EE5630 Digital Signal Processing
HW#1
Lecturer: Yi-Wen Liu
Due Sunday March 8, 2020

1. (Problem 2.5 in textbook)
A causal LTI system is described by the difference equation

$$y[n] - 5y[n-1] + 6y[n-2] = 2x[n-1].$$

(a) Determine the homogeneous response of the system, i.e., the possible outputs if $x[n] = 0$ for all *n*.
(b) Determine the impulse response of the system.
(c) Determine the step response of the system.

2. (Problem 2.30 in textbook)
If the input and output of a causal LTI system satisfy the difference equation

$$y[n] = ay[n-1] + x[n],$$

then the impulse response of the system must be $h[n] = a^n u[n]$.
(a) For what values of *a* is this system stable?
(b) Consider a causal LTI system for which the input and output are related by the difference equation

$$y[n] = ay[n-1] + x[n] - a^N x[n-N],$$

where *N* is a positive integer. Determine and sketch the impulse response of this system. *Hint*: Use linearity and time-invariance to simplify the solution.
(c) Is the system in part (b) an FIR or an IIR system? Explain.
(d) For what values of *a* is the system in part (b) stable? Explain.

3. (Problem 2.35 in textbook)
Consider an LTI system with frequency response

$$H(e^{j\omega}) = e^{-j\left(\omega - \frac{\pi}{4}\right)}\left(\frac{1 + e^{-j2\omega} + 4e^{-j4\omega}}{1 + \frac{1}{2}e^{-j2\omega}}\right), \qquad -\pi < \omega \leq \pi.$$

Determine the output $y[n]$ for all n if the input for all n is

$$x[n] = \cos\left(\frac{\pi n}{2}\right)$$

4. (Problem 2.40 in textbook)
Determine which of the following signals is periodic. If a signal is periodic, determine its period.

(a) $x[n] = e^{j(2\pi n/5)}$

(b) $x[n] = \sin(\pi n/19)$

(c) $x[n] = ne^{j\pi n}$

(d) $x[n] = e^{jn}$

5. (Problem 2.47 in textbook)
The system T in Figure 1 is known to be *time invariant*. When the inputs to the system are $x_1[n]$, $x_2[n]$, and $x_3[n]$, the responses of the system are $y_1[n]$, $y_2[n]$, and $y_3[n]$, as shown.

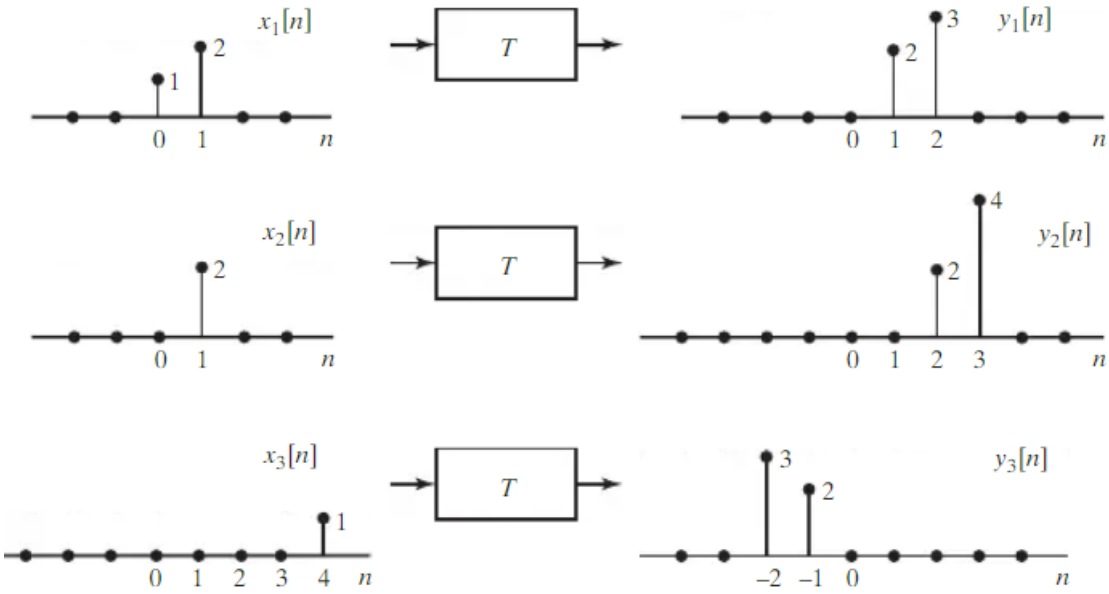

Figure 1

(a) Determine whether the system *T* could be linear.

(b) If the input $x[n]$ to the system *T* is $\delta[n]$, what is the system response $y[n]$?

(c) What are all possible inputs $x[n]$ for which the response of the system *T* can be determined from the given information alone?

Notice:

1. Each question should be in different file (.jpg .jpeg .png), and you should name those files Q1, Q2, … Q5.
2. Archive all the files into a zip file. (There would be 5 files inside the zip file.)
3. Name the zip file as “HW1_StudentID.zip”. (such as HW1_108061xxx.zip)