

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E. in Signal Processing and Communication

Semester: I

Subject Name: **Mathematical Methods in Signal Processing**

Subject Code: **714101**

Sr. No	Course Content
1	Introduction and Foundations: Signal processing fundamentals, mathematical topics embraced by signal processing, Mathematical models, Models for linear systems and signals, Adaptive filtering, Gaussian random variables and random processes, Markov and hidden markov models, Some aspects of proofs, An application: LFSRs and massy's algorithm.
2	Signal Spaces: Metric spaces, Vector spaces, Norms and normed vector spaces, Inner products and inner-products spaces, Induced norms, The Cauchy-Schwarzs inequality, Direction of vectors: orthogonally, Weighted inner products, Hilbert and banach spaces, Orthogonal subspaces
3	Representation and approximation in vector spaces: The approximation problem in Hilbert space, The orthogonality principle, Error minimization via gradients, Matrix representations of least-squares problem, Minimum error in Hilbert-space approximations, Approximation by continuous polynomials, Approximation by discrete polynomials, Linear regression, Least squares filtering, Minimum mean-squares filtering, Minimum mean-squared error filtering, Comparison of least squares and minimum mean squares, Frequency domain optimal filtering.
4	Linear operators and matrix inverses: Linear operators, Operators norms, Ad joint operator and transposes, Geometry of linear equations, Four fundamental subspaces of a linear operator, Some properties of matrix inverses, Some results on matrix rank, Another look at least squares, Pseudo inverses, Matrix conduction number, Inverse of a small rank adjustment, Inverse of a block matrix.
5	Eigenvalues and eigenvectors: Eigen values and linear systems, Linear dependence of eigenvectors, Diagonalization of a matrix, Geometry of invariant subspaces, Geometry of quadratic forms subject to linear constraints, The Gershgorin circle theorem, Karhunen-loeve low rank approximations principal methods, Eigen filters.
6	The singular value decomposition: Theory of SVD, Matrix structure from the SVD, Pseudo inverses and SVD, Numerically sensitive problems, Rank-reducing approximations: effective rank, System identification using the SVD, Total least-squares problems, Partial total least squares, Rotation of subspaces, Computation of the SVD.

7	<p>Detection theory:</p> <p>Introduction to hypothesis testing, Neyman-pearson theory, Neyman-pearson testing with composite binary hypotheses, Bayes decision theory, Some M-ary problems, Maximum-likelihood detection, Approximations to detection performance: the union bound, Invariant tests, Detection in continuous time, Minimax bayes decisions.</p>
8	<p>Estimation theory:</p> <p>The maximum-likelihood principle, ML estimates and sufficiency, Estimation quality, Applications of ML estimation, Bayes estimation theory, Bayes risk, Recursive estimation</p>
9	<p>Basic concepts and methods of iterative algorithms:</p> <p>Definitions and qualitative properties of iterated, Contraction mappings, Rates of convergence for iterative algorithms, Newton's method, Steepest descent, LMS adaptive filtering.</p>

Reference Books:

1. Todd Moon and Wynn C.Stirling, "Mathematical Methods and Algorithms for Signal Processing", Pearson Education
2. Chi-Tsong Chen, " Digital Signal Processing – Spectral Computation and Filter Design", Oxford University Press
3. Michael J. Roberts, "Fundamentals of Signal and Systems", TMH Publications
4. Philips, Parr and Riskin,"Signal,System and Transform", Pearson Education