Name: …………….. ID No.:…………………

EENG/INFE 226 SIGNALS AND SYSTEMS
LAB 3
SOME FUNDAMENTAL PROPERTIES OF SYSTEMS

Objective

The objective of this experiment is to introduce using MATLAB to define an LTI system and determine on its main features, such as; linearity, causality stability invertibility and time variance. This is achieved by examining the performance of the system for particular inputs that will show those characteristics.

1. Linearity:

A system is linear if superposition holds. Specifically, a linear system must satisfy the two properties:

- **1 Additive**: the response to $x_1(t)+x_2(t)$ is $y_1(t) + y_2(t)$
- **2 Scaling**: the response to $ax_1(t)$ is $ay_1(t)$ where $a \in C$
- **Combined**: $ax_1(t)+bx_2(t) \rightarrow ay_1(t) + by_2(t)$

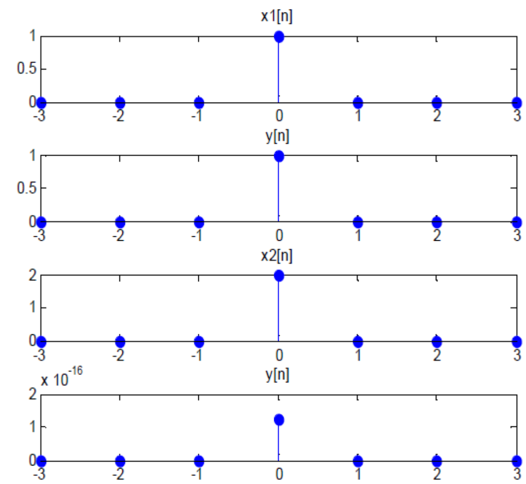

Figure 1 Exercise 1 Result

Exercise 1

The system is $y[n] = sin\,(\frac{\pi}{2}x[n])$ is not linear. Show that it violates linearity by giving a counter example. A good example is the set of signals

$$x1[n] = \delta[n]$$

$$x2[n] = 2\delta[n]$$

Write a MATLAB code to demonstrate this example. This can be done as follows:

- Define the domain of the two signals to be from -3 to 3 and save it as a vector n
- Define the signal x1 as a vector of the values [0 0 0 1 0 0 0]
- Define the signal x2 =2x1
- Evaluate the output corresponding to the x1 input, and label it as y1
- Evaluate the output corresponding to the x2 input, and label it as y2

On the same graph window, plot the signals x1, x2, y1 and y2 using the commands (subplot) and (stem). Your results should be as depicted in Figure 1.

***Q**: Is y2 equal to 2y1, what is your coment?*

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2. Causality

A causal system is a system where the current output depends on past/current inputs but not future inputs.

Exercise 2

The system $y[n] = x[n] + x[n+1]$ is not causal. Use the input signal $x[n] = U[n]$ to show this, as follows:

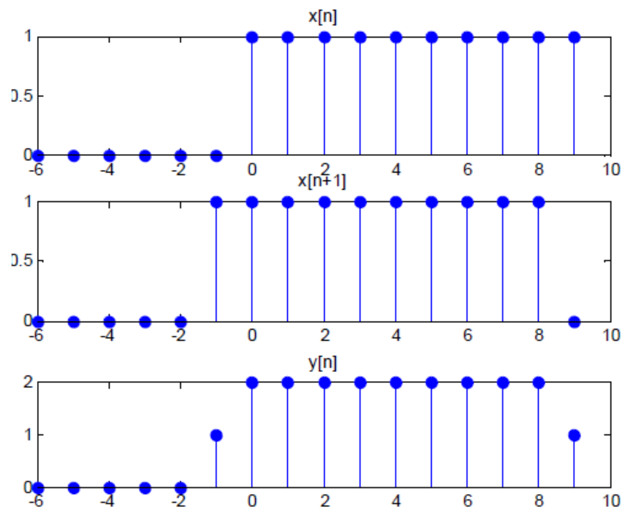

Figure 2 Exercise 2 Result

- Define the time (sample) interval to be between -6 and 9, and label it as n.
- Define the signal x[n]=U[n] as an array with the values 0 for n<0 and 1 for n>=0 and label it as x.
- Define the signal x[n+1] =U[n+1] as an array of zeros for n<-1 and 1 for n>=-1 and label it as x_shift.
- Define the output signal y[n] as x[n]+x[n+1] .
- On the same window, plot the signals x[n], x[n+1] and y[n] using the commands (subplot) and (stem).You should have a plot identical to the one shown in Figure 2.

Q: What is your comment about the system causality?

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3. Stability

For a stable system, if an input signal is bounded, then the output signal must also be bounded.

Exercise 3

The system y[n]=log(x[n]) is not stable because the (log) function goes to minus infinity at the 0 input. Write a MATLAB code to illustrate this. Proceed as follows:

- Define the domain vector as n ranging between -2 and 3.
- Define the input signal x as a vector of the values: 1, 2, 0, 3, 4 and 5.

- Declare the output vector as y= log(x). using the(log) function.
- Using stem and subplot commands, plot the input signal x[n] and the corresponding output signal y[n]. The result should appear as shown in Figure 3.

***Q**: Comment on your result. How does this result indicate that the system is unstable?*

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4. Invertible and Inverse Systems

Invertible System A system is invertible if the input signal can be uniquely determined from knowledge of the output signal. Therefore, invertibility requires the system to be one-to-one and generate a distinct output for each input.

Exercise 4

The system $y[n] = \sin(2\pi x[n])$ where x[n]=[0 1 2 3 4 0] is not invertible. Illustrate this by showing that the system is not one-to-one. As follows:

- Define a vector of n values of 0,1,2,3,4 and 5 and label it as n.
- Define x[n] as a vector of the values 0,1,2,3,4 and 5.
- Define the output as $y[n] = \sin(2\pi x[n])$.
- Plot x[n] and y[n] using the commands (stem) and (subplot). Your result should be as shown in Figure4.

***Q**: Comment on the result justifying the claim that the system in not invertible*

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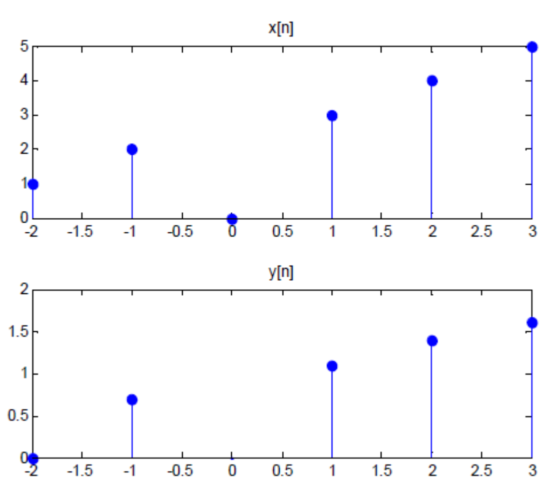

Figure 3 Exercise 3 Result

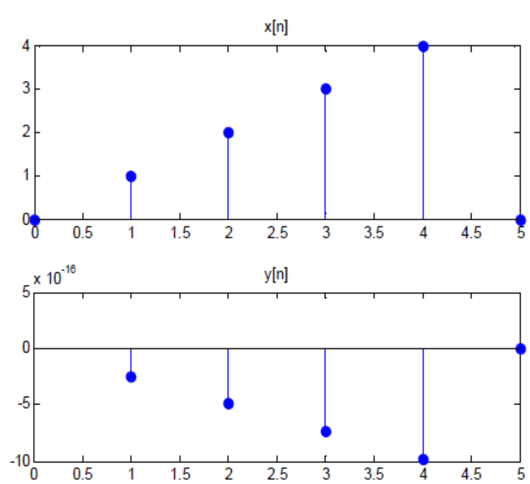

Figure 4 Exercise 4 Result