UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN
Department of Electrical and Computer Engineering

ECE 310 Digital Signal Processing – Spring 2026

Homework 2

Profs. Snyder, Shomorony **Due: Friday, Feb 6, 11:59pm on Gradescope**

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1. Consider the systems specified by the following input-output relations, where $x[n]$ is the input and $y[n]$ the output:

   (a) $y[n] = x[n+1] - 2x[n-2]$

   (b) $y[n] = 5x[-n] + 1$

   (c) $y[n] = x[3] \cdot x[n]$

   (d) $y[n] = e^{j\pi n}x[n]$

   For each system, determine if it is: (i) linear or non-linear, (ii) time-invariant or time-varying, (iii) causal or non-causal. **Justify your answers with proofs, counter-examples, or explanations**.

2. Compute the convolution $x[n] * h[n]$ for the $x[n]$ and $h[n]$ given below.

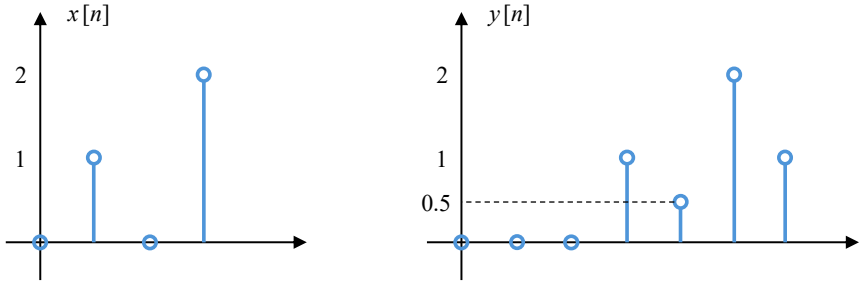
   (a) $x[n] = \{3, \underset{\uparrow}{4}, -2\}$, $h[n] = \{1, 0, \underset{\uparrow}{-2}, 0, -1\}$

   (b) $x[n] = (\frac{1}{2})^{n-1}u[n-1]$, $h[n] = -n(u[n+2] - u[n-2])$

   (c) $x[n] = 2^n u[n]$, $h[n] = \{1, \underset{\uparrow}{-1}, 2\}$

   (d) $x[n] = e^{j\pi n}u[n]$, $h[n] = 2^{-n}u[n-2]$

3. An example of an input $x[n]$ and corresponding output $y[n]$ of an LTI system are shown below.



   Determine the impulse response $h[n]$ of this system.

4. Suppose that we have an LTI system with **step response** $g[n] = (\frac{1}{3})^n u[n]$ (i.e., $g[n]$ is the response of the system to a unit step $u[n]$ as input). Find the output $y[n]$ of the system to the input $x[n] = \delta[n] - 5\delta[n-1]$.

   Hint: Represent $\delta[n]$ in terms of shifted versions of $u[n]$.

5. Consider an LTI system described by the following linear constant coefficient difference equation (LCCDE):

$$y[n] = \frac{1}{4} e^{j\frac{\pi}{3}} y[n-1] + x[n]$$

where we assume zero initial conditions; i.e., $y[m] = 0$ for $m < 0$. Determine the impulse response $h[n]$ of the system.