Chapter 1: Discrete Time Signals and Systems

1. **What is a signal in the context of digital signal processing?**

A signal is a pattern of variation that carries information, represented mathematically as a function of one or more independent variables.

1. **Differentiate between continuous-time and discrete-time signals.**

Continuous-time signals are defined for all instants of time, while discrete-time signals are defined only at discrete instants of time.

1. **Give examples of different types of signals encountered in real life.**

Examples include electrical signals (voltages, currents), acoustic signals (audio, speech), video signals (intensity variations in images), and biological signals (gene sequences).

1. **What is digital signal processing?**

Digital signal processing involves the representation, transformation, and manipulation of signals and the information they contain using digital methods.

1. **List the advantages of digital signal processing over analog signal processing.**

Advantages include high accuracy, high reliability, flexibility, ease of integration, handling high-dimensional signals, lower costs (reusable, reconfigurable), data logging, and adaptive capability.

1. **What is sampling? State the sampling theorem.**

Sampling is the process of converting a continuous-time signal to a discrete-time signal by taking measurements at regular intervals. The sampling theorem states that a continuous-time signal can be completely represented by its samples if the sampling frequency is at least twice the highest frequency component in the signal (fs ≥ 2fm).

1. **Define quantization in digital signal processing.**

Quantization is the process of mapping a continuous range of amplitude values to a finite set of discrete levels in digital signal processing.

1. **What is the relationship between sampling period and sampling frequency?**

The sampling period (T) is the inverse of the sampling frequency (fs): T = 1/fs.

1. **How is a discrete-time signal mathematically represented?**

A discrete-time signal is mathematically represented as x(n) or x(nT), where n is an integer representing the sample number and T is the sampling period.

1. **What is the process of converting an analog signal to a digital signal?**

The process involves sampling (converting continuous signal to discrete samples) and quantization (converting continuous amplitude to discrete levels), followed by encoding the quantized values into binary form.

1. **Define the unit impulse (delta) signal.**

The unit impulse or delta signal, denoted as δ(n), is defined as δ(n) = 1 for n = 0, and δ(n) = 0 for n ≠ 0.

1. **What is a unit step signal? How is it mathematically represented?**

A unit step signal, denoted as u(n), is defined as u(n) = 1 for n ≥ 0, and u(n) = 0 for n < 0.

1. **Define a ramp signal. Write its mathematical equation.**

A ramp signal, denoted as ur(n), is defined as ur(n) = n for n ≥ 0, and ur(n) = 0 for n < 0.

1. **What is an exponential signal? Write its mathematical representation.**

An exponential signal is represented as g(n) = aⁿ for n ≥ 0, where 'a' is the base of the exponential.

1. **How is a discrete-time sinusoidal signal expressed mathematically?**

A discrete-time sinusoidal signal can be expressed as x(n) = A cos(ω₀n + θ) or x(n) = A sin(ω₀n + θ), where A is the amplitude, ω₀ is the frequency in radians/sample, and θ is the phase in radians.

1. What are the conditions for a discrete-time signal to be periodic?
2. If a signal has a fundamental frequency of 0.25 cycles/sample, what is its fundamental period?
3. Define an even signal. Give an example.
4. Define an odd signal. Give an example.
5. What is meant by decomposing a signal into even and odd parts?
6. How do you determine if a discrete-time signal is an energy signal?
7. How do you determine if a discrete-time signal is a power signal?
8. Can a signal be both an energy signal and a power signal?
9. Define a causal signal. Give an example.
10. What is an anticausal signal?
11. What is meant by time-shifting of a discrete-time signal?
12. Explain the process of amplitude scaling of a discrete-time signal.
13. What is time-scaling (downsampling and upsampling) of a discrete-time signal?
14. Define folding operation on a discrete signal.
15. How do you add two discrete-time signals?
16. How do you multiply two discrete-time signals?
17. What is a discrete-time system?
18. Define a linear system. What is the principle of superposition?
19. What is a time-invariant system?
20. Define an LTI (Linear Time-Invariant) system.
21. List the basic elements used in block diagram representation of discrete-time systems.
22. Differentiate between static and dynamic systems.
23. What is the procedure to test a system for time invariance?
24. How would you test a system for linearity?
25. Differentiate between causal and non-causal systems.
26. What are stable and unstable systems?
27. Define FIR and IIR systems.
28. What is discrete or linear convolution?
29. Why is convolution important in signal processing?
30. Describe the procedure for computing linear convolution.
31. What is the relationship between convolution and LTI systems?
32. What is the length of the output sequence when two sequences of lengths N1 and N2 are convolved?
33. Describe the graphical method for computing linear convolution.
34. What is circular convolution?
35. How does circular convolution differ from linear convolution?
36. What is correlation? How does it differ from convolution?
37. Define cross-correlation and auto-correlation.
38. What is the length of the correlation sequence for two input sequences of lengths N1 and N2?
39. What is the significance of correlation in signal processing?
40. For an LTI system, what is the relationship between the input, impulse response, and output?
41. Define system function or transfer function of a discrete-time system.
42. What is the Z-transform of a discrete-time signal?
43. What is meant by region of convergence (ROC) in Z-transform?
44. State the convolution property of Z-transform.
45. What is DTFT (Discrete-Time Fourier Transform)?
46. How are DFT and DTFT related?
47. What are the limitations of using DTFT in practical applications?
48. Define aliasing in the context of signal processing.
49. What is the Nyquist rate and its significance?
50. How does undersampling affect signal reconstruction?
51. What is meant by deterministic and random signals?
52. Give examples of deterministic and random signals.
53. What is meant by the fundamental period of a periodic signal?
54. If a discrete-time signal is a sum of two periodic signals with periods N1 and N2, what will be the period of the resulting signal?
55. Define symmetric and antisymmetric discrete-time signals.
56. How can any discrete-time signal be expressed as a sum of even and odd parts?
57. What is the impulse response of an LTI system?
58. Define the step response of a discrete-time system.
59. How is the frequency response of a discrete-time system related to its impulse response?
60. What are the conditions for a discrete-time system to be causal and stable?
61. Define a moving average system. Is it an FIR or IIR system?
62. What is a recursive system? Give an example.
63. What is a non-recursive system? Give an example.
64. Define a decimation system in signal processing.
65. Define an interpolation system in signal processing.
66. What is a cascaded system? How is its overall system function determined?
67. What is a parallel system? How is its overall system function determined?
68. Define the frequency response of a discrete-time system.
69. How is the phase response of a discrete-time system calculated?
70. What is meant by a minimum-phase system?
71. Define a maximum-phase system.
72. What is group delay in a discrete-time system?
73. What is phase delay in a discrete-time system?
74. Define stability in terms of BIBO (Bounded Input Bounded Output).
75. What are the sufficient conditions for a discrete-time LTI system to be stable?
76. Define causality in terms of the impulse response of a system.
77. How does causality affect the frequency response of a system?
78. What is meant by the ROC (Region of Convergence) of a system's transfer function?
79. How are the poles and zeros of a system's transfer function related to its stability?
80. What is a digital filter? How is it related to discrete-time systems?
81. Define a zero-state response of a discrete-time system.
82. Define a zero-input response of a discrete-time system.
83. What is the total response of a discrete-time system?
84. Explain the difference between digital and analog signals in terms of their values.
85. How does a first-order difference equation represent a discrete-time system?