Course Type	Course Code	Name of Course	L T P	Credit
DC	NGPC528	**Geophysical Inversion**	**3 0 0**	**3**

Learning Objectives:

This subject will provide the knowledge of foundation of inverse theory and various practical aspects for solving inverse problems in applied geophysics. Clear understanding of data model relationship, local and global optimization techniques, model- based inversion, data-driven inversion, regularization and concepts of Bayesian theory for stochastic inversion.

Learning Outcome:

The primary objective of the course is to introduce fundamental and advanced aspects of inversion for geophysical exploration. At the end of the course, with acquired knowledge, students will be able to solve the linear and non-linear geophysical inverse problems for geophysical exploration.

Sl. No	Description of Lectures	Lecture Hrs.	Learning Outcome
1.	Foundation of Inverse theory: Vector space, Hilbert space; norm and dimension; common matrices in inverse problems, rank of a matrix, Matrix partitioning; eigen values and eigen vectors, inverse of a matrix- Moore-Penrose inverse, singular value decomposition.	7	Understanding of linear algebra and vector algebra for inversion.
2.	Forward and inverse problems in geophysics: definition of model, relation between model and data space, examples of forward and inverse problems; inversion as an appraisal problem. Classification of inverse problems: linear, quasi linear and nonlinear inverse problems, examples, Structure of an inverse problem: existence, approximation, uniqueness and stability; formulation of an inverse problem as minimization of a functional. Defining objective function for joint inversion. Joint inversion.	8	Understanding of "data" and "model" and their relationships and structure of an inverse problem.
3.	Least squares inversion: steepest descent, conjugate gradients, scaled-conjugate gradient, Gauss Newton, Levenberg-Marquardt approaches.	7	Understanding of local optimization.
4.	Model and Data: Variance and Covariance- Understanding of uncertainty and resolution. Tikhonov regularization.Backus-Gilbert method for continuous inversion. Constrained inversion: Role of a priori information, Tikhonov regularization, Occam's principle, Occam's inversion.	8	Understanding of regularization, and use of prior information in inversion.

5.	Stochastic inversion: Nonlinear inversions and global optimization-: an overview; Monte Carlo, Reversible Jump Markov-Chain Monte Carlo, simulated annealing, genetic algorithm, Trans-dimensional inversion in geophysics. tabu search. Neural networks, Bayesian neural networks, particle swarm optimization and hybrid methods, comments on speed and accuracy.	**5**	Understanding of stochastic and global optimization.
6.	Application: Examples of inverting geophysical data over 1D and 2D structures: gravity and magnetic anomalies, resistivity, IP and MT data. Examples of travel time and velocity inversion, full waveform inversion, cross-hole tomography.	**7**	Application of inversion techniques to various geophysical problems.
	Total Classes	**42**	

Text books

1. Menke, W., 1989, Geophysical data analysis: Discrete inverse theory, Academic Press, International Geophysical series, Vol. 45, 3rd Edition. MATLAB Edition

2. Sen, M.K., 2013, Global Optimization Methods in Geophysical Inversion. Second Edition.

Reference Books

1. Gubbins, D. 2004, Time series analysis and Inverse theory for Geophysicists, Cambridge Univ. Press,
2. Scales, J. A., Smith M. L. and Trietel, S., 2001, Introductory Geophysical Inverse Theory, Samizdat Press, Golden Colarado, USA,
3. Tarantola, A, 1987, Inverse Problem Theory, Elsevier Publishers, New York.