GUJARAT TECHNOLOGICAL UNIVERSITY

BE 4 SEMESTER – OLD PAPER – S22 TO S25 – QUESTION BANK

Subject Name & Code: Signal & Systems - 3141005

Chapter 1: Introduction to Signals & Systems

Repeated Questions:

1. Classification of Signals:

- **Q.** Compare / Explain Energy and Power signals. **(WINTER 2022, 3 Marks; SUMMER 2023, 3 Marks OR; SUMMER 2024, 3 Marks; SUMMER 2025, 3 Marks)**
- **Q.** Classify signals. Give examples of each. **(SUMMER 2023, 7 Marks OR; SUMMER 2024, 7 Marks)**

2. Properties of Systems:

- **Q.** Explain the properties of continuous time and discrete time systems. **(SUMMER 2023, 7 Marks; SUMMER 2024, 7 Marks; SUMMER 2025, 7 Marks)**

3. Even and Odd Parts (Numerical):

- **Q.** Find even and odd parts of x(t) = u(t). **(WINTER 2023, 3 Marks OR; SUMMER 2024, 3 Marks)**

Other Important Questions:

1. Basic Definitions:

- **Q.** Define energy and power. Hence, define energy signal and power signal. **(WINTER 2023, 4 Marks)**
- **Q.** Define (1) Signal (2) System (3) Deterministic Signal. **(SUMMER 2022, 3 Marks)**
- **Q.** (1) Describe Inverse System. (2) Describe Time-Invariant System. **(SUMMER 2022, 4 Marks)**
- **Q.** (1) Write the relation between Unit Step and Impulse function. (2) Write the relation between Unit Step and Ramp function. **(SUMMER 2022, 4 Marks)**

2. Signal Operations and Sketching:

- **Q.** If the given signal $x(t) = e^{-at}u(t)$. Draw the signals: $x(-t + 2)$ and $x(-t - 3)$. **(WINTER 2022, 4 Marks)**
- **Q.** Explain (1) Time Shifting and (2) Time Scaling operation with neat figures. **(SUMMER 2022, 4 Marks)**
- **Q.** Sketch the following waveform: $x(t) = u(t + 1) - 2u(t) - 2u(t - 1)$. **(SUMMER 2024, 3 Marks)**

3. Even/Odd Components and Periodicity (Numerical):

- **Q.** Find the even and odd components of $x(t) = \cos(t)\sin(t)$. **(SUMMER 2023, 3 Marks)**
- **Q.** Find whether the given signals are periodic or not? If yes, give its fundamental period. (i) $x(t) = 3\sin 200\pi t + 4\cos 100t$ (ii) $x(n) = e^{j(\pi/2)n}$. **(WINTER 2023, 7 Marks OR)**

4. System Properties (Numerical):

- **Q.** Determine whether the following systems are: (1) Memoryless (2) Causal (3) Stable (4) Time Invariant (5) Linear. (I) $y(t) = x(0.5t)$ (II) $y[n] = x[n - 1] + x[n]$. **(WINTER 2022, 7 Marks)**
- **Q.** Determine if the following systems described by (1) $y(t) = \sin[x(t + 2)]$; (2) $y[n] = x[2 - n]$ are memoryless, causal, linear, time invariant, stable. **(SUMMER 2022, 7 Marks)**
- **Q.** Define: System. Determine whether the system $y(t) = tx(t)$ is: 1. Causal or Non-Causal 2. Time-variant or Time-invariant 3. Static or Dynamic. **(SUMMER 2025, 4 Marks)**
- **Q.** Explain following property for the system $y(t) = 10x(t) + 5$: (i) Linearity (ii) Time-invariance (iii) Causality (iv) Dynamicity. **(WINTER 2023, 7 Marks OR)**

Chapter 2: Behaviour of Continuous Time (CT) & Discrete Time (DT) LTI System

Repeated Questions:

1. Stability and Causality of DT LTI Systems:

- **Q.** State & prove a condition for a discrete time LTI system to be stable. **(WINTER 2022, 3 Marks; SUMMER 2023, 3 Marks; WINTER 2023, 3 Marks; SUMMER 2024, 4 Marks; SUMMER 2025, 4 Marks OR)**
- **Q.** Prove that a DT LTI system is causal if and only if $h(n) = 0$ for $n < 0$. **(SUMMER 2023, 3 Marks OR; WINTER 2023, 4 Marks OR; SUMMER 2024, 3 Marks OR)**

2. Properties of Convolution:

- **Q.** Prove Commutative property of convolution. **(SUMMER 2023, 4 Marks; WINTER 2023, 4 Marks; SUMMER 2024, 4 Marks OR)**
- **Q.** List out / write any three properties of convolution. **(SUMMER 2022, 3 Marks; SUMMER 2023, 3 Marks)**

3. Convolution (Numerical):

- **Q.** Obtain convolution integral of: $x(t) = 1$ for $-1 \le t \le 1$ and $h(t) = 1$ for $0 \le t \le 2$. **(WINTER 2022, 7 Marks; SUMMER 2025, 7 Marks)**
- **Q.** Obtain linear convolution of two discrete time signals / response of system to unit step: $x[n] = u[n]$ and $h[n] = a^n u[n]$, $a < 1$. **(SUMMER 2022, 7 Marks OR; WINTER 2022, 7 Marks OR)**

4. Difference Equations (Numerical):

- **Q.** Find the natural response of the system described by difference equation $y(n) - 1.5y(n-1) + 0.5y(n-2) = x(n)$; $y(-1) = 1$, $y(-2) = 0$. **(WINTER 2023, 4 Marks; SUMMER 2025, 4 Marks)**

Other Important Questions:

1. Convolution Sum – Theory:

- **Q.** Evaluate the convolution $x[n] * \delta[n - n_0]$. **(SUMMER 2022, 3 Marks)**
- **Q.** Define Convolution sum. Show that (1) $x[n] * \delta[n] = x[n]$ (2) $x[n] * u[n - n_0] = \sum_{k=-\infty}^{n-n_0\{0\}} x[k]$. **(SUMMER 2022, 7 Marks OR)**
- **Q.** State and explain associative property of convolution sum. **(SUMMER 2025, 3 Marks)**

2. Convolution (Numerical):

- **Q.** Find discrete convolution of following pairs of signals: $x(n) = \{1, 3, 5, 7\}$ and $h(n) = \{2, 4, 6, 8\}$. **(WINTER 2023, 3 Marks)**
- **Q.** Compute convolution using graphical method: $y(n) = x(n) * h(n)$, $x(n) = \{1, 1, 0, 3\}$, $h(n) = \{1, -2, 3, -4\}$. **(SUMMER 2024, 7 Marks)**
- **Q.** Determine the convolution sum of two sequences using graphical method: $x(n) = \{1, 4, 3, 2\}$; $h(n) = \{1, 3, 2, 1\}$. **(WINTER 2023, 7 Marks)**
- **Q.** Compute the convolution sum $y(n) = x(n) * h(n)$: 1. $x(n) = \delta(n) - \delta(n-2)$ and $h(n) = u(n)$ 2. $x(n) = u(n)$ and $h(n) = u(n)$. **(SUMMER 2025, 7 Marks OR)**
- **Q.** Evaluate continuous time (CT) convolution integral given as: $y(t) = e^{2t}u(t) * u(t+2)$. **(SUMMER 2024, 7 Marks OR)**

3. System Response (Numerical):

- **Q.** A system is described by difference equation $y(n) = 0.5y(n-1) + x(n)$. Input given to system is $(1/3)^n u(n)$ and initial condition is $y(-1) = 1$. Determine the zero state response. **(SUMMER 2023, 7 Marks OR)**
- **Q.** Find the step response of the system whose impulse response is: (1) $\delta[n+2] + \delta[n-3]$ (2) $u[n]$. **(WINTER 2022, 4 Marks)**

- **Q.** Determine the response of the system with impulse response h(t) = u(t) for the input x(t) = $e^{-2t}u(t)$. **(SUMMER 2022, 7 Marks)**

4. Stability of LTI Systems (Numerical):

- **Q.** Determine whether the following system with impulse response h(t) = $e^{-3t}u(t)$ is stable or not. **(WINTER 2023, 4 Marks OR)**
- **Q.** Determine whether the following system with impulse response h(n) = $2^{n}u(-n)$ is stable or not. **(SUMMER 2025, 4 Marks)**

Chapter 3: Introduction to Fourier Series, Fourier Transform

Repeated Questions:

1. Fourier Series:

- **Q.** State Dirichlet condition for Fourier Series Representation. **(SUMMER 2023, 3 Marks; WINTER 2023, 4 Marks)**

2. Properties of Fourier Transform:

- **Q.** Prove the duality property of Fourier Transform. **(SUMMER 2022, 4 Marks OR; WINTER 2022, 7 Marks OR - includes Define the continuous time Fourier Transform. State and prove Duality property; SUMMER 2023, 4 Marks; SUMMER 2024, 4 Marks)**
- **Q.** State and prove time scaling property of Fourier Transform. **(SUMMER 2022, 3 Marks OR - states frequency shifting, time shifting and time scaling properties; SUMMER 2023, 4 Marks OR; SUMMER 2025, 3 Marks OR)**
- **Q.** State and prove / explain time shifting property of Fourier Transform. **(WINTER 2022, 7 Marks; SUMMER 2025, 3 Marks; SUMMER 2025, 4 Marks OR)**

3. Relations and Comparisons between Transforms:

- **Q.** Obtain the relationship between Laplace transform and Fourier Transform. **(SUMMER 2023, 4 Marks; SUMMER 2024, 4 Marks)**
- **Q.** Bring out difference between DFT and Fourier Transform (FT). **(SUMMER 2022, 4 Marks; WINTER 2023, 4 Marks OR; SUMMER 2024, 4 Marks OR)**

4. Fourier Transform of Sinusoidal Signals (Numerical):

- **Q.** Obtain Fourier Transform of sinusoidal signals (cosine/sine, with or without u(t)). **(SUMMER 2022, 7 Marks OR - $x(t) = \cos\omega_o t$; $x(t) = \cos\omega_c t\, u(t)$; SUMMER 2023, 4 Marks OR - $x(t) = \cos(2\pi ft)u(t)$; WINTER 2023, 7 Marks - $x(t) = \cos\omega_o t$; $x(t) = \sin\omega_o t\, u(t)$; SUMMER 2024, 4 Marks OR - $x(t) = \sin(2\pi ft)u(t)$)**

Other Important Questions:

1. Fourier Series – Theory:

- **Q.** State equations for trigonometric Fourier Series and exponential Fourier Series. **(SUMMER 2022, 3 Marks)**
- **Q.** Explain the trigonometric Fourier series. **(WINTER 2023, 3 Marks)**

2. Fourier Series – Numerical:

- **Q.** Use definition of the Fourier Series to determine the time domain signal represented by the following Fourier series coefficients: $X[k] = j\delta[k-1] - j\delta[k+1] + \delta[k-3] + \delta[k+3]$, $\omega_o = 2\pi$. **(SUMMER 2022, 7 Marks)**
- **Q.** Determine complex exponential Fourier series of $\cos(\omega_o t)$. **(WINTER 2022, 4 Marks OR)**
- **Q.** Determine the trigonometric Fourier Series of $\delta_{T_o}(t) = \sum_{k=-\infty}^{\infty} \delta(t - kT_o)$. **(WINTER 2022, 7 Marks OR)**
- **Q.** Find the Fourier series coefficients for the continuous time periodic signal $x(t) = 1.5$ for $0 \le t < 1$, $= -1.5$ for $1 \le t < 2$, with fundamental frequency $W_o = \pi$. **(WINTER 2023, 7 Marks OR)**

3. Fourier Transform – Theory and Properties:

- **Q.** State convolution property of Fourier Transform and find Fourier Transform of $y(t) = e^{-at}u(t) * u(t)$. **(WINTER 2022, 7 Marks)**
- **Q.** Enlist frequency shifting and time differentiation properties of Fourier transform. Prove any one of them. **(WINTER 2023, 4 Marks)**
- **Q.** Enlist and explain properties of Fourier transform. **(SUMMER 2025, 7 Marks OR)**

4. Fourier Transform (Numerical):

- **Q.** Find the Fourier Transform of $x(t) = e^{-3t}u(t)$. **(SUMMER 2023, 3 Marks OR)**
- **Q.** Find the Fourier Transform of $x(t) = e^{-5t}u(-t)$. **(SUMMER 2024, 3 Marks OR)**
- **Q.** Obtain Fourier Transform of a Unit Step Function. **(WINTER 2022, 4 Marks)**
- **Q.** Obtain the Fourier Transform of following functions: (1) x(t) = 1 (2) x(t) = sgn(t). **(SUMMER 2022, 4 Marks OR)**
- **Q.** Compute the Fourier transform of $x(n) = (1)^n u(n)$. Also give applications of Fourier transform. **(SUMMER 2025, 7 Marks)**

5. DFT, DTFT and Other Transform Relations – Theory:

- **Q.** Give the difference between DFT and DTFT. **(WINTER 2022, 3 Marks)**
- **Q.** Define DFT and IDFT. **(WINTER 2022, 3 Marks OR)**
- **Q.** Explain time shifting and periodicity property of Laplace Transform. **(SUMMER 2024, 3 Marks OR)**
- **Q.** Explain relation between Fourier transform and z transform using necessary equations. **(WINTER 2023, 3 Marks OR)**

6. DFT and DTFT (Numerical):

- **Q.** Compute DFT of the sequence x[n] = {1, 2, 3, 4} using its definition. **(SUMMER 2023, 7 Marks)**
- **Q.** Obtain DFT of unit impulse δ(n). **(SUMMER 2023, 3 Marks)**
- **Q.** Find DTFT of the sequence x(n) = {1, 0, 4, 2}. **(SUMMER 2024, 3 Marks)**
- **Q.** Compute DFT of the following sequence using its definition: x[n] = {0, 1, 3, 2}. **(SUMMER 2024, 7 Marks)**
- **Q.** Determine 2-point and 4-point DFT of a sequence x[n] = u[n] − u[n − 2]. **(WINTER 2022, 7 Marks)**
- **Q.** Find the DFT of the sequence x(n) = {1, 1, −2, −2}. **(WINTER 2023, 3 Marks)**
- **Q.** Calculate the DFT of a sequence x[n] = {1, 1, 0, 0} and check the validity of DFT by calculating its IDFT. **(WINTER 2023, 7 Marks)**
- **Q.** Find DTFT of the sequence x(n) = {1, 0, 2, 3}. **(SUMMER 2025, 4 Marks)**
- **Q.** Find 4-point DFT of the sequence x(n) = {1, 3, 4, −2}. **(SUMMER 2025, 3 Marks)**

Chapter 4: Z Transform

Repeated Questions:

1. Region of Convergence and Properties:

- **Q.** Define / explain ROC of Z-Transform and write its properties. **(SUMMER 2022, 4 Marks - write any four properties of ROC; SUMMER 2023, 4 Marks OR; WINTER 2023, 7 Marks; SUMMER 2024, 7 Marks)**
- **Q.** State and prove / explain differentiation property of Z-Transform. **(SUMMER 2023, 4 Marks; WINTER 2023, 3 Marks OR; SUMMER 2024, 4 Marks; SUMMER 2025, 7 Marks)**

2. Inverse Z-Transform (Numerical):

- **Q.** Determine the Inverse Z-Transform of $X(z) = 1 / [(1 + z^{-1})(1 - z^{-1})^2]$, ROC: $|z| > 1$. **(SUMMER 2023, 7 Marks OR; SUMMER 2024, 7 Marks OR)**

Other Important Questions:

1. Z-Transform and ROC (Numerical):

- **Q.** Obtain Z-Transform of $x(n) = n^2u(n)$ and $x(n) = (-2)^nu(-n - 1)$. **(SUMMER 2023, 7 Marks)**
- **Q.** Determine the z-transform of the following finite duration sequence $X(n) = \{1, -3, 4, 5, 7\}$. **(SUMMER 2024, 3 Marks)**
- **Q.** Determine z Transform of following sequences: (1) $x[n] = \alpha^{-|n|}$, $0 < \alpha < 1$ (2) $x[n] = 2^nu[n] + 3^nu[-n - 1]$. **(WINTER 2022, 4 Marks)**
- **Q.** Find z Transform of $x[n] = na^nu[n]$. **(WINTER 2022, 4 Marks OR)**
- **Q.** Determine the Z-Transform & ROC of the following sequence $x(n) = (3)^nu(n) - (2)^nu(-n - 1)$. **(WINTER 2023, 7 Marks OR)**
- **Q.** Determine z-transform of $x[n] = \cos(\Omega_o n)u[n]$. **(SUMMER 2022, 7 Marks)**
- **Q.** Find the z-transform and ROC of the following sequence: $x[n] = ½\delta[n + 1] + 5(½)^{-n}u[n] + 4^nu[-n - 1]$. **(SUMMER 2022, 4 Marks OR)**
- **Q.** Determine the Z-Transform & ROC of the following sequence $x(n) = 3^nu(n) - 4^nu(n)$. **(SUMMER 2025, 3 Marks)**
- **Q.** Find the z-transform of the signal $x(n) = (-1/5)^nu(n) + 5(1/2)^nu(-n - 1)$. **(SUMMER 2025, 3 Marks OR)**

2. Z-Transform Properties and Theorems:

- **Q.** State and prove Time Shifting Property of z Transform. **(WINTER 2022, 3 Marks)**
- **Q.** State and prove Time Reversal Property of z Transform. **(WINTER 2022, 3 Marks OR)**
- **Q.** Explain Scaling property in the z-Domain. **(WINTER 2023, 3 Marks)**
- **Q.** State final value and initial value theorem for z-transform. **(SUMMER 2022, 3 Marks)**
- **Q.** State any three properties of z-transform. **(SUMMER 2022, 3 Marks OR)**

3. Inverse Z-Transform (Numerical):

- **Q.** Determine the Inverse Z-Transform of $X(Z) = [¼z^{-1}] / [(1 - ½z^{-1})(1 - ¼z^{-1})]$, ROC: $|Z| > ½$. **(SUMMER 2023, 7 Marks)**
- **Q.** Obtain x(n) using long division method for $X(Z) = z / (z - 1)$ for both possible ROCs. **(SUMMER 2023, 7 Marks OR - implied)**
- **Q.** Determine the Inverse Z-Transform of $X(z) = (1 + z^{-1}) / (1 - z^{-1} + 0.5z^{-2})$. Assume that x[n] is causal. **(SUMMER 2024, 7 Marks OR)**
- **Q.** Determine inverse z Transform of $X(z) = 1 / (1 - 1.5z^{-1} + 0.5z^{-2})$ if (1) ROC: $|z| > 1$ (2) ROC: $|z| < 0.5$ (3) ROC: $0.5 < |z| < 1$. **(WINTER 2022, 7 Marks OR)**
- **Q.** Determine the inverse z-transform of $X(z) = (z + 2) / (2z^2 - 7z + 3)$ by partial fraction expansion method, if the ROCs are (1) $|z| > 3$ (2) $|z| < ½$ and (3) $½ < |z| < 3$. **(SUMMER 2022, 7 Marks OR)**

- **Q.** Using partial fraction method, determine the sequence that goes with the following z-transforms: $X(z) = 3 / (z - ¼ - ⅛z^{-1})$ and x(n) is absolutely summable. **(SUMMER 2025, 7 Marks)**
- **Q.** Using partial fraction expansion find the inverse z-transform of $X(z) = 1 - [⅓z^{-1}] / [(1 - z^{-1})(1 + 2z^{-1})]$, $|z| > 2$. **(SUMMER 2025, 7 Marks OR)**

4. Convolution, Causality and Stability using Z-Transform:

- **Q.** Find the convolution of the signal using z Transform: $x_1[n] = a^n u[n]$, $a < 1$ and $x_2[n] = u[n]$. **(WINTER 2022, 7 Marks)**
- **Q.** Discuss Causality and Stability of LTI systems using z-transform. **(SUMMER 2022, 3 Marks OR)**

Chapter 5: Sampling & Reconstruction

Repeated Questions:

1. Sampling Theorem and Aliasing:

- **Q.** State and prove / define Sampling Theorem. **(WINTER 2022, 3 Marks - define; SUMMER 2024, 7 Marks OR; SUMMER 2025, 7 Marks OR)**
- **Q.** What is aliasing? How can we eliminate Aliasing? / Explain aliasing effect. **(WINTER 2022, 3 Marks OR; SUMMER 2025, 3 Marks OR)**

2. Reconstruction of Signals:

- **Q.** Write a short note on zero order hold with its application. **(SUMMER 2023, 4 Marks; SUMMER 2024, 4 Marks)**
- **Q.** Explain reconstruction of a signal from its samples using interpolation. **(SUMMER 2023, 7 Marks; WINTER 2023, 7 Marks - with sampling theorem; SUMMER 2025, 4 Marks OR)**

Other Important Questions:

1. Sampling Rate (Numerical):

- **Q.** Find the Nyquist rate and interval of $x(t) = 5\cos 1000\pi t \cos 4000\pi t$. **(WINTER 2022, 4 Marks)**
- **Q.** A bandpass signal has a spectral range that extends from 20 kHz to 82 kHz. Find the sampling frequency. **(WINTER 2022, 4 Marks OR)**

2. Signal Reconstruction:

- **Q.** List out the difficulties faced during signal reconstruction. **(SUMMER 2025, 4 Marks)**

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