FACULTY OF ENGINEERING & TECHNOLOGY

Effective from Academic Batch: 2022-23

Programme: **BACHELOR OF TECHNOLOGY (Electronics and Communication)**

Semester: **VII**

Course Code: **202060707**

Course Title: **Statistical Signal Processing**

Course Group: Professional Elective Course

Course Objectives: Many practical signals are random in nature or modelled as random processes. The course, Statistical Signal Processing involves processing these signals and forms the backbone of modern communication and signal processing systems. This course will contain broad components of statistical signal processing: random signal modelling, estimation and detection theory and different applied filters.

Teaching & Examination Scheme:

Contact hours per week			Course Credits	Examination Marks (Maximum / Passing)				
				Theory		J/V/P*		Total
Lecture	Tutorial	Practical		Internal	External	Internal	External	
3	0	2	4	50/18	50/17	25/9	25/9	150/53

* **J**: Jury; **V**: Viva; **P**: Practical

Detailed Syllabus:

Sr. No	Contents	Hours
1	**Review of random variables:** Distribution and density functions, moments, independent, uncorrelated and orthogonal random variables; Vector-space representation of Random variables, Schwarz Inequality Orthogonality principle in estimation, Central Limit theorem, Random processes, wide-sense stationary processes, autocorrelation and autocovariance functions, Spectral representation of random signals, Wiener Khinchin theorem Properties of power spectral density, Gaussian Process and White noise process. Random signal modelling: MA(q), AR(p), ARMA(p,q) models.	09
2	**Parameter Estimation Theory:** Principle of estimation and applications, Properties of estimates, unbiased and consistent estimators, Minimum Variance Unbiased Estimates (MVUE), Cramer Rao bound, Efficient estimators; Criteria of estimation: the methods of maximum likelihood and its properties; Bayesian estimation: Mean square error and MMSE, Mean Absolute error, Hit and Miss cost function and MAP estimation.	09

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3	**Estimation of signal in presence of white Gaussian Noise:** Linear Minimum Mean-Square Error (LMMSE) Filtering: Wiener Hoff Equation, FIR Wiener filter, Causal IIR Wiener filter, Noncausal IIR Wiener filter, Linear Prediction of Signals, Forward and Backward Predictions, Levinson Durbin Algorithm, Lattice filter realization of prediction error filters.	**09**
4	**Adaptive Filtering:** Principle and Application, Steepest Descent Algorithm Convergence characteristics; LMS algorithm, convergence, excess mean square error, Leaky LMS algorithm; Application of Adaptive filters; RLS algorithm, derivation, Matrix inversion Lemma, Initialization, tracking of non-stationarity.	**09**
5	**Kalman filtering:** State-space model and the optimal state estimation problem, discrete Kalman filter, continuous-time Kalman filter, extended Kalman filter.	**04**
6	**Spectral analysis:** Estimated autocorrelation function, periodogram, Averaging the periodogram (Bartlett Method), Welch modification, Blackman and Tukey method of smoothing periodogram, Parametric method, AR(p) spectral estimation and detection of Harmonic signals, MUSIC algorithm.	**05**
		45

List of Practicals / Tutorials:

1	To Study Central limit theorem using MATLAB simulation.
2	To study Correlation using MATLAB simulation.
3	To study Least Mean Square Estimation using MATLAB simulation
4	To study stationary and wide sense stationary process using MATLAB simulation.
5	To study the IIR and FIR filter.
6	To study optimum linear filer.
7	To study LMS algorithm for adaptive filtering.
8	To study of different adaptive filter algorithms for noise cancellation.
9	To study and design Kalman filter.
10	To study the spectral analysis of speech signal.

Reference Books:

1	Charles W. Therrien, **Discrete Random Signals and Statistical Signal Processing**, Prentice Hall Signal Processing Series.
2	M. H. Hayes, **Statistical Digital Signal Processing and Modeling**, John Wiley & Sons, Inc.,
3	D.G. Manolakis, V.K. Ingle and S.M. Kogon, **Statistical and Adaptive Signal Processing**, McGraw Hill, 2000.
4	Monson H. Hayes, **Statistical Digital Signal Processing and Modeling**, John Wiley and Sons, Inc, Singapore, 2002.
5	J. G. Proakis et. al., **Algorithms for Statistical Signal Processing**, Pearson Education, 2002.
6	Simon Haykin, **Adaptive Filter Theory**, Prentice Hall, 1996.
7	Chonavel, T., **Statistical Signal Processing Modelling and Estimation,** Springer 2001.
8	Jean-Pierre Colinge, **FinFETs and Other Multi-Gate Transistors**, , Springer New York, NY, https://doi.org/10.1007/978-0-387-71752-4

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Supplementary learning Material:	
1	NPTEL and Coursera Video lectures.

Pedagogy:

- Direct classroom teaching
- Audio Visual presentations/demonstrations
- Assignments/Quiz
- Continuous assessment
- Interactive methods
- Seminar/Poster Presentation
- Industrial/ Field visits
- Course Projects

Internal Evaluation:

The internal evaluation comprised of written exam (40% weightage) along with combination of various components such as Certification courses, Assignments, Mini Project, Simulation, Model making, Case study, Group activity, Seminar, Poster Presentation, Unit test, Quiz, Class Participation, Attendance, Achievements etc. where individual component weightage should not exceed 20%.

Suggested Specification table with Marks (Theory) (Revised Bloom's Taxonomy):

Distribution of Theory Marks in %						**R**: Remembering; **U**: Understanding; **A**: Applying; **N**: Analyzing; **E**: Evaluating; **C**: Creating
R	**U**	**A**	**N**	**E**	**C**	
15	**40**	**10**	**15**	**10**	**10**	

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Course Outcomes (CO):

Sr.	Course Outcome Statements	%weightage
CO-1	Understand and implement random variable, functions, process and modelling	**25**
CO-2	Carried out the estimation process during signal processing along with noise interference.	**25**
CO-3	Introduce and design adaptive filters algorithm for smart applications	**25**
CO-4	Implement different methods and parameters to evaluate data spectrum	**25**

Curriculum Revision:	
Version:	**2**
Drafted on (Month-Year):	June -2022
Last Reviewed on (Month-Year):	-
Next Review on (Month-Year):	June-2025

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