Semester	AUG 2022
Open to semester	5,7,21
Course code	**EC3183/DS3143/EC6334/DS6124**
Course title	**Parameter Estimation and Inverse Theory**
Credits	3 /4
Course Coordinator & participating faculty (if any)	Rahul Dehiya
Nature of Course	Lectures
Pre-requisites	None
Objectives (goals, type of students for whom useful, outcome etc)	Objectives: • This course is intended to discuss fundamental concepts of inverse modeling and to enable the students to formulate and solve inverse problems. Outcomes: At the end of this course, a student would: • Formulate an inverse problem, understand the impact of noise on an inverted model, learn about uncertainties associated with the inverted model and limitations of inverse modeling.
Course contents (details of topics /sections with no. of lectures for each)	1. Introduction: Introduction to forward and inverse problem, Linear and non-linear inverse problem, Application of inverse theory in different areas of science and engineering 2. Brief revision of linear algebra: Linear vector space, linear combination, linear independence, basis and dimension of a vector space, functional, norms and normed vector space. 3. Ill posed problems: Well posed and ill posed problems, underdetermined, overdetermined and mix-determined systems. 4. Solution of linear inverse problems: Least square solution, minimum norm solution, maximum likelihood method, Tikhonov regularization method, estimation of trade-off parameter using L-curve and generalized cross validation (GCV) method, Model and data resolution, Backus-Gilbert

	method 5. Singular value decomposition: Singular value decomposition, singular value and singular vector, Moore-Penrose generalized inverse, truncated singular value decomposition method, Impact of noise on inverted model, Relation between singular value decomposition and Tikhonov regularization method 6. Non-linear inverse problem: Solution of non-linear inverse problem using quasi-linear methods, Gradient, sensitivity (Jacobian) matrix and Hessian matrix, Newtons method, Gauss-Newton method, Quasi-Newton method, Levenberg-Marquardt algorithm, steepest decent method 7. Global optimization techniques: Introduction to stochastic inversion techniques, Markov chain Monte Carlo method, Bayesian inversion, Simulating annealing, genetic algorithm Additional work for Ph.D. students : Write a forward and inverse modeling code for 1-dimensional plane-wave electromagnetic data using the techniques learned in the course.
Evaluation /assessment	End-Sem Examination-40% Mid-Sem Examination-30% Others-30%
Suggested readings (with full list of authors, publisher, year, edn etc.)	1. Geophysical Data Analysis: Discrete Inverse Theory MATLAB Edition, (2012), by Menke W, Academic Press. 2. Inverse Problem Theory, (2005), by Tarantola, A., SIAM Publication. 3. Parameter Estimation and Inverse Problems, (2018), by Aster Richard C., Brian Borchers and Clifford H. Thurber, Elsevier.