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IIT ISM INDIAN INSTITUTE OF TECHNOLOGY INDIAN SCHOOL OF MINES DHANBAD

Legacy that Inspires the Future

Course ID: 2414024

Ref. No.: GIAN/S-24-25/188 Dated: 22-11-2024

One Week GIAN Course On

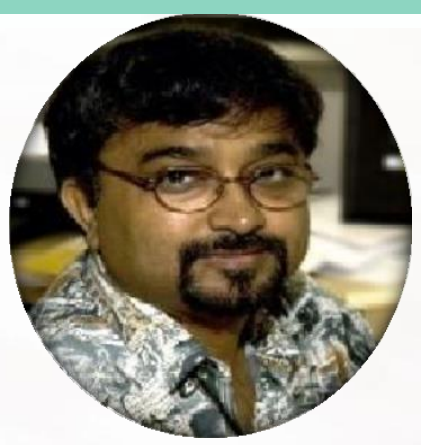
Inverse Methods and Machine Learning: Applications in Geosciences

Last Date for Registration June 16, 2025

EDC, IIT(ISM) Dhanbad

June 23 – 27, 2025

Foreign Faculty: Prof. Mrinal K. Sen



Name: Prof. Mrinal K. Sen
Designation: Professor
Department: Earth and Planetary Sciences and Institute for Geophysics
University/Institute: University of Texas at Austin, Austin, TX, USA
Email: mrinal@utexas.edu
Phone: +15124710466

Mrinal K. Sen is a professor of Geophysics at the Department of Earth and Planetary Sciences and the Institute for Geophysics at the University of Texas at Austin He also holds the Shell Companies Foundation Centennial distinguished Chair in Geophysics. During 2013 and 2014, Prof. Sen served as the director of the National Geophysical Research Institute, Hyderabad, India. He received his integrated M.Sc degree from ISM Dhanbad and Ph.D. from the University of Hawaii at Manoa, USA, in 1987. Prof. Sen is known internationally for his work on theoretical and computational seismology, and geophysical inversion. He has published over 200 peer-reviewed journal papers and two books on Geophysical Inversion. He has received many awards including the Honorary membership of the Society of Exploration Geophysicists (SEG) "for extraordinary contributions as a geophysicist, educator, and author", the 'Joseph C. Walter award for research excellence, the 'distinguished educator award' at the University of Texas, Decennial Gold Medal of the Indian Geophysical Union, the Hari Narayan Award of the Geological Society of India, and the distinguished alumnus award from ISM and the University of Hawaii at Manoa. He is the recipient of the 2018 Virgil Kauffman gold medal of the SEG for making significant advancements in the sciences of exploration geophysics in the last five years. His recent works include: uncertainty quantification using trans-dimensional Hamiltonian Monte Carlo methods, error analysis of finite difference and finite element methods, and Physics-based machine learning for seismic data analysis. He is the SEG's 2024-25 Distinguished Instructor short course's global instructor.

National Faculty & Course Coordinator: Dr. Saumen Maiti

Name: Dr. Saumen Maiti
Designation: Associate Professor
Department: Department of Applied Geophysics
University/Institute: Indian Institute of Technology(Indian School of Mines) Dhanbad
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Saumen Maiti is an Associate Professor at Dept. of Applied Geophysics, IIT(ISM) Dhanbad**.** He did his graduation in Physics Honors from Narendrapur Rama Krishna Mission Residential College under University of Calcutta in 1999. He obtained his M. Sc. Tech in Applied Geophysics from Indian School of Mines (ISM), Dhanbad in 2002. He did his PhD in Geophysics from CSIR-National Geophysical Research Institute (NGRI)/degree awarded by Osmania University in 2009. Dr. Maiti served Central Water and Power Research Station (CWPRS), Pune during 2005-2007.He was selected for JSPS-KAGI21 Exchange Programme for East Asian Young Researchers, Kyoto University, Japan in 2009. He served Indian Institute of Geomagnetism(IIG), Mumbai as "Fellow" during 2007-2012 and was promoted there as "Reader" on January 2013. He has developed multiple linear and powerful non-linear modelling framework using Machine Learning(ML) and Artificial Intelligence (AI) that can be used for regression, prediction and classification problems in exploration geophysics/applied geophysics. He has published more than 38 research papers in international peer reviewed refereed journals. He has supervised 8 PhD students and 50 Int-M.Tech/M.Sc.Tech (AGP)/M.Tech(ESE) students. His research is sponsored by Ministry of Earth Sciences (MoES) ad Science and Engineering Research Board (SERB)/DST, Govt. of India. He is a recipient of prestigious Krishnan Gold Medal, awarded by Indian Geophysical Union (IGU) in 2013. Dr. Maiti has conducted numerous training courses and delivered lectures in national/international conference/meeting. He was a Panellist, on the Theme "*Inversion and Machine Learning Techniques for Geophysical Data*" of the VAIBHAV Summit, session V13H4S2 on 17 Oct 2020, https://vaibhav.gov.in/v11.php.

Organized by

Indian Institute of Technology (Indian School of Mines)
Dhanbad-826004 Jharkhand, INDIA
https://www.iitism.ac.in

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Course Overview:

One Week GIAN Course On

Inverse Methods and Machine Learning: Applications in Geosciences

June 23– 27, 2025

Inverse methods and machine learning are becoming increasingly popular in different branches of science and engineering, for the quantitative interpretation of spacio-temporal datasets. The application of inverse methods in geoscience for estimating subsurface structures and rock properties dates to the era of hand-held calculators. Over the years, we have witnessed rapid progress not only in the development of robust techniques for 2D/3D subsurface model building from surface/borehole/ remotely sensed data but also orders of magnitude increase in data volume.

Most of the knowledge of the Earth's interior comes from the analysis of observations acquired at the surface. Inversion and machine learning techniques are used to extract meaningful information about the earth's interior, by solving the inverse problems to fully understand the complex, interrelated processes for sub-surface characterization as well as the exploration and management of sustainable earth's resources. Such inverse problems are generally ill-posed resulting in non-unique estimates. A special mathematical framework exists that formalizes inverse problems. There are mainly two approaches: (i) deterministic and (ii) stochastic. A deterministic approach uses a greedy algorithm, which obtains an acceptable fit between observations and predictions. A regularization theory is used to address the ill-posed nature of the problem. However, regularization may introduce unrealistic smoothing. Consequently, the stochastic approach based on a probabilistic description of the inverse problem offers an attractive alternative within the Bayesian framework in which the posterior probability density function (PPD) based on prior, likelihood and scaling information is the answer to our inverse problem. The Markov Chain Monte Carlo (MCMC) samples directly form a target posterior distribution to tackle non-linear/intractable posterior integrals. The method is based on a probabilistic/random walk model and can be very slow in some applications. Faster MCMC methods such as Langevin or Hamiltonian MCMC use gradient information which can be the foundation to deal with big datasets optimization. More recently, 'Trans-dimensional' approaches to solve an inverse problem have gained popularity since it treats the number of model parameters as a variable as well. All these techniques –linear and non-linear – involve very expensive forward calculation and are necessarily specific to the particular dataset used. Moreover, because of the intractable and/or nonlinear nature of the inverse relationship between data and model parameters and to process big datasets, practitioners have also started to investigate the use of machine learning algorithms (ML) which can be used to train a system using a set of examples (input/target) in supervised mode. Once the model is trained, it can approximate any complex (nonlinear) relationship between the input and the target domains with arbitrary precession. It has evolved as the key tool for complex pattern analysis using a supervised/unsupervised learning theory for exploration and sustainable resource/energy management practices in today's world.

This course will focus on the basic concepts, theoretical background and practical applications of some of the popular inverse methods and machine learning/deep learning techniques. The foundations of inverse theory and its practices including machine learning and/or deep neural networks/clustering to recover the earth parameters/ resource parameters of systems from a set of observed data will be discussed. The course will also cover the methods of estimating uncertainty in the estimated solutions. The robustness of the algorithms in the presence of correlated/color noises in the observation/data will also be discussed. Hands-on training will be imparted to the participants so that they can use the techniques in their applications.

Objectives:

The primary objectives of the course include:

i) Exposing participants to the fundamentals of inverse theory and machine learning, and practices in geosciences.

ii) Building skill and confidence amongst the participants on the application of inversion techniques and machine learning for solving complex problems in various domains of geosciences and in decision- making for optimal use of earth resources.

iii) Providing exposure to practical problems and their solutions, through case studies and live project assignments in geophysical/seismic exploration and/or natural resource management.

iv) Enhancing the capability of the participants to formulate inverse problems, solve them using deterministic/stochastic and/or ML algorithms and quantify uncertainty in various problems in geosciences.

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Schedule

One Week GIAN Course On

Inverse Methods and Machine Learning: Applications in Geosciences

June 23– 27, 2025

Day-1	**Inaugural Function**	
	Lecture-1	**Inversion: Forward and Inverse Problems, Model and Data, Difficulties in model parameter estimation, Examples of inverse problems** Prof. Mrinal K Sen
	Lecture-2	**Matrix Inversion: Solution of Over-determined, Even -determined and Under-determined Inverse Problem, Singular Value Decomposition; Vector Space, Hilbert Space, Norms.** Dr. Saumen Maiti
	Tutorial-1	**Problem-Solving Session with Matrix Inversion in Seismology, Seismic, Gravity and Geo-Electrical Exploration.** Prof. Mrinal K Sen
Day-2	**Lecture-3**	**Inversion and Linear Algebra: Data Resolution Matrix, Model Resolution Matrix, Geophysical Inversion and Framework for Solving an Appraisal Problem. Solution of Least-Squared Inversion, Solution of Damped Least-Squared Solution, Regularization.** Dr. Saumen Maiti
	Lecture-4	**Statistical Approach: Multi-variate distributions, Probability, Bayesian approach, Prior, Likelihood and Posterior distributions.** Prof. Mrinal K Sen
	Tutorial-2	**Linear Problem-Solving Session: Gravity and Seismic Tomography; Effect of Regularization.** Prof. Mrinal K Sen
Day-3	**Lecture-5**	**Optimization Techniques: Local and Global Optimization. Local Optimization Techniques: Gradient Descent, Steepest Descent, Conjugate Gradient.** Prof. Mrinal K Sen
	Lecture-6	**Local Optimization Techniques: Gauss-Newton, Levenberg-Marquardt; Challenges for Local Optimization Approaches with Examples.** Prof. Mrinal K Sen
	Tutorial-3	**Problem-Solving Session with Local Optimization** Prof. Mrinal K Sen
Day-4	**Lecture-7**	**Global Optimization Techniques: Simulated Annealing, Very Fast Simulated Annealing, Genetic Algorithms, Markov Chain Monte Carlo (MCMC).** Prof. Mrinal K Sen
	Lecture-8	**Data-Driven Inversion: Neural Networks (NN), Bayesian Neural Networks, Support Vector Machine, Random Forest, Fuzzy Logic.** Dr. Saumen Maiti
	Tutorial-4	**Problem-Solving Session with Examples: Neural Network Inversion and Support Vector Machine of Well log, Resistivity and Gravity Data** Dr. Saumen Maiti
Day-5	**Lecture-9**	**Fundamentals of Machine Learning (ML) and Deep Learning (DL), Convolutional NN.** Prof. Mrinal K Sen
	Lecture-10	**Convolutional Neural Networks, Long-Short-Term Memory (LSTM) Network, Hybrid CNN-LSTM Networks, Autoencoder, Generative Adversarial Network (GAN).** Dr. Saumen Maiti
	Tutorial-5	**ML/DL Exercises for litho-logy clustering, Rock Type Characterization and Reservoir Parameter Forecasting, and Basement Depth Mapping using Geo-spatial Data with Bouguer Gravity Data for Resource Management.** Dr. Saumen Maiti
Day-6	**Date of Examination**	**June 28, 2025**

Who can attend?

- Executives, engineers, scientists and researchers from geosciences, applied sciences, computer sciences, and service and government organizations including R&D laboratories.
- Students at all levels (B.Tech/M.Sc./M.Sc. Tech/M.Tech/PhD) or faculty from reputed academic institutions and technical institutions.

About the Dept. of Applied Geophysics

The Department of Applied Geophysics, IIT (ISM) was established during the International Geophysical Year in 1957. Since then it has grown to be one of the premier geophysics departments in India imparting excellent teaching and research. The department of Applied Geophysics attains 50 years of existence in 2007. The department has grown in multifold and now offering three years M.Sc. Tech. and five years integrated M.Sc. Tech. in Applied Geophysics. Jointly with department of Applied Geology, a two-year M. Tech. in Petroleum Exploration is being run since 1983. The department has introduced a new M.Tech course on Earthquake disaster, Hazard and Risk Mitigation since 2015-16 academic session. In addition, it offers doctoral programme in applied geophysics. The academic programs encompass many interesting various fields of study. The department is well equipped with state of the art geophysical instruments. The department has a seismological observatory having a broadband recording facility and computational laboratory. The department has been recognized by University Grant Commission as a vibrant research centre with the support of several national programmes such as DRS I, DRS II, UGC-SAP I, II & III, and COSIST. In addition, the department has also been supported by Department of Science and Technology under its FIST programme. A large number of geophysicists from IIT (ISM) have held, and today occupy prestigious positions in national and international oil companies, R & D, and academic institutes around the world.

Important

- Participants for the course will be selected on first come first served basis.
- Lectures (2 hours daily) | Tutorials and Homework (2 hours daily).
- All the participants will be provided course certificates.
- Tutorials and homework based on Python, MatLab, and other computational tools.

Course Coordinator

Dr. Saumen Maiti

Associate Professor, Department of Applied Geophysics, Indian Institute of Technology (Indian School of Mines), Dhanbad-826004, INDIA.

Phone: 0326-223-5067, +91-9471192208 **Email**:saumen@iitism.ac.in

Local GIAN Coordinator

Prof. Sukha Ranjan Samadder

Associate Dean (Research & Development), Indian Institute of Technology (Indian School of Mines), Dhanbad-826004, INDIA.

Email: adrnd@iitism.ac.in

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About IIT(ISM) Dhanbad

One Week GIAN Course On

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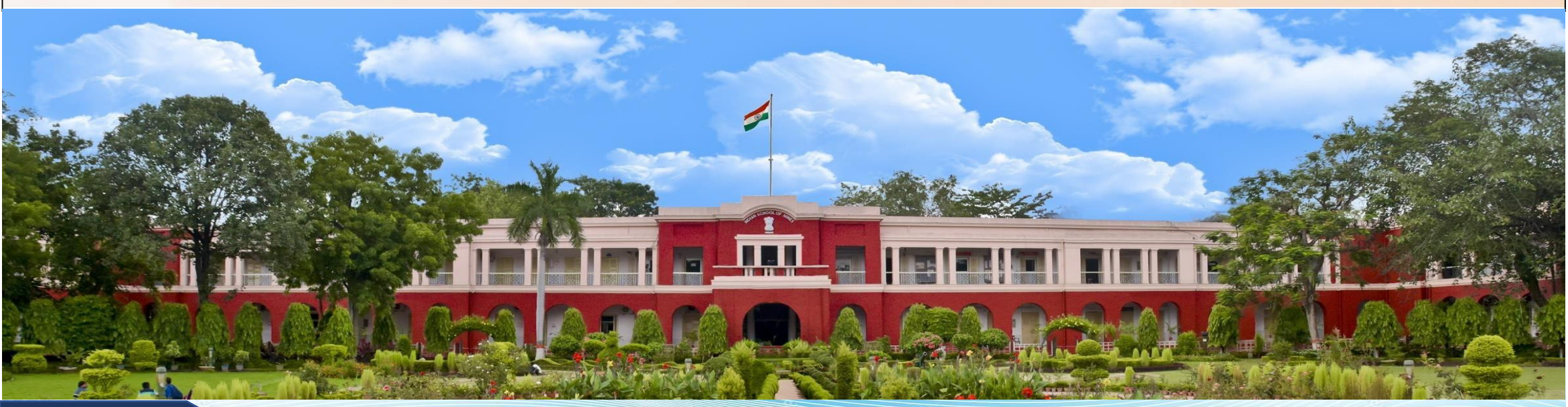
June 23–27, 2025

The Indian Institute of Technology (Indian School of Mines), Dhanbad, spans an expansive 393-acre campus in the heart of India's prime coking coal belt, about 260 km from Kolkata. Established on December 9, 1926, by Lord Irwin, the then Viceroy of India, the institution was founded to address the need for skilled professionals in mining and related fields, with a focus on disciplines such as Mining and Applied Geology. In 1967, the Indian School of Mines (ISM) gained the status of a deemed university under Section 3 of the UGC Act, 1956. Over the years, it expanded its academic scope to include core engineering disciplines, becoming a comprehensive institution of global repute for engineering, science, and management education. On September 6, 2016, the Government of India elevated ISM to the status of an Indian Institute of Technology (IIT), renaming it the Indian Institute of Technology (Indian School of Mines), Dhanbad. A fully residential campus with world-class facilities, IIT(ISM) Dhanbad offers a diverse range of academic programs. These include B.Tech. (4 years) courses across 12 major engineering disciplines, integrated M.Tech. (5 years) programs in Applied Geology, Applied Geophysics, and Mathematics & Computing, as well as M.Tech., M.Sc., M.Sc. Tech, MBA, and Ph.D. programs. The institute has made significant contributions to India's growth in mining, mineral exploration, petroleum, and groundwater sectors, solidifying its position as a premier technological institute.



Course Fee

S. No.	Category	Amount (including GST)
1.	Students – B.Tech., B.A., B.Sc., M.Tech., M.A., M.Sc., Integrated M.Sc., M.Sc. (Tech.)	₹ 1,180/-
2.	Research Scholars, Post doctoral Fellows	₹ 3,540/-
3.	Faculty and Teachers from Academic Institutions (Public and Private)	₹ 11,800/-
4.	Participants from industry/Research organizations (Public and Private)	₹ 23,600/-
5.	Students (Foreign)	US $ 350
6.	Industry Sponsors	₹ 35,400/-

Bank Details

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Account No.: 0986101009746

IFSC Code : CNRB0000986

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31012626009746@cnrb

- **Number of Seats are limited to 50 only.**
- **Last date for registration is 16th June 2025.**
- **All registered participants must fill out this google form**:

Google Form Link: https://docs.google.com/forms/d/1pUoQfj_cZOi53e5jfQp-846_ScrYh3iKBrViyPL6W3Y/edit

Accommodation

Details	Charges (including GST)
IIT (ISM) Guest House: A/C room on twin sharing basis per day (Exclusive of food)	₹ 672/
Hostel: (Non-A/C room on twin sharing basis per day) (Exclusive of food)	₹ 236/-

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Course ID: 2414024 **One Week GIAN Course On**

Inverse Methods and Machine Learning: Applications in Geosciences

Ref. No.: GIAN/S-24-25/188 Dated: 22-11-2024

Registration cum Accommodation Request Form

Name (Capital Letters): .....Gender (M/F) :.....

Qualification:.....Designation:.....

Category (Faculty/Scientist/Engineer/Officer/Industry Executive/Scholar/Student): .....

Organisation: .....

Mailing Address with PIN Code: .....

.....

Contact Details : Off :..... Res : .....

Mobile : ..... Email: .....

Payment : .....DD No. : .....Date : .....

Signature & Date

DD in favour of **"Registrar, Indian Institute of Technology (ISM), Dhanbad"** payable at CANARA BANK, Saraidhela Branch, Dhanbad. (IFSC:CNRB0000986). **SB Account No: 0986101009746 OR NEFT/RTGS** (Please furnish the full details if NEFT/RTGS like Name of Account Holder, UTR No./Transaction ID, Name of Bank and Branch, Date and Amount of payment).

IIT (ISM) Guest House / Hostel accommodation required: YES / NO (on payment basis)

Accommodation Charges on Sharing Basis (Exclusive of Food) :

- ₹ 672/- per day in IIT(ISM) Guest House
- ₹ 236/- per day in Hostel .

Send filled form to :

Dr. Saumen Maiti, Associate Professor, 5th Floor New Academic Complex, Department of Applied Geophysics, Indian Institute of Technology (Indian School of Mines), Dhanbad-826004, INDIA.
Email the scanned copy of the filled form to: saumen@iitism.ac.in

Last Date of Registration: June 16, 2025