University of Notre Dame
Department of Electrical Engineering
EE 30344 – Signals and Systems I
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Homework 10

Due: Friday, November 10, 2006, in class

Reading: cf. `http:/www/nd.edu/~mhaenggi/ee344/overview.html`

Problems from textbook: 5.13; 5.19; 5.21g,j; 5.22d,f; 5.23; 5.24(1,4,5); 5.29a(i), 5.30a,b(i,ii); 5.34a

Hint: For 5.21j, use the "differentiation in frequency" property.

Other (quiz-like) problems:

1. Let $x[n]$ be an even rectangular pulse of length $2N+1$. Consider the specific case where $N=3$.
   (a) Define $Y(e^{j\omega}) = e^{-j\omega N}X(e^{j\omega})$ and sketch $y[n]$.
   (b) Let $q[n] = \mathrm{Od}\{y[n]\}$ and sketch $q[n]$.
   (c) Determine $Q(e^{j\omega})$ and verify that it is purely imaginary and odd. What is $Q(1)$?

   Now, consider the signal

$$w[n] = \begin{cases} -n-2N-1 & \text{for } -2N \leqslant n \leqslant -1 \\ n-2N & \text{for } 0 \leqslant n \leqslant 2N-1 \\ 0 & \text{elsewhere} \end{cases}$$

   (d) Sketch $w[n]$ and determine $W(e^{j\omega})$.
   Hint: How are $q[n]$ and $w[n]$ related?
   (e) Let $d[n] = q[n] - q[n-1]$. Determine $D(e^{j\omega})$ by
   (i) Deriving it directly from $Q(e^{j\omega})$.
   (ii) Decomposing $d[n]$ into a sum (scaled and shifted) unit impulses.
   Compare your results from (i) and (ii).

2. Consider the DT LTI system given by the difference equation

$$y[n] = -ay[n-1] + b_1x[n] + b_2x[n-1]\,.$$

   (a) Determine the frequency response $H(e^{j\omega})$ of this system by
   (i) using the method from Chapter 3.
   (ii) taking the FT of the difference equation and using $H(e^{j\omega}) = Y(e^{j\omega})/X(e^{j\omega})$.
   (b) Determine the impulse response $h[n]$.
   (c) For which a, b_1, b_2 is this system noncausal? Unstable? Memoryless?
   (d) Find a set of coefficients a, b_1, b_2 such that this system is a
   (i) LP filter.
   (ii) HP filter.
   You may use Matlab for this problem. Plot $|H(e^{j\omega})|$ using Matlab (`freqz` command) to verify that your filters have the desired magnitude response. Put a LP plot and a HP plot in your dropbox.