UCLA DEPARTMENT OF ELECTRICAL ENGINEERING

EE113: DIGITAL SIGNAL PROCESSING

Midterm 1 Exam
Date: November 2, 2020, Duration: 1 hour 50 minutes

INSTRUCTIONS:

- The exam has 6 problems
- The exam is open-book and open notes.
- Calculator is allowed.
- Please submit all your work as a single PDF file on CCLE.

Your name:_____

Student ID:_____

Table 1: Score Table

Problem	a	b	c	d	Total	Score
1	5	5	5	5	20	
2	10	10			20	
3	10				10	
4	10	10			20	
5	10	10			20	
6	10				10	
Sum					100	

Problem 1 (20 pts)

An LTI discrete-time system has an impulse response $h[n] = u[n+1] - u[n-4]$, and as input the signal $x[n] = u[n] - u[n-(N+1)]$ for a positive integer N. The output of the system is denoted as $y[n]$.

a) (5 pts) Derive input output relationship in the form of difference equation.

b) (5 pts) If $N = 4$, without calculating $y[n]$, what is the length of the output $y[n]$? Explain your answer.

c) (5 pts) Is the system stable?

d) (5 pts) Is the system causal?

Problem 1 extra page

Problem 2 (20 pts)

A discrete-time system is represented by a difference equation

$$y[n] = \frac{1}{3}\left(x[2n+1] + x[n/3] + x[n-1]\right)$$

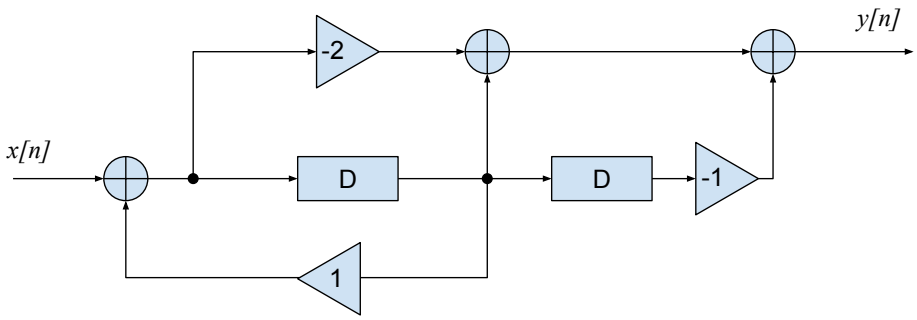
a) (10 pts) The input of the system is generated by sampling an analog signal $x(t) = 2cos(t)$ using two different sampling periods $T_1 = 1/6$ seconds and $T_2 = \pi/6$ seconds. If we want the discrete-time signal $x[n]$ to be periodic, which of the two sampling periods would you use? For the chosen sampling period what would be the fundamental period of $x[n]$?

b) (10 pts) If $x[n]$ is periodic, would the output of the system also be periodic. What would be the fundamental period?

Problem 2 extra page

Problem 3 (10 pts)

Consider the following block diagram representation of an LTI system. Derive the input-output equation.



Problem 3 extra page

Problem 4 (20 pts)

Assume x[n] has nonzero samples only in the interval $-N_1 \leq n \leq N_2$. Generally, over what interval of time will the following sequences have non-zero samples:

a) (10 pts) $r[n] = x[n] * x[-2n]$

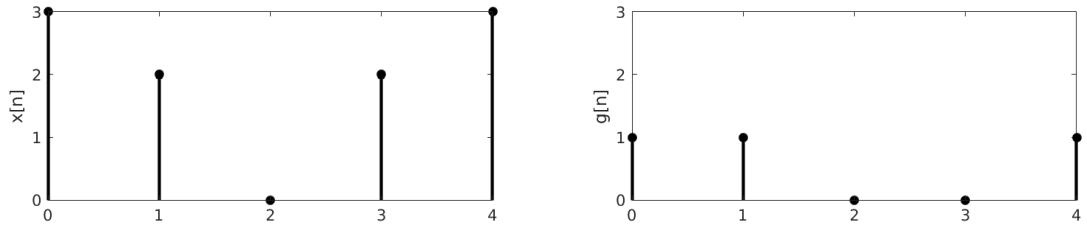
b) (10 pts) $y[n] = x[n] * x[n+1]$

Problem 4 extra page

Problem 5 (20 pts)

In this problem, you will use the properties of periodic convolution to calculate the DTFS coefficients of the signal.

a) (10 pts) Find the DTFS coefficients of the periodic signals $x[n]$ and $g[n]$ signals shown below. Only one period is shown for each signal.



b) (10 pts) Let $h[n]$ be a signal defined as $h[n] = x[n] \otimes g[n] \otimes x[n]$. Find the DTFS coefficients of $h[n]$.

Problem 5 extra page

Problem 6 (10 pts)

Let $x[n] = 1 + e^{j\omega_0 n}$ and $y[n] = 1 + \frac{1}{2}e^{j4\omega_0 n} + \frac{1}{2}e^{j3\omega_0 n}$ be two signals with a fundamental period N, such that $\omega_0 = 2\pi/N$.

Find the DTFS coefficients of their product $z[n] = x[n]y[n]$, assuming $N = 3$.

Problem 6 extra page