Digital Signal Processing I ECE 561
Fall 2004 Test 1

1. Create vectors b and a for the following difference equation:

$$y[n] + 0.8y[n-2] - 0.7y[n-4] = x[n] + 0.5x[n-1] + 0.25x[n-2].$$

   Use Matlab to generate the frequency transfer function $H(\omega)$ and plot the following

   (a) real and imaginary parts versus ω on the same plot (5 points)
   (b) magnitude and phase verus ω (on different plots) (5 points)
   (c) the real part versus the imaginary part (5 points)
   (d) magnitude (dB) and unwrapped phase versus ω (on different plots) (5 points)

2. Find the linear and circular convolutions of [1 -1 4 0 2] with [1 0 -3 1 -4]. (10 points)

3. Use Matlab to plot the continuous convolution of $\text{rect}(x) * \text{rect}(x/5)$. (5 points)

4. Use Matlab to calculate and plot the continuous function $t \cdot \text{tri}(t)$ and its Fourier transform. Identify the expected symmetry and find the frequency corresponding to the maximum spectral magnitude. (10 points)

5. Download the file `horn16.wav` from the class web page.

   (a) Load the file and find the sample frequency. (5 points)
   (b) Plot the magnitude of the frequency spectrum from 0 to 3kHz. (5 points)
   (c) Find the frequency for the highest peak in the spectrum. (5 points)
   (d) Find the frequencies of the next three highest peaks. Are these frequencies harmonically related (simple multiples of a fundamental)? (5 points)

6. Given a system described by the following difference equation.

$$y[n] + \frac{1}{14}y[n-1] - \frac{2}{7}y[n-2] = x[n] + \frac{1}{4}x[n-1]$$

   (a) Write the analytic equation for the transfer function $H(e^{j\omega})$. (5 points)
   (b) Expand the transfer function as a partial fraction and then inverse transform it to find the analytic expression for the impulse response. Calculate the first three values. (5 points)
   (c) Use `y = filter(b,a,x)` where $x[n] = \delta[n]$ in Matlab to plot the impulse response. List the first three values. (5 points)
   (d) Find the general form of the homogeneous solution. (5 points)
   (e) Use `filter` to plot the solution for $x[n] = (2/3)^n u[n]$. List the first five values (5 points)
   (f) Find the discrete time Fourier transform of the $x[n]$ defined above. (5 points)
   (g) Find the analytic form of $y[n]$ for the $x[n]$ defined above (zero rest). Calculate the first five values (5 points)