ADIKAVI NANNAYA UNIVERSITY

M. Sc. Geophysics Course Structure (W.E.F. 2017-18)

Paper Code	Title of the Paper	Internal marks	External marks	Total marks	No. of Credits
Semester - I		**100**	**550**	**650**	**26**
GP101	Numerical methods and Computer programming	25	75	100	4
GP102	Basics of Geology	25	75	100	4
GP103	Physics and dynamics of the Earth	25	75	100	4
GP104	Signal processing	25	75	100	4
GP105	Numerical methods and Computer programming lab	-	50	50	2
GP106	Basic Geology lab	-	50	50	2
GP107	Physics and Dynamics of the Earth lab	-	50	50	2
GP108	Signal processing lab	-	50	50	2
GP109	Seminar presentation/Viva-Voce	-	50	50	2
Semester - II		**100**	**550**	**650**	**26**
GP201	Essentials of Geology	25	75	100	4
GP202	Principles of Remote sensing techniques	25	75	100	4
GP203	Seismology	25	75	100	4
GP204	Gravity and magnetic methods of exploration	25	75	100	4
GP205	Geology lab	-	50	100	2
GP206	Remote sensing lab	-	50	50	2
GP207	Seismology lab	-	50	50	2
GP208	Gravity and magnetic exploration lab	-	50	50	2
GP209	Seminar presentation/Viva-Voce	-	50	50	2
Semester – III		**100**	**550**	**650**	**26**
GP301	Electrical methods of Exploration	25	75	100	4
GP302	Seismic methods of Exploration	25	75	100	4
GP303	Marine geophysics	25	75	100	4
GP304	Seismic data processing and interpretation	25	75	100	4
GP305	Electrical methods of exploration lab	-	50	50	2
GP306	Seismic methods of exploration lab	-	50	50	2
GP307	Marine geophysics lab	-	50	50	2
GP308	Well logging and formation evaluation lab	-	50	50	2
GP309	Seminar presentation/Viva-Voce	-	50	50	2
Semester – IV		**100**	**550**	**650**	**26**
GP401	Electromagnetic methods of Exploration	25	75	100	4
GP402	Well logging and Formation Evaluation	25	75	100	4
GP403	Elective Paper Petroleum geology and geophysics **OR** Environmental & Groundwater Geophysics **OR** Engineering and mining Geophysics	25	75	100	4
GP404	Electromagnetic methods of exploration lab	-	50	50	2
GP405	Seismic data processing and interpretation lab	-	50	50	2
GP406	Elective paper lab	-	50	50	2
GP407	Project work (report, presentation and Viva) **				
(a)	Report	25	25	50	2
(b)	Presentation	25	25	50	2
(c)	Viva	25	25	50	2
GP408	Comprehensive Viva-Voce	-	50	50	2
	TOTAL	**400**	**2200**	**2600**	**104**

** Project work has to be carried out during the summer vacation after the first year and/or during December/January season in the second year.

ADIKAVI NANNAYA UNIVERSITY

M. Sc. Geophysics Course – I semester

101: Numerical Methods and Computer programming

Unit I: Numerical solution of algebraic and transcendental equations - methods of bisection, false position and Newton - Raphson; Interpolation - finite differences, symbolic relations, Newton's formula, Gauss' central difference formulae, Bessel's formula, Lagrange's formula, Richardson's extrapolation; Numerical differentiation - maximum and minimum of a tabulated function, cubic spline method; Numerical Integration - Trapezoidal rule, Simpson' s formulae, Romberg's integration, Weddle's formula, numerical double integration; Numerical solution of ordinary differential equations, solution by Taylor's series, Picard's method of successive approximations, methods of Euler and Runga-Kutta; Finite element methods, basic concepts, boundary and initial value problems, variational formulation, variational methods of approximation, Ritz method, finite element analysis of 1d and 2d problems.

Unit II: Solution of linear system of equations – Matrix inversion method, Gauss' elimination method, Gauss-Jordan method, Jacobi's method, Gauss Seidel method, method of factorization, Centro-symmetric equations, ill-conditioned systems, generalized inversion techniques, properties, linear inversion, non-linear inversion – incorporating prior information, parametric inversion, assessing the uncertainty in inverted models.; Principles of least squares – fitting of polynomials, normal equations, linear and non-linear curve fitting, sum of exponentials, Chebysev polynomials.

UNIT III: C-Programming: character set, delimiters, keywords, identifiers, constants, variables, rules for defining variables, data types, comma and conditional operators, arithmetic operators, relational operators, logical operators, bitwise operators, priority of operators, input and output in C, formatted and unformatted functions, library functions;

IF statement, IF…. ELSE statement, nested IF, GOTO statement, break statement, CONTINUE statement, SWITCH-CASE statement, nested switch statement, FOR statement, WHILE statement, DO-WHILE statement, arrays, working with string and standard functions.

UNIT IV: Pointers, pointer declaration, arithmetic operations with pointers, pointers and arrays, array of pointers, pointers to pointers, pointers and strings, void pointers, function definition and declaration, prototypes, types of functions, call by value and reference, functions returning more values, functions with arrays and pointers, recursion, pointer to function, storage classes.

Preprocessor directives, structures and unions, bit wise operators, files, command line arguments, dynamic memory allocation, graphics in C.

Text Books/Reference books:

1. Introductory methods of Numerical analysis by S. S. Sastry, Prentice-Hall of India, New Delhi.
2. Higher Engineering Mathematics by B. S. Grewal, Khanna Publications.
3. Numerical Methods in Engineering and Sciences by B. S. Grewal, Khanna Publications.
4. Let us C by Yashavant P. Kanetkar, BPB publications.
5. Computer basics and C programming by V. Rajaraman, Prentice-Hall of India Pvt. Ltd., New Delhi.
6. Computer oriented numerical methods by V. Rajaraman, Prentice-Hall of India Pvt. Ltd., New Delhi.

102: Basics of Geology

UNIT I: Introduction and Scope of Geology: Branches of Geology, relation with other sciences and Geophysics. Weathering and Erosion – physical, chemical and biological weathering, Geological work of wind - erosion – its products, sediment transport by wind, types of dunes. Geological work of glaciers, featured formed by glacial transportation and related features. Geological work of rivers – initial, youth, mature and old stages of river, important features formed by river action – canyons, meanders, Ox - bow lakes, flood plains, natural levees, denudation, Peni plains, monad rocks, Drainage patterns, types of deltas and process of their formation.

UNIT II: Geomorphology: Fundamental concepts of Geomorphology, principles of Geomorphology, Geomorphological features formed by geological work of mountains and mountain building activity, plate tectonics and earth quakes, seas, waves and currents of sea and their transportation. Features formed by marine erosion, deposition; Evolution of major geomorphic process in India; Study of topographic and thematic maps.

UNIT III: Physiographic divisions of ocean floor: Continental margins, abyssal plains, seamounts and guyots, aprons, submarine canyons, deep sea channels, turbidity currents and submarine sedimentation, mid oceanic ridge system and its structure, aseismic ridge systems, island arcs, trenches, hotspots and their mechanism, Coral reefs and processes of formation of coral reefs; Temperature, salinity and density of sea water, composition of sea water.

UNIT IV: Introduction to Stratigraphy: Principles of Stratigraphy and its classification, Principles of Correlation, fossils and their importance in Stratigraphy, physiographic divisions of india, Stratigraphic units of india, Geological Time Scale; Indian stratigraphy (Introduction, classification and economic importance of Archeans, Dharwars, Cuddapah, Vindhyan, Gondwana groups, Deccan traps, Siwaliks and Quaternary formations etc.)

Text Books/Reference books:

1. Introduction to Physical Geology by A. K. Datta,
2. A text book of Geology by P. K. Mukherjee, World Press.
3. Principles of Physical Geology by A. Holmes and D. L. Holmes.
4. Principles of Geomorphology by W. S. Thornbury, Wiley Eastern, New Delhi.
5. Indian geology and stratigraphy by M. S. Krishnan,
6. Geology of India by M. Ramakrishnan and R. Vaidyanadhan,
7. Historical Geology by Ravindra Kumar,

106: Basic Geology Lab:

Exercises for basic geology lab

1. Observation, drawing and description of 3D models of Rivers (3 stages), meanders, ox-bow lakes, drainage patterns and other geomorphological features.
2. Study and interpretation and description of topographic maps.
3. Study of schematic maps of sea floors from continental shelves to deep sea trenches.
4. Identification and description of various marine geomorphological features.
5. Study and mapping of various geographic divisions and stratigraphic units of India.
6. Study of Palaeogeographic maps of Cuddapah, Vindhyan, Gondwana and other important stratigraphic areas of India.

103: Physics and Dynamics of the Earth

Unit I: The Universe and the solar system: Milky Way and the solar system, modern theories about the origin of the solar system, the earth, meteorites and other planetary bodies; Age of the Earth and the Universe.

Interior of the Earth: Broad structure of the earth, Major subdivisions of the Earth – Crust (continental and oceanic), Mantle (upper and lower) and Core (outer and inner) their structures and composition, variation of density, temperature, pressure, acceleration due to gravity and elastic constants within the Earth.

Thermal history of the Earth – Terrestrial heat flow measurements in land and oceanic areas, methods, thermal properties of rocks, transfer of heat within the Earth, the Earth's internal sources of heat, continental heat flow - variation of continental and oceanic heat flows with age, with depth and lithospheric age.

Unit II: Gravity field and figure of the earth - Earth's gravitational attraction, force of gravity on the surface of the Earth, gravitational theory, the figure of the Earth, Clairaut's theorem, the geometric and gravitational flattening, International gravity formula, rotation of the earth, gravitational potential, spheroid and geoid; Isostasy and models of isostasy, isostatic compensation and vertical crustal movements.

Theory of continental drift, evidences for continental drift, sea-floor spreading hypothesis - Vine-Matthews-Morley hypothesis, rates of sea floor spreading, drift of the Indian continent; Plate tectonics - The lithosphere, lithospheric plates, distribution of major and minor lithospheric plates, types of plate margins – constructive, destructive and conservative plate margins, triple junctions their evolution and stability, forces acting on lithospheric plates, relative magnitudes of forces driving plate motions.

Lithospheric plate motion on the surface of a sphere, Euler poles of rotation, absolute plate motions; mantle viscosity, concepts of mantle convection models, coupling between plates and mantle convection; plate tectonics and evolution of Himalayas.

UNIT III: Geochronology – Dating of rocks, advent of radioactive methods, closed and open systems, Uranium-Lead method: the Concordia-Discordia diagram, Interpretation of discordant ages, isochron diagrams, Potassium-Argon method, Rubidium-Strontium method, Argon-Argon method, Radioactive Carbon and Tritium methods, mass spectrometer, Fission-track dating, age of the Earth; History of Precambrian chronology, subdivisions of Precambrian time.

UNIT IV: Geomagnetism – General features of Earth's magnetic field, field of uniformly magnetized sphere; The magnetic fields of external and internal origins and their separation, the origin of the Earth's internal magnetic field, the dynamo theory and dynamo models; secular variations and westward drift of the Earth's magnetic field; Paleomagnetism, Field reversals, polar wandering.

Transient magnetic variations, Quiet day solar daily variation Sq, magnetic storms, auroras and airglow, theories of magnetic storms and aroras, the physical properties of upper atmosphere, the magnetosphere; Natural Remanent Magnetisation (NRM) - Measurement of NRM by Astatic and Spinner magnetometer, demagnetization effect; IGRF.

Text Books/Reference books:

1. The Solid Earth, An introduction to global geophysics, C.M. R. Fowler, Cambridge University Press, Second edition.
2. Fundamentals of Geophysics by William Lowrie, Cambridge University Press.
3. Physics and Geology by J.A. Jacobs, R. D. Russel and J. Tuzo Wilson, McGraw-Hill International series.
4. Plate tectonics and crustal evolution by Kent C. Condie, Butterworth-Heinemann
5. Interior of the Earth by M. H. P. Bott. Edward Arnold
6. Geodynamics of the Indian Peninsula and the Indian plate margins by R. K. Varma, Oxford & IBH publishing co. pvt. Ltd.

104: Signal Processing

UNIT I: Definitions of signal and noise, various classes of signals – continuous, piece wise continuous, absolute integrable, singularity, unit impulse, unit step etc., Fourier series, Dirichlet conditions, Fourier analysis of continuous, discontinuous, even and function, Gibb's phenomenon, complex form of Fourier series; Fourier integral theorem, Fourier sine and cosine integrals.

UNIT II: Fourier Transforms: The Fourier Transform (FT) and its properties – linear, scaling, shifting properties, modulation, frequency and shifting theorems, derivation and integration theorems; Fourier transforms of gate, exponential, impulse, step, singularity and periodic functions; Amplitude, phase and power spectra; Spectrum of observational data, Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT), FFT algorithm.

UNIT III: Z-Transforms: The Z-Transform (ZT) and its properties, ZT of casual and non-casual sequences, use of ZT in Geophysics; Inverse ZT, analysis of discrete-time systems, application of ZT to the analysis of Discrete-Time systems; Introduction to Hankel, Hilbert, Wavelet and Walsh transforms and their applications in geophysics.

Time-series analysis: Discrete time signals, auto and cross correlations and their applications; convolution, methods and properties of convolution; Deconvolution and its applications in signal analysis, impulse response and transfer functions, delay properties of wavelets,

UNIT IV: Band limited signals, sampling theorem, Nyquist frequency, aliasing, sampling of band and time limited signals, reproduction of continuous function from sampled data; windowing, types of windows, spectral leakage; Wiener Khinchin theorem, spectrum computation *via* autocorrelation and periodogram.

Digital filtering, design, amplitude and phase response, low-pass, high-pass and band-pass filters, optimum filters, Butterworth filter, recursive and non-recursive filters, optimal and optimum Weiner filters; deconvolution, deterministic and statistical deconvolution, predictive deconvolution, time-variant deconvolution, frequency filtering.

Text Books/Reference books:

1. Seismic data Analysis by Oz Yilmaz, Society of Exploration Geophysicists, Tulsa, USA.
2. Spectral analysis in Geophysics by B. Markus Bath, Elsevier Science.
3. Digital signal processing and time series analysis by Enders A. Robinson and M. T. Silvia, Holden-Day, The University of California.
4. Digital signal processing by S. Salivahanan, Tata McGraw Hill Education (India), Pvt. Ltd.

ADIKAVI NANNAYA UNIVERSITY

M. Sc. Geophysics Course – II Semester Syllabus (W.E.F. 2017-18)

201: Essentials of Geology

UNIT I: Crystallography: Introduction, Elements of crystallography – Characters of crystals, symmetry elements, Brief classification of 6 systems; Basics of physical properties of minerals, Isomorphism, polymorphism; Classification of minerals, brief description of physical properties of quartz, feldspar, mica, pyroxene, amphibole and garmet group and clay minerals.

UNIT II: Petrology: Definition, classification of rocks of rocks - Igneous, sedimentary and metamorphic rocks, distinguishing features between three types of rocks; Composition and constitution magma, forms of Igneous rocks, structure of igneous rocks, brief classification of igneous rocks, origin of sedimentary rocks, classification of sedimentary rocks based on their structures and textures, metamorphism, types, grades and zones of metamorphism, brief classification of metamorphic rocks.

UNIT III: Economic Geology: Origin and classification of economic minerals, geological thermometers, magmatic concentration, hydrothermal process, sedimentation, metamorphism, metallic and non – metallic minerals, placer deposits; Introduction to Hydrocarbons (including Petroleum, natural gas, coal, gas hydrates, coal bed methane, shale gas, poly metallic and manganese nodules).

UNIT IV: Structural Geology: Principles of stress and strain, structural features of rocks – primary and secondary structures, strike and dip. Folds – introduction, classification and origin. Faults – Introduction, classification, causes of faults and recognition of faults in the field. Joints – introduction, Classification and origin unconformities – definition, types and origin of unconformities, Different types of field and laboratory scales used in the preparation of geological maps, different symbols used in the preparation of geological maps.

Text Books/Reference books:

1. Rutley's elements of mineralogy by C.D. Gribble,
2. An introduction to rock forming minerals by W. A. Deer, R. A. Howai and J. Zusmann, Longman group Ltd., London.
3. Igneous and Metamorphic Petrology by A. Philpots, 1992.
4. A text book of Geology by P. K. Mukherjee, World Press.
5. Principles of petrology by G.W. Tyrrel, B. I. Publications Pvt. Ltd.
6. Structural Geology by M. P. Billings, Printice Hall of India Pvt. Ltd., New Delhi.
7. Structural geology and tectonic principles by P. C. Badgley.

202: Principles of Remote sensing techniques

UNIT I: Electromagnetic radiation**,** electromagnetic spectrum, Planck's law, Wien's displacement law, Interaction with the atmosphere, earth's surface and matter, selective and non-selective scattering, impact of scattering on remotely sensed data, atmospheric windows and absorption bands.

Spectral reflectance curves of water, snow, clouds, vegetation, soils, rocks/minerals; imaging and non-imaging sensors, radiometers, spectrometers, spectro radiometers, line scan systems, array scanning systems, multispectral scanner systems, whiskbroom and pushbroom imaging systems, circular/conical/side scanning systems; sensor characteristics, spatial resolution, spectral resolution, radiometric resolution and temporal resolution.

UNIT II: Platforms for data acquisition – Air borne and space borne platforms; Satellite orbits - geo-synchronous and sun-synchronous orbits; Indian Remote Sensing Satellites.

Microwave remote sensing: Wavelength bands, geometry of the radar image, passive microwave radiometers, penetration of the radar signal, polarization; advantages and disadvantages of passive microwave remote sensing; active microwave remote sensing: SLAR, SAR; look direction and look angle, Interpreting Brightness values, satellite image radars, LiDAR, scope of micro wave remote sensing in earth science applications.

UNIT III: Thermal remote sensing: thermal radiometry, microwave radiometers, thermal scanners, thermal properties of objects, geometry of thermal images, thermal image and its interpretation, heat capacity mapping mission, TM thermal data, scope of thermal remote sensing in earth science applications.

Hyperspectral remote sensing: spectroscopy, image cube, AVIRIS, spectral matching, spectral mixing analysis, data libraries, MODIS, processing of hyper-spectral data, applications of hyperspectral remote sensing, scope of hyperspectral remote sensing in various earth science applications.

UNIT IV: Image resolution, field data and image interpretation, target variables, system variables, operation conditions, measurement of resolution, mixed pixels, kinds of field data, nominal data, field radiometry, locational information, geographic sampling, image interpretation tasks, strategies, keys and equipment.

Elements of image interpretation, collateral information, interpretive overlays, preparation for manual interpretation, image scale calculations, image registration, image enhancement, image filtering, image smoothening, image classification – Supervised, Unsupervised and Fuzzy classifications, classification accuracy assessment.

Text Books/Reference books:

1. Remote sensing of the environment: An earth resource perspective by John R. Jensen, Second edition, Pearson Education, Inc.
2. Digital remote sensing by Prithvish Nag and M. Kudrat, Concept publishing company, New Delhi.
3. Hyperspectral data, analysis techniques and applications, Ed. R. R. Navalgund and S. S. Ray, Indian Society of remote sensing.
4. Remote sensing and image interpretation by T. M. Lillesand, Kiefer, R. W., and Chipman J.W., Wiley.
5. Remote sensing geology by Ravi. P. Guptta, Springer International Edition, Springer (India) Pvt. Ltd. New Delhi.

203: Seismology

UNIT I: Introduction: Elastic theory – elastic, inelastic and plastic behavior of material, the stress matrix, the strain matrix, longitudinal strain, dilatation and shear strain, Elastic constants and internal relationships between them, elastic parameters in terms of lame constant; Seismic waves – Body waves - Longitudinal waves, Transverse waves - Surface waves - Rayleigh waves, Love waves; Seismic wave equation and the solution to the seismic wave equation; The energy in seismic disturbance, the attenuation of seismic waves, the dispersion of seismic waves.

UNIT II: The earthquake seismology: Introduction, definition of an earthquake, focus, epicenter, location of the epicenter of an earthquake, classification of earthquakes – based on the depth of the focus and on the causative mechanism; Travel-time curves and velocity depth curves; Earth quake size – Intensity, magnitude and the relation between them, earthquake frequency, energy released in an earthquake; Secondary effects of an earthquake.

Continental margins: Types of continental margins – Passive, Active and transform continental margins, classification and distribution of continental margins on the globe, the global seismicity, belts of active seismicity; hotspots and mantle plumes, plume generation mechanism, evidence of mantle plumes from seismology and geoid.

UNIT III: Instrumentation: Introduction, principle of seismometer – vertical motion seismometer, horizontal motion seismometer, the equation of seismometer – effect of instrumental damping, long period seismometer, short period seismometer, broad band seismometer; The seismogram – Analogue recording, digital recording, phases on a seismogram.

UNIT IV: Analysis of earthquakes: Source parameters of an earthquake and their determination; Analysis of earthquake focal mechanisms – single couple and double couple radiation pattern, fault plane solutions, machanics of faulting, focal mechanism at active plate margins, focal mechanism at continental collision zones; Earthquake prediction – prediction of the location, time and size of an earthquake, reservoir induced seismicity, seismic zonation.

Text Books/Reference books:

1. Fundamentals of Geophysics by William Lowrie, Cambridge University Press.
2. Introduction to Seismology by Markus Bath,

204 - Gravity and Magnetic methods of exploration

UNIT I: Principle of gravity and magnetic prospecting: Properties of Newtonian potential, Laplace's and Poissons's equations, Green's theorem, Gauss' law, continuation integral, concept of gravity anomaly; Rock densities, factors controlling rock densities; Principles of gravity prospecting instruments - static and astatic gravimeters, Zero-length spring; Concept of magnetic anomalies, Origin of magnetic anomalies, induced and remanent magnetizations; Dependence of magnetic anomalies on latitude and orientation; Magnetic susceptibility, factors controlling susceptibility, magnetic classification of minerals and rocks, laboratory and in-situ methods of determining susceptibility; Principles of magnetic prospecting instruments - Fluxgate, Nuclear, Proton precession and Optical pumping magnetometers.

UNIT-II: Gravity and magnetic surveying for mineral and Hydrocarbon exploration and geological mapping, establishment of base stations, gravity drift correction; Reduction of gravity and magnetic data; Free-air, Bouguer and Complete Bouguer gravity anomalies and magnetic anomalies; Bouguer density and its in-situ determination – Nettleton's density profiling and Seigert's methods; Airborne magnetometry, orientation mechanisms, survey techniques, data acquisition and reduction; Gradient measurements; Satellite magnetometry.

Regional, residual and noise anomalies in gravity and magnetics; Regional residual separation - graphical, average, grid and curve fitting techniques, reliability of different types of residuals; Vertical derivative calculations; Equivalent stratum, upward and downward continuations - classical methods using continuation integral, harmonic analysis and Fourier transformation.

UNIT III: Interpretation of gravity and magnetic anomalies: Qualitative interpretation - Nature of anomalies, identification of structural features and litho contacts from contour maps; Ambiguity in gravity and magnetic interpretation, strategies for resolving the ambiguity.

Quantitative interpretation: Concepts of forward modeling and inversion; Forward modeling of gravity anomalies - Gravity anomaly equations and characteristics of anomaly profiles of point and line masses, circular discs, vertical cylinders, sheets, faults and rectangular slabs; Generalized equations for the magnetic anomalies of single pole, sphere, line dipoles, dykes, sheets and faults, anomaly equations and characteristics of anomaly profiles; Interpretation by thumb rules and characteristic curves; Poisson's relation, similarity of magnetic anomalies of two-dimensional bodies in different components; Magnetic equivalence of dykes, faults and anticlines.

UNIT IV: Forward modeling of gravity and magnetic anomalies of two-dimensional and three-dimensional bodies - graticules, computer models; Inversion of gravity anomalies of 2-D polygonal bodies; Automatic gravity modeling of sedimentary basins by Bott's method and density interfaces, concepts of density contrast and density difference, inversion of gravity anomalies of density interfaces; Mass estimations from gravity anomalies; Magnetic inversion - 2d polygonal bodies, dykes and magnetic interfaces; Interpretation in frequency domain, depth calculations.

Application of gravity and magnetic methods for regional geological mapping, oil and mineral exploration with special reference to salt domes, structural traps, sulphide ores, ferrous and non-ferrous ores, diamonds, placer deposits, coal, groundwater, engineering problems.

Text Books/Reference books:

1. Milton B.Dobrin and Carl H.Savit, Introduction to Geophysical Prospecting, 1988, McGraw-Hill International Edition, Geology Series, New Delhi
2. Telford W. M. et. al., Applied Geophysics, 1988, Oxford & IBH Publishing Co. Pvt . Ltd., New Delhi.
3. Philip Kearey and Michael Brooks, An introduction to geophysical exploration, 2000, Blackwell Science.
4. I. V. Radhakrishna Murthy, Gravity and magnetic Interpretation in Exploration Geophysics, Geological Society of India Memoir No.41.
5. Gravity and magnetic methods of prospecting by B. S. R. Rao and I. V. R. Murthy.

ADIKAVI NANNAYA UNIVERSITY
M. Sc. Geophysics Course – III semester Syllabus (W.E.F. 2017-18)

301: Electrical methods of explorations

UNIT – I: Classification of electrical methods, Electrical properties of rocks and minerals – electrical potentials, electrical conductivities, magnetization permeability, and polarization potentials; Laboratory measurements of resistivities, dielectric constants, Typical values of electrical resistivities, dielectric constants and magnetic permeability of rocks and minerals; Factors affecting the resistivity of rocks; Archie's law, isotropy and anisotropy, Dar zarrowk parameters – longitudinal conductance and transverse resistance, Ohm law.

UNIT – II: Resistivity methods: Potentials in homogeneous media - single current electrode at depth, single current electrode at surface, two current electrodes at surface, current distribution; effect of inhomogeneous ground - Distortion of current flow and potential at plane interface, surface potential at horizontal beds; Potential due to buried sphere, effect of anisotropic ground and topography; Equipment for electrical resistivity field work – power sources, meters, electrodes and wires, different electrode layouts and field procedures ; Concepts of true resistivity, apparent resistivity and strip resistivity, apparent resistivity for multi layered earth, principle of reciprocity, reflection coefficient, principle of equivalence and suppression.

UNIT – III: Interpretation of resistivity data: Resistivity modeling, resistivity transforms and their use; Vertical sounding – two and multiple horizontal beds - types of sounding curves - interpretation of sounding curves – curve matching, partial curve matching - multi layer approach; interpretation using auxiliary curves; Lateral resistivity mapping – vertical contacts and vertical dykes, mapping three-dimensional anomalies, measurement of overburden depth and resistivity; Introduction to computer inversion of sounding curves - Basic approach and iterative inversion.

UNIT – IV: SP Method: Self potentials – origin – classification – electro chemical and electro kinetic potentials; Measurement of self potentials, equipment and field techniques; SP anomalies over different geometrical models – sphere, sheet etc., interpretation of SP anomalies.

Induced polarization method: Sources of Induced polarization effects, electrode polarization, membrane polarization. Methods of IP measurement - frequency domain method, Time domain method, metal factor, phase shift and phase components, relation between time and frequency domain measurements, field equipment and field procedures, noise sources, IP sounding and profiling, plotting of results, pseudo sections, interpretation, spectral IP, magnetic induced polarization measuerements.

Application of SP, resistivity & IP methods in regional geology, mineral and ground water explorations, limitations & advantages.

Text Books/Reference books:

1. Applied Geophysics (2nd edition) by W.M Telford, L. P. Geldart and R. E. Sheriff, Cambridge University Press.
2. Electrical methods in Geophysical Prospecting by George Vernon Keller and Frank C. Frischknecht, Pergamon Press.
3. D.C. Geo electric sounding by P.K Bhattacharya & H.P. Patra
4. Geo sounding principles Vol. 1 by O.Koefoed.

302: Seismic methods of exploration

UNIT – I: Fundamentals of seismic methods of exploration: Propagation characteristics of seismic waves in media - Elastic wave velocities of rocks - factors affecting elastic wave velocities; Seismic anisotropy, acoustic impedance, ray paths in layered media, reflection and refraction of seismic waves at interfaces, Snell's law, critical refraction, diffraction, dispersion, multiples, ghost reflections and reverberations, phases, Zeoppritz equations; Seismic reflection and refraction methods of exploration – fundamental differences.

UNIT II: Seismic Detectors/Receivers: Geophone and types of geophones – Frequency response and damping, electrical characteristics, physical characteristics, response testing, cables; Detector arrays, array design and array response; Seismic energy sources - Explosive and non-explosive sources - dynamite, Vibroseis – sweep correlation, sweep control, sweep design, side-lobe noise, Vibrator problems and possible solutions, determination of field parameters for optimized vibrosies operation; Thumper, Land air-gun and other land energy sources; Penetration signatures of various energy sources; Seismic instrumentation – Basic components, instrument noise and sampling, amplification, A/D conversion and conversion operations, filtering, dynamic range, recording formats and recording channels, telemetry systems, sign-bit recording.

UNIT III: Seismic reflection surveys: Geometry of reflected ray paths, travel time curves and calculation of layer parameters, single and multiple horizontal and dipping reflectors; Ray paths for multiple reflections, the seismic trace, shot gather, CMP gather; Multichannel reflection surveying - multichannel reflection survey design, vertical and horizontal resolutions, split spread and end-on spreads, common depth point and common mid pint surveying; Three component (3C) seismic reflection surveys, Vertical seismic profiling; display of reflection data – reflection seismogram; Seismic survey parameters – survey planning, noise analysis, array performance analysis, parameter optimization.

UNIT IV: Seismic refraction surveys: Geometry of refracted ray paths - single and multiple horizontal and dipping planar interfaces, faulted planar interfaces - calculation of layer parameters; Geometry of refracted ray paths non planar interfaces – delay time, plus-minus and generalized reciprocal methods of interpretation; The hidden and blind layer problems; reversed and un reversed refraction profiling, refraction travel time curves - Low velocity layer, hidden layer problems and refraction across faulted interface; Refraction survey procedures, fan shooting, broad-side shooting, long refraction profiles.

Seismic 3d surveys: Introduction to 3d layouts - swath, brick, odds and evens, zig-zag, button patch, full range 3d and loop survey.

Text Books/Reference books:

1. Milton B.Dobrin and Carl H.Savit, Introduction to Geophysical Prospecting, 1988, McGraw-Hill International Edition, Geology Series, New Delhi
2. Telford W. M. et. al., Applied Geophysics, 1988, Oxford & IBH Publishing Co. Pvt . Ltd., New Delhi.
3. Philip Kearey and Michael Brooks, An introduction to geophysical exploration, 2000, Blackwell Science.

303: Marine Geophysics

UNIT I: Marine gravity and magnetic: Gravity and magnetic survey procedures in marine environments, gravity and magnetic instrumentation for sea surface and under water measurements, reduction of marine gravity and magnetic data and calculation of anomalies; Continental and oceanic gravity anomalies, gravity anomalies across mountain chains, oceanic ridges and subduction zones and continental margins, Isostatic gravity anomalies.

UNIT II: Oceanic magnetic anomalies, sea floor spreading, linear magnetic anomalies, dating the ocean floor, geomagnetic time scale, geomagnetic polarity, marine magnetic anomalies and geomagnetic polarity, magnetostratigraphy, geomagnetic polarity time scale, frequency of polarity reversals, early Mesozoic and Paleozoic reversal history.

UNIT III: Marine seismics: Detectors/Receivers for marine seismic - Hydrophones - Types of hydrophones, streamers, depth control, streamer depth indicators, streamer heading and noise; Detector arrays, array design and array response; Marine seismic energy sources - Air-Guns – Air-Gun arrays, Sparker, Maxipulse, Water gun, Steam gun; Penetration signatures of various energy sources; Marine 2D and 3D reflection and refraction shooting – single and two streamer systems, alternate shooting, circular shooting, 3D bottom cable survey, multiple streamers, marine sonobuoy surveys.

UNIT IV: Position fixing in seismic surveys - Satellite surveying – Global Positioning System (GPS), Radio navigation, Navigation systems, navigation planning for an offshore program using radio positioning systems; Seabed imaging - Single beam echo sounding, echo sounders and echo sounding profiles, imaging bathymetric data, swath mapping – side scan sonar, multibeam swath sounding, hybrid systems, bathymetric measurements using electromagnetic waves.

Text Books/Reference books:

1. Marine geophysics by E. J. W. Jones, John Wiley Publications.
2. Introduction to Geophysical Prospecting byMilton B. Dobrin and Carl H.Savit, 1988, McGraw-Hill International Edition, Geology Series, New Delhi.
3. Fundamentals of Geophysics by William Lowrie, Cambridge University Press.
4. Applied Geophysics by Telford W. M. et. al., 1988, Oxford & IBH Publishing Co. Pvt . Ltd., New Delhi.

304: Seismic data processing and interpretation

UNIT I: Introduction, General stages in seismic data processing or processing sequence; Preprocessing – Demultiplexing, editing, true amplitude recovery (TAR), static correction, deconvolution, CDP gather, preliminary stacking; Processing analysis – Velocity analysis, static analysis, deconvolution analysis, filter analysis and ramp analysis; Processing – Normal Move Out, residual static correction, pre-stack ramp, CDP stack, deconvolution, frequency filtering, migration, final stacking.

UNIT II: Stacking – vertical stack, diversity stack and CDP stack; Velocity analysis – Types of velocities, Velocity determination from wells, seismic reflection data; Velocity searching techniques – manual computations, computer assisted computations, criteria for velocity function estimation; Velocity accuracy – statistical errors, non statistical errors, effect of RMS velocity error on interval velocity estimation.

UNIT III: Reflection data processing, static and dynamic corrections, study of shot gather, identification of seismic events and noise; analysis of analog records, seismic sections, automatic processing; format conversion, trace editing, pre-filtering, gain applications, geometric spreading correction, programmed gain control, RMS and instantaneous AGC and relative trace balancing; deconvolution, construction of convolution model, effect of random noise, multiple attenuation, dip filtering, deconvolution strategies; velocity analysis and static corrections; NMO, factors affecting velocity analysis, residual static corrections, refraction static corrections; migration, different methods, dip move out correction (DMO), prestack migration, AVO analysis.

UNIT IV: Seismic sections - plotting, display, events, isochronal and isopach maps, identification of geological structures, structural and stratigraphic traps - pitfalls in interpretation. Hydrocarbon indicators, bright spots, seismic attributes, AVO, reflector curvature, AVO attributes and interpretation.

Seismic stratigraphy: Introduction - stratigraphic patterns, depositional patters and lithology - seismic sequence - seismic facies - reflection character - simple and complex reflection configuration - seismic reflection character analysis.

Text Books/Reference books:

1. Seismic data Analysis by Oz Yilmaz, Society of Exploration Geophysicists, Tulsa, USA.
2. Milton B. Dobrin and Carl H. Savit, Introduction to Geophysical Prospecting, 1988, McGraw-Hill International Edition, Geology Series, New Delhi.

ADIKAVI NANNAYA UNIVERSITY

M. Sc. Geophysics Course – IV semester syllabus (W.E.F. 2017-18)

401: Electro Magnetic methods of Exploration

UNIT I: Basics - Electromagnetic induction, primary and secondary fields and their relations – real and imaginary components, inductive and resistive limits, response function, elliptical polarization, Maxwell's equations, boundary conditions, wave equation, plane wave characteristics, propagation of EM wave in conducting media, wave number, impedance, skin depth versus effective depth.

Classification of EM Methods: Sources used, continuous wave and pulse excitation principles, measured components. Brief principles of solving electro dynamic problems including scale modelling, field of a large loop, magnetic dipole and electric dipole in air, frequency and time domain approaches.

UNIT – II: Field of magnetic dipole and electric dipole (both transient and frequency domains) in homogeneous, isotropic space. Response of stratified medium to the above sources. Frequency and transient response of local conductors, sphere and cylinder, in homogeneous field. effect of frequency and magnetic permeability on the secondary fields. Sphere as an example, generalized induction parameter. Effect of overburden and host rock on E.M response.

Methods using artificial fields: Surface low frequency methods, Turam, Tilt angle and slingram methods - principles, field procedures and various corrections, quantitative interpretation. Operation at low induction numbers. Surface transient methods, description of different current functions, various T-R configurations general field procedures, interpretation of surface transient method data.

UNIT – III: Radio wave methods: Principles, theory and description, VLF EM/EMR. Interpretation of VLF EMR data. Application of Ground penetrating Radar (GPR), applications in shallow depth investigations. Principles of EM sounding, field procedures, geometric versus parametric sounding, data preparation, interpretation and applications.

Methods using natural fields: Principle of MT, origin of earth's natural EM field, magneto telluric source field characteristics. MT field procedures and instrumentation cagniard's relation independence over N- layer medium apparent resistivity and phase MT tensor.

MT signal processing: Swifts optimum rotation, skew, tipper, ellipticity, coherences, static shift, remote reference magnetatellurics. Induction arrows, polar diagrams, 1-D, 2-D interpretation of magnetotelluric data application.

UNIT – IV: Principles of AMT, controlled source audio magnetotellurics, marine MT and AFMAG, telluric current method: principles and field procedures. Telluric profiling technique, theoretical consiuations, relative ellipse, absolute ellipse, triangle, polygon and amplitude ratio methods of interpretation of telluric data. Comparision of telluric with MT.

Airborne EM methods: Continuous wave systems, Different systems in operation Airborne transient system (input)n description. Rigid room helicopter system, passive airborne EM system. AFMAG & VIF different noises in AEM systems and methods of suppression, interpretation of AEM data applications.

Geomagnetic depth soundings: Origin and classification of long period geomagnetic variations, separation of magnetic field of internal and external origin, normal and anomalous fields. Interpretation of geomagnetic depth sounding data. Magnetometer array studies, principles of ocean bottom electromagnetic methods.

Text Books/Reference books:

1. Applied geophysics Telford et.al revised edition
2. Mining geophysics Vols 1 & 2 – SEG publications
3. Electrical methods of geophysical prospecting Keller & frischknechtt
4. Geosounding principles Vol.II Patra & Mallick
5. Mining geophysics, Parasnis
6. Introduction to geophysical exploration – Kearey & Brooks.

402: Well logging and formation evaluation

UNIT-1: Petrophysical parameters – porosity - water saturation – permeability - formation factor - formation temperatures - resistivity index - formation factor porosity relationships; Borehole environment – distribution of resistivities around the borehole; Data acquisition - surface equipment – wire line (cable) - down hole equipment – tools – sensors – detector – signals – electrical pulse – digital; Open hole and cased hole operations - logging while drilling (LWD).

UNIT-2: Electrical logging: SP log, resistivity logging, historical development, conventional systems, focused systems, normal, lateral, laterolog, induction log, micrologging devices, need for development, data processing, depth corrections, borehole effects and corrections, borehole compensation, other environmental corrections, invasion effects, fluid effects, log quality control; Acoustic logging developments and various acoustic logging techniques; Radioactive logging: Nuclear logging – Neutron-Density logging, developments, gamma ray and natural gamma ray spectroscopy logs (NGS), new developments, dipmeter, Carbon-Oxygen logging, pulsed neutron log, cement bond log.

UNIT-3: Determination of porosity from resistivity and non-resistivity porosity tools, density, neutron-sonic logs, lithology and porosity from cross-plots, determination of fluid saturation from resistivity porosity cross plots, permeability from logs, Quick look interpretation techniques, identification of clean, shaly and hydrocarbon bearing zones, minerals. Computer processed interpretation (CPI) software. Complex reservoir and fractured reservoir interpretation, formation fluid sampling, MDT, SFT, sidewall casing.

UNIT-4: Production logging – fundamentals of production logging – applications – categories – tools – temperature, radioactive tracer and flow meter tools; Composite log, parameters, preparation, analysis, pore pressure prediction, exponent, shale density; Well completion - well completion techniques, perforation and tools for perforation; Applications of formation evaluation.

Text Books/Reference books:

1. Formation evaluation by Edward J. Lynch
2. Fundamentals of well log interpretation – the acquisition of well log data by O. Serra, Elsevier Science Publishing company, Inc., New York.
3. Log interpretation principles/Applications, Schlumberger educational services, Texas, USA.

403: Petroleum geology and geophysics (Elective Paper)

UNIT I: Physical and Chemical properties of Hydrocarbon and nonhydrocarbon gases, gas hydrates and crude oil; Composition, occurrence and economic significance of gas hydrates, identification of gas hydrates; Classification of crude oil, Origin of Petroleum – organic, inorganic, thermogenic, biogenic, source rocks, nature and types, characterization, evaluation of source rock potential; Genesis of petroleum by Fisher-Tropsch synthesis.

UNIT II: Migration of petroleum, primary and secondary, mechanics of oil and gas movement through pore space; Maturation concepts, qualitative and quantitative evaluation, chemical and optical methods of Kerogen and bitumen analysis, diagenesis, catagenesis and metagenesis, TTI concept, measurement of the distance or petroleum migration.

UNIT III: Definitions of porosity, permeability, classification of porosity, measurement of porosity, permeability, interpretation of permeability data, relationship between porosity, permeability and grain size, shape, packing, sorting, orientation and depositional process; Reservoir rocks - clastic, carbonate and unconventional reservoir rocks; Reservoir traps - Nomenclature, distribution of petroleum within a trap, classification of traps – structural, stratigraphic diapiric, hydrodynamic and combinational traps;

UNIT IV: Nonconventional energy resources: Plastic and solid hydrocarbons – occurrence and composition; Tar sands – Composition, geological distribution and origin of tar sands; Oil shales – Chemical composition, distribution of oil shales; Coal Bed Methane: Environments of deposition of coal beds, coal grades, concept of cleats, mineral composition of coal, drilling for coal bed methane, core studies, logging of coal beds and evaluation, dewatering and CBM production, estimation of gas in place, shale gas.

Application of surface geophysical techniques viz., gravity, magnetic and seismics for hydrocarbon exploration; Application of various subsurface geophysical and/or well logging techniques for hydrocarbon exploration and basin analysis.

Text Books/Reference books:

1. Geology of Petroleum by A. I. Leverson,
2. Elements of Petroleum Geology by Richard C. Shelley, 1985, Second edition, Academic Press, California, USA.

403: Environmental and Groundwater Geophysics (Elective Paper)

UNIT I: Hydrologic Cycle, the groundwater in the hydrologic cycle; Hydrologic budget; Origin and Occurrence of groundwater – Origin of groundwater, rock properties affecting groundwater, vertical distribution of groundwater, geologic formations as aquifers, types of aquifers, groundwater basins and regional groundwater flow systems, springs, hydrothermal phenomena, groundwater in permafrost regions.

UNIT II: Groundwater movement – Darcy's Law, verification and validity; Permeability, intrinsic permeability, hydraulic conductivity, transmissivity, hydraulic conductivity of geologic materials, determination of hydraulic conductivity; Groundwater flow rates and flow directions, general flow equation, unsaturated flow, infiltration.

UNIT III: Quality of Groundwater – Salinity in groundwater, sources of salinity, measures of water quality, groundwater samples, chemical analysis, physical analysis, biological analysis, water quality criteria, changes in chemical composition, dissolved gases, temperature; Pollution in groundwater – Municipal sources, industrial sources, agricultural sources, miscellaneous sources and their causes; Monitoring of groundwater quality, remediation of contaminated groundwater; Application of various geophysical techniques in ground water pollution identification and mapping.

UNIT IV: Saline water intrusion in aquifers – occurrence, structure and shape of fresh-salt water interface, effect of seawater intrusion, control of saline water intrusion, identification of saline water intrusion with the help of geophysical techniques.

Surface and subsurface investigations of groundwater – Geological, remote sensing and geophysical exploration (electrical, seismic and potential field methods) techniques; Application of various geophysical logging techniques (resistivity, SP, natural gamma, gamma-gamma, neutron, temperature, caliper, acoustic etc.) for groundwater investigations.

Text Books/Reference books:

1. Groundwater hydrology by David Keith Todd and Larry W. Mays, 2005, Third edition, John Wiley and Sons, Inc.
2. Application of surface geophysics for groundwater investigations by A.A. R. Zohdy, G. P. Eaton, and D. R. Mabey, U.S. Geological survey, 1990.
3. Ground water by H. M. Raghunath, New age international publications.