Spectral Analysis
ELEC 532
Assignment 2

Due: Wednesday 9 February 2000

Do the following exercises with your group and turn in one set of plots per group.
Save trees — use subplots and overlays!

1. **Window resolution**

   Consider the two-component signal

   $$x[n] \;=\; A_1 \cos(2\pi f_1 n) \;+\; A_2 \cos(2\pi f_2 n), \qquad n = 0, 1, \ldots, 63.$$

   (a) Compute a periodogram of $x[n]$ with $A_1 = A_2 = 1$, $f_1 = 0.25$ and $f2 = 0.35$. How close can you move f_2 towards f_1 and still resolve the two sinusoids?

   (b) Repeat the experiment but first windowing the data. (Window of your choice.) What do you find?

   (c) Now compute a periodogram (unwindowed) of $x[n]$ with $A_1 = 30$, $A_2 = 1$, $f_1 = 0.25$ and $f_2 = 0.31$. Can you find the lower amplitude sinusoid? Repeat using the data window of your choice (Hamming is a good choice). What do you find?

   (d) If you have time, repeat the above using various other lengths of signal and window. What do you find?

   (e) If you have time, add some white Gaussian noise to $x[n]$ and repeat the experiments.

   (f) What are your conclusions regarding data windows and the "resolution" of the periodogram.

2. **Peridogram of "Steven Kay's Test Data"**

   (a) Plot the *real* version of Kay's test data $x[n]$. `stem` is a useful command for this purpose.

   (b) Compute a basic periodogram of $x[n]$. Use a log scale for the PSD plot.

(c) Compute a periodogram of the windowed signal $w[n]\,x[n]$, where $w[n]$ is a window of your choosing of the same length as $x[n]$. Comment on your result compared to the unwindowed periodogram.

3. **Peridogram of White Noise**

   (a) Sketch the power spectral density of a white noise random process.

   (b) Using the `randn` command, compute the periodogram of an iid white Gaussian process. Try several lengths for the process, from say 16 points to 1024 points.

   (c) As we get more data, we would like our spectral estimate to get better and better. What happens to the periodogram?

   (d) Does windowing the data before computing the periodogram help us at all?

4. A Ph.D. candidate proposes windowing the auto-correlation function instead of the data to obtain the PSD. How good will his thesis be? Discuss the pros and cons of such a proposal with your study group.

5. With your study group, discuss and synthesize the major *themes* of this week of lectures. Turn in a one page summary of your discussion. You need turn in only one summary, but include the names of all group members. Please do not write up just a "table of contents."