ENGINEERING SCIENCES

Programme Code: ENGG00

Programme Outcome:

The PGD course undertaken by officers of the geophysics discipline of the Atomic Minerals Directorate for Exploration and Research (AMD) is designed to strengthen research and development capabilities in the exploration of strategic and critical minerals required for the country's nuclear power program. Through intensive academic training and field-based research, officers develop advanced knowledge in geophysical exploration techniques related to uranium, beach sand minerlas and rare earth and rare elements.

During the one-year training at the Training School, officers gain hands-on experience in modern geophysical methods, data acquisition systems, and advanced data processing tools and techniques. They are trained to identify and formulate geological research problems relevant to mineral exploration using geophysical approaches. Under the guidance of senior officers, each M. Tech candidate undertakes an independent research project involving detailed literature review, identification of knowledge gaps, and systematic planning of field investigations using appropriate geophysical methods.

Officers carry out geological and geophysical fieldwork both independently and as part of teams, which includes systematic acquisition of geophysical data from field areas. The acquired data are subsequently processed using advanced software tools and techniques to map subsurface geological features. The processed datasets are further interpreted through 2D and 3D modelling to generate realistic representations of subsurface structures and mineralization. These models are constrained and integrated with geological, geochemical, radiometric data, and laboratory results to develop comprehensive interpretations that effectively guide exploration programmes. The M. Tech training thus equips officers with the ability to synthesize multidisciplinary datasets and generate reliable exploration targets.

Overall, the outcome of the M. Tech programme is the development of highly skilled officers capable of conducting scientific research, applying advanced geophysical exploration techniques, and contributing effectively to the discovery and evaluation of uranium and other strategic mineral resources, thereby supporting AMD's national objectives.

DETAILED COURSE STRUCTURE

NUCLEAR GEOPHYSICS MODULE					
Sr. No	**Subject Title**	**Course Code**	**Hours**	**Credits**	**Marks**
1	Nuclear Physics	NG-101	45 (30L+15P)	3	150
2	Geology for Geophysicists	NG-103	45	3	150
3	Nuclear Reactors and Fuel Cycle	NG-104	30	2	100
4	Remote Sensing and GIS	NG-201	50 (30L+20P)	3	150
5	Airborne Geophysics	NG-202	45 (30L+15P)	3	150
Nuclear Geophysics Module total			215	14	700

Core Geophysics Module					
Sr. No	**Subject Title**	**Course Code**	**Hours**	**Credits**	**Marks**
1	Theory of fields	GP-101	20	1	75
2	Computational Geophysics	GP-102	45	3	150
3	Gravity and Magnetic Methods	GP-103	40	3	150
4	Electrical Methods	GP-104	25	1	75
5	Surveying	GP-105	15	1	50
6	Electro Magnetic Methods	GP-201	25	1	75
7	Seismic Methods	GP-202	25	1	75
8	Signal processing and Inversion techniques	GP-203	45	3	150
9	Well logging Techniques	GP-204	30	2	100
10	Geophysical Data Processing	GP-205	70	4	150
11	Digital Electronics and Microprocessors	GP-206	15	1	50
12	Field Training (10 weeks)	GL-301	10 weeks	6	400
13	Seminar	GL-302	4 days	2	100
14	Internal Assessment	GL-303			100
Core Geophysics Module total			335	29	1700

Theory: 15 hours = 1 credit;

Practical: 30 hours = 1 credit

NUCLEAR GEOPHYSICS MODULE COORDINATOR

Chief Coordinators:

Dr. V Ramesh Babu: headbarcts.amd@gov.in

Course	Coordinators* Shri/Dr	Contact
Nuclear Physics	R. B. Bhaskara Rao	balabhaskararao.amd@gov.in
Basic Geology for Geophysicist	Chanchal Sarbajna	chanchal.amd@gov.in
Nuclear Reactors and Fuel Cycle	R. B. Bhaskara Rao	balabhaskararao.amd@gov.in
Remote sensing and GIS	Shailesh Tripathi	stripathi.amd@gov.in
Airborne Geophysics	Shailesh Tripathi	stripathi.amd@gov.in

CORE GEOPHYSICS MODULE COORDINATOR

Course	Coordinators* Shri/Dr	Contact
Theory of fields	Vibhore Shrivastava	Vibhore.amd@gov.in
Computational Geophysics	Indresh Kumar	Indreshkumar.amd@gov.in
Gravity and Magnetic Methods	Srinivasulu	Srinivasulu.amd@gov.in
Electrical Methods	B. Srinivasa Rao	bsrinivasrao.amd@gov.in
Surveying	Rajesh Kumar Singh	rksingh.amd@gov.in
Electro Magnetic Techniques	M. Satyanarayana	msatyanarayana.amd@gov.in
Seismic Methods	S. Vijay Kumar	vijays.amd@gov.in
Signal Processing and Inversion techniques	Virendra Singh	virendrasingh.amd@gov.in
Well logging Techniques	Dr. H. A. Khan	habibalikhan.amd@gov.in
Geophysical Data Processing (Lab)	Y Sivakrishna	sivakrishna.amd@gov.in
Digital Electronics and Microprocessors	D. U. Jiwane	jiwane.amd@gov.in
Field Project Module	B Shankaraiah	shankar.amd@gov.in
Seminars	Dr. V. Ramesh Babu	rameshbabu.amd@gov.in
Internal Assessment	Mrs Madhavi Shankar	svmadhavi.amd@gov.in

NUCLEAR GEOPHYSICS MODULE

NG-101: Nuclear Physics (45 Lecture Hrs)

Coordinators: R. B. Bhaskara Rao
(balabhaskararao.amd@gov.in)

Course Details:

- **Nuclear Physics**
  - Structure of nucleus - Atom, Electron, Proton and Neutron, the Proton-Electron hypothesis of the constitution of the nucleus, Proton-Neutron hypothesis.
  - Magnetic and Electric property of the Nucleus.
  - Additional Properties of Atomic Nucleus.
  - Natural Radioactivity - Basic theory of Radioactive disintegration, disintegration constant, Half-life, Mean-life, Units of Radioactivity.
  - Alpha decay - Velocity and Energy of Alpha Particle, Absorption of Alpha Particle, Range, Ionization and Stopping Power, Range-Energy curve, Nuclear Energy Levels and the Theory of Alpha Decay.
  - Beta decay - Velocity and Energy of Beta Particle, Absorption of Beta Particle, Range, Ionization and Stopping Power, Range-Energy curve, Nuclear Energy Levels and the Theory of Beta Decay, Symmetry law and Non-conservation of parity in Beta Decay .
  - Gamma decay - Gamma decay, Internal Conversion, Nuclear energy levels theory, Absorption of gamma ray with matter; Interaction of radiation with matter - Interaction of charged particles, Interaction of gamma rays: Photoelectric effect, Compton scattering, Electron-Positron pair-production.
  - Natural decay series - Uranium Series, Thorium Series, and Actinium Series.
  - Radioactive growth and decay: Mathematical explanation of growth and decay curve.
  - Radioactive equilibrium and Disequilibrium: Secular Equilibrium, Transient Equilibrium, Ideal Equilibrium.
  - Counting statistics: Explanation of Binomial Distribution, Poisson Distribution and Gaussian Distribution.
  - Propagation of errors; Artificial radioactivity: Explanation of Induced Radioactivity, Radioactivity cross-section.
- **Radiation detection and measurement**
  - General properties of detectors - Efficiency, Resolution, Dead time of the detectors.
  - Gaseous detectors - Ionization Chamber, Proportional Counter, Geiger-Muller Detector etc.
  - Scintillation detectors: The basic function of a scintillation detectors, photo multiplier tube and its function; Various types of Scintillation detectors, Detection mechanism of NaI(Tl).
  - Semiconductor detectors: The Basic principle of Semiconductor Detector, Energy Gap, Various types of semiconductor detectors and its principles, Resolution, Fano factor;
  - Neutron detectors: Slow and Fast Neutron detection methods, Nuclear Reaction of Interest in Neutron Detection, Counters based on Neutron Moderation.
  - Other detectors - Explanation of Cherenkov Detectors, Photographic Emulsions, Thermoluminescent Dosimeters, Track Etch Detectors etc.
  - Alpha spectrometry and its application in uranium exploration programme.
  - He emanometry
  - Neutron logging and it’s advantage over gamma ray logging.
- **Practicals**
  - **Gamma ray spectrometry**
    - Estimation of Ra(eq), ThO_2 & %K by gamma ray spectrometry.

- Beta-Gamma technique : Explanation and practice of technique used for the estimation of U3O8 in the sample
- Gamma ray logging & core analysis :
- Explanation and practice of technique used for Gamma ray logging
- Shielded Probe Logging and analysis of core samples

- **Instrumental Neutron Activation Analysis (INAA)**
  Principle and operation of Instrumental Neutorn Activation Analysis (INAA), Radiochemical Neutorn Activation Analysis (RNAA)
- **Radon Emanometry**
  Methods for the measurement of Radon in water samples.

Course Outcomes:

This course enables students to understand the structure and properties of atomic nuclei, radioactive decay processes, and radiation interactions with matter. It also develops practical skills in radiation detection, measurement techniques, and statistical analysis through laboratory experiments. Students gain hands-on experience in gamma spectrometry, neutron activation analysis, radon emanometry, gamma ray logging, and core assay for geological and environmental applications.

References:

1. Radiation Detection and measurement – By G.F.Knoll.
2. Nuclear Physics- By D.C.Tayal.
3. The Atomic Nucleus- By R.D.Evans.
4. Measurement and Detection of Radiation- By N. Tsoulfanidis.
5. Nuclear Physics -by Irving Keplan
6. Practical Gamma-Ray Spectrometry – by Gordon R. Gilmore
7. Radioactivity in Geology: Principles and applications –by E M Durrance
8. Nuclear radiation detectors – by S. S. Kapoor

NG-103: Geology for Geophysicists (45 Lecture Hrs)

Coordinators: Chanchal Sarbajna
(chanchal.amd@gov.in)

Course Details:

- **Introduction to geology**
  - The origin, and internal structure of Earth
  - Composition of crust mantle and core
  - Geomorphic processes and sedimentation
  - Orogenic processes, and mountain building activity
  - Volcanism
- **Dynamic of Earth**
  - Continental Drift and theory of plate tectonics.
  - Different type of plate margins and association of metallic deposits in different tectonic settings
- **Introduction to minerals and major rock types**
  - Major rock forming silicates and common ore minerals
  - Formation and classification of igneous rocks
  - Primary igneous structures
  - Sedimentary rocks and their structures
  - Metamorphism, Metamorphic facies and Grade
- **Structural Geology**
  - Primary structural elements and their attitude
  - Classification and types of Folds
  - Classification and types of Faults, and Joints
  - Unconformities and criteria of recognition
  - Shear Zones
- **Principles of Stratigraphy and Elements of Indian Stratigraphy**
  - Geological Time Scale
  - Correlation and Geochronology
  - Indian Precambrian shield areas, important Phanerozoic successions and Himalayan geology
- **Introduction ore Forming processes and mode of occurrences of common ore deposits**
  - Introduction to ore geology, classification and ore forming processes
  - Classification of ore deposit. Epigenetic and syngenetic deposits
  - Orthomagmatic processes and examples of orthomagmatic deposits
  - Classification of Pegmatites and pegmatitic deposition.
  - Skarn and deposit of lateral secretion
  - Hydrothermal deposits, forms and classification
  - Hydrothermal processes. Examples of modern ore solutions, aquous transport of metals and deposition of metals from ore solution, meteoric and juvenile solutions and their discrimination
  - Weathering, Supergene enrichment and residual deposits
  - Sedimentary deposits, deposits formed by mechanical transport and by chemical precipitation, Eh-pH diagram
  - Metamorphic and metamorphosed ore deposits
  - Ore mineralization through geological time with Indian examples
- **Uranium Geology**

    - Distribution and time bound characters of uranium
    - Control of uranium mineralization and uranium ore minerals
    - Spatial and temporal characters of uranium deposits and classifications
    - Types of uranium deposits with Indian examples
    - Utilization of Geophysical parameters for exploration of different types of uranium deposits
- **Practicals and Tutorials**
    - Identification and interpretation of geological features in topographic maps
    - Identification and interpretation of structural elements in geological maps: Faults, folds, unconformities
    - Stereographic plotting of planes and lines
    - Construction of geological cross-sections, stratum contours and isopach maps.
    - Identification and description of hand specimens of common silicate minerals, Common igneous, sedimentary and metamorphic rocks, common sulphides and oxides ore minerals and economic rocks
    - Introduction to optical identification of minerals

Course Outcomes:

This course provides a strong foundation to the students in geological principles, rock types, structural geology, stratigraphy, and ore-forming processes relevant to geophysical applications. It develops skills in geological interpretation, mineral identification, and map analysis. Students gain practical understanding of uranium geology and its exploration using integrated geological and geophysical approaches.

References:

1. Anthony M. Evans, An Introduction to Ore Geology Oxford Blackwell Scientific Publication, London, 1980.

2. Guilbert, J.M.and Park, C.F.Geology of Ore Deposits, Freeman, W.H, 1986.

3. Jensen M.L. and Bateman, A.L. Economic Mineral Deposits, Wiley, 1979. B.J.Skinner, and S.C.Porter, The Dynamic Earth – An introduction to Physical Geology, Wiley, 1989.

4. G.W. Tyrrel, The Principles of Petrology: An introduction to science of rocks, BI Publications, India. 1985.

5.Maurice E. Tucker. Sedimentary Petrology- An Introduction, Oxford Blackwell Scientific Publication, London, 1981.

6. P.D. Duff, (Ed). Holmes, Principles of Physical Geology, 4th Edition. ELBS, 1992.

8. H.H.Read, and J.Watson, Introduction to Geology I and II. Macmillan, 1978.

9. G.H.Davies, Structural geology of rocks and regions, Wiley, New York, 1996.

10. Anthony Philpotts, An Introduction to Igneous and metamorphic Petrology, Willey Publication, 1990.

NG-104: Nuclear Reactors and Fuel Cycle (30 Lecture Hrs)

Coordinators: B. Bhaskara Rao
(balabhaskararao.amd@gov.in)

Course Details:

- **Introduction**
  The need for nuclear energy, power scenario in India, Atomic Energy establishments in India and programmes of DAE.
- **Nuclear reactor theory and types of reactors**
  - The Neutron-Nuclei interactions , introduction to neutron cross sections, Neutron flux, Mean free path
  - Scientific fundamentals of fission and fusion processes and resultant release of energy.
  - Fission cross-section, Fertile and Fissile Nuclear fuel, Conversion and Breeding,The fission products and energy distribution in the fission products .Prompt and delayed neutrons.
  - The Neutron Energy spectrum, Neutron life cycle in a reactor, Multiplication of neutrons and chain reaction, Criticality
  - Nuclear Reactor structure and function of the components, Moderator, Coolant
  - Types of Nuclear Fission Reactors, Typical reactor control system, Steady and dynamic behavior of reactors.
  - Shielding, Fuel Burnup, Safety systems in nuclear power plants.
  - Introduction to fusion reactors,
- **Nuclear Fuel Cycle**
  - Overview of the Nuclear fuel cycle, Mining, milling, purification and conversion of uranium, Uranium enrichment
  - Nuclear fuel cycle options for PHWR, BWR, PWR and FBR: Nuclear materials, Nuclear fuel cycle in India, specifications of fuel, Quality management in Nuclear application
  - Transport and storage of irradiated fuel, Reprocessing of spent nuclear fuel, Recycling of uranium and plutonium
- **Radioactive Waste management**
  Classifications of radioactive waste, nuclear waste disposal technologies, Selection criteria for repositories, Properties of geological repositories
- **Radiation Safety**
  Industrial, Medical, Agriculture, Space and other peaceful uses of Nuclear technology; Need for environmental protection, Indian legislation and controls related to environment, Environmental impact assessment clearances related to setting up of a nuclear power plant and its operation, Environment survey requirements, Remedial measures and preventive measures.
- **Environmental issues**
  Need for environmental protection, Indian legislation and controls related to environment, environmental impact assessment clearances related to setting up of a nuclear power plant and its operation, Environment survey requirements, Remedial measures and preventative measures, **Tailing Ponds and its management.**

Course Outcomes:

This course imparts knowledge of nuclear reactor physics, reactor systems, and neutron behavior. It introduces the stages of the nuclear fuel cycle, radioactive waste management, and radiation safety practices. Students also develop awareness of environmental protection measures, regulatory frameworks, and safety standards in nuclear power generation.

References:

1. P.D. Wilson (Editor) 1996, The Nuclear Fuel Cycle from Ore to Wastes, Oxford University Press.
2. C.K. Gupta (1989) Materials in Nuclear Energy Applications, volume 1 & 2, CRC Press, Inc. USA.
3. D. Bhaskar Rao (Editor) 2001, Nuclear Materials Issues and Concerns, Volume 1 & 2, Discovery Publishing House, New Delhi.
4. Lawrence Berkeley National Laboratory, university of California, Geological Problems in Radioactive Waste isolation; A World Wide Review (Proc. 28th Int. Geological Congr. Washington, DC, 1989), Lawrence Berkeley Natl Lab. Berkeley, CA (1991).
5. International Atomic Energy Agency, Radioactive Waste Management: An IAEA Source Book, IAEA, Vienna (1992)
6. Nuclear Reactor Engineering: Reactor Systems Engineering. by Samuel Glasstone and Alexander Sesonske, CBS Publishers & Distributors Pvt. Ltd.
7. Atomic Energy (Radiation Protection) Rules 2004.
8. Guidelines/Codes of Atomic Energy Regulatory Board. www.aerb.gov.in
9. Encyclopedia of Occupational Health and Safety (Part–II) – International Labour Office.
10. Handbook of Laboratory Safety- Norman V. Steere
11. Radiation Protection in the Health Sciences- Marilyn E. Noz, Gerald Q. Maguire Jr.

NG-201: Remote Sensing and GIS (50 Lecture Hrs)

Coordinators: Shailesh Trpathi
(stripathi.amd@gov.in)

Course Details:

- **Introduction**
  - Fundamental concepts of Remote Sensing – Electromagnetic Spectrum, Energies available for sensing, Interaction of EMR with the atmosphere and terrain features
  - Mineral and Rock spectra. Application of energy bands for Geological studies
- **Imaging systems and sensors**
  - Sensors in space today- Radiometric, Spectral and Spatial resolutions
  - Selection of spectral and spatial resolutions for different geological themes
  - Identification of the satellite data product, product codes, browsing of quality, product availability and procurement procedure
- **Elements of remote sensing and data interpretation**
  - Fundamentals of image interpretation and geological applications-Tone, Texture, Drainage patterns and anomalies, colour, size and Object to background relationship
  - Applications of geomorphology. Lithological and structural interpretation from satellite data
  - Aerial Photo interpretation, Stereo pairs and geological mapping using aerial photographs
  - Fundamentals of Thermal Remote Sensing, Microwave Remote Sensing and Hyperspectral Remote sensing
- **Digital image processing**
  - Objective of Digital Image Processing, Georectification, Image mosaicing
  - Image enhancement: Single band enhancement - Contrast stretching – Linear contrast stretching, Multiple linear stretching, Logarithmic or functional stretching, Gaussian stretching, Histogram equalization stretching and Density slicing
  - Application of stretching techniques for geological interpretation and for anomaly zone extraction from airborne radiometric images; Edge enhancement – Anisotropic Kernels (Linear edge), Gradiant image (1st Derivative), Laplacian image (2nd Derivative), Image smoothening
  - Application of different edge enhancements to radiometric images; multiple image enhancement - Addition and substration of images, Principle Component Transformation, Image ratioing.
  - Application of these transformations for geological and radiometric interpretation; Spectral and spatial resolution merging – different methods, and its application to geological studies
- **Digital Image classification**
  Supervised classification, unsupervised classification, Application of classification for geological studies
- **Geographical Information Systems (GIS)**
  - Introduction to GIS, Basic map concepts and Data layer generation, Topology building and Attribute Table generation
  - Getting spatial data into GIS and making spatial data usable
  - Getting attribute table in GIS and making it Linked and usable
  - Defining real world coordinate system and Map projections to multi-coverage database
  - Performing GIS analysis – Spatial operation, generating buffers, manipulating spatial features, polygon overlay and tabular analysis
  - Integration of geospatial datasets, thematic mapping, geological model based integration for target delineation. Generation of mineral potential map with concept and case studies

- **Geo-modelling**
  - Introduction, principles of various modelling techniques in mineral exploration; concepts of mathematical modelling
  - Vector and Raster geographical information system
  - Geological, geophysical and geochemical data used in modelling
  - Presentation of case study- nature of data, grid file generation, interpolation algorithms, validation of surface fitting, mathematical equations of trend surface, estimation of parameters of surface equations, goodness of fit, preparation of residual maps for variables and uranium accumulation trend analysis
- **Practicals**
  - Handling data products: different sensors and scale; procedure of browsing and selecting data; Interpretation of satellite data based on elements of Remote sensing - sedimentary, Igneous and Metamorphic terrain; Interpretation of structural features.
  - Digital Image Processing: Georectification and Mosaicing; contrast stretching, edge enhancement, multiple image enhancements, Merging images, and image classification, using both satellite and radiometric data.
  - GIS: working on ERDAS DIPS and ArcGIS for spatial data creation; defining real world coordinate system and Map projections; working on ArcGIS for some GIS analysis; Map Presentation

Course Outcomes:

This course equips students with a strong foundation in remote sensing principles, satellite data interpretation, and digital image processing for geological applications. It develops practical skills in GIS-based spatial analysis, geospatial data integration, and mineral potential mapping. Students gain hands-on experience in satellite data processing, image classification, and geo-modelling techniques being used in both mineral exploration and other geological studies.

References:

1. Remote Sensing and Image Interpretation - Thomas M, Lillesand and Ralph, W.
2. Remote Sensing Application for Mineral Exploration - Ed.William L. Smith
3. Remote Sensing data Book – 1999 - Gareth Rees
4. Remote Sensing for Geologists – a Guide to image interpretation - Gary L. Prost (2001)
5. Remote Sensing for Earth Sciences. Ed - Andrew
6. Remote Sensing Geology - Ravi P. Gupta
7. Remote Sensing and GIS “by Basudeb Bhatta Oxford University Press

NG-202: Airborne Geophysics (45 Lecture Hrs)

Coordinators: Shailesh Trpathi
(stripathi.amd@gov.in)

Course Details:

- **Introduction**
  Application of airborne geophysical surveys in mineral exploration;Procedures for obtaining needed licences for flying in an area
- **Survey designing and implementation**
  Planning of airborne geophysical surveys - survey design, fixation of survey parameters- flight height, flight line spacing and direction, and selection of suitable geophysical methods.
- **Airborne survey instruments**
  - Magnetometer, Gravimeter, Electromagnetic system, Gamma Ray Spectrometer and their working principles. Navigational aids - DGPS, Radio altimeter, Barometer.
  - Types of platforms. Precautionary measures in flying – weak link mechanism, airworthiness of equipment.
- **Data acquisition and Quality control**
  Selection of base frequency, Sampling interval, pulse duration in case of EM methods, format of output data. Calibration procedures, Types of noise in different sets of data, Quality control, data validation.
- **Processing of AGRS, airborne magnetic and Electromagnetic data**
  - Radiometric data - Application of attenuation coefficients, stripping coefficients,
  - Magnetic data – Drift, IGRF, Heading corrections; Levelling and micro-levelling
  - Electromagnetic data – High altitude Correction, Compensation, Filtering and Levelling
- **Qualitative interpretation and Presentation of Airborne geophysical data**
  - Profiles, contour maps, images, ratio maps of U, Th, K, Ternary image of AGRS data
  - Airborne magnetic data – Derivative maps, RTP, Analytic signal, Tilt derivative
  - Airborne EM data – Time channel image maps, decay constant images
  - Processing of various image maps of radiometric, magnetic and EM data – Qualitative interpretation; Identification of structural and lithological information; Delineation of target zones
- **Quantitative Interpretation of Airborne geophysical data**
  - AGRS data - Statistical analysis and identification of target zones; Integration with geology
  - Magnetic data – Depth estimation, Spectral, Werner and Euler, 2D and 3D Modeling and inversion
  - EM data – Conductivity Depth imaging (CDI) sections, Maxwell plate modelling
  - Integrated interpretation of geological and airborne geophysical data – Identification of target areas for sub-surface exploration

Course Outcomes:

This course enables students to understand airborne geophysical survey design, instrumentation, and data acquisition techniques. It develops competence in processing, qualitative and quantitative interpretation of radiometric, magnetic, and electromagnetic datasets. Students learn to integrate geological and airborne geophysical data for accurate subsurface target delineation in mineral exploration.

References:

1. M.B. Dobrin and C.H. Savit, 1988. Introduction To Geophysical Prospecting, Mcgraw Hill.
2. L.L. Nettlton, 1976, Gravity And Magnetic In Oil Prospecting ,Mcgraw Hill
3. W.M. Telford, L.P. Geldart and R.E. Sheriff, 1990, Applied Geophysics, Cambridge University Press.
4. I.V. Radhakrishna Murthy, 1998, Gravity and Magnetic Interpretation In Exploration Geophysics, Geological Society Of India, Bangalore.

5. B.S.R. Rao And I.V. Radhakrishnal Murthy, 1978, Gravity And Magnetic Methods Of Prospecting, Arnold-Henniman Pub. Co.
6. Parasnis, D.S. 1997, Principles Of Applied Geophysics. Chapman & Hall
7. Proceedings of Exploration 97: Fourth Decennial Conference on Mineral Exploration. Toronto 1997 Ed. A.G. Gubin
8. Proceedings of Exploration 07: Fifth Decennial Conference on Mineral Exploration. Toronto 2007 Ed. B. Milkcreit
9. Proceedings of International Conference on Airborne Electromagnetics, Sydney. Exploration Geophysics Vol 29 No. 1 & 2 1998
10. Electromagnetic Methods In Applied Geophysics. Applications Ed. Misac N Nabighian, Society Of Exploration Geophysicists 1992
11. Guidelines for Radioelement Mapping Using Gamma Ray Spectrometry Data. International Atomic Energy Agency, Technical Report July 2003.

CORE GEOPHYSICS MODULE

GP-101: Theory of Fields (20 Lecture Hrs)

Coordinators: Vibhore Shrivastava
(Vibhore.amd@gov.in)

Course Details:

- **Scalars and vectors**
  Mathematical and physical fields, Continuity, Scalar and Vector fields.
- **Poisson's and Laplace equations**
  Staticfieldsinfreespace,Coulomb'slaw,Newton'slaw,Fieldintensity,linesofforce,chargedensity,Curlofvector,Stoke'stheorem,Gauss'slaw,Gauss'sdivergencetheorem,Poisson'sandLaplace'sequations,Electricaldipole, Doublelayer.
- **Harmonic functions & Green's theorem**
  Natureofconductorsanddielectrics,Harmonicfunctions,orthogonalcurvilinear,sphericalandcylindricalco-ordinates,Methodofimages,Green'stheorem,Green'sfunction,Green'sequivalentstratum,DirichletandNeumannproblems
- **Electric fields**
  Electric fields in conductors, Ohm's law in integral and differential forms. Conductive current and displacement current, equation of continuity. Relation between resistance and capacitance.
- **Magnetic fields**
  Magneticfields,Magneticflux,Magneticvectorpotential,Inductioninmagneticmedia,Relationbetweengravityandmagneticpotentials.TheH-field,magneticsusceptibilityandpermeability,boundaryconductions,feeromagnetism,magneticpoles,magneticscalarpotential.
- **Electromagnetic induction**
  Electromagneticinduction.Lawsofinduction,Electricandmagneticenergydensities,displacementcurrents,Poynting'stheoremMaxwell'sequationsandelectromagneticwaves.Thewaveequation,thewavesinconductingmedia,vectorandscalarpotentialsofanelectromagneticfield.Electromagneticradiationfromanoscillatingdipole.

Course Outcomes:

This course builds students a strong mathematical foundation in field theory, electromagnetic theory, and potential field concepts essential for geophysics. It develops analytical skills for solving field equations and understanding electromagnetic wave propagation. Students gain the ability to apply theoretical concepts to gravity, magnetic and electrical field problems.

References:

1. V.L.S. Bhimasankaram and S.V. Seshagiri Rao, 1973, Theory of Fields, Osmania University, Hyderabad,
2. Alexander A. Kaufman, 1994, Geophysical Field Theory and Method: Gravitational, Electric and Magnetic Fields. Academic Press.

GP-102: Computational Geophysics (45 Lecture Hrs)

Coordinators: Indresh Kumar
(Indreshkumar.amd@gov.in)

Course Details:

- **Mathematical Physics**
  - VECTORS: Double & Triple integrals, application, Line integral, Green's theorem in a plane, surface integral, Divergence theorem, Stokes theorem, Laplacian differential Operators in Cylindrical & Spherical System, example problems.
  - TENSORS: Introduction, Definition, Contraction, Direct product Quotient rule, Pseudo tensors, Dual Tensors, some example problems.
- **Analytic functions:** Functions of a complex variable, Mappings Limits, theorems on Limits, continuity Derivatives, Differentiation formulas Cauchy Riemann Equations, Sufficient conditions, Cauchy–Riemann Equations in polar Form, Analytic Functions Harmonic Functions. Some example problems.
- **Residues:** The residue theorem, the principal part of a function poles quotients of Analytical functions, Evaluation of improper real integrals, improper integrals Involving Trigonometric functions, integration around Branch point.
- **Special functions:** Gamma function, The Beta function, Relation between Beta & Gamma function, Bessel function, Recurrence formulae for J(x), Expansion of J0(x) & J1(x) Values of J1/2(x), Generation function for Jn (X), some example problems.
- **Partial differential equations (Linear & nonlinear evolution equations)**
  - System of linear differential equations, matrix forms, diagonalization, exponential of matrix operators, complex and multiple eigen values, Jordan form, stability theory, inhomogeneous linear systems, approximate solutions of linear/ nonlinear systems
  - The occurrence of diffusion equation in 3D inhomogeneous and anisotropic geophysical media, Elementary solutions of diffusion equation, Boundary value problems in Cartesian, cylindrical and spherical media, Separation of variables, the theory of Green's function for diffusion equation, integral transform methods.
  - The occurrence of wave equation in 3D inhomogeneous and anisotropic geophysical media, Elementary solutions of equations equation, Boundary value problems for waves in Cartesian, cylindrical and spherical media and Separation of variables for wave propagation The theory of Green's function for wave equation, integral transform methods. Vector wave equation, Helmholtz theorem, scalar and vector potentials for waves. Variational methods in wave theory.
  - Perturbation methods for inhomogeneous and nonlinear problems, regular and singular perturbations, perturbation in Eigen value problems, method of matched asymptotic approximations, boundary layer theory, WKB theory, summation of series.
- **Finite difference methods**
  - Difference methods for hyperbolic partial differential equations- Introduction-One space dimensions – two space dimensions – First order equations – System of first order equations with examples
  - Numerical methods for elliptic partial differential equations – Introduction – Difference methods for linear boundary value problems, Definition for Convergence and stability. General second order linear equation – Equation in polar coordinates – Quasi-linear Elliptic equations.
- **Finite element methods**
  - Variation principle-Weighted residual methods-Least square method-Partition method-Galerkin method- Moment method – Collocation method – Ritz method.
  - Finite Elements – Line segment element – Triangular element – Rectangular elements with

example.

- Finite Element Error Analysis – Approximation errors – Various measures of errors – Convergence of solution – Accuracy of the solution – Eigen value problems
- Numerical integration over finite element: Ritz finite element method – Least square finite element method – Galerkin finite element method – Assembly of element equations – Application to initial and boundary value problem.

Course Outcomes:

This course has enabled students to develop strong mathematical foundations and advanced computational skills required to solve complex geophysical problems. They have gained in-depth knowledge of numerical methods, including finite difference and finite element techniques, along with a clear understanding of partial differential equations governing key geophysical processes such as heat flow, wave propagation, and potential field behavior. Students have learned to effectively translate geological problems into mathematical models and solve them using appropriate computational approaches.

Through this training, students have acquired the ability to design and implement algorithms for simulating geophysical data in 1D, 2D, and 3D domains. They have developed practical skills in handling real-world data, including discretization, stability analysis, error estimation, and convergence assessment of numerical solutions. The course has also strengthened their capability to simulate subsurface conditions, interpret geophysical responses, and integrate computational outputs with geological understanding.

As a result, students are now equipped to develop reliable numerical models, analyze and interpret simulation results, and apply modern computational techniques to address challenges in geophysical exploration, including mineral, groundwater, and energy resource investigations.

References:

1. Murray R-SPIGEL, May 1981, Advanced Calculus, McGraw Hill, International Book Company, Singapore.
2. R.V.Churchill, 1963 Fourier series and boundary value problems, McGraw Hill Koga Kusha Ltd., Tokya.
3. L.A. Pipes, 1970, Applied Mathematics for Engineers & Physicists, McGraw Hill, Koga Kusha Ltd., Tokyo.
4. B.S. Grewal, 1999, Higher Engineering Mathematics, Khanna Publishers Delhi.
5. EevinKreyszig, 1979, Advanced Engineering Mathematics, John Wiley &Sons.
6. Harry LAN, 1950, vector and Tensor Analysis, McGraw Hill, Book Company Inc., Tokyo.
7. George Arfkin, 1970, Mathematical Methods for Physicists Academic Press.
8. R.V. Churchill, J.W. Brown, R.F. Verhey, 1974, Complex variables and Applications-McGraw Hill Book Company.
9. Charles, B. Officer, 1974, Introduction to theoretical Geophysics, Springer – Verlag Publ. Comp.
10. Partial Differential Equations, I. N. Sneddon, 1970, Tata McGraw Hill, New Delhi.
11. Partial Differential Equations in Engineering Problems, K. S. Miller, 1970, Prentice Hall.
12. Carslaw HS and Jaeger JC, 1958. Conduction of heat in solids, Oxford
13. Whitham, GB, Linear and nonlinear waves, Wiley-interscience
14. Bender, CM and Orszag, SA, Advanced mathematical methods for scientist and engineers, McGrawhill
15. M.K.Jain, S., R.K. Iyengar,, R.K. Jain, Computational Methods for partial Differential Equations, Wiley Eastern Limited, New Age International Limited, New Delhi.

GP-103: Gravity and Magnetic Methods (40 Lecture Hrs)

Coordinators: Srinivasulu
(Srinivasulu.amd@gov.in)

Course Details:

- **Gravity Methods**
  - **Introduction& Principles of Gravity**
    Principles of Gravity method. Earth's gravitational field, Gravitational potential, Potential field equations, Derivatives of potential, Poisson's equation
  - **The Earth's Figure and gravity**
    Geoid, Figure of Earth, Isostacy, Geodetic measurements
  - **Gravity instruments**
    Gravity prospecting instruments: Stable and unstable gravimeters, Theory and principle of gravimeter, zerolengthspring, Superconducting gravimeter, Calibration of gravimeter
  - **Field operations**
    Ground surveys, drift correction, marine surveys, airbornegravity
  - **Gravity data processing**
    Corrections applied to gravity data;
    FreeAir, Bouguer and Isostatic anomalies, land, marine and airborne
  - **Gravity anomalies**
    Gravity anomalies due to regular bodies-Sphere, vertical and horizontal cylinders, sheet, step/fault and bodies of arbitrary shape,
  - **Interpretation**
    Simple interpretation methods using thumb rules, characteristic curves, curve matching, excess mass estimation, location of mass centre, overburden effects, maximum-depth rules.
- **Magnetic Methods**
  - **Geomagnetic field**
    Principles of Magnetic method. Geo magnetic field, Magnetic field of external and internal origin, Van Allen radiation belts, diurnal variation, magnetic storms, Dipole, non-dipole fields and their origin, Secular variation.
  - **Magnetic petro-physics and Remanent magnetization**
    Magnetic petro physics. Factors affecting magnetisation of rocks and magnetic minerals, magnetism of igneous, metamorphic and sedimentary rocks, magnetic signatures in different ore environments, Remanent magnetization
  - **Reversals of Earth's magnetic field and sea floor spreading**
    Magnetic character of continental and oceanic crusts, reversals of magnetic field, sea floor spreading and plate tectonics.
  - **Magnetometers**
    Theory and principles of magnetometers. Flux gate, Proton precision, Optical pumping and SQUID. Gradiometers. Measurement of remanence and magnetic susceptibility.
  - **Field operations and corrections**
    Ground surveys, marine surveys, airborne magnetic; diurnal correction, IGRF corrections
  - **Data processing**
    Processing of gravity and magnetic data. Regional-residual separation, graphical method, Polynomial fitting, Smoothing and enhancement techniques, wavelength filtering, matched filtering, Upward and downward continuation, derivatives, reduction to pole for magnetic data, analytical signal, susceptibility mapping,,
  - **Magnetic anomalies**
    Magnetic anomalies due to thin dyke, sheet, step/fault and bodies of arbitrary shape.

- **Depth estimates**
  Spectral analysis, Average depth estimates, Werner Deconvolution, Euler depth estimates.
- **Modeling and inversion**
  Direct and inverse methods of interpretation. Ambiguity in interpretation of data and Applications of gravity and magnetic methods in mineral application.

Course Outcomes:

During the course, students are taught the fundamental principles and practical methodologies of gravity and magnetic methods used in geophysical exploration. The teaching covers instrumentation, survey design, field data acquisition, data processing techniques, and interpretation methods. Emphasis is placed on integrating geophysical results with geological and geochemical datasets for meaningful subsurface interpretation. The course delivery is application-oriented, with examples drawn from mineral exploration activities carried out by AMD in different geological terrains. Students are trained using real field datasets during tutorial sessions, enabling them to gain hands-on experience in processing and interpretation. Live demonstrations of data acquisition are also conducted to provide practical exposure to field procedures and operational aspects.

References:

1. M.B. Dobrin and C.H. Savit, 1988. Introduction to Geophysical Prospecting, Mcgraw Hill.
2. L.L. Nettlton, 1976, Gravity And Magnetic In Oil Prospecting ,Mcgraw Hill
3. W.M. Telford, L.P. Geldart and R.E. Sheriff, 1990, Applied Geophysics, Cambridge University Press.
4. I.V. Radhakrishna Murthy, 1998, Gravity and Magnetic Interpretation in Exploration Geophysics, Geological Society of India, Bangalore.
5. B.S.R. Rao And I.V. Radhakrishna Murthy, 1978, Gravity And Magnetic Methods Of Prospecting, Arnold-Henniman Pub. Co.
6. D.S. Parasnis, 1979, Principles of Applied Geophysics, Chapman and Hall.
7. B.Bhattacharya, 1965, Two Dimensional Harmonic Analysis as a Tool for Magnetic Interpretation. Geophysics Vol. 30, Pp 829-857.
8. Paterson, N.R. And Reeves, C.V. Geophysics 1985 Applications of Gravity and Magnetic Surveys: The State Of The Art in 1985. Geophysics, Vol 50 Pp 2558-94.

GP-104: Electrical Methods (25 Lecture Hrs)

Coordinators: B. Srinivas Rao
(bsrinivasrao.amd@gov.in)

Course Details:

- **Fundamental principles**
  Electrical properties of rocks and minerals and their determinations, fundamentals of direct current flow, relationship between point and line pole potential distribution.
- **Measuring system**
  Quantities measured in various electrical methods and description of the instruments used
- **D.C. Resistivity Methods**
- True and apparent resistivity, Current flow and potential in homogenous and non-homogenous media. Potential at a plane interface, Surface potential due to horizontal beds, Effect of anisotropy and topography.
- Geo-electrical parameters- Longitudinal conductance, Transverse resistivity, longitudinal resistivity.
- Various configurations and their geometric factors, Comparison of electrode arrays,
- Principle of reciprocity, Electrode effect, Depth of investigation,
- **Resistivity Profiling and Sounding**
- Resistivity profiling and sounding. Typical profiles across contacts, dykes.
- Expressions for apparent resistivity over layered earth, Principle of equivalence and suppression, Resistivity transform and linear filter theory, Interpretation of vertical electrical sounding curves.
- Applications and case histories. Mise-a-la-masse method.
- **Self- Potential method**
  Origin & mechanism of self-potentials, field procedure, equipment, non-polarisable electrodes. Interpretation of anomalies due to simple shaped bodies.
- **Induced Polarisation method**
  a. Induced Polarisation method: IP phenomenon, electrochemical theory, over voltage, fixed layer, double layer, Faradaic and non-Faradaic paths, Warburg impedance, equivalent circuits, IP phase angle, mathematical formulation of IP response, Factors affecting IP phenomenon,
  b. Time domain, frequency domain and Spectral IP measurements and their equivalence.
  c. Complex resistivity, Cole-Cole model, Discrimination of minerals,
  d. Negative IP, Field procedure and equipment, EM and capacity coupling, Computation of theoretical IP curves, IP soundings and interpretation, Magnetic Induced Polarisation method,
  e. Field procedure and equipment, advantages, Applications and case histories.

Course Outcomes:

This course imparts students on the electrical properties of rocks and minerals, principles of direct current flow, and potential distribution in the subsurface, along with the quantities measured and instruments used in electrical geophysical surveys. They learn the fundamentals of DC resistivity, including true and apparent resistivity, current flow in homogeneous and heterogeneous media, and the effects of layering, anisotropy, and topography. The course also covers geo-electrical parameters, electrode configurations, geometric factors, depth of investigation, and principles such as reciprocity and electrode effects. Students are trained in resistivity profiling and vertical electrical sounding (VES), including interpretation of layered earth models using concepts like equivalence, suppression, and linear filter theory, as well as applications in mapping geological structures such as contacts and dykes, including the mise-à-la-masse method. Further, students are introduced to the self-potential (SP) method, its origin, field procedures, and interpretation of anomalies. The induced polarization (IP) method is covered in detail, including its electrochemical basis, time-domain and frequency-domain measurements, complex resistivity, and models such as Cole–Cole, along with advanced topics like negative IP, electromagnetic and capacitive coupling, and magnetic IP. Upon completion, students will be able to understand, design, and carry out electrical and IP surveys, process and interpret geophysical data, and confidently apply these techniques in mineral exploration and subsurface investigations

References:

1. Summer, J.S., 1976, Principles of induced polarization for geophysical exploration. Elsevier Scientific Publishing Company.
2. Telford, W.M., Geldart, L.P. and Sheriff, R.E., 1990. Applied Geophysics (second edition). Cambridge University Press.
3. M.B. Dobrin And C.H. Savit, 1988. Introduction To Geophysical Prospecting, Mcgraw Hill.
4. Parasnis, D.S. 1997, Principles of applied geophysics. Chapman & Hall
5. philipkearey, 2007, an introduction to geophysical exploration. michael brooks, ian hill blackwell.
6. proceedings of exploration 97: fourth decennialconferrence on mineral exploration. toronto 1997 ed. a.g.gubin
7. proceedings of exploration 07: fifth decennialconferrence on mineral exploration. toronto 2007 ed. b. milkcreit
8. Overvoltage research and geophysical applications. ed j.r. wait. pergamon 1959

GP-105: Surveying (15 Lecture Hrs)

Coordinators: Rajesh Kumar Singh
(rksingh.amd@gov.in)

Course Details:

- **Introduction to Surveying**
  Objective of surveying and its importance, Classification, principles of surveying, types and various applications of surveying; Field and office work; Scale of a map or plan, Study of Topo Sheets
- **Linear measurements**
  Conventional Instruments for measuring distances, ranging and chaining out of survey lines, Obstacle in chaining and errors in chaining, corrections Principles, offsets, booking field notes, problems
- **Linear measurements (EDMs)**
  Theory and characteristics of electromagnetic waves, radio waves, infrared, laser waves, principle of distance measurement with EDMs
- **Angular measurements**
  Principles and constriction of prismatic compass, bearing of lines, local attraction, magnetic declination and examples.
- **Leveling Instruments**
  Definition, different type of leveling instruments, curvatures and refraction corrections, reciprocal leveling, errors in leveling and problem solving.
- **Plane Table Surveying**
  General, Methods, Intersection, Traversing, Resection, two point problem and Three Points problem etc.
- **Theodolite**
  The essentials of transit theodolite, definition and terms, temporary adjustments, measurement of horizontal and vertical angles, different operations and sources of error, theodolite traversing, Omitted Measurements.
- **Total Station**
  Principle, working and construction, Corrections to be applied.
- **Coordinate system**
  Coordinate System in Geodesy - Geocentric Cartesian Coordinates, Topocentric Cartesian or local geodetic Cartesian Coordinates, Geodetic Coordinates, Planimetric Cartesian coordinate
- **Datums**
- Datums - Horizontal datums - Everest spheroid, WGS – 84, datum transformation; Vertical datums - Mean Sea Level, Geoid, EGM 96
- **Projection**
- Projection – Polyconic projection, Traverse Mercator projection (TM Projection), Universal Transverse Mercator Projection
- **Global Positioning System (GPS), DGPS and Mobile mapper**
  GPS & DGPS - Theory, principles, operation and applications

Course Outcomes:

The surveying course has enabled students to develop a strong foundation in surveying principles, instruments, and field techniques required for accurate spatial measurements. They have gained practical skills in distance and angle measurement, mapping, and leveling, along with hands-on experience in conducting field surveys and maintaining systematic field records. The course has also introduced them to modern techniques such as GPS-based positioning and the use of geodetic coordinate systems for precise location determination.

Students have developed the ability to prepare, analyze, and interpret topographic and engineering survey data, including map reading and scale understanding in geological exploration. They are now capable of applying appropriate surveying methods for different field conditions, identifying and minimizing errors, and integrating field observations with office computations. Overall, the course has equipped them with the essential skills required for reliable data acquisition and its application in geophysical, geological, and geospatial investigations.

References:

1. C.Venkatramaiah : Text book of Surveying, Universities Press, 1996
2. C.L.Kochhar : A Text book of Surveying
3. Dr.B.C.Punmia, Ashok Kumar, Jainand Arun Jain : Surveying, Vo.1 and II
4. Satheesh Gopi, R.Sathi Kumar, N.Madhu : Advanced Surveying: Total Station, GIS and Remote Sensing
5. Elliott D Daplan, ChiristopherJ.Hegarty : Understanding GPS; Pinciples and Applications
6. Ahmed El-Ranbbany : Introduction to GPS

GP-201: Electromagnetic Methods (25 Lecture Hrs)

Coordinators: M. Satyanarayana
(msatyanarayana.amd@gov.in)

Course Details:

- **Basic Principles and Theory**
  - Maxwell's equations, electromagnetic potential and wave equations, Boundary conditions, self and mutual inductance, electromagnetic energy and power, Poynting vector,
  - Diffusion equation and its solution, skin effect and skin depth, Reflection and transmission of electrical and magnetic fields, elliptic polarisation, amplitude and phase relations, real (in phase) and imaginary (quadrature) components

- **Source of EM waves and EM wave propagation**
  Classification of electromagnetic methods, Sources for EM waves, EM wave propagation, al, near and far fields, radiation resistance, Field due to a rectangular loop, horizontal wire, horizontal circular coil, vertical straight wire, Phasor diagram, Electric circuit analogy for an EM system. Negative screening, overburden effect, current channelling and current gathering. EM response over bodies with high magnetic permeability.
- **Frequency domain EM methods**
  Classification of electromagnetic methods, Dip angle and Turam methods, Horizontal and vertical loop EM methods, Frequency and geometric soundings, Very low frequency (VLF) method- VLF station, parameters measured, Controlled source audio magneto telluric method (CSAMT), Ground Penetrating Radar method
- **Field procedure and processing of FDEM**
  Field procedures and instruments, Processing of Turam data Interpretation of HLEM data and Turam data using standard curves. Fraser and Hjelt filters, Derivation of Current density cross section from VLF data. Processing and interpretation of CSAMT data.
- **Time Domain EM methods**
  Comparison of FDEM and TDEM methods, Survey configuration, Impulse and Step response measurements, Diffusion time, Transient EM response over confined targets, homogenous half-space, layered earth, Diffusion time, thin sheets.
- **Field procedure and processing of TDEM**
  Field procedure and equipment. Interpretation using plate model. Interpretation of sounding data over layered earth.
- **Natural source EM methods**
  - Magneto-telluric, telluric and AFMAG methods. Origin and characteristic of these fields.
  - Applications and case histories.

- **Field procedure and processing of MT data**
  Field procedure and equipment. Interpretation of the MT soundings data.

Course Outcomes:

This course has enabled students to develop an in-depth understanding of electromagnetic (EM) theory and its critical role in geophysical exploration. They have gained knowledge of the physical principles governing EM wave propagation and subsurface interactions, and have learned how these principles are applied in frequency-domain, time-domain, and natural source EM methods. The course has provided hands-on experience in data acquisition techniques, as well as in processing, modeling, and interpretation of EM datasets using modern computational approaches.

Students have developed the ability to analyze EM responses to identify variations in subsurface electrical conductivity and to delineate conductive structures with confidence. They are now capable of integrating EM data with geological information to interpret subsurface features effectively. As a result, they are well-equipped to apply EM methods in real-world scenarios, particularly in mineral exploration, groundwater investigations, and environmental and engineering studies.

References:

1. Electromagnetic Methods In Applied Geophysics. Applications Ed. Misac N Nabighian, Society Of Exploration Geophysicists 199. Vol. 1 & 2

2. M.B. Dobrin And C.H. Savit, 1988. Introduction To Geophysical Prospecting, Mcgraw Hill.

3. W.M. Telford, L.P. Geldart And R.E. Sheriff, 1990, Applied Geophysics, Cambridge University Press.

4. Philip Kearey, 2007, An Introduction To Geophysical Exploration. Michael Brooks, Ian Hill Blackwell.

5. Proceedings Of International Conference On Airborne Electromagnetics, Sydney. Exploration Geophysics Vol 29 No. 1 & 2 1998

6. Proceedings Of Exploration 97: Fourth DecennialConferrence On Mineral Exploration. Toronto 1997 Ed. A.G. Gubin

7. Proceedings Of Exploration 07: Fifth DecennialConferrence On Mineral Exploration. Toronto 2007 Ed. B. Milkcreit

8. Appliciations Of Transient Electromagnetic Techniques Technical Note Tn 7 Geonics Limited, Canada 1980

GP-202: Seismic Methods (25 Lecture Hrs)

Coordinators: S. Vijay Kumar
(vijays.amd@gov.in)

Course Details:

- **Introduction & Seismic theory**
  Introduction, role of seismic prospecting in geophysical exploration; Seismic waves and laws governing their reflection, refraction, attenuation and scattering Hooke's law, Elastic wave propagation,Wave equation, Elastic constants, Elastic waves, Huygene's and Fermat's principles, Snell's law, Reflection, refraction and diffraction from multilayered media. Factors affecting seismic wave velocities, Partition of energy at an interface, acoustic impedance, Reflection and transmission coefficients, Zoeppritz's equation,
- **Geometry of Seismic wave paths and seismic events**
  Reflection paths in a constant velocity layer, velocity gradient and ray path curvature, geometry of refraction paths; Diffractions, multiples, Surface waves, Effects of Reflector curvature, seismic noise and attenuation
- **Source of seismic energy and geophone Digital seismic recording**
  Sources of seismic energy: Explosives, impact, vibroseis and airgun and their main characteristics, recording of seismic signals, geophones and their response characteristics, principles of digital recording of seismic signals Grouping of geophones, Noise profile analysis, Source-detector arrays, Directional shooting, Instrumentation, Digital seismic recording- general lay out, pre-amplifier, filters, multiplexers, A-D converter, AGC, SEG formats. Telemetry systems.
- **Seismic Refraction method**
  Historical development and background of Refraction and Reflection methods, difference between refraction and reflection surveys. Seismic refraction method. Head wave refraction, critical angle, Time distance curves, Critical distance, Geometry of refraction paths – two layer and multilayer media. Velocity inversion/hidden layer problem, Field layouts, Fan shooting, Interpretation of refraction data – graphical and analytical approaches.
- **Seismic Reflection method**
  Seismic reflection method. Principle, Time-distance graph, Geometry of reflection paths – horizontal reflector, dipping reflector. Common depth point technique, Stacking chart and CDP diagram for normal and crooked profiles, Static corrections, NMO, Velocity analysis, Migration, Wavelet propagation, attribute analysis. Wide angle reflections. Deep seismic soundings. Field procedure
- **Seismic Data Processing**
  Demultiplex, Deconvolution and Filtering, Static Corrections, Amplitude Corrections, Dynamic Corrections, Muting, CMP stack,

- **Specialized Methods**
  3-Dmethods,Vertical Seismic Profiling, Seismic Tomography, Cross-Holemethods

Course Outcomes:

This course has enabled students to develop a strong theoretical and practical understanding of seismic wave propagation and its application in subsurface investigations. They have gained knowledge of different types of seismic waves, their behavior in various geological media, and the principles of seismic data acquisition using modern instruments and survey designs. The course has also provided training in seismic data processing techniques, including signal enhancement, noise reduction, and preparation of data for interpretation.

Students have developed skills in interpreting both seismic refraction and reflection data for accurate imaging of subsurface structures. They are now capable of identifying geological features such as layer boundaries, faults, and discontinuities, and understanding their significance in different exploration contexts. Through practical exposure, they have learned to integrate seismic results with geological information for reliable subsurface characterization. Students have gained the expertise required to apply seismic methods effectively in mineral exploration, hydrocarbon prospecting, groundwater studies, and engineering site investigations, making them well-prepared for real-world geophysical challenges.

References:

1. C.L. Liner, 2004, Elements Of 3d Seismology, Pennwell Corporation, U.S.
2. R.E. Sheriff And L.P. Geldart, 1995 Exploration Seismology, Cambridge University Press.
3. E.S. Robinson And C. Coruh, 1988. Basic Exploration Geophysics, John Wiley And Sons, New York
4. M.B. Dobrin And C.H. Savit, 1988. Introduction To Geophysical Prospecting, Mcgraw Hill.
5. Encyclopedic Dictionary Of Exploration Geophysics. Sheriff, R.E. Society Of Exploration Geophysicists, 1984.

GP-203: Signal processing and Inversion techniques (45 Lecture Hrs)

Coordinators: Virendra Singh
(virendrasingh.amd@gov.in)

Course Details:

- **Signal Processing**
  - **Introduction**
    Signals, noise and their classification, continuous and discrete signals. digitization, sampling interval and aliasing, wavelets, Z transform, linear system, Dirac delta function and impulse response of a linear system
  - **Convolution and Correlation Techniques**
    Convolution, methods for convolution, properties of convolution, autocorrelation, cross-correlation, and their applications, time domain and frequency domain concepts
  - **Integral transforms**
    1. 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, radial and angular spectra.
    2. Hankel transform and Hilbert transforms, their properties, the concept of analytic signal and its use in geophysics; the notions of instantaneous frequency and phase
  - **Digital filtering**
    Digital filtering of geophysical data, amplitude and phase response of filters, ideal and realizable low pass, high pass, band pass and notch filters; Wiener filtering, extrapolation, matched filters
  - **Weighting functions (Windows)**
    Hanning window, Hamming window and their comparison, triangular window, Bortlett window, Parren window, Denieil window, practical applications of windows.
  - **Spectral estimation**

  Power spectrum, method for calculation of power spectrum, three basic data models, Moving Average (MA) method, Maximum Entropy Method (MEM), Maximum Likelihood Method (MLM)
- **Inversion Techniques**
  - **Introduction**
    Forward and inverse problems in geophysics: definition of model, relation between model and data space, examples of forward and inverse problems; inversion
  - **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 various inverse problems in geophysics, reduction to a matrix equation, linear inverse problem, solution of inverse problem
  - **Least squares inversion**
    Steepest descent, conjugate gradients, Gauss Newton, Levenberg-Marquardt approaches, overdetermined and underdetermined problems, weighted least squares and weighted damped least squares solution model and data covariance -understanding uncertainty and resolution
  - **Regularization & Constrained inversion**
    Tikhonov regularization and Backus-Gilbert method Role of a priori information, Occam's principle.

Course Outcomes:

This course provides comprehensive understanding of signal processing, spectral analysis, and inverse problem theory in geophysics. It develops skills in digital filtering, convolution, inversion, and uncertainty analysis. Students gain the ability to process, model, and interpret complex geophysical datasets accurately.

References:

1. E.A. Robinson and S. Trietel, 1980. Geophysical signal analysis. Prentice Hall, New Jersey
2. Ronald N. Bracewell, 1999, The Fourier Transform and its applications, McGraw-Hill.
3. John F. Clearbout, 1985, Fundamentals of geophysical data processing with applications to petroleum prospecting. Blackwell Scientific Publications
4. P.S.Naidu&M.P.Mathew, Advances In Exploration Geophysics 5: Analysis Of Geophysical Fields. A Digital Signal Processing Approach. Elsiver. Amsterdam
5. Marcus Bath Spectral Analysis In Geophysics. Elsevier. Amsterdam
6. W. Menke,1989, Geophysical data analysis: discrete inverse theory, Academic Press.
7. J.A. Scales, M.I. Smith and S. Trietel, 2001, Introductory Geophysical Inverse Theory, Samizdat Press.
8. D. Gubbins, 2004, Time series analysis and inverse theory for geophysicists, Cambridge University Press.
9. Bath: Spectral analysis in geophysics
10. I. Tarantola: Inverse problem theory methods for data fitting and model parameter estimation.

GP-204: Well logging techniques (30 Lecture Hrs)

Coordinators: H. A Khan
(habibalikhan.amd@gov.in)

Course Details:

- **Objectives& Basic Concepts**
  Objective, Basic concepts in well logging, definition importance, rock composition – matrix, shale, salt, clay and fluids; porosity of rocks-classification, packing of grains, permeability – absolute, effective and relative; permeability associated with fractures and solution channels: resistivity of rocks-their dependence on salt concentration in water; relationship between permeability and porosity; resistivity index and its relation with water saturation. Archie's equation, Humble's equation, borehole environment, Principles, operational procedures, equipment, classification and application of well logging techniques
- **Self- Potential logging**
  Spontaneous Potential (SP) and Natural Gamma Ray Logs: Origin of SP; static SP and its determination, factors affecting shape and amplitude of SP curve; role of SP in formation evaluation; estimation of formation water resistivity (Rw) from SP log..
- **Natural gamma ray logging**
  Sources of natural radioactivity and gamma radiation; geochemical behaviour of potassium, thorium and uranium; radioactivity of shales and clays; simple and spectral gamma ray tool including radiation detectors; calibration of simple and spectral gamma ray tool; factors affecting gamma ray log response; depth of investigation and unwanted borehole effects in gamma log; qualitative and quantitative users of simple and spectral gamma ray log. How SP log is different from gamma ray log.
- **Density log and Neutron log**
  - Density Log: Interaction of gamma rays with matter; principle of density log; energy requirements of gamma ray sources for density log; measurement tools – single and double detector type; log characteristics – depth of investigation and bed resolution; litho-density log – principles and formation evaluation.
  - Neutron Log: interaction of neutrons with matter, neutron sources and neutron detectors, neutron moderation and principle of neutron log, neutron logging tools – single spacing type, side wall-neutron porosity probes, borehole compensated systems; corrections in porosity measurements due to the presence of shale; rock type, borehole, and cased hole; depth of investigation and source-detector spacing; calibration of logging systems. Porosity cross plots.
- **Electrical Resistivity Logs**
  - Concepts of resistivity in well logging; factors affecting the resistivity of electrolyte bearing rocks. Unfocussed Resistivity Devises: single-electrode systems and its limitations; normal and lateral resistivity tools and their limitations; factors affecting normal and lateral resistivity measurements; micro-resistivity measurements-tools, applications and limitations. Focused Resistivity Devices: principle of measurements, tools and factors influencing resistivity measurements.

- **Acoustic Logging and Induction logging**
  - Porosity Logs, acoustic Log: principles; factors affecting acoustic wave velocity; acoustic logging tools single and double receiver type tools; borehole compensated systems; cycle skipping in acoustic log; bed thickness effect on acoustic log; depth of investigation; porosity evaluation of consolidated and un compacted sandstones (clean as well as shaly) and carbonates rocks; overpressure, identification, seismic applications.
  - Induction Resistivity Measurements: principle, two-coil induction tool and its geometric factor, focusing of two coil sonde, skin effect, factors affecting induction resistivity

measurements.

- **Other logging tools**
  - Temperature and caliper logs – principles and applications. Magnetic Susceptibility Log. Nuclear Magnetic- Resonance Log. Borehole gravity.
- **Interpretation of logging data**
  - Interpretation of Well-Log Resistivity Data: Determination of water saturation (Sw) of clean formations using
    - Archie's cross-plot
    - Hingle plot
    - formation factor comparison method
    - resistivity ratio methods
    - movable hydrocarbon method: determination of water saturation of (Sw) of shaly formations.
  - Qualitative and quantitative interpretation of well logs. Determination of reservoir parameters.
  - Delineation of lithology and fractures from logs. Saline water-fresh water interface from log data.
  - Applications. Field examples.

Course Outcomes:

This course develops strong knowledge of borehole logging principles, instrumentation, and formation evaluation methods. It provides practical skills to the interpretation of electrical, nuclear, acoustic, and radioactive logs. Students gain expertise in lithological identification, porosity estimation, and reservoir characterization.

References:

1. O. Serra, 2003. Well Logging And Geology, Technip, Paris
2. O. Serra, 1984. Fundamentals of Well Log Interpretation, Elsevier.
3. R.M. Bateman, 1985, Open Hole Log Analysis And Formation Evaluation, Reidel, Dordrect.
4. G. Asquith and C. Gibson, 1982. Basic Well Log Analysis for Geologists, Academic Press, London.

GP-205: Geophysical Data Processing (70 Lecture Hrs)

Coordinators: Y Sivakrishna
(sivakrishna.amd@gov.in)

Course Details:

- **Gravity and Magnetic Methods**
  - **Forward Modeling**
    Computation of gravity and magnetic anomalies due to two dimensional and three dimensional regular shaped bodies
  - **Magnetic anomaly variation**
    Study of variation of magnetic anomaly with magnetic latitude, azimuth and dip of the body
  - **Corrections to field data and profile plotting**
    - Bouguer gravity anomaly computation Magnetic anomaly computation
    - Plotting of profile data and filtering of noise in time domain and frequency domain
  - **Gridding and 2D space domain filtering**
    - Gridding of profile data using various gridding algorithms;
    - Inverse distance, kriging, bicubic spline. Application of 2D filters in space domain
  - **Frequency domain processing**
    Fourier transform of gridded data; Spectral analysis; Computation of radially averaged spectrum; Spectral depth estimates; Regional-residual separation, upward downward continuation of data, Computation of vertical derivatives, Reductionto pole for magnetic data, amplitude of analytical signal, tilt derivative
  - **Depth estimation techniques**
    Werner deconvolution; Euler deconvolution
  - **Inversion of field data**
    Inversion of gravity and magnetic anomalies.
- **Electrical Methods**
  - **Self- Potential (SP) method**
    Plotting of SP data; Processing and computation of body parameters
  - **DC Resistivity method**
    - Plotting of Resistivity profiling data of different electrode arrays;
    - Plotting of resistivity sounding data – Double log plots – Identifying the bedrock from sounding data in field Interpretation of VES sounding data
  - **Induced Polarization method**
    - Plotting of time domain and frequency domain IP data;
    - 2D gridding of Resistivity and IP data; Delineation of lithologies and target zones Plotting of pseudo-depth sections of Resistivity and IP data
    - Inversion of IP/Resistivity pseudo-section data
- **Electromagnetic Methods**
  - **VLF-EM data**
    Current density cross sections from VLF data,
  - **TURAM and HLEM**
    Interpretation of HLEM data using master curves, Processing of Turam data and interpretation by using characteristic curves.
  - **TEM data**
    Interpretation of TEM profiles using plate mode, interpretation of TEM sounding data using inversion procedures,

- **MT and CSAMT data**
  Plotting and processing of MT and CSAMT data

- **Seismic Methods**
  - **Construction of wave fronts**
    Construction of wave fronts for two and three layer cases, Interpretation of refraction data – graphical approach (Mean minus T and Hale's methods) and analytical approach (Generalised reciprocal method).
  - **CDP diagram and stacking**
    Construction of CDP diagram and stacking chart for normal and crooked profiles. NMO correction.
  - **Seismic Refraction data**
    Interpreting seismic refraction data from literature; determining seismic velocityby X^2-T^2 method
  - **Seismic Reflection data**
    Interpreting seismic refraction data from literature; determining seismic velocity by X^2-T^2 method
  - **Processing and Interpretation of well log data**
    - Qualitative interpretation of well logs and their correlation
    - Interpretation of SP and Electrical resistivity logs Interpretation of density and magnetic susceptibility logs
    - Interpretation of radioactive logs – natural gamma, spectral, neutron and density logs
    - Delineation of Saline water-fresh water interface log data.
    - Calculation of formation factor, porosity, permeability, resistivity, fluid saturation Formation evaluation of integrated well log data
    - Applications and field examples.

Course Outcomes:

This course equips students with advanced skills in processing and interpretation of gravity, magnetic, electrical, electromagnetic, seismic, and well log data. It develops competence in filtering, inversion, modeling, and depth estimation techniques. Students gain the ability to integrate multi-disciplinary datasets for accurate subsurface characterization.

GP-206: Digital Electronics and Microprocessors (15 Lecture Hrs)

Coordinators: D. U. Jiwane
(jiwane.amd@gov.in)

Course Details:

- **Number Systems**
  Decimal, binary, octal and hexadecimal number systems, Inter conversion of decimal, binary and hexadecimal numbers, BCD numbers, BCD addition and subtraction.
- **Logic Gates & Logic Families**
  - AND, OR, NOT, NAND, NOR, and exclusive OR gates, NAND and NOR gates as universal gates.
  - TTL logic circuits (NAND and NOR gates only), comparison of TTL, ECL and CMOS.
- **Boolean Algebra**
  De Morgan's theorems, standard POS and SOP forms, min-term and max-term representation of Boolean functions, simplification of Boolean functions using K-maps (upto 4 variables).
- **Combinational Circuits**
  Half and full adders, half and full subtractors, multiplexer, demultiplexer, encoder, decoder, BCD-to-seven segment decoder
- **Flip-flops**
  R-S, J-K, master-slave and edge triggered J-K, T and D Flip-flops
- **Sequential Circuits**
  Shift registers, ring counters, ripple and synchronous counter, modulo- N counter, decade counter, digital-to-analog converter (binary weighted register and ladder types), and analog -to- digital converter (using D /A converter and comparator).
- **Digital Wave form Generator**
  Concept of timer IC 555 and its use for waveform generation (astable and monostable only).
- **OP-AMP**
  Concept and Characteristics of OP-AMP and its use as : Adder, subtractor, differentiator, integrator, logarithmic and exponential operators, inverting and non-inverting amplifiers, differential amplifier, CMRR, analog computer (for 2nd order differential equations).
- **Memories**
  Concept of Random Access Memory (RAM), static and dynamic RAM, Read Only Memory (ROM), PROM and EPROM
- **Microprocessors**
  Evolution of microprocessors, organisation, architecture and pin description of 8085 microprocessor, addressing modes and instruction set, input / output interfacing devices (8255, 8251), simple programs for addition / subtraction, developmental trends in microprocessor technology (8086, 80186, 80286, 80386, 80486 and Pentium). Intel microprocessor 8085 CPU architecture, Instruction set of 8085. Assembly language of 8085. Addressing modes and different arithmetic, logical, data transfer and other instructions with simple programs, counter and time delays, BCD arithmetic, 16-bit operations, Stack and subroutines. Interrupt structure and serial I/O, Timing diagrams of different instructions, Memory and I/O interface. Introduction to 8086 CPU, Addressing modes of 8086, Assembly language programs, Interfacing memory and I/O devices. DOS routines, Minimum and Maximum modes of 8086. Interfacing different peripherals: 8155,8255,PPI, 8254, 8279, 8257 Chips to 8085 and 8086. Introduction to 8087 Math co- processor and I/O processor. Interfacing ADC and Key board, and different types of displays.
- **Application of Microprocessors**
  Application of Microprocessors in Geophysical Instrumentation: Microprocessor based data acquisition, frequency, temperature and voltage measurements using microprocessors.

- **Practicals**
  Handling and operation of power supply, Multimeter and oscilloscope, RC Coupled amplifier, Emitter follower Logic Gates, Flip-flops, digital ICs, 555 timer, microprocessors, Experiments with IC 741 Operational amplifier.

Course Outcomes:

This course provides fundamental knowledge of digital electronics, logic circuits, microprocessors, and instrumentation systems. It develops practical skills in circuit design, programming, and data acquisition. Students gain competence in applying microprocessor-based systems for geophysical instrumentation and measurement applications.

References:

1. Millman and Halkias Electronic devices and Circuits, International student Edition, Mc Graw-Hill International Book Company, 1972.
2. D. Patranabis., Principles of industrial instrumentation.
3. W.D. Cooper, Electronic instrumentation and Measurement techniques, Prentice Hall of India Pvt. Ltd., New Delhi 1979.
4. Anthony S.Maneva, Solid state electronic circuits for Engineering Technology (McGraw – Hill, Kogakusha, Ltd., International student edition 1983.
5. Jacob Millman&Christors C, Halkias 1983 Integrated electronics, analog and digital circuits and systems. International student edition McGraw – Hill, Kogakusha Ltd
6. Malvino and Leach, Digital principles and Applications.
7. Jain : Modern Digital Electronics
8. Malvino : Digital Computer Electronics
9. Puri : Digital Electronics
10. Mathur : Introduction to Microprocessors
11. Sheth&Hebber : Microprocessors
12. Gaonkar : Microprocessors Architecture, Programming and Application
13. Ram : Microprocessors and Microcomputers
14. Gaikwad : Operational Amplifier

GL-302: Field Training (10 Weeks)

Coordinators: B Shankaraiah
(Shankar.amd@gov.in)

Course Details:

Students visited field areas to get acquainted with exploration program in AMD in different field areas viz., uranium exploration, Rare Metal and Rare Earth investigations and Beach sand minerals. As a part of Industrial tour, students visited IGCAR, Kalpakkam, BARC (V), IREL-OSCAM-Chhatrapur, UCIL, Jaduguda.

Following areas visited during the field training: Uranium Exploration at M.C. Palle, YSR Kadapa district Andhra Pradesh; Koppunuru and Sarangapalli, Guntur district; Andhra Pradesh. Basic Geophysical Exploration M.C. Palle (YSR Kadapa district, A.P.). Beach Sand Investigations (Visakhapatnam, Andhra Pradesh). Structural Geology (Singhbhum Shear Zone, Jharkhand). RMRE recovery plant at Pandikimal, Jharsuguda district, Odisha and Xenotime Recovery Plant, Siri, Chhattisgarh.

GL-302: Seminar (Two Seminar talks, one talk in each semester) (4 Days)

GL-303: Internal Assessment