Course Type	Course Code	Name of Course	L	T	P	Credit
DC	NGPC516	Mathematical Functional Analysis	3	0	0	3

Course Objective
The primary objective of the course is to introduce fundamental and advanced aspects of time series analysis techniques for geo-record analysis and processing.
Learning Outcomes
Upon successful completion of this course, students will: • have practical knowledge on geophysical/geological time/space series data analysis. • have practical knowledge on periodicity, how to design a filter, algorithm for signal enhancement and noise removal. • have Practical knowledge on signal processing techniques for exploration of geoscience.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Introduction:** Signal and System: Basic theory and introduction to signal and system, types of signals; Classification of signals, continuous and discrete signals. Types of noises; Energy and phase spectra, properties of time signal (time invariance, causality, linearity). Time series analysis: Auto regressive (AR), Moving average (MA) and Autoregressive moving average (ARMA) processes; Probability theory, Discrete, continuous and mixed random variables, probability density function, cumulative density function, notions of stationarity, ergodicity.	9	Understanding basic definitions and techniques for time series analysis
2	**Data analysis:** Fourier transforms, Fourier transforms of some commonly used functions, utility of domain transformation; Inverse Fourier transform; Use of one and two dimensional Fourier transforms in solving geophysical problems, Hankel transform and Hilbert transforms, their properties, the concept of analytic signal and its use in geophysics; Z transforms, inverse Z transform; Discrete Fourier transform and Fast Fourier transforms; Discretization of continuous signals, sampling theorem, aliasing; reconstruction of a signal from its samples-Gibb's phenomenon. Walsh transform and applications in geophysics; Wavelet transform and their applications in geophysics. Singular spectrum analysis (SSA) in geophysics.	9	Analysis and interpretation of complex signals and their application in geophysics

3	**Convolution:** Convolution theorem, unit impulse response and transfer function, convolution in time domain and in frequency domain; Correlation and Application in processing of random geophysical signals. Earth as a low pass filter.	7	Learning techniques to understand and interpret geophysical signals
4	**Digital filters:** Basic concepts, types of filters, ideal filters; Martin Graham, Butterworth and Chebyshev filters. Inverse filtering: Wiener filters, de-convolution-predictive and homomorphic, cepstral analysis.	6	Learning to identify relevant information from noisy signals
5	**Processing** of random signals. Power Spectrum Analysis: Power Spectrum Estimation; Periodogram, Maximum likelihood method (MLM) and maximum entropy method (MEM).	4	Interpretation of complex signals and representation
6	**Applications:** Signal enhancement for gravity and magnetic maps: regional and residual separation, continuations, calculation of derivatives, pseudo gravity transformations, reduction to poles and equator. Removal of shot generated noise- de-ghosting and dereverberation.	7	Familiarization with practical geophysical signal analysis
	Total:	**42**	

Text Books

1. Bath, M., 1974. Spectral Analysis in Geophysics. Elsevier, Amsterdam, Netherlands.
2. Gubbins D., 2004, Time series analysis and inverse theory for geophysicists, Cambridge University Press.

Reference Books

1. Baskakov, S. 1986, Signals and Circuits, Mir Publishers
2. Beauchamp, K.G., 1975. Walsh Functions and their Applications. Academic Press, New York, NY 236pp.
3. Blakeiy, Richard J., 1995, Potential Theory in Gravity and Magnetic Applications, Cambridge University Press.
4. Dimri, V. P., 1992, Deconvolution and Inverse Theory: Applications to Geophysical Problems, Elsevier Science.
5. Kanasewich, E. R., 1975, Time Sequence Analysis in Geophysics, The University of Alberta Press
6. Naidu, P. S., and Mathur, M. P., 2012, Analysis of Geophysical Potential Field: A Digital Signal Processing Approach: Elsevier
7. Robinson, E. A., 1967, Statistical communication detection with special reference to digital data processing of radar and seismic signal: GriffIn
8. Robinson, E. A., 1981, 'Time Series Analysis and Application: D. Reidel Yilmaz, 0. Seismic Data Processing, Society of Exploration Geophysicists.
9. Yilmaz, O., Seismic data processing, Society of Exploration Geophysicists