ECE 351 DSP: Assignment 1

Instructor: Manuj Mukherjee

Total: 30 points

Submission deadline: 11:59PM 25.09.2022

I. Coding assignment

[**Total**: 10 points]

Instruction: You can write the codes in either Python or MATLAB, though Python is preferred. Make sure to run and check your code before submitting.

A word on the notation: I shall represent finite duration causal signals as arrays. For example, $x[n] = [1, 2, 3]$ means $x[0] = 1$, $x[1] = 2$, and $x[2] = 3$, and $x[n] = 0$ for all other n.

I.1 Consider the system in Figure 1. Write a code that computes the output $y[n]$ when $x_1[n] = [1, -1, 3]$ and $x_2[n] = [2, -3, 1, 4]$ and plots it. You are not allowed to compute the result by hand, obtain $y[n]$, and then simply plot it. The code should be doing the calculation. You are however allowed to initialize the arrays $x_1[n]$ and $x_2[n]$ to be large enough to incorporate the delay element z^{-3}.

[**Hint**: Recall that you are plotting discrete time signals so use stem instead of plot from matplotlib.pyplot.]

[4 points]

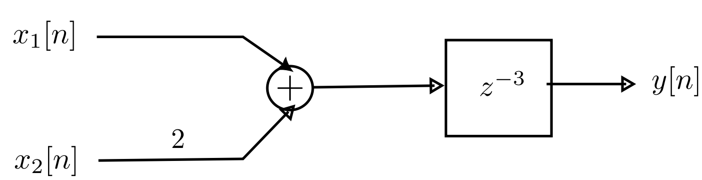

Fig. 1: System for Prob I.1

I.2 Consider the recursive system governed by the difference equation $y[n] = 3y[n-1] + 2x[n]$. Write a code that computes and plots the output $y[n]$ for $0 \leq n \leq 3$, when $x[n] = [1, 4, 6, 7]$.

[**Hint**: To calculate $y[0]$, you should use the initial condition that $y[n]$ at $n = -1$ is equal to 0]

[6 points]

II. THEORETICAL ASSIGNMENT

[**Total**: 20 points]

Instruction: Each question is of 10 points. Attempt all 3 questions. You will be graded according to the best 2 out of 3 policy.

II.1 (i) Consider the sequence $x[n] = [1, 2, 3, 4]$. Draw the sequences $x[n-2]$ and $(-1)^n x[n]$.

(ii) Consider the sequences $x_1[n] = \cos(\frac{\pi}{3}n)$ and $x_2[n] = \cos(\frac{\pi}{\sqrt{3}}n)$. Comment on their periodicity.

(iii) Show that $\delta[n] = u[n] - u[n-1]$.

[4+4+2=10 points]

II.2 (i) Consider the LTI system given in Figure 2. The impulse responses of the constituent systems are respectively $h_1[n] = (\frac{1}{2})^n u[n]$, $h_2[n] = \delta[n]$, and $h_3[n] = (\frac{1}{4})^n u[n]$. Compute the frequency response, i.e., the DTFT of the impulse response, of the entire system.

[**Hint**: To simplify your calculations, first obtain the impulse response of the whole system using the associative and distributive properties of convolution.]

(ii) Compute the phase delay of the system at $\omega = \frac{\pi}{2}$.

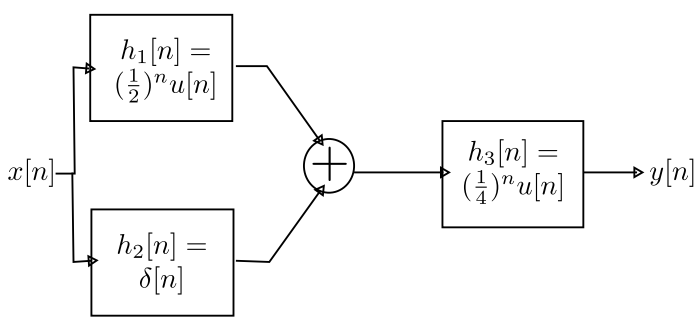

Fig. 2: System for Prob II.2.(i)

(iii) Comment whether the red coloured area in Figure 3 can be the region of convergence (ROC) of the Z-transform of some signal.

[5+3+2=10 points]

II.3 Consider the system in Figure 4.

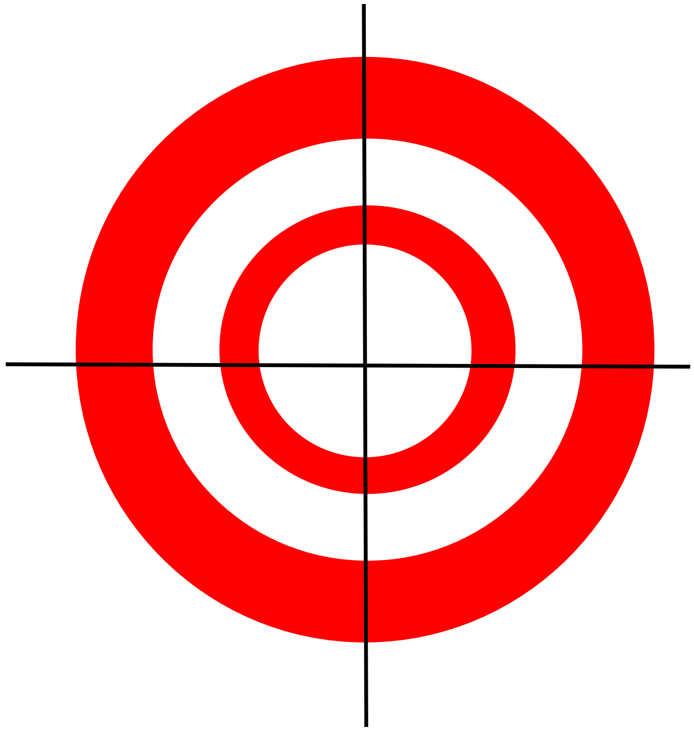

Fig. 3: System for Prob II.2.(ii)

(i) Compute the impulse response $h[n]$ for this system.

[**Hint:** Note that impulse response of the system is the system output when the input is an unit impulse.]

(ii) Determine the system output when $\omega_0 = \frac{\pi}{2}$ and the input is $x[n] = \cos(\frac{\pi}{3}n)$.

[**Hint:** You are allowed to directly use the results we obtained in class regarding output of systems with sinusoidal inputs.]

[5+5=10 points]

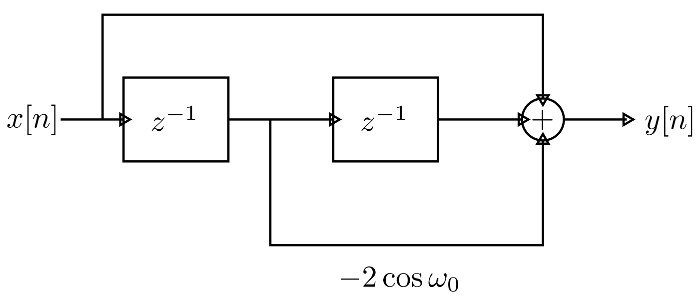

Fig. 4: System for Prob II.3