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ECES 352
HW 6
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Problem 6.1

(a) $y[n] = 3x[n-1] + x[n] + 3x[n+1]$

Linear

(b) $y[n] = x[n]\cos(0.3\pi n)$

Time invariant

(c) $y[n] = |x[-n]|$

Non causal

(d) $y[n] = x[n-2] + 2x[n] + x[n+2]$

Linear

(e) $y[n] = nx[n]$

Linear

(f) $y[n] = (x[-n])^2$

Non-causal

Problem 6.2

(a) Write an equation for x[n]. Make sure to express x[n] as a real-valued signal.

$$X\left(e^{j\omega}\right) = 3e^{j\pi} + 2e^{j0.3\pi+j-\frac{\pi}{2}} + 2e^{-j\left(0.3\pi+\frac{\pi}{2}\right)}$$
$$= -3 + \ 2\left[2\cos(0.3\pi + \frac{\pi}{2}\right] = -3 - 4\sin(0.3\pi)$$

(b) Determine the formula for the input signal y[n].

$$y[n] = \sum_{k=0}^{\backslash infinity} h(k)x(n-k)$$

Problem 6.3

(a) Determine whether or not the system defined by (1) is (i) linear, (ii) time-invariant, (iii) causal.

Not linear

(b) For the system of Equation (1), determine the output y_1[n] when the input is:

$$x_1[n] = 2\cos(0.6\pi n) = e^{j0.6\pi n} + e^{-j0.6\pi n}$$

$$y(n) = [x(n+1)]^3 \rightarrow y(n) = 2\cos(1.8\pi[n+1]) + 6\cos(0.6\pi[n+1])$$

Problem 6.4

(a) Make a plot of u[n] for -5 <= n <= 10. Describe the plot of u[n] outside this range.

$$u[n] = \{ \begin{matrix} 1 & for\ n > 10 \\ 0 & for\ n < \ -5 \end{matrix}$$

(b) We can use the unit step sequence as a convenient representation for sequences that are given by formulas over a range of values. Make a plot of the sequence

$$x[n] = u[n] - u[n-5]$$
$$for - 5 \leq n \leq 10$$

$$x[n] = \{ \begin{matrix} 1 & for\ 0 < n < 5 \\ 0 & else \end{matrix}$$

(c) Now make a plot of the sequence:

$$x[n] = (0.9)^n(n[n] - u[n-5])$$
$$for - 5 \leq n \leq 10$$

n	x[n]
0	1
1	0.9
2	0.81
3	0.729
4	0.65

(d) Suppose that x[n] in part (e) is the input to a 4-point running average system. Compute and plot y[n], the output of the system for -5 <= n <= 10.

Problem 6.5

$$y[n] = \sum_{k=0}^{4}(2-k)x[n-k]$$

(a) Determine the filter coefficients $\{b_k\}$ of this FIR filter

$$= 2x[n] + x[n-1] - x[n+3] - 2x[n-4]$$

(b) Find the impulse response, h[n], for this FIR filter. The impulse response is a discrete-time signal, so make a (stem) plot of h[n] versus n.

$$= 2\delta[n] + \delta[n-1] - \delta[n+3] - 2\delta[n-4]$$

(c) Use the above difference equation to compute the output y[n] when the input is

$$x[n] = \begin{cases} 0 & n < 0 \\ 5 & 0 \le n \le 5 \\ 1 & 6 \le n \le 10 \\ 0 & n \ge 11 \end{cases}$$

Make a plot of both x[n] and y[n] vs. n.

Problem 6.6

DO NOT UNDERSTAND, WILL ASK QUESTIONS ABOUT THIS PROBLEM IN CLASS

(a) Suppose the LTI system #1 is described by the difference equation:

$$w[n] = x[n] - 0.2x[n-1]$$

Determine the impulse response $h_1[n]$ of the system.

(b) The LTI system #2 is described by the impulse response

$$h_2[n] = (0.2)^n(u[n] - u[n-L]) = \sum_{k=0}^{L-1}(0.2)^k\delta[n-k] = \begin{cases} (0.2)^n & n = 0, 1, \dots, L-1 \\ 0 & otherwise \end{cases}$$

For the special case of L = 10, use convolution to show that the impulse response sequence of the overall cascade system is

$$h[n] = h_1[n] * h_2[n] = \delta[n] - (0.2)^{10}\delta[n-10]$$

(c) Generalize your results in part (b) for the general case of L any integer value

(d) Obtain a single difference equation that relates y[n] to x[n]

(e) How would you choose L so that y[n] = x[n] in Figure 1; i.e. how would you choose L so that the second equation system “undoes” the effect of the first system?

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Problem 6.7

A linear time-invariant discrete-time system is described by the difference equation

$$y[n] = x[n] - 2x[n-1] + x[n-2] + 3x[n-4]$$

(a) Draw a block diagram that represents this system in terms of unit-delay elements, coefficient multipliers, and adders

(b) Determine the impulse response h[n] for this system. Express your answer as a sum of scaled and shifted unit impulse sequences.

$$y[n] = \delta[n] - 2\delta[n-1] + \delta[n-2] + 3\delta[n-4]$$

(c) Use convolution to determine the output due to the input:

$$h_d[n] = \delta[n] + \delta[n-1] - \delta[n-2]$$

	1	**-2**	**1**	**0**	**3**
1	1	-2	1	0	3
-2	-2	4	-2	0	-6
-1	-1	2	-1	0	-3

$$h_d[n] = \{1, 0, 4, 0, 2, -6, -3\}$$

Use convolution again to determine $y_d[n]=x_d[n] * h_d[n]$, the output of this system when the input is:

$$x_d[n] = \delta[n] - 2\delta[n-1] + \delta[n-2] + 3\delta[n-4]$$

	1	**-2**	**1**	**0**	**3**
1	1	-2	1	0	3
0	0	0	0	0	0
4	4	-8	4	0	12
0	0	0	0	0	0
2	2	-4	2	0	6
-6	-6	12	-6	0	-18
-3	-3	6	-3	0	-9

$$x_d[n] = \{1, -2, 5, -8, 9, -2, 23, 0, 3, -18, -9\}$$

How does your answer compare to the answer in part (c)?