University of Massachusetts Dartmouth

Department of Electrical and Computer Engineering

ECE 475/574 DISCRETE-TIME SIGNAL PROCESSING

Problem Set No. 1

Issued: Wednesday, September 4, 2024 **Due:** Friday, September 13, 2024

ECE 475: Problems 1.1, 1.2, 1.3, and 1.4
ECE 574: All Problems (i.e., 1.1, 1.2, 1.3, 1.4, and 1.5)

Problem 1.1. For each of the following systems, indicate whether it is (1) casual, (2) linear, and (3) time-invariant.

(a) $y_a[n] = a\,x[n] + b$
(b) $y_b[n] = \sin(x[n])$
(c) $y_c[n] = 3\,x[n^2]$
(d) $y_d[n] = e^{x[n]}$

Rubric for Problem 1.1

Criterion/section	Points ECE 475 / ECE 574
Use correct procedure to determine if the system is casual, linear and time-invariant	3 pt
Provide correct solution to determine if the system is casual, linear and time-invariant	2 pt
Each section	5 pt
	20 pt

Problem 1.2. Determine whether each of the following signals is periodic. If the signal is periodic, state its period. If it is not periodic, provide clearly why not.

(a) $x[n] = e^{j\left(\frac{\pi n}{6}\right)}$
(b) $x[n] = \dfrac{\sin\left(\pi n / 5\right)}{\pi n}$
(c) $x[n] = e^{j\left(\frac{\pi n}{\sqrt{2}}\right)}$

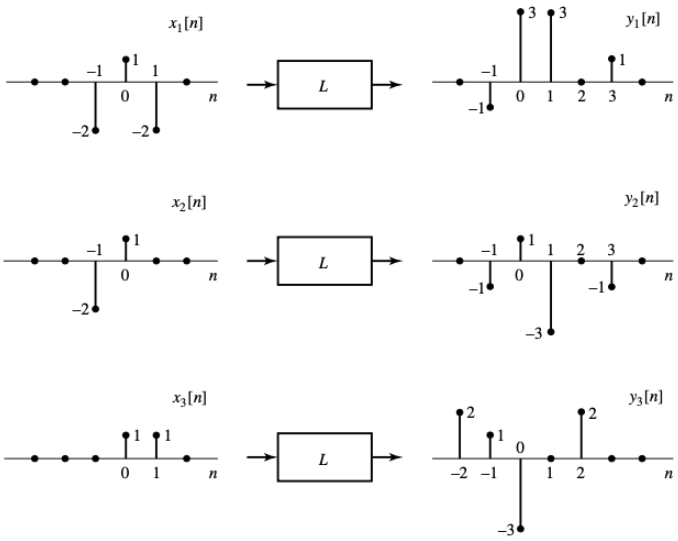
Rubric for Problem 1.2

Criterion/section	Points ECE 475 / ECE 574
Use correct procedure to determine if the signal is period	3 pt
Provide correct solution to determine if the system is period and the corresponding period	2 pt

Each section	5 pt
	15 pt

Problem 1.3. The system L in the figure below is known to be linear. Shown are three outputs signals $y_1[n]$, $y_2[n]$, and $y_3[n]$ in response to the input signals $x_1[n]$, $x_2[n]$, and $x_3[n]$, respectively.

(a) Determine whether the system L could be time-invariant.
(b) If the input $x[n]$ to the system L is $\delta[n]$, what is the system response $y[n]$?



Rubric for Problem 1.3

Criterion	Points ECE 475	Points ECE 574
Use correct procedure to determine if the system is time-invariant	15	8
Provide correct solution to determine if the system is time-invariant	7	4
Use correct procedure to determine the output of the system y[n] when the input x[n] = δ[n]	8	5
Provide correct solution of y[n]	5	3
	35 pt	20 pt

Problem 1.4. Let $y_1[n]$ be the output of an LTI system when the input is $x_1[n]$ as shown in Figure P1.4.1. Assume all signals in the question are zero outside the region shown.

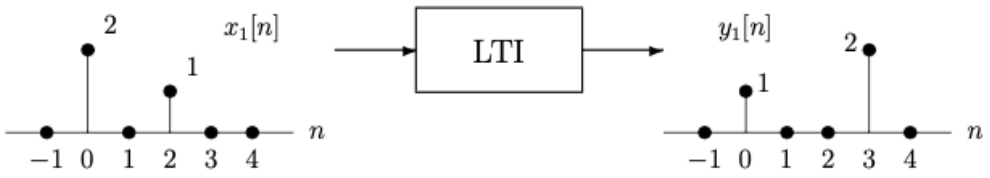


Figure P1.4.1: Input $x_1[n]$ and output $y_1[n]$

If the signal $x_2[n]$ as shown in Figure P1.4.2 is used as the input to the same system, sketch the output $y_2[n]$.

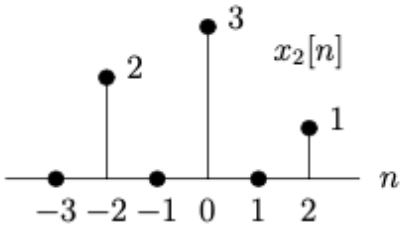


Figure P1.4.2: Input $x_2[n]$

Rubric for Problem 1.4

Criterion	Points ECE 475	Points ECE 574
Identify relationship between x_2 [n] and x_1[n]	13	10
Use correct procedure to determine the output y_2[n]	12	7
Provide correct solution of y_2[n]	5	3
	30 pt	20 pt

Problem 1.5. System 1 is an LTI system with the impulse response $h_1[n]$ shown in Figure P1.5.1. When the input to System 1 is the signal $x_1[n]$, the output is the signal $y_1[n]$ as shown in Figure P1.5.1.

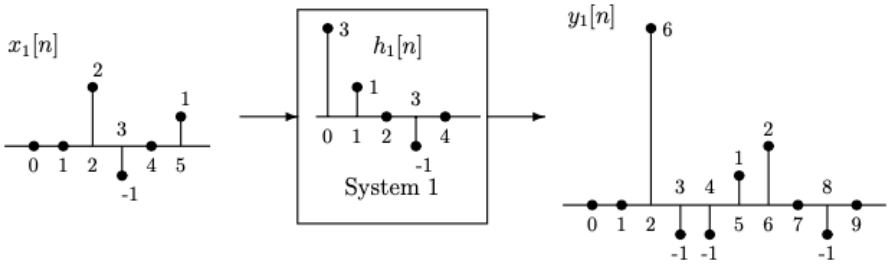


Figure P1.5.1: System 1 with impulse response $h_1[n]$

System 2 is a different LTI system with the impulse response $h_2[n]$ shown in Figure P1.5.2. When the input to System 2 is $x_2[n]$, the output $y_2[n] = y_1[n]$. Determine and Sketch $_{x2}[n]$.

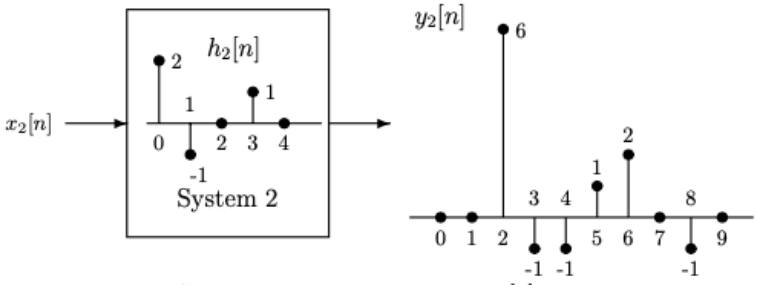


Figure P1.5.2: System 2 with impulse response $h_2[n]$

Rubric for Problem 1.5

Criterion	Points ECE 574

Identify relationship between h_2 [n] and x_1[n]	10
Use correct procedure to determine the output x_2[n]	10
Provide correct solution of x_2[n]	5
	25 pt