Digital Filtering Exercises

The due date for this homework is Sun 14 Apr 2013 8:00 PM EDT.

Question 1

An interesting digital filter is described by the difference equation

$$y(n) = ay(n-1) + ax(n) - x(n-1), \; a = rac{1}{\sqrt{2}}$$

Let's see why it is "interesting."

Find the unit-sample response of this filter. In other words, what is the output y(n) when the input x(n) equals $\delta(n)$? When we have a unit-sample input, the output is frequently called h(n).

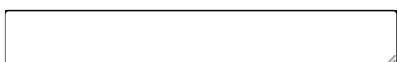
Provide **numeric** answers for the first four values of h(n): h(0), h(1), h(2), and h(3) using $a=\frac{1}{\sqrt{2}}$. Separate each value by a space.

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Question 2

What is this filter's transfer function? Express your answer using the filter parameter a rather than is numeric value.

$$H\left(e^{j2\pi f}\right)=?$$



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Question 3

The "interesting" aspect arises when we consider the transfer function's magnitude and phase. What is the magnitude $\left|H\left(e^{j2\pi f}\right)\right|$?

You should answer by starting with an expression that involves the filter's parameter a.

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Question 4

What is the phase of this transfer function?

Your answer should be an expression that involves the filter's parameter a. Use the function ${\tt atan2}$ anywhere the arc-tangent function is needed. For example, the phase of a+jb would be typed as ${\tt atan2}(b,a)$ (note the order of ${\tt atan2}$'s arguments).

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Question 5

What is this filter's output to $\sin\!\left(\frac{\pi}{4}\,n\right)$ when $a=\frac{1}{\sqrt{2}}$?

Type your answer as a expression for the output signal.

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Question 6

A discrete-time, linear, shift-invariant system has an output y(n) for $n=0,1,2,3,\ldots$ equal to $1,-1,0,0,\ldots$

Assuming the difference equation is of the form

$$y(n)=a_1y(n-1)+a_2y(n-2)+b_0x(n)+b_1x(n-1)$$
 , what are the

filter coefficients that correspond to this input-output signal pair?

Your answer should be numeric values for the coefficients, typed in the order $a_1 \ a_2 \ b_0 \ b_1$ and separated by spaces.

Question 7

What is this filter's transfer function?

Your answer should be the complex-valued transfer function as a function of frequency f.



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Question 8

What description best fits this filter's action on its inputs?

Highpass

	Something	else.
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Bandpass

Question 9

Echoes

Echoes occur not only in canyons and deep valleys, but also in auditoriums and telephone systems. In one case in which the signal has been sampled, the input signal x(n) emerges from an echo system along with scaled and delayed copies of itself: $y(n) = x(n) + a_1 x(n-n_1) + a_2 x(n-n_2)$.

To simulate this echo system the FEE students want to write the most efficient (quickest) program that implements this input/output relationship. Suppose the duration of the input x(n) is 1000 and that $a_1=\frac{1}{2}$, $n_1=10$, $a_2=\frac{1}{5}$, and $n_2=25$. In the Discussion Forum, half the students votes just to program the difference equation and the other half votes to program a frequency-domain approach that exploits the speed of the FFT. Which approach is the most efficient?

	Frequency	domain
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Question 10

What is the transfer function of the digital filter that removes echoes? In other words, when y(n) is the input, we want the original signal x(n) to be the output.

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In accordance with the Hono	r Code, I certi	fy that my	answers here	e are my	own
work.					

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