

## EOPE3007 ADVANCED SIGNAL PROCESSING (3-0-0)

### Course Objective

This course aims to build a clear understanding of advanced signal-processing concepts, including multirate processing, linear prediction, and adaptive filtering. It focuses on developing the ability to design and analyze filters and apply them in practical scenarios. The course also introduces key spectral-estimation techniques for effective analysis of signals.

### Module I (06 Hours)

Multirate Signal Processing: Introduction to multirate systems; decimation by a factor  $D$ ; interpolation by a factor  $I$ ; sampling-rate conversion by a rational factor  $I/D$ . Filter design and implementation for sampling-rate conversion. Multistage implementation of sampling-rate conversion, applications of multirate signal processing, sampling-rate conversion of bandpass signals.

### Module II (06 Hours)

Linear Prediction and Optimum Linear Filters: Innovations representation of a stationary random process; forward and backward linear prediction; solution of normal equations; properties of linear-prediction error filter. AR lattice and ARMA lattice–ladder filters.

### Module III (06 Hours)

Adaptive Filters: Adaptive direct-form FIR filters – LMS algorithms; adaptive direct-form filters – RLS algorithms; adaptive lattice–ladder filters.

### Module IV (06 Hours)

Power Spectral Estimation: Estimation of spectra from finite-duration signal observations; periodogram. Non-parametric methods: Bartlett, Welch, Blackman–Tukey methods. Comparison of non-parametric power-spectrum estimation methods.

### Module V (06 Hours)

Parametric Methods for Power Spectrum Estimation: Relationship between autocorrelation and model parameters. Yule–Walker method for AR parameters, Burg method, unconstrained least-squares estimation, sequential estimation methods for AR parameters. MA and ARMA models; minimum-variance spectral estimation.

### Course Outcomes (COs)

Upon completion of the course, the students will be able to:

- CO1 Apply multirate signal-processing concepts for sampling-rate conversion and system implementation.
- CO2 Analyze linear prediction techniques and design optimum linear filters.
- CO3 Implement adaptive filtering algorithms (LMS, RLS, lattice) for various signal-processing applications.
- CO4 Evaluate power-spectral characteristics of signals using non-parametric estimation techniques.
- CO5 Estimate AR/MA/ARMA model parameters and analyze signals using parametric spectral-estimation methods.

### Text Books

1. Proakis J.G. & Manolakis D.G., Digital Signal Processing: Principles, Algorithms and Applications, Pearson, 4th Edition
2. Oppenheim A.V. & Schaffer R.W., Discrete-Time Signal Processing, Pearson, 3rd Edition

### Supplementary Reading

1. Gopi E.S., Algorithm Collections for Digital Signal Processing Applications Using MATLAB, Springer, 1st Edition