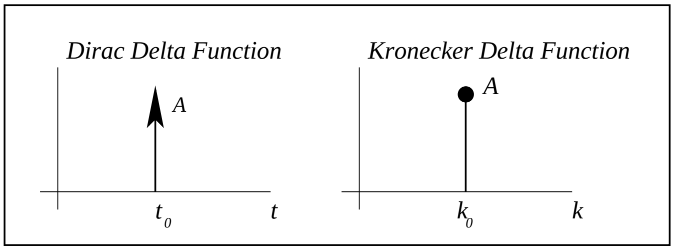
ECE486 Test 2, In Class Portion

April 21, 2005

Closed Book, Closed Notes, No Calculators or Computers

When you are finished with this portion of the exam, turn it in and go to work on the computer portion. After you turn this exam in, you may not return to this part of the test.

In all of your plots, please be sure to distinguish between the Dirac delta function (shown on the left, with zero width, infinite height, and area labeled next to the arrow head), and the Kronecker delta function (shown on the right, with finite height labeled next to the dot).



All frequency-domain plots should clearly label the frequencies and amplitudes of major peaks.

You may use the following transform pair

$$r(n) = \begin{cases} 1 & n = 0, \ldots, M-1 \\ 0 & \text{elsewhere} \end{cases} \qquad R(f) = \frac{\sin(M\pi f)}{\sin(\pi f)} \exp\left(-j\pi(M-1)\right)$$

Problems begin on the next page...

1. Let $r(n)$ be defined as above as a width $M = 12$ rectangular pulse, and let $R(k)$, $k = 0, 1, \ldots, 15$ be the 16-point DFT of $r(n)$.

   (a) Give the expression for $R(k)$ (closed-form — no summations or integrals).

   (b) Is a filter with impulse response $r(n)$ a linear phase filter? (Justify your answer.) If so, find the delay associated with the filter.

   (c) Define $Y(k) = R(k)e^{j2\pi 2k/N} + R(k)e^{-j2\pi k/N}$. Sketch the inverse 16-point DFT of $Y(k)$.

   (d) Now let $x(n)$, $n = 0, 1, \ldots 127$ be a 128-sample discrete-time sequence. To evaluate the convolution of $x(n)$ and $r(n)$, 128-point DFTs are used to evaluate $X(k)$ and $R(k)$. An output sequence $y(n)$, $n = 0, 1, \ldots 127$ is then determined using the inverse DFT of the product $X(k)R(k)$. Identify the sample indexes for which $y(n)$ provides the *linear* convolution of $x(n)$ and $r(n)$.

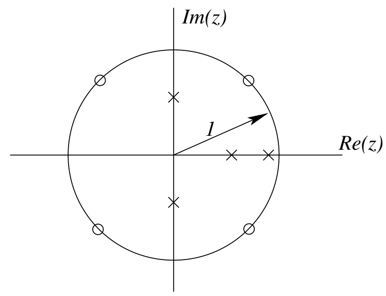
(Extra page for problem 1 answers...)

2. The characteristics of a discrete-time system are summarized by the difference equation, transfer function, and pole/zero diagram below.

$$y(n) - 1.4y(n-1) + 0.7y(n-2) - 0.35y(n-3) + 0.1125y(n-4) = x(n) + x(n-4)$$

$$H(z) = \frac{z^4 + 1}{z^4 - 1.4z^3 + 0.7z^2 - 0.35z + 0.1125}$$

Poles	Zeros
0.5	$\exp(j\pi/4)$
0.9	$\exp(-j\pi/4)$
0.5j	$\exp(j3\pi/4)$
-0.5j	$\exp(-j3\pi/4)$



(a) Is this filter a linear phase filter? (Justify your answer.) If so, find the delay associated with the filter.

(b) Show how the system can be implemented as a cascade of second-order systems. Draw a block diagram of your implementation using Direct-Form II sections. Label all coefficients in your diagram.

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Open Book, Open Notes
Calculators and Computers allowed

You may use your own printed or written reference material. Communication with other people is not allowed. Web browsers should be closed. Use of chat rooms, bulletin boards, firstclass etc. is not allowed.

Results submitted after the end of the test will not be accepted or graded.

Do not send output to the printer. Printed output will not be accepted or graded.

All submitted filter designs should have real coefficients.

1. Use the window method to design a linear phase lowpass filter which meets the following specifications:

Passband:	$0 < \|f\| < 0.1$
Passband Gain:	12 dB $\pm$ 0.1 dB
Stopband:	$0.12 < \|f\| < 0.5$
Stopband Attenuation:	≥ 50 dB

   Submit your design for grading using:

   ```
   ece486_submit('lastname_1',h);
   ```

   In the space below, give the filter order, the number of filter coefficients, and the type of window function used (including any parameters). Indicate the delay associated with the filter.

2. Find an equi-ripple FIR filter design which meets the same specifications as given in problem 1. Submit your design for grading using

   ```
   ece486_submit('lastname_2',h);
   ```

3. Design a 51-coefficient linear phase filter with magnitude response which approximates the function $1 + 5f^2$ over the band $0 \leq f \leq 0.2$. Submit your design for grading using. Your design should attempt to attenuate frequencies above $f = 0.3$.

   ```
   ece486_submit('lastname_3',h);
   ```