Course Structure for Five Year Integrated M. Sc. Tech / Three Year M. Sc. Tech. (Applied Geophysics)

FIRST SEMESTER/SECOND SEMESTER for Five year integrated M.Sc. Tech. (AGP)only

Theory papers

Sl No.	Subject Code	Name of the course	L T P	Credits
1.	AMC 11101	Mathematics I & II	3 1 0	7
2.	APC11101/ ACC 11101	Physics/Chemistry	3 1 0	7
3.	MMC 11103/ MMC 11102	Engineering Graphics/Manufacturing Processes	1 3 0	5
4.	EEC 11101/ EIC 11101	Electrical Technology/Electronics Engineering	3 1 0	7
5.	MMC11103/ HSC 11101	Engineering Mechanics/English for Science and Technology	3 1 0	7
5.	GLD/CMD 11301	Earth System Science (S)/ Global energy Scenario & Energy Security of India (S)	3 0 0	6
6.	CSC 11301/ HSC 12305	Computer Programming (S)/Value Education, Human Right and Legislative Procedure (S)	3 0 0	6
Practical				
1.	APC 12201/ ACC 12201	Physics/Chemistry	0 0 3/2	3/2
2.	EEC 12201/ EIC 12201	Electrical Technology/Electronics Engineering	0 0 3/2	3/2
3.		Counseling/Special class/Co-curricular Activities	0 0 0	6
		Total	19 7 3	54

THIRD SEMESTER for Five year integrated M.Sc. Tech. (AGP) only

Theory papers

Sl No.	Subject Code	Name of the course	L T P	Credits
1.	HSE-13302	Philosophy of Science	3 0 0	6
2.	APC-93101	Mechanics-I	4 0 0	8
3.	APC-93102	Optics	4 0 0	8
4.	APC-93103	Waves and Oscillation	4 0 0	8
5.	AMR-13101	Methods of Applied Mathematics-I	4 1 0	9
6.	GPC-93101	Scope of Geophysics (Sessional)	0 2 0	2
Practical				
1.	APC-93201	Physics Lab-III	0 0 3	3
2	APC-93202	Physics Lab- IV	0 0 3	3
		Total	19 3 6	47

FOURTH SEMESTER for Five year integrated M.Sc. Tech. (AGP) only

Theory papers

Sl No.	Subject Code	Name of the course	L T P	Credits
1.	APC-94101	Mechanics-II	3 0 0	6
2.	APC-94102	Electricity and Magnetism	3 0 0	6
3.	AMC - 14101	Numerical and Statistical Methods	4 0 0	8
4.	HSC- 14306	English for Professional Communication	3 0 0	6
5.	EIC - 22101	Microprocessor and their application	3 0 0	6
6.	GPC-94101	Glimpses of Geophysics (Sessional)	0 2 0	2
Practical				
1.	APC-94201	Physics Lab-V	0 0 3	3
2	APC-94202	Physics Lab- VI	0 0 3	3
3.	AMC - 14201	Numerical and Statistical Methods	0 0 3	3
4.	SWC-34701	Co-Curricular Activity	0 0 0	3
		Total	16 2 9	46

FIFTH SEMESTER (5 year Integrated) / FIRST SEMESTER(3 year course)

Theory papers

Sl No.	Subject Code	Name of the course	L T P	Credits
1.	GLC-13101	Mineralogy, Petrology and Stratigraphy	3 0 0	6
2.	GPC-95101	Geophysical Prospecting	3 1 0	7
3.	GPC -95102	Solid Earth Geophysics	3 1 0	7
4.	AMC -31102	Computer Programming	3 1 0	7
5.	GLC-15162	Sedimentology and Petroleum Geology	4 0 0	8
Practical				
1.	GLC-13201	Mineralogy, Petrology and Stratigraphy	0 0 3	3
2.	GPC-95201	Geophysical Prospecting	0 0 3	3
3.	AMC - 31202	Computer Programming	0 0 2	2
		Total	16 3 8	43

SIXTH SEMESTER (5 year Integrated) / SECOND SEMESTER (3 year course)

Theory papers

Sl No.	Subject Code	Name of the course	L T P	Credits
1.	MECR- 22131	Surveying	3 0 0	6
2.	GLC-14103	Physical Geology and Structural Geology	3 0 0	6
3.	GPC-96102	Seismology	3 0 0	6
4.	AMC- 32101	Object Oriented Programming	3 0 0	6
5.	MEC-22132	Methods of Mining & Unit Operation	3 1 0	7
Practical				
1.	GLC-14203	Physical Geology and Structural Geology	0 0 3	3
2.	GPC-96201	Seismology	0 0 3	3
3.	AMC - 32201	Object Oriented Programming	0 0 3	3
4.	GLC-14906	Local Geological Field Excursion (one week agreed by AGL Deptt.) Two week Proposed by BOCS members		2
5.	SWC-36701	Co Curricular Activities		3
	GPC-96001	Summer Industrial Training (Two Weeks) * Marks to be added to the next semester		
		Total	15 1 9	45

SEVENTH SEMESTER (5 year Integrated)/ THIRD SEMESTER (3 year course)

Theory papers

Sl No.	Subject Code	Name of the course	L T P	Credits
1.	GPC-97101	Signal Analysis Theory	3 0 0	6
2.	GPC-97102	Exploration Seismology: Acquisition	3 0 0	6
3.	GPC-97103	Resistivity and Induced Polarisation Methods	3 0 0	6
4	GPC-97104	Gravity and Magnetic method	3 0 0	6
5.	GPC-97105	Remote Sensing: Principles and Data Acquisition System	3 0 0	6
Practical				
1.	GPC-97201	Exploration Seismology: Acquisition	0 0 3	3
2	GPC-97202	Resistivity and Induced Polarisation Methods	0 0 3	3
3.	GPC-97203	Gravity and Magnetic method	0 0 3	3
4.	GPC-97204	Remote Sensing: Principles and Data Acquisition System	0 0 3	3
5.	GPC-97401	Seminar		2
6.	GPC-97901	Summer Field Training		4
		Total	15 0 12	48

EIGHTH SEMESTER (5 year Integrated) / FOURTH SEMESTER (3 year course)

Theory papers

Sl No.	Subject Code	Name of the course	L T P	Credits
1.	GPC-98101	Geophysical Signal Processing	3 0 0	6
2.	GPC-98102	Exploration Seismology: Processing, Modeling and Interpretation	3 0 0	6
3.	GPC-98103	Electromagnetic Method	3 0 0	6
4.	GPC-98104	Image Processing and Geographic Information System	3 0 0	6
5.	GPC-98105	Well logging Principles and Tools	3 0 0	6
Practical				
1.	GPC-98201	Geophysical Signal Processing	0 0 3/2	3/2
1.	GPC-98202	Exploration Seismology: Processing, modeling and Interpretation	0 0 3	3
2.	GPC-98203	Electromagnetic Method	0 0 3	3
3.	GPC-98204	Image Processing and Geographic Information System	0 0 3/2	3/2
4.	GPC-98205	Well logging Principles and Tools	0 0 3/2	3/2
	GPC-98401	Seminar		2
	GPC-98601	Winter Geophysical Training		5
	SWC-38701 (for 4th Sem AGP only)	Co Curricular Activities		3
	Summer Industrial Training (Two Weeks) * Marks to be added to the next semester			
		Total	15 0 10.5	47.5 (8th Int. AGP) 50.5 (4th AGP)

NINTH SEMESTER (5 year Integrated) / FIFTH SEMESTER (3 year course)

Theory papers

Sl No.	Subject Code	Name of the course	L T P	Credits
1.	GPC-99101	Magnetotelluric and Ground Penetrating Radar Methods	3 1 0	7
2.	GPC-99102	Geophysical Inversion	3 1 0	7
3.	GPC-99103	Geothermics and Geodynamics	3 1 0	7
4.	GPC-99104	Formation Evaluation	3 0 0	6
Practical				
1.	GPC-99201	Magnetotelluric and Ground Penetrating Radar methods	0 0 3	3
2	GPC-99202	Geophysical Inversion	0 0 3	3
3.	GPC-99203	Formation Evaluation	0 0 3	3
4	GPC-99801	Dissertation	0 0 0	5
5.	GPC-99901	Summer Industrial Training		4
		Total	12 3 9	45

TENTH SEMESTER (5 year Integrated) / SIXTH SMESTER (3 year course)

Theory papers

Sl No.	Subject Code	Name of the course	L T P	Credits
1.	MSC-26151	Industrial Management	3 0 0	6
2.	GPC-90101	Environmental Geophysics	3 1 0	7
3.	GPC-90102	Reservoir Geophysics and Deep Water Imaging, Rock Physics, Prestack Imaging, Water Resources Management, Natural Disaster & Hazards	3 0 0 (One to be chosen)	6
4.	AMC-90101	Numerical Techniques in Geophysics	3 1 0	7
Practical				
1.	AMC-90201	Numerical Techniques in Geophysics	0 0 3	3
2.	GPC-90801	Dissertation	0 6 0	6
3.	GPC-90401	Seminar		4
4.	GPC-90501	Composite Viva Voce		3
5.	SWC-30701	Co Curricular Activities		3
		Total	12 8 3	45

THIRD SEMESTER (5 year Integrated M.Sc. Tech. AGP)

Philosophy of Science

3 0 0

1**. Introduction** : Rationale for study of Philosophy of Science prevalence of imbalances; General Approach, Nature, Scope and Relation of the subject with Historical Development; Science and Philosophy vis-à-vis need for Intellectual and Moral Balance. Scientific and Philosophical approaches to knowledge development and knowledge application (Emphasis on Earth and Mineral Sciences).

2. **Foundations of Philosophy** : Nature, Concept, Scope Methodology, Divisions and Implications.

3. **Concept and Nature of Science**: Origin/Aim. Methodology, Scope and Development: Nature of Scientific Methods; Movements; Scientific Thought, Division s of Science, Scientific Laws and Scientific Explanations.

4. **Convergence of Science and philosophy:** Unified Theory; Space Time Relationship; Patterns of Change; Deeper issues and broad involvements of Science; Status of Scientific Proposition and Concepts of Entities, Epistemic and Ontological aspects.

5. **Philosophical Analysis and Scientific Practice:** Philosophical Base of Eastern Thought and their parallel in Science; The Essential of Unity between Eastern Thought Pattern and Western Science, Need for harmony between Intuitive Thought and Rational Knowledge; Philosophers of Sciences with reference to Western Thought, Philosophers of Science – Western and Eastern.

6. Inter-relationship of Science and Culture: Science and Aesthetics, Science and Human Values, Science in the full tradition, Science vis-à-vis Human Conduct and Social Affairs; Social Significance of Science; Implications of Philosophy of Science for a new peaceful Social Order, Synthesis of Eastern "World View" and Western "Materialism".

Mechanics-I

4 0 0

Law of motion, motion in a uniform field, components of velocity and acceleration in different coordinate systems, uniformly rotating frame, Centripetal acceleration, Coriolis force and its applications.

Motion under central force, Kepler's law, Gravitational law and field, Potential due to a spherical body, Gauss and Poisson equations for gravitational self-energy , Earthquakes, Seismic waves and Seismographs, Galitzin's Seismograph, Determination of the Epicentre and the focus, Modern application of seismology.

System of particles, Centre of mass, equation of motion, conservation of linear and angular momenta, Conservation of energy, single stage and multistage rockets, elastic and inelastic collisions.

Rigid body motion, Rotational motion, Moment of inertia and their products, principal moments and axes, Euler's equations, precessional motion, top, Gyroscope.

Kinematics of moving fluids, equation of continuity, Bernoulli's theorem, viscous fluids, streamline and turbulent flow, Poiseulle's law, capillary tube flow, Reynold's number, Stoke's law.

Surface tension and surface energy, molecular interpretation of surface tension, pressure on a curved liquid surface, wetting.

Optics

4 0 0

Geometrical Optics

Fermat's Principle: Principle of extremum path, aplanatic points of a sphere and other applications.

General theory of image formation: Cardinal points of an optical system, general relationship, thick lens and lens combinations. Lagrange's equation of magnification, telescopic combination, telephoto lenses and eyepieces.

Aberration in images: Chromatic aberrations, achromatic combination of lenses in contact and separated lenses, Monochromatic aberrations and their reductions; aspherical mirrors and Schmidt corrector plates, aplanatic points, oil immersion objectives, meniscus lens.

Optical instruments: Entrance and exit pupils, need for a multiple lens eyepiece, common types of eyepieces.

Physical Optics:

Interference of light: The principle of superpositions, two-slit interference, coherence requirement for the sources, optical path retardations, lateral shift of fringes, Rayleigh refractometer and other applications. Localised fringes; thin films, applications for precision measurements for displacements.

Haidinger fringes: Fringes of equal inclination. Michelson interferometer, its application for precision determination of wavelength, wavelength difference and the width of spectral lines. Twymann-Green interferometer and its uses. Intensity distribution in multiple beam interference, Tolansky fringes, Fabry-Perot interferometer and etalon.

Fresnel diffraction: Fresnel half-period zone plates, straight edge, rectilinear propagation

Fraunhoffer diffraction: Diffraction at a slit, half-period zones, phasor diagram and integral calculus methods, the intensity distribution, diffraction at a circular aperture and a circular disc, resolution of images, Rayleigh criterion, resolving power of telescope and microscope systems, outline of phase contract microscopy.

Diffraction gratings: Diffraction at N parallel slits, intensity distribution, plane diffraction grating, reflection grating and blazed gratings. Concave grating and different mountings. Resolving power of a grating and comparison with resolving powers of prism and of a Fabry-Perot etalon

Double refraction and optical rotation: Refraction in uniaxial crystals, its electromagnetic theory. Phase retardation plates, double image prism. Rotation of plane of polarization, origin of optical rotation in liquids and in crystals, Applications.

Waves and Oscillation

4 0 0

Waves:

Waves in a one-dimensional chain of particles; classical wave equation; wave velocity, boundary conditions and normal modes, dispersion relations, dispersive waves, acoustic and optical modes.

Waves in continuous media: Speed of transverse waves on a uniform string, speed of longitudinal waves in a fluid, energy density and energy transmission in waves, typical measurements, dispersion in waves, group velocity and phase velocity, their measurements.

Superposition of waves: Linear homogeneous equations and the superposition principle, interference in space and energy distribution; beats and combination tones.

Ultrasonic: Production, detection and applications of ultrasonic waves.

Oscillations:

Free oscillations of simple systems: Equilibrium; concept of potential well, small oscillations, approximate solutions, linear and transverse oscillations of a mass between two springs, diatomic molecule, reduced mass concept.

Damped and forced oscillations: Damped oscillations; critical damping, Q of an oscillator. Forced oscillator with one degree of freedom; Transient and steady state oscillations, resonance energy absorption, low and high frequency responses.

Free oscillations of system with two degrees of freedom: Two dimensional oscillator; normal modes, longitudinal and transverse oscillation of coupled masses, energy transfer between modes, coupled pendulum.

Fourier analysis: Fourier series and Fourier coefficients; simple examples, use of exponential representation for harmonic oscillations, expression for Fourier coefficients. Non-periodic disturbance; representation by Fourier integral, Fourier transform. Case of a wave train of finite length, constancy of $\Delta x.\Delta k$ (the uncertainty product), applications.

Methods of Applied Mathematics – I

4 1 0

Section-A :: **Analysis of Complex Variables :** Limit, continuity and differentiability of function of complex variables. Analytic functions. Cauchy-Riemann's and Cauchy's integral theorem, Morera's theorem, Cauchy's integral formula, Expansion of fuction of complex variables in Taylor's and Laurent's series, singularities and poles. Resdue theorem, contour integration, conformal mappings and its application, Bilinear Transfromation.

Section-B : Special Functions: Solution in series of ordinary differential equations, Solution of Bessel and Legendre equations, recurrence relations and generating function for J_n (X). Elliptic integrals and Error function and their properties.

Section-C: Laplace Transform and PDE: Laplae Transform of simple functions, first and second shifting theorems, t-multiplication and t-division theorems; Laplace transforms of derivatives, integrals and periodic functions.

Inverse Laplace transform and convolution property. Use of Laplace transform in evaluating complicated and improper integrals and solutions of ordinary differential equations related to engineering problems.

Partial Differential Equations : Classification of partial differential equations, solutions of one dimensional wave equation, one dimensional unsteady heat flow equation and two dimensional steady heat flow equation in Cartesian and polar coordinates by variable separable method with reference to Fourier trigonometric series and by Laplace transform technique.

Scopes of Geophysics (Sessional)

0 2 0

Evolution history of Earth and Solar System. Earth observation and measurement from space. The Global frame work : continental drift, ocean floor spreading, plate tectonics. The earth's gravity and magnetic field. Thermal properties. Seismology: Earthquake characteristics and description of important earthquakes. Overview of Geophysics exploration methods, mapping and application.

Physics lab - III and Physics lab - IV (Practical)

0 0 3 and 0 0 3

Experiments for determination of velocity, frequency an other parameters of sound (Kundt's Tube, Melde's Experiment, Experiment on beats etc.); Determination of acceleration due to gravity by compound pendulum; experiments using spectrometer-μ- λ curve, S-λ curve etc.; Experiments on lens and mirror and on interference and diffraction using optical bench; Experiment on polarization (on birefringenes of mica using quarter wave plates, Babinet compensator etc.); waveform analysis with the help of computer: Lisajous figures etc., Experiment on birefringenes of mica using quarter wave plates, Babinet compensator etc.,

FOURTH SEMESTER (5 year Integrated M.Sc. Tech. AGP)

Mechanics-II

3 0 0

Motion in a non-inertial frame: Motion of a point particle in a general (rigid) non-inertial frame of reference, Galilean Relativity, Larmor theorem.
Concept of stress and strain: Normal stress, shear stress, state of stress at a point, ultimate strength, allowable stress, factor of safety , normal strain, shear strain, Hooke's law, Poisson's ratio, Generalised Hooke's law, Analysis of axially loaded members.
Transformation of Stress and Strain: Transformation of stress and strain, Principal stresses, Principal strains, Mohr's circle for stress and strain.
Vector Analysis: Scalar and vector fields, vectors depending on a single parameter (e.g. time), derivative of a vector with respect to the parameter, Linear dependence and independence of vectors, Vector functions of two and three parameters and their derivatives.
Types of binding in solids: Covalent binding and its origin, Ionic binding, energy of binding, transition between covalent and ionic binding, metallic binding, van der Waals binding, hydrogen bond.

Electricity and Magnetism

3 0 0

Electric field: Coulomb's law; unit of charge (SI and other systems of units), Conservation and quantisation of charge; field due to different charge distributions, monopole, dipole, quadrupoles, line charge, sheet charge. Torque on a dipole in uniform field and non-uniform fields, flux of an electric field. Gauss's law; applications to deduce E fields, force per unit area on the surface of a charged conductor.
Potential: Line integral of electric field and electrical potential; field as the gradient of potential. Potential energy of a system of charges; pair of charges, line charge, sheet charge, spherical shell of charge, charged hollow disc. Field equations for E in vacuum. Energy associated with E field. Differential form of Gauss' divergence law, Poisson's equation, Laplace's equation, boundary conditions, and Uniqueness theorems.
Electric field around conductors: Induced charges; field and potential inside a conductor, field near the surface of a conductor, method of images.
Electric fields in matter: Atomic and molecular dipoles; induced dipoles, polarisability tensor, electronic and molecular contributions. Electrical field caused by polarized matter, E and D fields, permittivity, dielectric constant. Capacitor field with a dielectric, field equations in presence of dielectric. The field of a polarized sphere, dielectric sphere in a uniform field. Energy in dielectric systems; polarisability and susceptibility, frequency dependence of polarisability, Clausius-Mossotti equation.
Magnetic effect of current: A critical review.
Magnetic field: magnetic field B seen through Lorentz force on a moving charge, unit for I defined through force on a straight current, torque on a current loop in B field, magnetic dipoles in atoms and molecules, gyromagnetic ratio.

Numerical and Statistical Methods

4 1 0

A. Numerical Methods

Solution of algebraic and transcendental equations by bisection, iteration, false position, secant and Newton Raphson methods, Genealised Newton's method for multiple roots.

Solution of a system of linear simultaneous equations by Gauss elimination, Gauss-Jordan, Crout's triangularisation, Jacobi and Gauss Seidel methods. Finite differences, Symbolic relations, differences and factorial notation of a polynomial, data smoothing, Interpolation and extrapolation, Newton-Gregory forward and backward, Gauss forward and backward, Stirling, Bessel, Everett, Lagrange and Newton's divide difference formulae, Inverse interpolation and integration, Trapezoidal, Simpson's $1/3^{rd}$, Simpson $3/8^{th}$, Weddle and Gaussian quadrature formulae.

Numerical solution of first order ordinary differential equation by Taylor's series, Picard's Euler's Modified Euler's, Runge-Kutta, Adams-Moulton and Milne's methods. Solution of simultaneous first order and second order ordinary differential equations with initial conditions by Taylor's series. Runge-Kutta and Milne's methods. Numerical solution of boundary value problems by finite difference and shooting methods.

B. Statistical Methods

Concept of a frequency distribution : Moments, skewness and kurtosis
Probability : Various approaches of probability-classical, frequency (statistical), subjective and axiomatic. Theorems on probability, conditional probability, Independence, Bayes Theorem.

Random variable-discrete and continuous. Distribution function and their properties, probability mass and density functions, Mathematical expectation, Moment generating function and its properties.

Probability distributions : Bernoulli, binomial, negative binomial, Poisson and normal distributions.

Theory of least squares and curve fitting.

Correlation-Simple, multiple and partial, Regression lines and regression coefficients, Multiple and partial regression.

Test of Significance : Normal test, t-test, Chi-square and F-test.

English for Professional Communication

3 0 0

Part I Professional Oral Communication

Course Introduction

Professional Communications: Need, principle, channels, forms and barriers; Speaking for professional Purposes : Nature of Oral Communication, Oral Communication Process, and characteristics of Oral Communication.

Group Discussion

Group Discussion (GD) : nature, uses and importance; Leadership function in GD; developing leadership qualities and positive group behaviour; Starting discussions: opening the discussion, stating objectives, suggesting good group procedure (Time management, speaking procedure, etc.; Giving opinions, asking for opinions and supporting opinions in GD; Making suggestions and asking for suggestions; Balancing points of view, expressing advantages, disadvantages and consequences; Some pitfalls in discussions, fallacies in argument and rebuttal, concluding and controlling discussions.

Microprocessors and their application

3 0 0

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 Mazimum 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.

Glimpses of Geophysics (Sessional)

0 2 0

Introduction to Geophysics, The Earth as a planet of the Solar System – Description of Earth : atmosphere, lithosphere, hydrosphere and earth’s interior, Physical Fields of the Earth.

Gravitational Field : The nature and the characteristics features of the gravitational field: The regularities in the distribution of the characteristics features of the gravitational field.

Terrestrial heat field – The terrestrial heat field and its nature: The terrestrial heat field structure, the heat conditions of the earth's crust, the temperature in the depths of the earth, the practical application of the Earth's Heat.
Magnetic Field : The nature, structure, and the characteristic feature of the magnetic field, the magnetic field of the structural elements of the earth's crust and its anomalies. General characteristics of these potential fields over Indian sub-cont. Exploration Geophysics.

Space based observation and mapping of earth. Introduction to Exploration Geophysics, scientific concepts and principles behind various types of Geophysical methods viz. magnetic, gravity, seismic and well logging methods. Their general quantitative data interpretation, application and importance with respect of mineral and oil exploration.

Physics Lab- V and Physics Lab-VI

0 0 3 and 0 0 3

Experiments on surface tension measurements- Jurin's Law verifications, Jager's Method, etc.; Experiments as viscosity measurements: bath in stationary and flowing fluid- Stock's Method, Poiseulli's Method, Rankin's Method etc; Experiments on specific heat measurements- Sealers's Method; Experiments on determination Stefan's Radiation constant; Experiments on electric bridge; Experiments on galvanometer-moving coil and ballastic; Experiments using potentiometer; Experiments on magnetometer; Experiments on Magnetic Hysteresis.

Numerical and Statistical Method Practical

0 0 3

A. Numerical Methods

Numerical solution of non-linear algebraic and transcendental equation by bisection, iteration, false position, secant and Newton Raphson methods.

Numerical solution of a system of linear simultaneous equation by Gauss elimination and Gauss seidel methods.

Interpolation by Lagrange's interpolation formula.
Numerical evaluation of definite integral by Trapezoidal, Simpon's $1/3^{rd}$, Simpson's $3/8^{th}$, Weddle and Gaussian quadrature formulae.

Numerical solution of first order ordinary differential equation by Euler's, Modified Euler's second and fourth order Runge-Kutta, Adams-Moulton and Milne's methods.

B. Scope of practice sessions:

Computation of raw moments, central moments, coefficient of variation, coefficients of skewness and kurtosis; Fitting of straight line, second degree polynomial (parabola), power curve and exponential curve; Computation of product moment correlation, multiple and partial correlation coefficients; Regression coefficients and regression lines, plane of regression. Application of tests of significance based on numerical data.

FIFTH SEMESTER (5 year Integrated) / FIRST SEMESTER (3 year course)

Geology -I (Mineralogy, Petrology & Stratigraphy)

3 0 0

Mineralogy

Minerals : Physical and chemical, Crystal, crystal classes and systems, Classification of minerals and properties of common silicate minerals (Quartz, Feldspar, Pyroxene, Amphibole, Garnet, Olivine, Mica), sulphides (Pyrite, Chalcopyrite, Galena, Sphalerite) andoxides (Haematite, Magnetic, Chromite, Pyrolusite, Psilomelane).

Petrology

Igneous rocks: Magma and lava, extrusive and intrusive forms, textures; Classification and description of some common igneous rocks (Granite, Dolerite, Basalt, Rhyolite, Pegmatite)

Sedimentary rocks : Sedimentation processes; Classification and description of some common sedimentary rocks (Conglomerate, Sandstone, Shale, Limestone)

Metamorphic rocks : Processes of metamorphism, textures and structures of metamorphic rocks; Classification and description of some common metamorphic rocks (Slate, Schist, Gneiss, Quartzite, Marble).

Stratigraphy

Principles of stratigraphy; Concepts of palaeontology; Fossils, their mode of preservation and significance as indices of age and climate; Concept of index fossils, Broad stratigraphic subdivisions and associated rock types of important ore provinces, coal belts and oil fields of India.

Suggested Reading

Krishnan, M.S, Geology of India
Mukherjee, P.K. Introduction to Geology
Read, H.H. Rutley's Elements of Mineralogy
Truner, F.J. and Verhoogen, J, Igneous and Metamorphic Petrology

Geophysical Prospecting

3 1 0

Introduction to Geophysics and Geophysical prospecting

Gravity method: Basis for gravity exploration, concept of geoid, international gravity formula, unit of gravity.
Gravimeters: Spring-mass system as basic gravimeters, principles of working of unstable gravimeters, zero length spring, La-Coste-Romberg and Worden gravimeters.
Drift Correction.
Gravity effect due to buried sphere, horizontal cylinder, semi-infinite horizontal sheet
Densities of common rocks and minerals.

Magnetic method: Magnetic susceptibility of rocks and their ranges, elements of earth magnetic field
Magnetometers: Fluxgate and Proton Precession Magnetometers
Diurnal Correction
Magnetic effect due to isolated pole, vertical dipole. Horizontal dipole and dipping dipole.

Spontaneous Potential (SP) Method: Origin of SP, Field procedure to conduct SP survey, removal of bias from SP anomalies, common minerals showing SP anomalies, interpretation of SP anomalies.

Seismic Method: Principles of Geometrical Optics, generation and propagation of seismic waves, seismic energy sources, geometry of refraction and reflection, interpretation of travel time curves for two layered earth- horizontal and dipping interface, field procedure-profile and broad side shooting, fan shooting, end on and split spread arrangements.

Resistivity Method: True and apparent resistivity, resistivities of common rocks and minerals, Electrode configurations—Schlumberger and Wenner, Vertical Electrical Sounding, Interpretation of two layered VES curves.

Well logging: Objectives of well logging, Borehole environment, surface logging setup, sources of SP in wellbore, Archie's law and Darcy's law

Suggested Reading:

Dobrin, M. B. and Savit, C., Introduction to Geophysical Prospecting
Parasnis, D. S., Applied Geophysics
Rao, B. S. R. and Murthy, I. V. R., Gravity and Magnetic Methods of Prospecting
Nettleton, L. L., Gravity and Magnetics in Oil prospecting
Telford, W. M., Geldart, L. P., Sheriff ND keys, D. A., Applied Geophysics

Solid Earth Geophysics

3 1 0

Introduction to geophysics, different branches of geophysics and relationship with other sciences. Formation of solar system , theories explaining its origin and characteristics of various planetary members; Earth: its rotation and figure. Gravity and its variation over the earth, Age of the earth and various methods of its determination. Earth: surface features, continents, continental margins, oceans. Thermal history and its characteristics over various earth surface features.. Earth's interior: physics status; variation of physical quantities and seismic wave velocity inside the earth, major sub divisions. Elements of earth's magnetism; history and various theories explaining origin. Secular variation and westward drift. Solar activity and magnetic disturbance

Suggested Reading:

Fowler, C.M.R., Solid Earth : An Introduction to Global Geophysics.
Howell, B. F., An Introduction to Geophysics, Mc-Graw Hill
Jacobs, J. A., A Text Book of Geonomy, Adam-Hilger
Lowrie, W., Fundamentals of Geophysics, Cambridge University Press
Tucker, R. H., Cook, A. H., Iyer, H. M. and Stacey, F. D., Global Geophysics, English Univ. Press.

Computer Programming

3 1 0

(Fresh Syllabus to be provided by Appl. Math Deptt.)

Fundamentals: Architecture of digital computers, number systems, data representation, binary arithmetic.
Operating systems: Introduction, classification; overview of operating system modules; introduction to UNIX and LINUX operating systems, Window Environment, algorithm and flowcharts.
FORTRAN: Preliminaries, control structures-selective and repetitive, arrays, format statements;
subprograms-functions, subroutines, DATA, SAVE, COMMON and EQUIVALENCE statements; file processing; additional data types- logical, double precision and complex types.
C : Preliminaries- introduction, constants, variables and data types, operators and expressions, I/O operations, decision making and branching; decision making and looping; arrays, structures and unions, user defined functions, pointers, file management, dynamic memory allocations and linked lists, the preprocessors

Suggested Reading:

Balaguruswami, E., Programming in ANSI C
Gottfried, B., Programming with C, Tata-McGraw-Hill.
Kumar, Ram, Programming with FORTRAN 77, Tata-McGraw-Hill.
Rajaraman, V. Fundamentals of Computers, Prentice-Hall.

Sedimentology & Petroleum Geology

4 0 0

Section A : Sedimentology

Classification of sedimentary rocks: Shape, size, mineralogy and texture of siliciclastic and carbonate sediments; primary sedimentary structures: depositional and erosional; paleocurrent analysis-scalar and vector properties. Sedimentary depositional environments, Facies sequence and paleogeography: siliciclastic (fluvial, deltaic, shallow and deep marine) and carbonate; facies sequence and geophysical log responses, Brief outline of Sequence Stratigraphy and identification of possible reservoir facies. Tectonics and sedimentation: extensional, compressional and conservative.

Section B: Petroleum Geology

Chemical composition and physical properties of petroleum crude, origin og petroleum, migration of oil and gas. Reservoir rocks-classification and petrophysical properties. Hydrocarbon traps – definition and classification, structural, stratigraphic and combination traps. Plate tectonics and global distribution of hydrocarbom reserves. Petroleferous basins of India-classification and tectonic setup.

Suggested Reading:

Allen and Allen, Basins in their plate tectonic environment
Emery and Mayers, Sequence Stratigraphy
Reading, H. G., Sedimentary Environment and Facies
Reineek and Singh, Depositional Sedimentary Environments
Sengupta, S. M., Introduction to Sedimentology
Shelley, Applied Sedimentology
Tucker, M. E. and Wright, V. P., Carbonate Sedimentology
Walker, R. G., Facies Model

GLC13251 (Mineralogy and Petrology Practical)

0 0 3

Mineralogy

Study of physical properties of minerals

(A) Rock forming minerals: Talc, Gypsum, Calcite, Fluorite, Feldspar (Orthoclase, Microcline, Plagioclase), Muscovite, Biotitem Quartz, Beryl, Tourmaline, Corundum, Kyanite, Serpentine, Garnet and Sillimanite.

(B) Ore minerals; Haematite, Magnetite. Chalcopyrite, Malachite, Azurite, Chromite, Bauxite, Pyrolusite, Psilomelane, Sphaslerite, Galena.

Petrology

Study of common rocks with reference to their structures, mineral composition and uses.

(A) Igneous Rocks: Granite, Syenite, Gabbro, Basalt, Dolerite, Lamprophyre, Aplite, Pegmatite.
(B) Metamorphic Rocks : Slate, Schists, Gneisses, Quartzite, Marble, Amphibolite, Charnockite.
(C) Sedimentary Rocks : Conglomerate, Sandstone, Shale, Carbonaceous Shale, Coal Limestone.

Computer Programming (Practical) 0 0 3

(Fresh Syllabus to be supplied by Deptt. of Appl. Math.)

1. Basic commands of DOS and UNIX

FORTRAN Language: Execution of programs using the following:

2. Control Structures – Logical IF, Arithmetic IF, Nested Block IF, Computer GOTO
3. Repetitive Structures – IF loop, DO-loop, Nested DO loop
4. Arrays – Traversing, Sorting, Searching, Inserting, Deleting operations, Use of two or more dimensional arrays.
5. Subprograms : Functions – Statement functions, Function Subprograms, Subroutine Subprograms.
6. Use of DATA, SAVE, COMMON and EQUIVALENCE Statements.
7. File Processing.

C-Language : Execution of programs using the following :

8. Decision Making and Branching – if statement, Nested if, Else if ladder, Blockif, Switch statement.

9. Decision Making and looping – while, do-while, for.
10. Arrays – Traversing, Sorting, Searching, Inserting, Deleting operations, Processing arrays with more than one dimensions.
11. User Defined Functions – Recursive functions, Nesting of functions.
12. Structures – Use of structure data type, array of structures, Unions.
13. Handling files in C-sequential, random access files.
14. Use of pointers
15. Linked List : Linear one – way Linked list-traversing, Insertion, Deletion and Searching operations.
16. Use of Processors : Simple preprocessors – macro substitutions, file inclusion directives.

Geophysical Prospecting (Practical)

0 0 3

1. Apply drift correction to the acquired gravity data
2. Apply diurnal correction to the given magnetic data
3. Interpretation of SP anomaly
4. Interpretation of VES data over two layered earth
5. 7Travel time distance curve for horizontal refractor
6. Travel time distance curve for horizontal reflector
7. Plot of Formation Factor vs. Porosity Calculation of formation water resistivity from SP Log
8. Calculation of Gravity effect due to sphere
9. Calculation of Magnetic effect due to sphere

SIXTH SEMESTER (5 year Integrated) / SECOND SEMESTER (3 year course)

Method of Mining and Unit Operation

3 1 0

Surface mining: Deposits amenable to surface mining; Box cut: objectives, types, parameters and methods; Production benches – objectives, formation and bench parameters, Unit operations and associated equipment, Classification of Surface Mining Systems.

Underground coal mining : Deposits amenable to underground coal mining; Classification of underground coal mining methods, Bord and pillar methods – general description and applications and merits and demerits; Selection of panel size, operation involved and associated equipment; Longwall methods – Types and their general description, applicability, merits & demerits; Selection of face length & panel length, operations involved and associated equipment; Methods of mining steeply inclined seams and thick seams; Hydraulic mining.

Underground metal mining : Deposits amenable to underground metal mining; Shape, size & position of drifts & cross cuts; Raises & Winzes; Classification of underground metal mining methods; Stoping methods – general description, applicability, operations involved and associated equipments for room and pillar mining. Stope & Pillar mining, shrinkage stoping, sub-level stoping, cut & fill stoping, VCR methods, Sub-level caving & Blocks caving.

References :

1. Mining, Boky
2. Coal Mining Practices, Statham
3. Longwall Mining, Syd. S Peng and H.S. Chiang.

Geology – II Physical Geology and Structural Geology

3 0 0

Physical Geology (1-0-0)

Evolution of the; Exogenous and endogenous processes shaping the earth. Transportation and deposition; Geological ork of running, wind, glaciers, seas and ground water, Diastrophism; Earthquakes and volcanoes.

Structral Geology (2-0-0)

Interpretation of topographic maps; Attitude of planar and linear structures; Effects of tophography on outcrops. Unconformities, folds, faults and joints – their nomenclature, classification and recognition. Forms of igneous intrusions – dyke, sill and batholith. Effects of fold and fractures on strata/ore bodies and their importance in exploration activities. Priniciples of stereographic projection.

Suggested Reading

Homes,A, Physical Geology
Mukherjee, P.K. Introduction to Geology
Billings,M.P, Structural Geology

Seismology

3 0 0

Introduction to Seismology and phenomena of earthquake and its effects. Elastic rebound theory, causes of intra and inter plate earthquakes, classification of earthquakes,Determination of Earthquake parameter. Seismicity and Seismotectonics of India & Himalaya, Frequency- Magnitude (b value), Velocity Structure and V_p/V_s study.

Localizing of magnitude scale, various magnitude scales and their limitations, seismic moment, stress drip and dimension of rupture during earthquakes.
Intensity scales: MM and MSK, impacts and assessment of earthquakes and related hazard and their mitigation.
Theory of elasticity, generalized Hooke's law, different types of elastic waves and their propagation characteristics, equations of motion of seismic body waves, Attenuation and dispersion of seismic waves
Instruments: Amplitude and phase characteristics of seismometers, short-period, long-period and broad-band seismometers, analysis of seismograms and identification of various phases on the seismograms, basic principle of strong motion instrument.
Ray characteristics and related parameters for horizontally and spherically stratified earth, basic principles of seismic tomography and receiver function analysis.
Elastic rebound theory, Fault plane solutions and related interpretation, moment tensors for different fault patterns, earthquake characteristics along constructive, conservative and destructive boundaries. Study of micro-earthquakes and induced seismicity, free oscillations of earth.
Seismic networks and arrays, stand-alone and telemetry systems.
Earthquake prediction: dilatancy theory, short-term, middle-term and long-term prediction

Suggested Reading:
Peter P. M., Shearer, Introduction to Seismology
Bath M., Introduction to Seismology
Lowrie, W., Fundamentals of Geophysics
Kasara K., Earthquake mechanics
Scholz, C.H., The mechanics of earthquakes and faulting
Bullen, K. E. and Bolt. B. A., An Introduction to the Theory of Seismology
Richter, C. F., Elementary Seismology
Gubins D., Seismology and Plate Tectonics
Kulhanek O, Anatomy of Seismograms
Krishna J., Chandrasekaran A.B. and Chandra B., Elements of Earthquake Engineering

Object Oriented Programming (OOP)

3 0 0

(Fresh Syllabus is to be provided by Deptt. of Appl. Math.)

OOPs: Basic concepts of OOPs; C++ preliminaries, data types, arrays, functions, classes and objects, constructors and destructors, function overloading, operator overloading and Type conversions; inheritance, pointers, polymorphism, console oriented I/O operations, file management, templates, exception handling.
JAVA: Introduction to JAVA

Information Technology: Introduction to data base management systems; Relational Data Base Management System, FOXPRO, internet and intranet, multimedia.

Suggested Reading

Balaguruswami, E., Object Oriented Programming with C++, Tata-McGraw Hill.
Balaguruswami, E., Programming with JAVA, Tata-McGraw Hill.
Lafore R., Object Oriented Programming with Turbo C++, Galgotia
Leon, A. and Leon M., Fundamentals of Information Technology, Leon Press

Surveying

3 0 0

Introduction to Surveying: Objective of surveying and its importance, Classification,principles of surveying, Application of Surveying in various fields of Engineering.
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, infra red, 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.
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.
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.
Contouring: General, Contour Interval, Characteristics, Methods of locating contours, Interpolation etc.

Global Positioning System (GPS) : Theory, principles and applica tions

Structural Geology Practical

0 0 3

1. Interpretation of Topographic Maps
2. Interpretation geological Maps – 1 : Altitude and Cross sections
3. Outcrop completion – 1: One point problem and V - rule
4. Outcrop completion – 2:Three point problem
5. Interpretation of geological Maps – 2 Unconformable beds
6. Interpretation of geological Maps – 3 : Folded beds
7. Interpretation of geological Maps – 4 : Faults and dykes
8. Stereographic projection - 1 : Planes and lines
9. Stereographic projection - 2 : Determination of angles and Bisectrix

Seismology Practical

0 0 3

1. Visit to ISMU observatory: objectives and present status.

2. Identify P- and S-phases on the seismogram. Estimate i) t_s-t_p, ii) τ, and iii) M_d. Interpret the characteristic features of the earthquake event.

3. Identify the various phases for both body and surface waves on the given three components record. Locate the earthquake also.

4. Find the locations of the two earthquakes whose travel-time parameters are given in the following table. Identify the origin time and focal depth of each earthquake. Consider the velocity of P-wave, V_P = 6.0 km/sec.

5. Identify all the phases on the teleseismic record.

6. The amplitude correction for the local magnitude computation is given in the table for California and Tehri region. Compute the magnitude of two earthquakes recorded in Tehri on standard Wood Anderson seismograph yielding maximum amplitude of 10 mm and 2 mm at 26 km and 260 km. Comment on the change in difference in magnitude so calculated using California and Tehri region amplitude corrections.

7. Compute LogA and $-\text{Log}A_O$ of the same earthquake, as in problem 6, if recorded on another seismograph - having the following response curve and 10000 magnifications, in Tehri region. What is the difference in the energy estimated for an earthquake recorded at 40 km yielding 10 mm on Wood Anderson seismograph if computed from the two sets of amplitude corrections?

8. The given intensities assigned to various localities on the basis of a field survey and the data collected through the earthquake questionnaire. Draw the isoseismal lines and write a short note about the isoseismal map so prepared.

9. Compute the angle of incidences of P-waves for a shallow focus earthquake (h=0.00 km) on the surface of the earth starting from a epicentral distance (Δ) of 20° at an interval of 1° using J-B table. Assume velocity of P-wave at the focus = 7.75km/sec. Plot i_h in the range of Δ = 20° to 60°, and plot $i_h \sim \Delta$.

10. Draw both the nodal planes (data given in the following table) based on lower hemisphere stereographic projection. Considering one as a fault plane find the following parameters: (i) Poles of two planes, (ii) P- and T-axes, (iii) Null and Slip vectors and slip angle, (iv) Details of dip and strike of the fault plane, and (v) type of fault with direction of motion along fault plane through a block model.

Object Oriented Programming Practical

1 Classes and objects, array of objects, Passing objects to member functions.
2. Function overloading, Friend functions, Passing objects to friend functions.
3. Member functions/Friend functions returning objects.
4. Pointer : Accessing data members and member functions using pointers.
5. Constructors and Destructors: Constructors, parameterized constructors, destructors.
6. Operator overloading : Overloading of unary operators such as minus, increment operator, decrement operator etc; Overloading of binary operators such as +, * etc. overloading of operators such as >> << etc.
7. Type of conversations : Basic type of class type, class type to basic type, one class type to another class type.
8. Inheritance: Single inheritance, Multiple Inheritance, Hierarchial Inheritance, Multilevel inheritance and Hybrid inheritance.
9. Constructors in derived classes.
10. Polymorphism : Run time polymorphism-virtual functions.
11. Console oriented 1/O operations : using ios class functions and flags, manipulators, User defined output functions.
12. File Processing: Sequential files, random files, Accessing files using class objects, Updating a file.
13. Templates : Function templates, Class Templates.
14. Error Handling.
    JAVA Programming
15. Simple programs in JAVA

SEVENTH SEMESTER (5 year Integrated) / THIRD SEMESTER (3 year course)

Signal Analysis: Theory

3 0 0

Signals, noise and their classification, continuous and discrete signals. Complex exponential Fourier series, Fourier integral, Fourier transform and its properties, energy and phase spectra, 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.

Hankel transform and Hilbert transforms, their properties, the concept of analytic signal and its use in geophysics; the notions of instantaneous frequency and phase.

Z transforms: definition and types, Z transforms of causal and non-causal sequences, properties of Z transforms and the region of convergence, use of Z transform in geophysics, inverse Z transform.

Introduction to wavelet transforms and Walsh transforms and their applications in geophysics.

τ-p transform

Suggested Reading:

Bath, M., 1974, Spectral Analysis in Geophysics: Elsevier

Beauchamp, K. G., 1984, Applications of Walsh and Related Functions: Academic Press

Mesko, A., 1984, Digital Filtering Applications in Geophysical Exploration for Oil: Pitmann Advanced Publishing Programme.

Papoulis, A., 1977, Signal Analysis: McGraw Hill

Press, W. H., Teukolsky, S. A., Vellerling, W. T., and Flanney, B. P., 1993, Numerical Recipe in Fortran: The Art of Scientific Computing: Cambridge University Press

Exploration Seismology : Acquisition

3 0 0

Travel time relation for direct, reflected and head waves over multi layered earth.

Land and marine energy sources, electromagnetic pulse and Accelerated Weight Drop. Basic theory and working principle of seismic transducers, MEMS technology (Digital Sensor) and marine transient EM. Concept of seismic channel. Seismic recording instruments. Non distributed and distributed systems. Telemetry system.

Various refraction/transmission shooting techniques: reduction of refraction data.

Seismic attenuation, reflection and transmission coefficients, Knott and Zoeppritz equations. Geometry of reflection ray path and time distance relationship, seismic noise and their cause.

Methodology for 2D reflection Survey: Different kinds of spread geometries, end on, slit spread, crooked lined profiling, linear and tapered geophone arrays, effect of arrays on the seismic response, optimization of spread geometry, offset matching, source arrays. Common depth point shooting and its advantages.

3D survey designing: Different 3D geometries, swath, MESA, GEOLAND, GX-III, 3D survey design shootings- in line, slant and orthogonal, optimization of source and receiver lines in a swath, optimization of different offsets. Offshore survey: Single, streamer and multiple streamer

surveys, feathering, Q Tech, OBS surveys. Various navigation and positioning systems used for reflection/refraction survey.
Computation of navigational data, geodesy- Elements of map projection.
Introduction to shear wave prospecting.

Suggested Reading:

Dobrin, M. B., and Savit, C. H., 1988, Introduction to Geophysical Prospecting (Fourth Edition), Tata McGraw Hill.
Evans, B., Field Geophysics: SEG Publications
Grifith, and King, Applied Geophysics for Engineers and Geologists.
Kearey, P., Brooks, M., and Hill, I., 2002, Introduction to Geophysical Exploration: BlackWell Scientific Publications.
Parasnis, D. S., 1997, Principles of Applied Geophysics (Fifth Edition), Chapman and Hall.
Telford, W. M., Geldart, L. P., Sheriff, R. E., and Keys, D. A., 1988, Applied Geophysics.

Resistivity and Induced Polarisation Methods

3 0 0

Electrical properties of rocks and minerals
Fundamental relation between potential, apparent resistivity, resistivity transform and layer distribution of a stratified earth.
Applications of linear filter theory; determination of filter coefficients, sinc response —filter length.
Recurrence relations: Flathe and Pekeris relations, determination of resistivity transforms
Potential due to a point source in an anisotropic medium, triangle of anisotropy.
Partial curve matching of three layer and four layer curves, Dar Zarrouk parameters, principle of equivalence, Resistivity modeling.
Mise-a-la-masse method.
Induced Polarisation Method: Introduction, sources of IP, membrane and electrode polarizations, time domain and frequency domain measurement of IP, chargeability, percent frequency effect and metal factors, apparent chargeability over layered earth, electromagnetic coupling.

Suggested Reading:

Bhattacharya, P. K. and Patra, H. P., 1968, Direct current geoelectric sounding: Principles and Interpretation,Elsevier Publishing Co.
Blaricom, R. V., 1992, Practical Geophysics II for the Exploration
Dobrin, M. B., and Savit, C. H., 1988, Introduction to Geophysical Prospecting (Fourth Edition), Tata McGraw Hill.
Keller, G. V., 1996, Rock and Mineral properties: in Nabighian, M. N., Ed., Electromagnetic Method in Applied Geophysics: Soc. of Explor. Geophys., 1, 13-51.
Koefoed, O., 1979, Geosounding Principles 1, Resistivity sounding measurements, Elsevier Scientific Publ. Co.
Telford, W. M., Geldart, L. P., Sheriff, R. E., and Keys, D. A., 1988, Applied Geophysics.

Gravity and Magnetic Methods

3 0 0

A review of land gravimetry; gravity measurements in sea, reduction of data and interpretation of Bouger anomaly maps; analytic methods for separation of regional and residuals; ambiguity in gravity interpretation and conditions for unique interpretation; upward and downward continuations of gravity anomalies; calculation of second vertical derivatives and horizontal gravity gradients, utility of such maps; gravity effects due to 2D and 3D bodies irregular shape; Methods for basement mapping; use of gravity survey in mineral and hydrocarbon exploration programs, search for metallic and nonmetallic ores, coal and lignite; mapping faults, exploring for salt domes, stratigraphic traps, uplifted horst and graben, use of gravity in regional geological studies including granitic plutons, thrust belts, accreted terrains, case histories.

Alkali Vapor magnetometer, measurement of earth's magnetic field and its gradient from air and sea, instrument mounting and stability of platforms, reduction of data, preparation and interpretation of anomaly maps, Interpretation of aeromagnetic maps. Werner and Euler deconvolutions, analytical signal, Source parameter Imaging, 2D and 3D modeling, spectral analysis for depth determination, utility of aeromagnetic maps in mineral and hydrocarbon exploration programs and regional studies, case histories; an overview of MAGSAT.

Suggested Reading:

Dobrin, M. B. and Savit, C., Introduction to Geophysical Prospecting.
Dehlinger, P., Marine Gravity
Heiskanen, and Veining Meinsez, Gravity Field of the Earth
Hinze, W. J., Utility of Gravity maps.
Nettleton, L. L., Gravity and Magnetics in Oil Prospecting.
Rao, B. S. R. and Murthy, I.V.R., Gravity and Magnetic Methods of Prospecting.
Tsuboi, C., Gravity

Remote Sensing : Principles and Data Acquisition System

3 0 0

Introduction: Physics of remote sensing: Electromagnetic radiation (EMR) and its spectrum; sources of EMR and governing laws; interaction of EMR with atmosphere and surface of the earth. Atmospheric windows; spectral signature and spectral reflectance, spectral responses of vegetation, water, soil etc.

Platforms: ground borne, airborne and space borne platforms; manned and unmanned space missions and satellites; importance and applications of various platforms with reference to remote sensing of earth resources.

Data acquisition: Types of sensors- photographic, single and multi band opto mechanical, thermal sensors, LISS and sensor array: their principle and operations; spectro-radiometers, microwave sensors: SLAR and SAR Systems.

Spectral and spatial resolutions: Applications of different sensor bands onboard important Remote Sensing Satellites-LANDSAT, SEASAT, SPOT, IRS and IKONOS.

Suggested Reading:

Curran, P J , Principles of Remote Sensing ELBS publn.
Lillesand T M and Kiefer R W, Remote Sensing and Image Interpretation, John Wiley Publn.

Rao, D. P., Remote Sensing for Earth Resources, AEG Publ.
Sabins, F F , Remote Sensing Principles and Interpretation, Freeman Co.
Siegel, B S and Gillespie, Alan, Remote Sensing in Geology, John Wiley Publn

Exploration Seismology : Acquisition (Practical)

0 0 3

1. Plotting of time distance curve for reflection and diffraction data.
2. Calculation of statics (elevation and weathering correction) on the basis of given models.
3. Acquisition and processing of refraction data using signal enhancement seismographs.
4. Acquisition of CDP reflection data using signal enhancement seismograph.
5. Acquisition of reflection / refraction data using accelerated weight drop seismic energy source.
6. Study of field reflection seismic records acquired for various spread configurations.
7. Study of the noise tests records and design of linear uniform array based on the field noise records.
8. Generation of response curves for various source receiver arrays.
9. Construction of CDP stacking chart.
10. Study of zero-offset VSP records and identification of down going, up going and multiples events.

Resistivity and Induced Polarization Methods (Practical)

0 0 3

1. To plot and discuss the potential lines for a point source and also to draw the variation of potential with distance.
2. To draw and discuss the equipotential lines for two point source.
3. To calculate the fraction of current of the total current with depth as a ratio of electrode separation on a plane passing through the midpoint of the current electrodes.
4. Draw current density versus depth curve for Jx component on the vertical line passing through the midpoint of current electrodes A and B.
5. To calculate and plot the current density for a) Jz component, b) Jx component on the veridical line passing through the current electrodes.
6. For given values of apparent resistivity draw pseudo section and interpret the result.
7. Acquistion and interpretation of multichannel resistivity and IP data.
8. To plot and interpret the given curves by Orellana method.
9. To plot and interpret the given curves by Ebert's method.

Gravity Method and Magnetic Methods (Practical)

0 0 3

1. Use of Worden Gravimeter in field and estimation of Drift correction.
2. Gravity Base Ties using Looping Method.
3. Bouguer Anomaly calculation for field stations after applying all corrections.
4. Nettleton's method of density determination for a given topography.
5. Regional – residual separation of gravity anomalies using different techniques for exploration.
6. Gravity anomaly variation across a vertical fault.

7. Estimation of ore mass using gravity anomalies.
8. Downward continuation of gravity anomalies in geophysical exploration.
9. Study of Gravity Anomaly Maps of India.

Remote Sensing: Principles and Data Acquisition System (Practical)

0 0 3

1. Numerical problems related with Wien's displacement law and Stefan Boltzmann law for calculating various radiation quantities.
2. Calculation of Emissivity and Thermal Inertia of rock materials.
3. Measurement of spectral reflectance over various land features in field within visible and near infrared region using spectro radiometer and their significance in remote sensing.
4. Interpretation of field as well as lab spectral reflectance curves taken within visible and near infrared for vegetation, water, rock and soil and their importance in remote sensing.
5. Examination of Stereo Aerial photograph under Mirror Stereoscope and identification of terrain type.
6. A) Study of the given B/W satellite imagery and noting down of various image details as given there in.
   B) Drawing of Latitude, Longitude and North direction on this imagery
7. Study of various type of imagery acquired by IKONOS, IRS, SPOT and LANDSAT series of Satellites and impact of spatial and spectral resolution on image quality.
8. Study of standard False color composite (FCC).

EIGHTH SEMESTER (5 year Integrated) / FOURTH SEMESTER (3 year course)

Geophysical Signal Processing

3 0 0

Discretization of continuous signals, sampling theorem, aliasing; reconstruction of a signal from its samples-Gibb's phenomenon.

Time series and wavelet: definition, properties, examples of geophysical time series; AR, MA and ARMA processes; convolution and correlation of time series and their use.

Discrete Fourier transform and Fast Fourier transforms; Estimation of power spectra from time series- periodogram and from auto correlation functions; use of windows.

Digital filters: Basic concepts, types of filters, ideal filters; design of Martin Graham, Butterworth and Chebyshev filters.

Inverse filtering: Wiener filters, deconvolution-predictive and homomorphic, ceptsral analysis.

Processing of random signals.

Applications:

Signal enhancement for gravity and magnetic maps: regional and residual separation, continuations, calculation of derivatives, pseudo gravity transformations, reduction to poles and equator.

Estimation of MT impedance tensor from observed time series.

Improvement of signal to noise ratio; source and geophone arrays as spatial filters.

Removal of shot generated noise- deghosting and dereverberation.

Earth as a low pass filter.

Suggested Reading

Baskakov, S., 1986, Signals and Circuits, Mir Publishers

Kanasewich, E. R., 1975, Time Sequence Analysis in Geophysics, The University of Alberta Press

Naidu, P. S., and Mathur, M. P., Analysis of Geophysical Potential Field: A Digital Signal Processing Approach: Elsevier

Robinson, E. A., 1967, Statistical communication detection with special reference to digital data processing of radar and seismic signal: Griffin

Robinson, E. A., 1981, Time Series Analysis and Application: D. Reidel

Yilmaz, O., Seismic Data Processing, Society of Exploration Geophysicists

Exploration Seismology: Processing, Modeling and Interpretation

3 0 0

Introduction to seismic data processing . Processing sequences- preparation of processing geometry, quality checks, true amplitude recovery, deconvolution, filtering, velocity analysis, statics, noise elimination through multichannel filtering, parameter optimization for generation final stacked section. DMO and migration, AVO and attribute analysis. Anisotropy processing: HTI, VTI .Mode .Converted Wave Processing.3D Processing techniques- generation of time slice and stacked sections.

Concepts of SRME, Radon. PSTM, Imaging, PSDM.

Seismic modeling: Introduction to wave equations & wave equation modeling.

Overview of Seismic Stratigraphy. Wavelet processing for seismic stratigraphic interpretation. Seismic sequence analysis and seismic facies analysis.

Interpretation: Study of seismic section and other geological aspects of prospecting, structural interpretation, construction of isochron and isopach maps, thin bed resolution and pitfalls,

prospect evaluation, new development such as work station environment in seismic interpretation using standard packages.

Suggested Reading:

Al Sadi, H. M., 1982, Seismic Exploration: Birkhauser Verlag
Claerbout, J. F., 1985, Imaging the interior of the earth, BlackWell Scientific Publications
Dobrin, M. B., and Savit, C. H., 1988, Introduction to Geophysical Prospecting (Fourth Edition), Tata McGraw Hill.
Lavergene, M., Seismic Methods
Lindseth, R. O., 1976, Digital processing of geophysical data - A review: Technica Publication

Telford, W. M., Geldart, L. P., Sheriff, R. E., and Keys, D. A., 1988, Applied Geophysics.
Waters, K. H., Reflection Seismology (Third Edition), John Wiley Publications
Yilmaz, O., Seismic data processing, SEG Publication.

Electromagnetic Method

3 0 0

Electromagnetic Method: Principle of electromagnetic induction; magnetic field due to a current carrying loop, elliptical polarization, plane of polarization, dip and tilt angles, nomograms for quantitative determination of parameters by dip angle method, VLF and AFMAG methods, TURAM method.

Response of a single closed conducting circuit by using a fixed horizontal transmitter-receiver system. Analysis of response function with frequency and different ranges of conductivities, amplitude and phase relations, vector diagrams and their significance.

Maxwell's equations, propagation of electrical and magnetic field as a dissipative wave, diffusion equation, propagation constant, Hertz vector, Lorentz condition, boundary conditions, Electromagnetic scale modeling, response of a thin conducting sheet in half-space, phasor diagrams, effect of a conducting host medium to the response of a thin conducting vein embedded in a conducting host, concept of current channeling.

Basic principles of transient electromagnetic methods, transient emf and magnetic field behavior due to various conductors; behavior of current density in half space by rectangular loop with time, concept of smoke ring, concepts of toroidal and poloidal induction in a conductive zone, brief account of various time domain systems frequency sounding and geometric sounding, merits of time domain methods over frequency domain methods.

Airborne EM

Suggested Reading:

Blaricom, R. V., 1992, Practical Geophysics II for the Exploration Geologist: Northwest Association Mining
Grant, F. S., and West, G. F., Interpretation Theory in Applied Geophysics
Gupta Sarma, D., and Maru, V. M., 1981, A study of some effects of a conducting host rock with a new modelling approaches: Geophysics, 36, 166-183.
Mining Geophysics, 1967, Volume II, SEG Publication
Nabighian, M. N., 1988, Electromagnetic Methods in Geophysics, Volume 1, SEG Publication.
Nabighian, M. N., 1991, Electromagnetic Methods in Geophysics, Volume 2, Parts A and B, SEG Publication.

Nair, M. R., Biswas, S. K., and Mazumdar, K., 1968, Experimental studies in the electromagnetic response of tilted conducting half-spaces to a horizontal loop prospecting system: Geoexploration, 6, 207-244.
Telford, W. M., Geldart, L. P., Sheriff, R. E., and Keys, D. A., 1988, Applied Geophysics.

Image Processing and Geographical Information System

3 0 0

Structure of Remote Sensing Images, Data format BIL, BSQ and BIP, type of data products. Image Processing technique as applied to satellite image data. Image restoration, reduction, magnification ,contrast enhancement (linear and non linear), histogram equalization, rationing, filtering and edge enhancement.
Special transformation: principal component analysis, vegetation indices
Principle of thematic information extraction and image classification technique-supervised and unsupervised classification, ancillary and contextual data in the classification process, principle of change detection registration, image differencing,
image Processing system consideration and characteristics.
Fundamentals of Geographic Information System (GIS): Definitions and terminology, functional element of GIS, map projection, data structure, comparison of raster and vector data model, data acquisition, data input and data processing, data management system, product and report generation.
Interpretation and application of remote sensing and GIS in mineral, ground water hydrocarbon and environmental management
Basic Geological mapping: Fundamental of geological interpretation of aerial and satellite photo images based on image and terrain elements including spectral signatures, identification of rock types and mapping, mapping of local and regional structural features such as fault, fractures, folds, joints.
Photo linear, curvilinear and circular features and their significance in oil exploration, geological guides, anomalies for mineral and oil prospecting including surface alteration and their manifestation on remote sensing images.
Remote sensing applications in water resources and environmental impact assessment studies.

Suggested Reading:

Anji Reddy, M. Remote Sensing and Geographical Information System, The Book Syndicate
Burrough, P. A., Principles of Geographical Information Systems for Earth Resources Assessment, Oxford Publ.
Jenson, J. R., Introrduction to Digital Image Processing, Prentice Hall, Publ.
Lo, C. P., Applied Remote Sensing, Longman Scientific and Technical Publ.
Mather, Paul, Computer Processing of Remotely Sensed Images, John Wiley.

Well logging: Principles and Tools

3 0 0

Basic concepts in well logging: definition, importance; rock composition- matrix, shale, silt, clay and fluids; porosity of rocks-classification, packing of grains; permeability- absolute, effective and relative; permeability associated with fractures and solution channels; resistivities of rocks-their dependance on salt concentration in water; relationship between permeability and porosity; resistivity index and its relation with water saturation.

Classification of log measurements, borehole environment, logging equipments: set up, truck, cable construction, recording equipments, log presentation, magnetic tape recording.
Logging tools: Basic principles, calibration, environment corrections, computation of reservoir parameters and their simple applications:
Resistivity: focused (SFL), micro resistivity devices, conventional induction logging tools.
Self potential: electrical analogue of SP, effects of bed thickness, hole diameter, shaliness, irregular invasion on SP response. SP in tight formations, bimetallism and bimagnetism effects on SP.
Natural gamma ray: Effects of borehole environment, logging speed, time constant and formation density on log response, corrections for caving and casing etc.; measurement of porosity using neutron sources: CNL, SNP; compensated density and sonic tools for porosity measurements.
Miscellaneous tools: Dipmeter, temperature, caliper, repeat formation tester, side wall coring tools.
Advanced logging tools: Introduction to NGS, TDT, CBL/VDL, LWD and MWD.
Brief introduction of flow meters, fluid density and temperature measurement tools. Brief account of perforation devices, depth control and safety aspects in wells.

Suggested Reading:

Bateman, R, M., Open Hole Log Analysis and Formation Evaluation
Bateman, R, M., Cased Hole Log Analysis and Reservoir Performance Monitoring.
Brock, J., Applied Open Hole Log Analysis
Ellis, D. V., Well Logging for Earth Scientists
Helander, D. P., Fundamentals of Formation Evaluation.
Serra, O., Fundamentals of Well Log Interpretation
Vaish, J. P., Geophysical Well Logging: Principles and Practices

Geophysical Signal Processing (Practical)

0 0 3/2

1. Computing DFT coefficients of a time series and estimating energy spectra through periodogram method.
2. Computing convolution and cross correlations of two time series.
3. Investigating the effect of various windows in reducing the energy leakage.
4. Estimating energy spectrum of a signal from auto correlation function.
5. Computing FFT of a signal and investigate the effects of padding zeroes to a short time series in estimated energy spectrum.
6. Computing the responses of Martin-Graham, Butterworth and Chebyshev filters and evaluating their performances.
7. Designing a notch filter to eliminate power line frequency from an observed signal.
8. Designing a spiking deconvolution filter using i) spectral division and ii) Wiener filtering.
9. Investigating the properties of different types of wavelets and converting a mixed phase wavelet to a minimum phase wavelet.
10. Computing the probability density function, mean and variance of a given random process.
11. Design commonly used signal enhancement filters, viz. continuations, second vertical derivation etc.
12. Computer 2D FFT and estimate radial spectrum.
13. Compute the frequency response of a source/receiver array.

14. Performing cepstral analysis of a signal composed of a primary and an echo.

Exploration Seismology: Processing, Modeling and Interpretation (Practical)

0 0 3

1. Computing Ricker wavelets with different dominant frequencies.
2. Generating the reflection time series given a sonic and density log.
3. Computer synthetic seismogram given the reflectivity series and source wavelet.
4. To prepare a stacking chart and obtain CMP gather.
5. Estimating stacking velocity from velocity analysis and applying NMO correction.
6. Standard processing of seismic data (from raw data to stacked section)
7. Computing interval velocity using Dix equation.
8. To investigate the resolution of thin beds and 'tuning effect' of thin beds on reflection amplitude.
9. Simulating various types of AVO curves.
10. Study of velocity spectrum plots and calculation of interval velocity using DIX's relation. Drawing of velocity profiles on the spectrum plots.
11. Convolution, Cross-correlation, and Auto correlation of seismic data through Fortran programming.
12. Plotting and viewing of field seismic data through CWP seismic UNIX software.
13 Generation of various types of synthetics records for simple and complex structure using CWP seismic UNIX software.
14. Processing of field seismic reflection data through shell scripting using CWP seismic UNIX software.
15. Wave equation migration schemes applied to synthetic stacked seismic sections.
16. Preparation of Isochron map of a given prospect.

Electromagnetic Method (Practical)

0 0 3

For the given data set plot the skin depth versus frequency and skin depth versus resistivity and discuss the significance of the plot.

2. Draw to scale the field setup, plot the given Vertical loop fixed Transmitter (VLFT) data and given qualitative and quantitative interpretation.
3. Draw the dip angle curves from the data obtained with broadside HLEM equipments and to locate any potential conductors and estimate their depth, dip and if possible the os product. Also discuss the advantage of using two frequencies in this type of survey.
4. Acquisition and interpretation of frequency domain em data.
5. Plot response function curve of Q value ranging from 10^{-2} to 10^{2}. Plot also the response for R/w values assuming inductance to be unity. Explain briefly the significance of these response curves. Write a FORTRAN program for the same.
6. The rectangular transmitting loop is 2000 feet by 1000 feet and the field ratios and phase readings are for lines 4N at stations 250 W to 1050 W in 100 ft steps. Transmitter frequency is 1000 Hz and the receiver coils are 100 feet apart. Calculate the NR, RR, $\sum\Delta\Phi$, R and I values from the TURAM data. Plot FR, RR, $\Delta\Phi$, $\Phi = \sum\Delta\Phi$, V,R, and I. Give a qualitative interpretation of data.

7. Explain semi-qualitatively or schematically the effect of overburden to the em field measured for the following two cases : The in-phase and quadrature computed for a vein type body embedded on a perfectly including host veins – 20% and – 5% respectively.

Case I : Overburden resistivity : 1000 ohm-m, Thickness of overburden : 10 m
Frequency of signal : 3600 Hz.

Case II : Overburden resistivity : 10 ohm-m, Other parameters remaining same as in (I).

8. For the given data set of inphase and out-of-phase components, frequency and coil separation interpret the anomaly with the help of available phasor diagram.
9. Acquisition and interpretation of very low frequency em data.
10. Acquisition and interpretation of time domain em data.

Image Processing and GIS (Practical)

0 0 3/2

1. Loading and installation of available Image Processing and GIS software i.e. PCI Geomatica and SPANS and checking it s functionality.
2. Creating individual folder and loading the Digital Image and reading the Header Information.
3. Study of PDF curve i.e. Histogram between DNs and frequency.
4. Applications of linear and non linear enhancement techniques and noting down the resulting improvement in image quality. Also preparing standard FCC.
5. Applications of high pass and low pass filter and discussing the resulting improvement in image quality.
6. Study of the selected scanned map data and its Geo referencing using Atlas data and proper GEOID and ELLIPSOID.
7. Digitization of corrected map data and creating point, line and area layers
8. Creating Attribute (Entity) Table and integration of various layers.
9. Object oriented integrated logical analysis of various raster/remote sensing and vector layers.

Well Logging : Principles and Tools

0 0 3/2

1. To plot porosity against permeability
2. To plot porosity against resistivity
3. To apply borehole correction on SP and resistivity logs
4. To apply borehole correction on gamma ray log
5. To calculate formation temperature
6. To calculate formation factor from resistivity log
7. To find out lithology from micro resistivity log
8. To find out lithology from neutron, density and sonic logs
9. Use of porosity logs to distinguish oil and gas
10. Use of CBL in cement evaluation

NINETH SEMESTER (5 year Integrated) / FIFTH SEMESTER (3 year course)

Magnetotelluric and Ground Penetrating Radar Methods

3 1 0

Magnetotelluric method: Sources of MT signal, interaction with the earth -uniform earth, horizontal layers, anisotropy, inhomogeneity, impedance tensor and tipper, topographic and regional effects, static shift.

Theory of electromagnetic wave propagation in horizontally layered earth and response over multi layered earth, skin depth for homogeneous and layered earth.

Data processing and analysis: auto and cross spectra, solution to the impedance and tipper equations, local and remote references, errors and noise. Robust and hybrid processing.

Interpretation: interpretation of MT data over a two layered earth, strike, rotation swift strike, polar diagram, tipper, skew, ellipticity, TE and TM modes, continental lower crust, MT study over cratons.

Audio magneto telluric methods (AMT).

Interpretation: 1D and 2D interpretation.

Case histories: Structural mapping for petroleum exploration, geothermal mapping, exploration for sulphides, gold, uranium. Detecting subsurface structures and water.

Ground Penetrating radar: Basics-similarity with seismics, antennas, pulse width and central frequency, time windows and samples; propagation of electromagnetic waves in group- Q and loss tangent, reflection and transmission coefficients.

Field procedure and interpretation: monostatic and bistatic arrangements, profiling and stacking, reflection and diffraction, distance determination, migration; depth of penetration and resolution. vertical and lateral resolution.

GPR Applications: fracture mapping, structures in sand and moraines, mapping groundwater table.

Suggested Reading:

Blaricom, R. V., 1992, Practical Geophysics II for the Exploration Geologist: Northwest Association Mining

Dobrin, M. B., and Savit, C. H., 1988, Introduction to Geophysical Prospecting (Fourth Edition), Tata McGraw Hill.

Kaufman, A. A., 1981, The Magnetotelluric Sounding Method, Elsevier Scientific Publishing Co.

Porstendorfer, G., Principles of Magnetotelluric Prospecting

Parasnis, D. S., 1997, Principles of Applied Geophysics (Fifth Edition), Chapman and Hall.

Telford, W. M., Geldart, L. P., Sheriff, R. E., and Keys, D. A., 1988, Applied Geophysics.

Vozoff, K., 1996, The Magnetotelluric Method; *in* Nabighian, M. N., Ed., Electromagnetic Method in Applied Geophysics: 2, Soc. of Explor. Geophys., 641-711.

Geophysical Inversion

3 1 0

Foundation of Inverse theory: mathematical back ground; vector space, Hilbert space; norm and dimension; common matrices in inverse problems, rank of a matrix, matrix partitioning; eigen values and eigen vectors, inverse of a matrix- Moore-Penrose inverse, singular value decomposition.

Forward and inverse problems in geophysics: definition of model, relation between model and data space, examples of forward and inverse problems; inversion as an appraisal problem.

Classification of inverse problems: linear, quasi linear and non linear inverse problems, examples. Structure of an inverse problem: existence, approximation, uniqueness and stability; formulation of an inverse problem as minimization of a functional.
Least squares inversion: steepest descent, conjugate gradients, Gauss Newton, Levenberg-Marquardt approaches, model and data covariance-understanding uncertainty and resolution.
Regularization: Tikhonov regularization and Backus-Gilbert method.
Constrained inversion: Role of a priori information, Occam's principle.
Stochastic inversion: Bayesian approach, a priori and a posteriori probabilities.
Nonlinear inversions and global optimization-an overview; Monte Carlo, simulated annealing, genetic algorithm, tabu search, neural networks and hybrid methods, comments on speed and accuracy.
Examples of inverting geophysical data over 1D and 2D structures: gravity and magnetic anomalies, resistivity, IP and MT data, travel time and velocity inversion, full waveform inversion, cross-hole tomography.

Geothermics and Geodynamics

3 1 0

Geothermics: Basics of geothermal history- Evolution of the earth as a member of the solar system; patterns of distribution of major chemical elements in the inner and outer planets of the solar system, Urey's hypothesis; major sources of heat inside the Earth since its accretion, role of radioactive heating, distribution of long-lived radioactive elements in crustal rocks; chondritic model; thermal history of the Earth, its solidification from molten magma, sinking of iron and formation of proto-core; geothermal gradient, adiabatic self compression.
Terrestrial heat flow studies: Terrestrial heat flow as a controlling factor of the geologic processes, measurement of continental and sub oceanic heat flow, temperature gradient probe, thermal conductivity of rocks, pattern of continental heat flow, heat flow values for continental shields and orogenic areas, problems of equivalence of continental and oceanic heat flow-Stacey's model.
Geothermal provinces in India: An overview of heat flow studies for different geological provinces in India, Geothermal provinces in India and their characteristics, Indian geothermal atlas; geothermal case studies for hydrocarbon bearing basins; aspects of geothermal exploration and modeling for basinal areas including the continental margins.
Crustal structure studies: Composition and structure of upper and lower continental crust, layering in oceanic crust, geophysical evidence for their evolution, isostasy, schemes of isostasy, reduction procedures, isostatic anomalies, study of isostatic compensation, crustal structure studies for mountains, plateau, basins in India, Gravity and DSS studies for the Himalayas.
Geodynamic models and plate tectonics: Oceanic magnetic anomalies and their interpretations, magneto stratigraphic time scale, paleomagnetic evidences from continental drift, APWP for different continents-their main results, seismological evidences for lithospheric deformation, concept of sea floor spreading and plate tectonics, plate margins and processes at plate margins, triple junction, Characteristic movement of Indian plate and formation of the Himalayas.

Suggested Reading

Bott, M. H. P., The Interior of the earth
Elder, Geothermal System
Goguel, Geothermics
GSI, Geothermal Atlas of India
LePicheon and Franchateau, Plate Tectonics

Meyer and Haenel, Geothermics with Special Reference to Applications
Robertson, The Nature of the Solid earth

Formation Evaluation

3 0 0

Formation Evaluation: General philosophy, models and structural approach.
Log interpretation techniques:
Quick look interpretation, cross-plots and overlays: SP vs R_{xo}/R_t, R_o vs R_t, neutron density, sonic density etc., frequency plots, z-plots.
Determination of porosity using neutron, density and sonic logs for single and dual mineral lithologies and porosity computation in shaly formations.
Lithology identification using M-N plots and MID plots for three mineral models
Rw determination from SP and resistivity using cross plots and overlays.
Water saturation: basic methods- Archie's equation, determination of saturation exponent, constants a and m in formation factor, ratio and cross plot techniques.
SHDT (stratigraphic high resolution dipmeter tool): Tool design, calculation, presentation and qualitative interpretation of dipmeter data.
Determination of petrophysical parameters of sedimentary rocks using core laboratory equipments; Application of well logs in characterization of coals- various tools and their responses in caved and uncaved formations; determination of quality of coal and rock strength, applications of well logs in mineral and ground water investigations.
Brief outlines of advanced logging tools: Induced gamma-ray spectrometry tools, chlorine, Carbon/ Oxygen, gamma ray spectrometry tool (GST), geo chemical logging tools (GLT), litho density tools (LDT), formation micro scanner (FMS), circumferential acoustic scanner tool (CAST)

Suggested Reading:

Bateman, R, M., Open Hole Log Analysis and Formation Evaluation
Bateman, R, M., Cased Hole Log Analysis and Reservoir Performance Monitoring.
Brock, J., Applied Open Hole Log Analysis
Ellis, D. V., Well Logging for Earth Scientists
Helander, D. P., Fundamentals of Formation Evaluation.
Serra, O., Fundamentals of Well Log Interpretation
Vaish, J. P., Geophysical Well Logging: Principles and Practices

Magnetotelluric and Ground Penetrating Radar (Practical)

0 0 3

1 Compute and plot real and imaginary part of wave number
From the given apparent resistivity compute the phase data and interpret the same.
2 Compute impedance, apparent resistivity and phase given models
3 Compute stability coefficient for the given data set. Also plot mean apparent resistivity, mean phase versus frequency.
4.Process the given MT time series data
5Compute the strike direction for the given data set using Swifts method

6 Compute the strike direction for the given data set using Phase Tensor
7 Determine the dimensionality for the given data set using impedance.
8 Determine the dimensionality for the given data set using phase tensor.
9 Interpret given polar diagrams
10 Resolve the 90^{o} ambiguity with the help of Swift's method and polar diagram.
11 Compute and plot the reflection coefficient of r-parallel and r-perpendicular versus angle of incidence at an air sea interface. Assume that the conductivity and dielectric permittivity of sea water as 3S/m and $\varepsilon=\varepsilon_o$
12 Interpret the given GPR section.

Geophysical Inversion (Practical)

0 0 3

1. Formulation of 2D forward problem in gravity/magnetics as linear and nonlinear problem
2. formulation of 1D resistivity/IP forward problem and computation of the sensitivity matrix.
3.Formulation of 1D MT forward problem and computation of sensitivity matrix.
4.Computing the sensitivity matrix for amplitude variation with offset (AVO) for isotropic/anisotropic reflector
5.Use of generalized (pseudo) inverse methods to invert different classes of AVO data.
6.Use of steepest descent (SD) and Gauss Netwon (GN) method to invert 1D resistivity/MT data
7.Use of conjugate gradient (CG)/ Marquardt Levenberg(ML) to invert noisy data
8.Computing data resolution and model resolution matrix and understanding their importance.

9.Using singular value decomposition to invert a near singular matrix-solving Christofel equation for homogenous isotropic medium
10.Comparison of performances SD, CG and Netwon's Method in inverting poststack seismic reflection data
11.To develop an algorithm for simulated annealing (SA)/ Very Fast SA to invert multiparameter data
12.To develop Genetic Algorithm (GA) and Neural Network (NN) algorithm
13.Evaluation of performances of local search and global search algorithm
14.To develop hybrid algorithm.

Formation Evaluation (Practical)

0 0 3

1.To interpret SP and resistivity logs
2.To interpret neurton, density logs
3.To cross plot resistivity versus density
4.To cross plot resistivity versus sonic travel time
5.To determine porosity from neutron density and sonic logs
6.To identify lithology using MN plots
7.To identify lithology using MID plots
8.To interpret LDT
9.To interpret FMS, dipmeter log
10.To interpret coal log data

TENTH SEMESTER (5 year Integrated) / SIXTH SEMESTER (3 year Course)

Industrial Management

3 0 0

Evolution of management theory and practice; Principles of scientific management, Function of management.

Concept of organizational behaviour – Leadership and Motivation.

Concept of human resource management – Selection Training and Development.

Finance management – Capital budgeting techniques; Pay back period, Accounting Rate of Return, Net Present Value, Internal Rate of Return, Profitability Index; Sources of capital; Cost concepts and break-even analysis.

Project management - Introduction, Network construction and identification of critical activities in Critical Path Method and Project Evaluation Review Technique
Introduction to marketing management, Concept of product life cycle.

Introduction to optimization techniques; Linear programming formulation and its graphical solution.

Environmental Geophysics

3 1 0

Earth and environment; elements of environment, man and environment
Atmosphere: origin, composition and structure, the troposphere as an environmental layer, air pollution, pollutants and its impact on weather, the ozone shield, green house effects and role of trace gases, global warming, acid rains.
Hydrosphere: Ocean and environment, the hydrologic cycle and the global Water balance, surface water hydrology, water pollutants and their effects on surface and ground water. Heavy metals etc. in ground water, their detection and abatements.
Minerals, Energy and Environment: mineral resources and environment, impact of mining and mineral resources.
Energy and environment: coal, oil and gas, geothermal energy, nuclear energy, solar energy.

Suggested Reading:

Jorgensen, S E, Principle of Environmental Sciences and Technology, Elsevier
Keller E A, Environmental Geology, Merril Publ.
Ramade Francois, Ecology of Natural Resources.
Strahler A N and Strahler A H, Environmental Geoscience -Interaction between Natural System and Man.
Tyler, G and Mitter Jr Environmental Science, Wadsworth Publishing.

Numerical Techniques in Geophysics

3 1 0

Solution of algebraic and transcendental equations by bisection, iteration, false position, secant and Newton Raphson methods, Generalized Newton's method for multiple roots.

Solution of system of linear simultaneous equations by Gauss elimination, Gauss-Jordan, Crout's triangularisation, Jacobi and Gauss Seidel methods, Numerical Solution of Tridiagonal system.

Finite differences, Symbolic relations, differences and factorial notation of a polynomial, data smoothing, Interpolation and extrapolation, Newton-Gregory forward and backward, Gauss forward and backwards, Stirling, Bessel, Everett, Lagrange and Newton's divided difference formulae, Inverse interpolation by Lagrange and iterative methods, Cubic splines, Numerical differentiation and integration, Trapezoidal, Simpson's $1/3^{rd}$, Simpson's $3/8^{th}$, Weddle and Gaussian quadrature formulae. Numerical solution of Integral Equations by finite difference method.

Numerical solution of first order ordinary differential equation by Taylor's series, Picard's Euler's, Modified Euler's, Runge-Kutta, Adams-Moulton and Milne's methods. Solution of simultaneous first order and second order ordinary differential equations with initial conditions by Taylor's series. Runge-Kutta nd Milne's methods. Numerical solution of boundary value problems by finite difference and shooting methods. Mumerical solution of Partial Differential Equation (Laplace, Heat Conduction and Wave Equation).

Numerical Techniques in Geophysics practical

0 0 3

Numerical solutions of non-linear algebraic and transcendental equations by bisection, iteration, false position, secant and Newton Raphson methods.

Numerical solution of a system of linear simultaneous equations by Gauss elimination and Gauss Seidel methods. Solution of Tridiagonal system.

Interpolation by Lagrange's interpolation formula.

Numerical evaluation of definite integral by Trapezoidal, Simpson's $1/3^{rd}$, Simpson's $3/8^{th}$, Weddle and Gaussian quadrature formulae.

Numerical solution of first order ordinary differential equation by Euler's Modified Euler's, second and fourth order Runge-Kutta, Adams-Moulton and Milne's methods. Numerical solution of simultaneous first order Ordinary differential equations and second order Ordinary differential equations with initial conditions by second and fourth order Runge-Kutta methods. Laplace Equation, Heat Conduction and Wave Equation.

Reservoir Geophysics

3 0 0

Section A

Reservoir: Definition, elements and types; Petrophysics: fluid properties, stress conditions, fluid flow in two and three dimensions, radial and spherical lows, generalized Darcy's law, phase behaviour: P-T & P-V diagrams.

Section B

Introduction to multi component seismic survey and utilization of shear wave output in complementing pressure wave outputs.
Application of 3D and 3C seismic data in reservoir studies.
Vertical Seismic Profiling: acquisition, processing and interpretation, Zero Offset VSP, Walkaway VSP, Faroffset VSP and 3D VSP
Passive Seismics
Use of crosshole seismic tomography and AVO in reservoir management.
Case studies of 4D seismics in reservoir management.

Section C
Deep Water Imaging

Introduction:
Deepwater: Indian and World Scenario
Deepwater Depositional System, Deepwater Challenges and Startegy
Problems associated with Seismic in Deep Water Imaging
Marine Controlled Source Electromagnetic (MCSEM): Physics of MCSEM, EM Boundary Condition and Attenuation, Numerical Studies and Case Studies

Principles of Marine Magnetotelluric and Case Studies

Suggested Reading:

Cosse, R., Basics of Reservoir Engineering
Craft, B. C and Hawkins, M., Applied Petroleum Reservoir Engineering.
Muskat, Flow of Homogeneous Fluids
William, D., McCain, Jr., The Properties of Petroleum Fluids.
Sheriff, R.E., Reservoir Geophysics

Water Resources Management

3 0 0

Hydrologic cycle, vertical distribution of groundwater
Aquifer types and their hydraulic properties: Aquifer, aquitard, aquiclude and aquifuge; types of aquifer, hydraulic properties.
Ground water flow and well hydraulics: Bernoulli's equation, Darcy's law, Laplace equation, steady state flow, unsteady state flow, steady radial flow to a pumping well from confined and unconfined aquifer, unsteady radial flow to a pumping well from confined aquifer, Theis, Chow's and Cooper Jacob solution for unsteady radial flow equation to a pumping well.
Approximate methods: Estimation of transmissivity, hydraulic conductivity, specific yield, storavity.
Catchment or watershed drainage, watershed discharge, overland flow, surface runoff, subsurface runoff, effluent and influent streams, factors affecting runoff, types of precipitation, depth-area-duration analysis, concept of hydrograph formation.
Water resource management in hilly, mining and coastal areas.
Artificial recharge, rain water harvesting, surface and groundwater abstraction structures.
Finite difference groundwater modeling.

Suggested Reading

Anderson, M. P., and Wossner, W. W., Applied ground water modeling simulation of flow and advective transportation.
Kenneth, N. B., Peter, F. F., Hans, M. G., Leonard, F. D., Hydrology and the management of watersheds.
Manual: Evaluation of Aquifer Parameters, Central Ground Water Board.
Patra, K. C., Hydrology and Water Resources Engineering
Raghunath, H. M., Hydrology, Principles, Analysis and Design.
Todd, D. K., Groundwater.

Natural Disasters and Hazards

3 0 0

Introduction to Natural Hazards, various type of hazards, assessment and risk calculation, mitigation and development of geo data base for a Decision Support system for strategic planning , relief and rehabilitation.
Earthquake Hazard: Status earthquake occurrence and its geographical distribution; brief of various earthquake hazards. Forecasting and prepared ness. Assessment and calculation of seismic hazard and risk. Seismic zoning and microzonation.
Land slide and subsidence: Classification of land slides ,causes of land slides, identification, prevention and control of land slides.
Subsidence**:** Types, causes and related hazards.
Flood: causes ,magnitude and frequency of floods, nature and extent of flood hazards.
Coastal Hazard: Tropical cyclone, Tsunami , coastal erosion, prevention , remedies and planning
Volcanic Hazard: Effects, activity, prediction and management.

Suggested Reading:

Bolt , B.A., Horn, W. L. Macdonald, G. A. and Scott, R. F.,Geological Hazards

Donald, R., Geology and Society.
Gupta, H. K. and Rastogi, B. K. , Dams and Earthquake, Elsevier
Keller, E. A., Environmental Geology, Merill Publ.
Powers of Nature , National Geographic Publ.
Strahler A N and Strahler A H, Environmental Geoscience -Interaction between Natural System and Man.

Prestack Imaging

3 0 0

Review of post stack imaging techniques. Mathematical background of wave equation migration techniques. The exploding reflector concept, its advantages and limitations. Kirchoff's Migration, Kirchoff's Integral, Time versus Depth and post stack versus prestack migration, time migration, depth conversion of time migration, post stack migration, pre stack migration.
Migratin velocity analysis, frequency domain migration, time versus frequency domain, geometrical overview of f-k migration, phase shift migration.
Finite Difference migration

Rock Physics

3 0 0

Purpose of rock physics. Practical use of rock physics transforms in reservoir property mapping and synthetic seismic generation.
Definitions and methods of rock physics. Elasticity. Static and dynamic moduli.
Importance of rock texture. Sediment in the thin section. Depositional regimes and their effect on texture and seismic and log signatures.
Factors effecting Porosity and Permeability
Porosity - Permeability Relation
Permeability damage
Effect of pore fluid of rock's seismic properties. Fluid substitution.
Importance of Vp/Vs and Poisson's ratio.
Effect of porosity on rock's elasticity
Porosity-velocity models. Effects of mineralogy and texture.
Porosity-velocity-texture models. Sand-shale mixtures and their elastic signatures.
Seismic signatures of compaction and overpressure.