# Lecture 4&5&6
# Digital Signal Processing

## Chapter 2

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# Topics That we discussed on Lecture 4

1. What is Discrete Time Signal? Is it correct to think that, a discrete time signal x(n) is equal to zero if n is not an integer. Explain your answer.
2. How many ways to represent a discrete time signal? What are they? Explain it with example.
3. Classify the discrete time signal.
4. Define with figure of the following signal:
    1. Unit sample sequence/unit impulse signal
    2. Unit step signal
    3. Unit ramp signal
    4. Exponential signal

# Topics That we discussed on Lecture 4

4. What is Energy signals and power signals.
5. Write down the mathematical equation to represent any signal's energy and power.
6. Show the relationship between power signal and energy signals. Or Show that, $P = \lim_{N\to\infty} \frac{1}{2N+1} E_N$
7. What happens for P if E is finite or infinite.
8. What happens for E if P is finite and nonzero or infinite.
9. Determine the power and energy of the unit step sequence.[See example:2.1.1]
10. Prove that, periodic signals are power signals.
11. Define the following signal with example/figure:
    i. Symmetric (even) and anti-symmetric (odd) signals.
    ii. Periodic signals and aperiodic signals

# Topics That we discussed on Lecture 4

12. Prove that, any arbitrary signal can be expressed as the sum of two signal components, one of which is even and the other is odd. Or, Prove that, $x(n)=x_e(n) + x_o(n)$
13. Show that any signal can be decomposed into an even and odd component. Is the decomposition unique? Illustrate your argument using the signals

$$x(n)=\{2,3,\underset{\uparrow}{\mathbf{4}},5,6\}$$

# Topics That we discussed on Lecture 5

14. A discrete-time signal $x(n)$ is defined as

$$x(n) = \begin{cases} 1 + \frac{n}{3}, & -3 \le n \le -1 \\ 1, & 0 \le n \le 3 \\ 0, & \text{elsewhere} \end{cases}$$

**(a)** Determine its values and sketch the signal $x(n)$.

**(b)** Sketch the signals that result if we:

(1) First fold $x(n)$ and then delay the resulting signal by four samples.

(2) First delay $x(n)$ by four samples and then fold the resulting signal.

# Topics That we discussed on Lecture 5

15. Prove that, the operations of folding and time delaying (or advancing) a signal are not commutative.
16. How many  ways to transform the  independent variable (time)? What are they?
17. Graphically explained the following operation
    i. Time Delay/advancing
    ii. Folding or reflection
    iii. Time scaling or down-sampling
18. How many  ways to modify the Amplitude? What are they?
19. What is discrete time system? Explain it with figure.

# Topics That we discussed on Lecture 5

20. **Example 2.2.1**

Determine the response of the following sytems to the input signal

$$x(n) = \begin{cases} |n|, & -3 \leq n \leq 3 \\ 0, & \text{otherwise} \end{cases}$$

**(a)** $y(n) = x(n)$

**(b)** $y(n) = x(n-1)$

**(c)** $y(n) = x(n+1)$

**(d)** $y(n) = \frac{1}{3}[x(n+1) + x(n) + x(n-1)]$

**(e)** $y(n) = max\{x(n+1), x(n), x(n-1)\}$

**(f)** $y(n) = \sum_{k=-\infty}^{n} x(k) = x(n) + x(n-1) + x(n-2) + \cdots$

21. Write down the input-output relationship of a accumulator.

# Topics That we discussed on Lecture 5

22. **Example 2.2.2**

The accumulator described by (2.2.3) is excited by the sequence $x(n) = nu(n)$. Determine its output under the condition that:

**(a)** It is initially relaxed [i.e., $y(-1) = 0$].
**(b)** Initially, $y(-1) = 1$.

23. Explain the operation of an adder, a constant multiplier, A signal multiplier, A unit delay element and A unit advance element.

25.

**Example 2.2.3**

Using basic building blocks introduced above, sketch the block diagram representation of the discrete-time system described by the input–output relation.

$$y(n) = \tfrac{1}{4}y(n-1) + \tfrac{1}{2}x(n) + \tfrac{1}{2}x(n-1)$$

where $x(n)$ is the input and $y(n)$ is the output of the system.

# Topics That we discussed on Lecture 6

26. Classify the discrete time system.
27. Define with example/Distinguish between them
    i. Static/System without Memory and dynamic systems/System without Memory.
    ii. Finite memory system and infinite memory system.
    iii. Time-invariant versus time-variant systems.
    iv. Linear and nonlinear systems.
    v. Stable and unstable systems.
    vi. Causal and non-causal systems.
28. What is superposition principle. Graphically represent and explain superposition principle.

# Topics That we discussed on Lecture 6

29. Explain the multiplicative or scaling property and additive property of a linear system.
30. What is the limitation of an unstable system?
31. Generate and Draw the following system
    i. Differentiator
    ii. Time multiplier
    iii. Folder
    iv. Modulator
32. Example: 2.2.4,2.2.5,2.2.6,2.2.7

# Topics That we discussed on Lecture 7

33. How many ways discrete time systems can be interconnected? What are they? Explain and draw them?
34. Prove that, the order in which the operations $\tau_1$ and $\tau_2$ are performed is, $\tau_1\tau_2 \neq \tau_2\tau_1$for arbitrary systems.
35. If the systems $\tau_1$ and $\tau_2$ are linear and time invariant, then prove that (a) $\tau_c$ is time invariant and (b) $\tau_1\tau_2 = \tau_2\tau_1$ , that is, the order in which the systems process the signal is not important t. $\tau_1\tau_2$ *and* $\tau_2\tau_1$ yield identical output sequences.
36. Find the output of series and parallel interconnection of a discrete time system.
37. What is the necessary and sufficient condition for Causality?/ LTI system is causal if and only if its impulse response is zero for negative values o f n.

# Topics That we discussed on Lecture 7

38. For a causal system , $h(n) = 0$ for $n < 0$, the limits on the summation of the convolution formula is modified into two equivalent formula. What are they?
39. What is correlation? What is the objectives in computing the correlation between the two signals? Where it is used?
40. What is superposition summation?
41. Summarize the process of convolution sum of two signal.

**Example: 2.3.1 to 2.3.7 and 2.6.1,2.6.2**

# Assignment

1. Show that any signal can be decomposed into an even and odd component. Is the decomposition unique? Illustrate your argument using the signals

$$x(n)=\{2,3,\underset{\uparrow}{\mathbf{4}},5,6\}$$

2. Determine the power and energy of the unit impulse signal.
3. Determine and draw the even and odd signal of the following signal.

$$x(n)=\{0,0,0,0,\underset{\uparrow}{\mathbf{10}},8,6,4,2\}$$

4. Show that the energy (power) of a real-valued energy (power) signal is equal to the sum of the energies (powers) of its even and odd components.

[ See exercise 2.5]

# Assignment

5. [ See exercise 2.2]

**2.2** A discrete-time signal $x(n)$ is shown in Fig. P2.2. Sketch and label carefully each of the following signals.

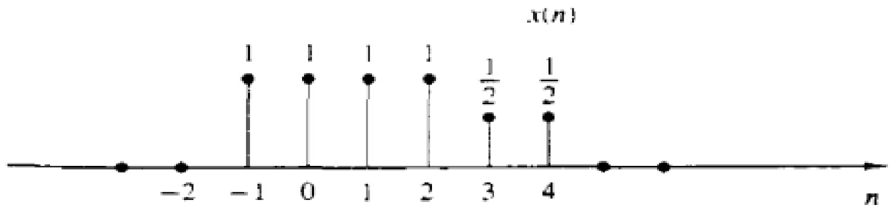


**Figure P2.2**

**(a)** $x(n-2)$ **(b)** $x(4-n)$ **(c)** $x(n+2)$ **(d)** $x(n)u(2-n)$
**(e)** $x(n-1)\delta(n-3)$ **(f)** $x(n^2)$ **(g)** even part of $x(n)$
**(h)** odd part of $x(n)$

6. [ See exercise 2.3]

7.

**2.3** Show that

**(a)** $\delta(n) = u(n) - u(n-1)$

8.

Draw the block diagram representation of the system,

i. y(n)=0.25 y(n-1)+.25x(n)+3x(n-1).

ii. y(n)=0.8 y(n-1)+2x(n)+3x(n-1).


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# Assignment

9.

**2.7** A discrete-time system can be

(1) Static or dynamic
(2) Linear or nonlinear
(3) Time invariant or time varying
(4) Causal or noncausal
(5) Stable or unstable

Examine the following systems with respect to the properties above.

**(a)** $y(n) = \cos[x(n)]$
**(b)** $y(n) = \sum_{k=-\infty}^{n+1} x(k)$
**(c)** $y(n) = x(n)\cos(\omega_0 n)$
**(d)** $y(n) = x(-n+2)$
**(e)** $y(n) = |x(n)|$

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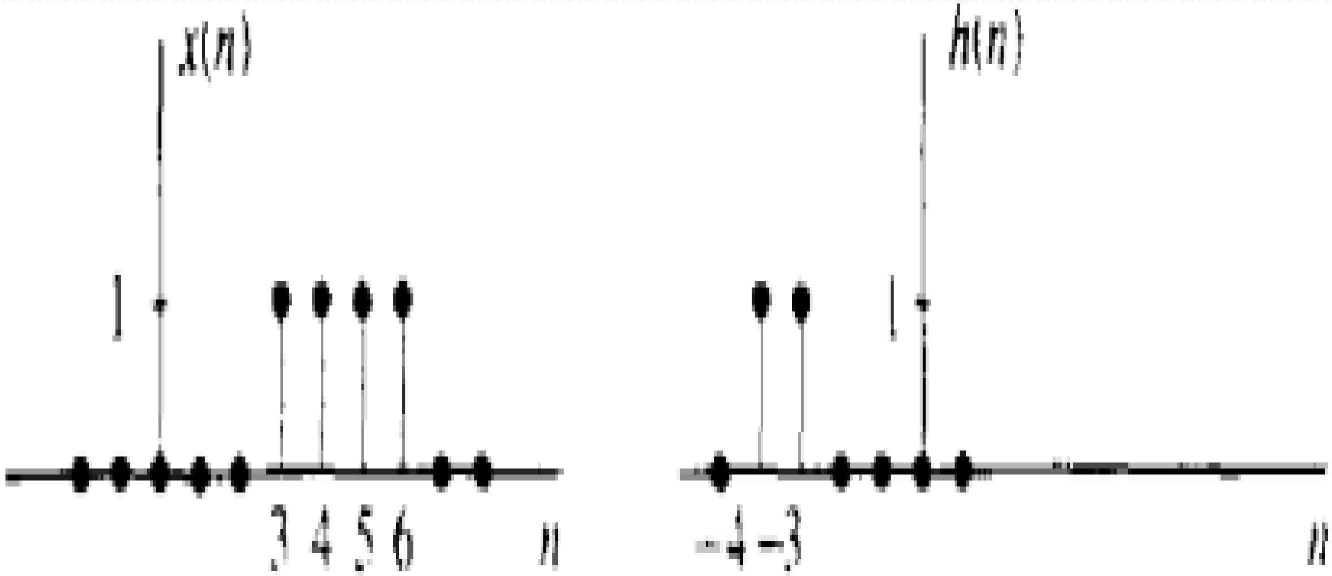
# Assignment

10.

**2.17** Compute and plot the convolutions $x(n) * h(n)$ and $h(n) * x(n)$ for the pairs of signals shown in Fig. P2.17.



# Assignment

**11.**

Compute the following :

i. Convolution
ii. Cross-correlation
iii. Auto-correlation

(a) $x_1(n) = \{\underset{\uparrow}{1}, 2, 4\} \qquad h_1(n) = \{\underset{\uparrow}{1}, 1, 1, 1, 1\}$

(b) $x_2(n) = \{\underset{\uparrow}{0}, 1, -2, 3, -4\} \qquad h_2(n) = \{\tfrac{1}{2}, 1, \underset{\uparrow}{2}, 1, \tfrac{1}{2}\}$

# Assignment

12.

2.59 Determine the autocorrelation sequences of the following signals.

(a) $x(n) = \{\underset{\uparrow}{1}, 2, 1, 1\}$

(b) $y(n) = \{\underset{\uparrow}{1}, 1, 2, 1\}$

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