \psi)$. Let $x_s(t)$ be the sum of these two sinusoids, i.e., $x_s(t) = x_1(t) + x_2(t)$.

(a) Determine values for M and ψ so that the amplitude of $x_s(t)$ is equal to zero.

(b) Suppose that $\psi = 0$. Determine the value for M so that the amplitude of $x_s(t)$ is equal to 13. (Since M is the amplitude, it should be a positive number, or zero.) In addition, determine the phase of $x_s(t)$.

(c) Suppose that $M = 5$. Determine value(s) for ψ so that the amplitude of $x_s(t)$ is equal to 1. Sketch a vector diagram of the complex amplitudes used to solve this problem and use that sketch to explain whether or not your answer is unique.

PROBLEM 2.7*:

A signal composed of sinusoids is given by the equation

$$x(t) = 2\cos(15t) + 3\cos(25t - \pi/4)$$

(a) Sketch the spectrum of this signal indicating the complex amplitude of each frequency component. You do not have to make separate plots for real/imaginary parts or magnitude/phase. Just indicate the complex amplitude value at the appropriate frequency.

(b) Define a new signal $w(t) = x(t - 0.1)$. Draw a carefully labelled sketch of the spectrum for $w(t)$.