

## EC403: Statistical Signal Processing

Details of course:-

Course Title	Course Structure			Pre-Requisite
	L	T	P	
Statistical Signal Processing	3	1	0	NIL

**Course Objective:** Statistical Signal Processing involves processing random signals and forms the backbone of modern communication and signal processing systems. This course covers stochastic signals in time and frequency domain, modeling of signals, estimation, detection, spectral estimation, adaptive filters

**Course Outcomes:**

1. Analyze stationary processes, including spectral and correlation analysis of wide-sense stationary data.
2. Apply parameter estimation techniques like MVUE, MLE, and Bayesian estimation to optimize estimators.
3. Implement MMSE and LMMSE signal estimation in white Gaussian noise using Wiener filtering.
4. Design and adapt FIR Wiener filters using steepest descent, LMS, and RLS algorithms for dynamic systems.
5. Evaluate Kalman filters and Gauss-Markov models for state estimation and steady-state analysis.

S. No.	Content	Contact Hours
Unit 1	<b>Stationary processes:</b> Strict sense and wide sense stationarity; Correlation and spectral analysis of discrete-time wide sense stationary processes, white noise, response of linear systems to wide-sense stationary inputs, spectral factorization.	6
Unit 2	<b>Parameter estimation:</b> Properties of estimators, Minimum Variance Unbiased Estimator (MVUE) Cramer Rao bound, MVUE through Sufficient Statistics, Maximum likelihood estimation- properties. Bayesian estimation-Minimum Mean-square error(MMSE) and Maximum a Posteriori(MAP) estimation.	10
Unit 3	<b>Signal estimation in white Gaussian noise:</b> MMSE, conditional expectation; Linear minimum mean square error (LMMSE) estimation, orthogonality	10

	principle and Wiener Hoff equation. <b>Wiener Filtering:</b> FIR Wiener filter, linear prediction-forward and backward predictions, Levinson-Durbin Algorithm, Non-causal IIR wiener filter, Causal IIR Wiener filtering.	
Unit 4	<b>Iterative and adaptive implementation of FIR Wiener filter:</b> Steepest descent algorithm, LMS adaptive filters, convergence analysis, least-squares (LS) method, Recursive LS (RLS) adaptive filter, complexity analysis, application- neural network.	8
Unit 5	<b>Kalman filters:</b> Gauss-Markov state variable models; innovation and Kalman recursion, steady-state behaviour of Kalman filters	8
Total		42

Books:-

S. No	Name of Books/Authors/Publisher
1	Manolakis D. G., V. K. Ingle, and S. M. Kogon, Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing, McGraw Hill, Inc., 2000.
2	Kay S. M., Fundamentals of Statistical Signal Processing: Estimation Theory, Prentice-Hall, Inc., 1993.
3	H. L. Van Trees, Detection, Estimation and Modulation Theory, Part I, John Wiley, 1968.
4	H. V. Poor, An Introduction to Signal Detection and Estimation, 2nd edition, Springer, 1994.
5	S. J. Orfanidis, Optimum Signal Processing, 2nd Edition, 2007 republication of the 1988 McGraw-Hill edition.