Geophysical Inversion

1.1. Course Number: GE325

1.2. Contact Hours: 3-0-0 Credits: 9

1.3. Semester Offered: 3rd Year-Even

1.4. Prerequisite: Basic knowledge of Mathematics, Physics, and Geology

1.5. Syllabus Committee Members: Dr. Satish Sinha and Dr. Piyush Sarkar

2. Objective: The primary objective of the course is to introduce fundamental and advanced aspects of geophysical inversion for geo-physical exploration.

3. Course Content: Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-topics	Lectures
1	Introduction to Inverse theory	Mathematical background; 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.	6
2	Forward and inverse problems	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 non-linear inverse problems, examples. Structure of an inverse problem: existence, approximation, uniqueness and stability; formulation of an inverse problem as minimization of a functional.	10
3	Least squares inversion and Regularization	Steepest descent, conjugate gradients, Gauss Newton, Levenberg Marquardt approaches, model and data covariance-understanding uncertainty and resolution. Tikhonov regularization and Backus-Gilbert method.	8
4	Advanced Inversion techniques	Constrained and Stochastic inversion: Role of a priori information, Occam‘s principle. Bayesian approach, a priori and a posteriori probabilities. Nonlinear inversions and global optimization: An overview; Monte Carlo, simulated annealing, genetic algorithm, tabu search, neural networks and hybrid methods, comments on speed and accuracy.	10
5	Inversion of data over 1 D and 2D geological structures	Gravity and magnetic anomalies, resistivity, IP and MT data, travel time and velocity inversion, full waveform inversion, cross-hole tomography.	6

Total	**40**

4. Readings:

4.1. Textbook:

- Menke, W., Geophysical data analysis: Discrete inverse theory, Academic Press, International Geophysical series, Vol. 45, 3rd Edition. MATLAB Edition
- Sen, M.K., Global Optimization Methods in Geophysical Inversion. Second Edition.

4.2. Reference Books:

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

5. Outcome of the course:

Knowledge on inverse theory. Knowledge on local and global optimization techniques. Knowledge on Bayesian trans-dimensional inversion. Inversion of 1D and 2D geophysical data.