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21EC33

Third Semester B.E./B.Tech. Degree Examination, Dec.2025/Jan.2026
Basic Signal Processing

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Explain the 4 fundamental subspaces with its dimensions? State Rank-Nullity Theorem. Prove the same with an example. **(10 Marks)**

b. Perform LU factorization on the below matrix. Also, show that the determinant of the given matrix is equal to the product of the determinant of L and the determinant of the U matrix.

$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 3 & 1 & 2 \end{bmatrix}$$ **(10 Marks)**

OR

2 a. Explain the following :

(i) Basis, Dimension and Span of a vector.

(ii) Projections and Least squares.

(iii) Linearly Independent and Dependent vectors. **(10 Marks)**

b. Develop a program to compute an orthogonal basis using the Gram-Schmidt orthogonalization procedure for the given vectors,

$x_1 = (3,0,-1)$ and $x_2 = (8,5,-6)$. Also find the orthogonal basis. **(10 Marks)**

Module-2

3 a. Explain positive Definite Metrices interms of Upper determinants, Pivots and Eigen values. Determine whether the metrices $(A*A^T)$ and (A^T*A) are Positive Definite. Justify your answer.

Given matrix $A = \begin{bmatrix} 1 & 1 \\ 1 & 2 \\ 2 & 1 \end{bmatrix}$. **(10 Marks)**

b. Explain Diagonalization of a matrix and the conditions under which the matrix is diagonalizable. Diagonalize the given matrix A and find A^100. Matrix A = $\begin{bmatrix} -1 & -4 \\ 8 & 11 \end{bmatrix}$. **(10 Marks)**

OR

4 a. Determine the Eigen values and Eigen vectors for the below 2×2 matrix :

$$\begin{bmatrix} 1 & -1 \\ 2 & 4 \end{bmatrix}.$$

Verify trace of a matrix is equal to the sum of Eigen values and the product of Eigen values is equal to the Determinant of the given matrix. **(10 Marks)**

b. Explain the concept of singular value decomposition (SVD) of a matrix. Find the matrices U, Σ and V for the given matrix A. The rank of the given matrix is 2.

$$Matrix\ A = \begin{bmatrix} 3 & 0 \\ 4 & 5 \end{bmatrix}$$ **(10 Marks)**

Module-3

5 a. Explain the following system classification properties with respect to discrete-time systems.

(i) Static – Dynamic systems

(ii) Stable – Unstable systems

(iii) Invertible systems

For each property, provide one illustrative example with mathematical expression. **(10 Marks)**

b. Let a discrete-time signal be defined as : x(n) = {0, 1, 2, 3, 4} for n = 0 to 4. Perform and demonstrate the following operations both mathematically and graphically :

(i) Amplitude scaling

(ii) Addition of two signals x(n), h(n)

(iii) Multiplication of two signals x(n), h(n)

(iv) Time scaling

(v) Time shift and Time reversal. Assume h(n) = {1, 1, 1, 1, 1}. **(10 Marks)**

OR

6 a. Explain the following system classification properties with respect to discrete-time systems :

(i) Linear-nonlinear systems

(ii) Time variant – invariant systems

(iii) Non causal systems.

For each property, provide one illustrative example with mathematical expression. **(10 Marks)**

b. Express the following discrete-time waveforms in terms of basic signals (unit step u(n) and ramp r(n)) :

(i) A discrete rectangular waveform of height 1 starting at n = 0 and ending at n = 4.

(ii) A discrete triangular waveform of height 2 peaking at n = 2, defined from n = 0 to n = 4.

Also plot the above two signals graphically. **(10 Marks)**

Module-4

7 a. Explain the concept of convolution in discrete-time systems. List its important properties of convolution with necessary mathematical expressions. **(10 Marks)**

b. Let the input signal x(n) and the impulse response h(n) of a discrete-time system,

$x(n) = \{1, 1, 1, 1\}$

$h(n) = \{2, 2\}$

Find output $y(n) = x(n) * h(n)$ using the convolution sum. Using both graphical and mathematical approaches and thus verify the result. **(10 Marks)**

OR

8 a. Define an invertible system. What are the conditions for a linear time invariant (LTI) system to be invertible? Explain the concept of deconvolution using appropriate expressions in the context of discrete time signals. **(10 Marks)**

b. For each discrete time impulse response h(n) given below, determine whether the corresponding system is :

(i) Memoryless

(ii) Causal

(iii) Stable

Given Discrete time impulse responses :

(i) $h(n) = e^{-2n}$

(ii) $h(n) = e^{2n}u(n-1)$

(iii) $h(n) = u(n+1) - 2u(n-1)$

(iv) $h(n) = 3\,\delta(n)$

(v) $h(n) = \cos(\pi n)\,u(n)$ **(10 Marks)**

Module-5

9 a. Explain the properties of the Region of Convergence (ROC) and properties of the Z-Transform. **(10 Marks)**

b. Determine the z-transform of the given signal :

$Y(n) = -a^n u(-n-1)$

Depict the ROC and pole and zero locations in the Z-plane. **(10 Marks)**

OR

10 a. Explain the significance of poles and zeros in the transform analysis of discrete time LTI systems. How do the locations of poles in the z-plane determine the causality and stability of a system? Discuss with reference to the Region of convergence (ROC). **(10 Marks)**

b. Find the inverse Z-transform of,

$$x(z) = \frac{10z}{(z-1)(z-2)}$$ **(10 Marks)**

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