DEPARTMENT OF GEOPHYSICS KURUKSHETRA UNIVERSITY KURUKSHETRA

Syllabus for Ph.D. Entrance in Geophysics (2011-12)

GP-101: Mathematical Methods in Geophysics

UNIT-I: Special Functions

Bessel's and Legendre's differential equations and their series solutions.
Legendre functions: Generating functions, Rodrigue's formula, Recurrence relations, Orthogonality, Expansion of an arbitrary function in a series of Legendre Polynomials, Associated Legendre functions and its recurrence relations and orthogonality property.
Bessel Functions: Generating functions, Recurrence relations, Integral representation, Orthogonality, Expressions when 'n' is half an odd integer, Spheraical Bessel functions.

UNIT-II: Complex Variables

Complex variable, limit, continuity and differentiability of function of complex variables, analytic functions, Cauchy Reimann's equations, Cauhy's integral theorem, Morera's theorem, Cauchy integral formula, Expansion by Taylors and Laurents series, singularities, Residue theorem, contour integration.

Unit-III: Integral Transforms

Fourier series, Fourier transform, inverse Fourier transform, properties of Fourier transform, application of Fourier transform in solving differential equations.
Laplace transform, Inverse Laplace transform, Convolution theorem, Properties of Laplace transform, application of laplace transform in solving differential equations.
A brief introduction to Hankel, Hilbert and Radon transforms.

Unit-IV: Partial Differential Equations

Solution by separation of variables of

(a) Wave equation: Transverse vibrations of a stretched string; Oscillations of a hanging chain, vibrations of rectangular and circular membrances, tidal waves in a canal.
(b) Laplace's equation: Laplace equation in Cartesian, Cylindrical and spherical coordinate systems, two dimensional steady flow of heat, General cylindrical and spherical harmonics.
(c) Diffusion equation: Variable linear heat flow, periodic heat flow in one dimension, two dimensional heat conduction.

RECOMMENDED BOOKS

(1) Applied Mathematics for Engineers and Physicists by L .Pipes & L.R. Horwell
(2) Mathematical Methods for Physicists by G. Arfken
(3) Mathematical Physics by B.S. Rajput
(4) Elementrary Applied Partial Differential Equations: With Fourier Series and Boundary Value Problems by Richard Haberman
(5) Integral Transforms by I. Sneddon
(6) Elements of Partial Differential Equations by I. Sneddon

GP-102: Solid Earth Geophysics

UNIT-I

A brief history of the development of Earth Sciences and of Geophysics in particular, An overview of Geophysical methods and their essential features, Problems of inversion and non-uniqueness in Geophysics, Origin & evolution of Earth, A review of the Earth's major surface features, its structure and composition, A brief review of the knowledge of the solar system and history of the earth-moon system

UNIT-II

Chemical composition of Earth, Rheological behaviour of crust and upper mantle, Geochronology: Radiometric dating and their advantages, meaning of radiometric ages, Major features of the Earth's gravitational field and relationship with tectonic processes in the crust and upper mantle, concept of isostasy, hypotheses of isostasy.

UNIT-III

Origin of geomagnetic field, polar wandering, secular variations and westward drift, reversals of geomagnetic field, geomagnetic storms, sea-floor spreading, Paleomagnetism and its uses, Thermal history of the Earth, sources of heat generation and temperature distribution inside the earth, convection in the mantle.

UNIT-IV

Earthquake seismology, Global seismicity and tectonics, Earth's internal structure derived from seismology, Earthquake mechanism and Anderson's theory of faulting, Continental drift and plate tectonics: its historical perspective and essential features, present day plate motions, Triple junctions, oceanic ridges, Benioff zones, trenches and island arcs, Mountain building, origin of Himalaya, Geodynamics of Indian subcontinent.

RECOMMENDED BOOKS:

(1) The Solid Earth by C.M.R. Fowler
(2) Understanding the Earth by I.G. Guass, P.S. Smith and R.G.L. Wilson
(3) The dynamic Earth by P.J. Wyllie
(4) Introduction to Geophysics by B.F. Howell
(5) Physics and Geology by J.J. Jacobs, R.D. Russel and J.T. Klilson
(6) Fundamental of Geodynamics by A.E. Schieddeggar
(7) Fundamentals of Geophysics by W. Lowrie

GP-103: NUMERICAL METHODS AND COMPUTER PROGRAMMING

UNIT-I

Basic computer organization, information storage media, computer software, computer languages, problem solving on a computer, algorithm, flowchart and computer program, introduction to computer operating systems: DOS, WINDOWS, UNIX/LINUX, concept of SHELL programming.

UNIT-II

FORTRAN preliminaries, constants, variables, data types, expression and statements, iterative statements, input/output statements, subroutine and functions, data sharing among subprograms/programs, operations with files, programming examples to handle problems of numerical and statistical type

UNIT-III

Programming language C: constants, variables, data types, expressions, operators, conditional statements, iterative statements, array, function, simple programming examples

C^{++} An object oriented language: Concepts of class, object, constructors, destructors, operator overloading, inheritance, pointers, virtual functions, simple programming examples

UNIT-IV

Numerical integration by Simpson's method, Trapezoidal method, Numerical differentiation, solution of algebraic equation, Netwon Raphson method, solution of simultaneous linear equations, Gauss method, Gauss-Jordon method, Gauss-Seidel method, matrix inversion, least square curve fitting, straight line and polynomial fits, solution of ordinary differential equations.

A brief introduction of Binomial, Poisson and normal distributions, concept of mathematical expectations

RECOMMENDED BOOKS

(1) Fundamentals of computers by V. Rajaraman
(2) FORTRAN 77 and Numerical methods by C. Xavier
(3) FORTRAN Programming and Numerical methods by R.C. Desai
(4) Let us C by Yashwant Kanetkar
(5) Object Oriented programming with C^{++} by E. Balagurusamy
(6) Advanced UNIX- A Programmers guide by Stephen Prata

GP-104: BASIC GEOLOGY

UNIT – I: INTRODUCTION

Earth Sciences, its subdivisions and relation to other sciences Importance of geology to mankind. Historical Geology: Materials and methods of historical geology, Geologic time, Age of the earth, Fundamental principles of geology. Geomorphological Processes: Exogenic processes (weathering, erosive and tectonic denudation), Geological processes by river, wind, glacier and waves and tides.

UNIT – II: MINERALOGY

Mineral: definition, chemical nature of minerals, Basic sub-atomic particles, atomic mass, atomic number, radioactivity, isotopes and ions, chemical bonding, processes of crystallisation in minerals, Physical properties of minerals, Classification of minerals, Physical properties, chemical composition, mode of occurrences and economic uses of some important rock forming minerals.

UNIT – III: PETROLOGY

Distinguish between rocks and minerals. Igneous Petrology: Magma and its crystallisation, Mode of occurrence, texture and structure, mineralogy and classification of igneous rocks. Sedimentology: Sedimentary processes, sedimentary environments of deposition, texture, structure and classification of sedimentary rocks. Metamorphic Petrology: Metamorphism, factors of metamorphism, types of metamorphism, texture, structure, mineralogy and classification of metamorphic rocks. Indian distribution of major rock types.

UNIT – IV: STRUCTURAL GEOLOGY

Primary and secondary structures of rock, Dip, strike, bearing and azimuth. Folds: definition and classification scheme, mechanism of folding, recognisation of folds in the field. Fault: definition and different terminology of fault, mechanism of faulting, recognisation of fault in the field, shear zone,

lineament. Joints: definition, types of joint. Unconformity: concepts, types, recognisation and significance of unconformities.

RECOMMENDED BOOKS:

(1) Rutley's Elements of Mineralogy By H.H. Read
(2) Structural Geology by M.P. Billings
(3) Principles of Physical Geology by A.H. Holmes
(4) A Text Book of Geology by P.K. Mukherjee
(5) The Principles of Petrology by G.W. Tyrrell
(6) Manual of Field Geology by R.R Compton

GP-201: Remote Sensing and GIS

Unit I

Introduction: Electromagnetic (EM) Spectrum, Interaction of EM radiations with earth's surface and atmosphere, special signatures, remote sensing platforms. Aerial photographs; types of aerial photographs, stereoscopic vision, stereoscopic parallax, measurement of height difference, vertical exaggeration, image distortion. Photo elements, geotechnical elements, photocharacteristics of different rock types and structures, photo-mosaic, rectification. Plotting instruments

Unit II

Satellite Imagery: Imagery vis a vis aerial photograph, active and passive sensors, MSS, LISS, CCD, Infrared and thermal scanners, different satellite programmes, microwave sensors, Remote sensing data products, fundamentals of image interpretations and analysis, visual interpretation of remote sensing data; false colour composite, Concept of digital image analysis, image restoration, image enhancement and information extraction. Supervised and unsupervised classification. Map accuracy assessment.

Unit III

Applications: Interpretation and analysis of aerial photographs and images for identification of different rock types, structures, lineaments and preparation of geological map. Recognition of landforms, drainage pattern and preparation of geomorphological map; applications in engineering projects (dam reservoir, tunnel alignment, route location etc), ground water prospecting, exploration for minerals and oil, geoenvironmental studies (soil conservation, land degradation etc), Disaster management (flood, landslide etc) and monitoring of atmospheric pollution.

Unit IV

Introduction to Geographical Information System (GIS), components of GIS, data structures, Concept of raster and vector data, digitization, editing, attribute attachment etc, creation of layers, Data Integration, vector to raster conversion and vice –versa. Introduction to Global Position System (GPS) and its uses.

Recommended Books:

1. Remote Sensing Geology (Springer Verlag). R.P. Gupta
2. Remote Sensing in Geology (John Wiley & sons). B.S. Siegel and A.R. Gillespie
3. Remote Sensing and image interpretation (John Wiley & sons). T.M. Lillesand and R.W. Kiefer
4. Remote Sensing Principles and interpretation (WH Freeman Company. F.F. Reeds
5. Remote Sensing fro Earth Resources (AEG publication), D.P. Rao

6. Principles of Remote sensing (ELBS London). P. J. Kuran
7. Advances in Geophysics Vol. 1 and 13 (Academic press) H.E. Landesberg
8. Handbook of Information issued by GSI (Airborne Mineral surveys and exploration wing), AEC (Atomic Minerals Divisions) and NGRI.
9. Principles of GIS, P. A. Burrough
10. Indian Society of Geomatics News letters 2004-2005
11. GPS: Theory and Practice (Springer Verlag). B. Hofman-wellenhof, H.lichtenegger and J.Collins

GP-202 STRATIGRAPHY, HIMALAYAN, ECONOMIC AND PETROLEUM GEOLOGY

Unit-1 Stratigraphy

Principles of stratigraphy, elements of stratigraphic classification, physical and structural sub-disciplines of Indian subcontinent and their characteristics, An outline of the geology of India with respect to distribution, classification, lithology and economic importance of the following: Archean, Dharwar, Cuddapah, Vindhyan, Gondawana.

Unit-2: Himalayan Geology

Tectonic divisions of the Himalaya, Geology and tectonics of the Sub-Himalaya including Tertiary of Assam Himalaya, Lesser Himalaya, Higher Himalayan Crystalline, Tethyan Sedimentary Zone, Indus-Tsangpo-Suture Zone and Trans Himalaya.

Unit-3. Economic Geology

Definition of ore, Ore and gangue mineral, Classification of ore deposits, Elementary idea s of the following processes of formation of ore deposits: Magmatic concentration, Pegmatitic, Sedimentation, Evaporation, Residual concentration, Mechanical concentration and Metamorphism, Chemical composition, Diagnostic characters, Occurrences, Uses and Distribution in India of important metallic and non-metallic mineral deposits.

Unit-4. Petroleum Geology

Petroleum, Origin of petroleum, Reservoir rocks, Migration of Oil and gas, Hydrocarbon traps, Formation water characteristics as oil exploration leads, Plate tectonics and global distribution of hydrocarbon reserves, Classfication of Indian basins and petroleum geology of Assam, Bengal, Cavery, Krishna-Godavari, Cambay and Bombay offshore basins.

Recommended Books

1. Economic Geology: Bateman
2. India’s Mineral Resources: Krishna Swami
3. Introduction to India’s Economic Minerals
4. Geology of India and Burma: Krishnan
5. Geology of India: Wadia
6. Geology of Petroleum: Leverson, A.I.
7. Petroleum Geology: Chapman, R.E.
8. Aspects of Tectonics: K.S. Valdiya
9. Dynamic Himalaya: K.S. Valdiya

GP-203: Geophysical Signal Processing

UNIT I: Signal and System
Signals: Various special signal and signal class, orthogonal function, band limited signals, sampling theorem, aliasing effect of sampling on reconstruction of continuous signal from their samples, extrapolation of band limited signals
Systems: Linear time invariant causal and stable system with continuous and discrete input, minimum phase signals, Hilbert transform

UNIT II: Discrere Transform
Z transform, properties of Z transform, and the region of convergence, Z transform of causal and non causal sequence, inverse Z transform
Review of Fourier Transform, Introduction to wavelet transform and Walsh transform and their application in geophysics
discrete fourier transform, Fast Fourier Transform (FFT), digital filters: recursive and non-resursive filters, Amplitude and phase response of filters, ideal and realizable low pass, band pass and high pass filters, direct and canonical realization scheme, Cascade and paraellel realization scheme, finite and infinite unit impulse response filter, cepstral analysis

UNIT III: Time series analysis
Introduction of stochastic process, autocorrelation and cross correlation, Stationarity, Wide sense stationarity, ergodicity, power spectral density function, Wiener Khinchine theorem, White Gaussian Noise, Wiener Filtering, Matched Filtering

UNIT IV: Applications
Importance of Windowing, Commonly used windows, extension of linear theory to two and three-dimensional cases, downward continuation, gravity convolution model, resistivity convolution model, Seismic convolution model, applications of FFT in geophysics, application of signal processing in seismology.

Reccomended Books

1. Signal and Systems, M.L. Meade and C.R.Dillon , Chapman and Hall London
2. Digital Signal Processing, 1975, Oppenheim, A.V. and R.W. Schafer, Prentice Hall, Englewood Cliffs, New Jersey
3. An Introduction to Statistical Communication Theory, J. B. Thomas, John Wiley, New York
4. Spectral Analysis in Geophysics, 1974, Markus Bath, Elsevier, Amsterdam
5. Signal Analysis, 1977, A. Popoulis, McGraw Hill New York
6. The Fourier Integrala nd its applications, A. Popoullis, , McGraw Hill New York
7. Time Sequence Analysis in Geophysics, 1975, E.R. Kanscwich

GP-204: Geophysical Fields and Waves

UNIT – I: Potential Field Theory:
Introduction to Geophysical fields; Inverse square law of field: Gravity, Magnetostatic and electrostatic, Green's theorem and Green's functions, Potential due to an arbitrary source distribution, continuation of potential fields, Dirichlet and Neumann problems.

UNIT-II: Thermal Conduction in Earth

Heat conduction equation; effect of advection; time scale of conductive heat flow;calculation of simple geotherms in continents; Geological applications of heat conduction in semi-infinite half space: (i) penetration of external heat into the earth due to periodic variation of surface temperature, (ii) instantaneous heating or cooling of semi-infinite half space and its application to cooling of oceanic lithosphere and (iii) thermal and subsidence history of sedimentary basins, Age of Earth on the basis of cooling.

UNIT-III: Wave Theory

Introductory remarks about seismic and electromagnetic waves, Elastic Waves: Analysis of stress and strain, properties of equilibrium and motion in terms of stresses/displacements for infinitesimal and finite deformation, Generlised Hook's Law, Isotropy, Aelotropy and Anelasticity.

Electromagnetic Waves: Maxwell's equations, constitutive relations, Plane electromagnetic waves in dielectric and conductor.

Kirchoff's integral theorem and Kirchoff's solution of diffraction at a slit.

UNIT-IV: Oceanography

Tidal Waves, driven tidal waves, seiches, geostrophic effect on tidal waves, internal tidal waves, surface waves, permanent waves, waves due to local disturbances, equilibrium theory of tides, dynamic theory of tides.

Books Reccomended

(1) Geodynamics applications of continuum Physics to geological problems : Turcotte & Schubert
(2) Interpretation theory in Applied Geophysics: F.S. Grant & G.F. West
(3) Electromagnetic theory: J. Stratton
(4) Heat conduction: I.R. Ingersoll
(5) Solid Earth: C.F. Fowler
(6) Fundamentals of Geophysics: W. Lowrie
(7) Introduction to theoretical Geophysics: C.B. Officer

GP-301: Seismology

UNIT – I: SEISMIC WAVE PROPAGATION

Review of basic concepts and relations in elasticity theory, Hook's Law, reflection and transmission of elastic waves at a plane boundary, plane waves, laws of simple reflection and refraction, head waves, total internal reflection, spherical waves, surface and interface waves, Rayleigh waves, Stoneley waves, love waves, dispersion curves, Free oscillations of the earth, toroidal and spheroidal oscillations, normal modes of a homogeneous sphere.

UNIT – II: EARTH STRUCTURE AND LOCATION

Travel time table: the ray parameter and seismic rays, time distance curves for local and teleseismic events, Inversion of travel times for earth's structure, the method of Herglotz and Wichert, Preliminary location of earthquakes, refining the locations, review of various types of field observations, salient features of seismograms with description of different seismic phases.

UNIT-III: EARTHQUAKE SOURCE PROCESS

Uniqueness and reciprocal theorems, Green's tensor for a uniform medium, mathematical models of earthquake source, radiation pattern for P & S waves from a shear fault, the fault plane solutions.

UNIT – IV: EARTHQUAKE PARAMETERS AND SEISMIC ZONING
Earthquake parameters: Intensity and magnitude scales, seismic moment, relation between parameters, scaling laws, seismic zoning, seismicity, induced seismicity, earthquake prediction, discrimination between earthquakes and explosions.

Recommended Books:

(1) Elementary Seismology: C.F. Richter
(2) Introduction to theory of seismology : K.E. Bullen
(3) Seismology and Plate Tectonics: David Gubbins
(4) Seismic waves and Sources: A. Ben-Menham & S.J. Singh
(5) Modern Global Seismology: Lay & Wallace
(6) Seismology: Shearer

GP-302: Gravity & Magnetic Prospecting

Unit – I: Basic Principles
Principles of Gravity and Magnetic methods, concept of Geoid, Spheriod, a review of magnetic field of the Earth, relation between gravity and magnetic potential, variation of gravity with elevation and depth, determination of density, isostasy and gravity, Magnetization of rocks-Dia, Para- and Ferromagnetism, Magnetic susceptibility of rocks and their ranges, Artificial versus natural source Methods.

Unit-II : Instrumentation
Gravity Prospecting Instruments: Absolute versus Relative measurements of Gravity, Pendulum apparatus, stable and unstable gravimeters, calibration of gravimeters, LaCoste-Romberg gravimeter, Worden gravimeter.
Magnetic Prospecting Instruments: Fluxgate magnetometers, Proton precession magnetometers, optical pumping instruments, Schmidt's horizontal and vertical magnetometrs.

UNIT-III: Gravity and Magnetic Surveys:
Gravity survey on land: setting up of a base station, tide and drift corrections, the reduction of gravity data: the latitude adjustment, the elevation adjustment, the excess mass adjustment, terrain correction, Gravity anomalies, Plan of conducting ground magnetic surveys, corrections applied to magnetic data, Airborne magnetic surveys and magnetic gradient surveys.

UNIT-IV: Interpretation
Separation of residual and regional anomalies: Graphical method, direct computation, second derivative method, polynomial fitting method, depth rules, gravitational and magnetic attraction of structures with

various simple shapes, ambiguity in gravity interpretation, model analysis, step model, ribbon model, Applications of gravity and magnetic methods in oil and mineral exploration.

Recommended Books:

(1) Basic Exploration Geophysics: Robinson
(2) Applied Geophysics: Telford et al.
(3) Introduction to Geophysical Prospecting: Dobrin & Saviet
(4) Geophysical prospecting for oil: Nettleton
(5) Introduction to Geophysical Exploration: Keary & Brooks
(6) Gravity and Magnetic methods of prospecting: B.S. Rama Rao & IVR Murthy

GP-303: Groundwater Geophysics

Unit I

Concept of hydrogeophysics, hydrology in relation to other sciences, hydrosphere, hydrologic cycle, surface and subsurface distribution of water, origin of ground water, springs, hydrometeorology, precipitation, evaporation, evapotranspiration, seepage, infiltration and runoff and methods of measurement, chemical quality of ground water, its comparison with ocean and surface water.

Unit II

Hydrological properties of water bearing materials, porosity, void ratio, permeability, transmissivity, storativity, specific yield, specific retention, diffusivity, field and laboratory method for determining permeability, movement of ground water and aquifer performance tests, Darcy's Law and its range of validity, theory of groundwater flow under steady and unsteady conditions: determination of permeability, transmissivity and storativity by discharge methods.

Unit III

Mode of occurrence of ground water, classification of rocks with respect to their water bearing characteristics, aquifers, Aquiclude, aquitards, classification of aquifers, remote sensing studies for water resources evaluation. Ground water exploration and management, water balance studies, hydrograph analysis, conjunctive and consumptive use of ground water, water well drilling, development of wells, concept of artificial recharge.

Unit IV

Monitoring the health of groundwater reservoir, Use of geophysical well logs to estimate water quality, Use of Gamma logs for aquifer monitoring, Use of IP for groundwater contamination, application of electrical and seismic methods for ground water problems.

Recommended Books:

1. A textbook of geomorphology (east West press). P.G. Worcester
2. Groundwater hydrology (John Wiley and Sons), David K. Todd
3. Principles of Hydrology, Ward
4. Handbook of Applied Hydrology, V.T. Chow
5. Introduction to groundwater Hydrology, Heath Trainer
6. Hydrology. O. Meinzer

7. Hydrogeology (John Wiley and Sons). Davis, S.N., Dewiest, J.R.N.
8. Groundwater (Tata McGraw Hill), Toman, C.F.
9. Geohydrology (John Wiley and Sons). Dewiest, J.R.N.
10. Groundwater (Tata McGraw Hill), Walton, W.C.
11. Groundwater (Wiley Eastern Ltd.) H.M. Raghunath
12. Basic Exploration Geophysics. Robinson
13. Hydrogeophysics (Kluwer Publishers), Y.Rubin and S. Hubbard

GP 304: Electrical Prospecting

Unit I Introduction to electrical methods

A rapid review of the method and techniques of electrical prospecting and their classifications. Electrical properties of rocks, electrical properties of rock and their measurement, anisotrophy and its effect on electrical fields. The geoelectric section and geological section. Basic concept on natural electric field.

Unit II Induced Polarization and Self Potential method

Electrode configuration, the choice of method and choice of site measurement, presentation of measured data.

S.P. Method: Origin of self potential, theoretical and experimental basis of S.P. method, field of polarized conducter, sphere and cylinder, determination of ore body parameter, downward continuation of S.P. data

I.P method: Sources of I.P, Membrane and electrode potential, time domain and frequency domain measurement of IP, chargeability, percent frequency effect and metal factor, dipole theory of I.P., transformation of time domain to frequency domain data

Unit III Resistivity Methods

D.C. resistivity method, fundamental laws, thepotential distribution at the surface of horizontally stratified earth, Stefanescu's expression: Kernel function and its relation to subsurface parameters, Flathe and Pekeris recurrence relation: principle of equivalence, principle of superposition and principle of suppression. Apparent resistivity function, computation of apparent resistivity model curves, vertical electrical sounding

Resistivity Transform, Method of determination of resistivity transform, Asymptotic method, Complete curve matching, auxillary point method, equivalent curve matching using maxima and minima, Dar Zurruck curve, Direct interpretation method, application of linear filter theory for resistivity interpretation.

Unit IV EM and Telluric/ magneto telluric method

Principles of EM prospecting, various EM methods, passive source and active source methods, theory of EM induction; elliptical polarization, Airborne electromagnetic survey.

Telluric methods: Theory of telluric method, field procedure and method of measurement, analysis of telluric field data, Magnetotelluric method, processing and interpretation of M.T. data.

Recommended Books :

1. Electrical method of geophysical prospecting: Keller, G.V. and Frish Knecht,
2. Geosounding principles: Koefoed, O.
3. The application of Kernel functions in neterpretating geoelectrical measurements, Geoexploration monograph series no. 2Gebruder, Brorntraegr, Berlin : Koefoed, O.
4. Direct current geoelectric sounding: Bhattacharya, B.K. and Patra, H.P.
5. Principles of direct current prospecting Gebruder: Kunetz, G.
6. Interpretation theory in applied geophysics, Mg Graw Hill Co. N.York
7. Kaufman and Keller, The Magnetic Sounding Methods: Grant, F.S. and West, G.B.,
8. Geoelectromagnetism: Wait, J.R.,

GP-401: PETROPHYSICS AND WELL LOGGING

UNIT-I :Reservoir Rocks and Their Petrophysical Parameters

Sedimentary basins; hydrocarbon traps; origin of petroleum; migration and accumulation of petroleum; properties of subsurface waters and petroleum.

Porosity; factors governing magnitude of porosity; engineering and geological classification of porosity and its use.

Permeability; classification of permeability; factors governing magnitude of permeability; permeability-porosity relationship.

Formation resistivity factor (F_R); correlations between F_R and tortuosity; correlations between F_R and cementation; correlations between F_R and water saturation; correlations between F_R and permeability.

Well logging - objectives and its place in geoexploration; wire-line logging vis-à-vis coring; drilling fluid and invasion.

Logging practice; depth of investigation and vertical resolution

UNIT-II:Spontaneous Potential (SP) and Natural Gamma Ray Logs

Origin of SP; static SP and its determination; factors affecting shape and amplitude of SP curve; role of SP log in formation evaluation; estimation of formation water resistivity (R_w) from SP log.

Sources of natural radioactivity and gamma radiation; geochemical behavior of potassium, thorium and uranium; radioactivity of shales and clays; simple and spectral gamma ray tool including radiation detectors; calibration of simple and spectral gamma ray tool; factors affecting gamma ray log response; depth of investigation and unwanted borehole effects in gamma log; qualitative and quantitative uses of simple and spectral gamma ray log, How SP log is different from gamma ray log

Temperature and caliper logs- principles and applications

UNIT-III:Porosity Logs

Acoustic Log: Principles; factors affecting acoustic wave velocity; acoustic logging tools- single and double receiver type tools; borehole compensated systems; cycle skipping in acoustic log; bed thickness effect on acoustic log; depth of investigation; porosity evaluation of consolidated and uncompacted sandstones (clean as well as shaly) and carbonates rocks; overpressure identification; seismic applications.

Density Log: Interaction of gamma rays with matter; principle of density log; energy requirements of gamma ray sources for density log; measurement tools- single and double detector type; log characteristics- depth of investigation and bed resolution; porosity measurements and other formation evaluations; factors affecting porosity measurements; litho-density log- principles and formation evaluation.

Neutron Log: Interaction of neutrons with matter, neutron sources and neutron detectors, neutron moderation and principle of neutron log, neutron logging tools- single spacing type, sidewall-neutron porosity probes, borehole compensated systems; corrections in porosity measurements due to the presence of shale, rock type, borehole, and cased hole; depth of investigation and source-detector spacing; calibration of logging systems.

Porosity cross plots.

UNIT-IV:Electrical Resistivity Logs

Concept of resistvity in well logging; factors affecting the resistivity of electrolyte bearing rocks.

Unfocussed Resistivity Devices: single-electrode systems and its limitations; normal and lateral resistivity tools and their limitations; factors affecting normal and lateral resistivity measurements; micro-resistivity measurements- tools, applications and limitations

Focused Resistivity Devices : principle of measurement, tools and factors influencing resistivity measurements.

Induction Resistivity Measurements: principle, two-coil induction tool and its geometric factor, focusing of two coil sonde, skin effect, factors affecting induction resistivity measurements, induction or electrode..
Interpretation of Well-Log Resistivity Data: Determination of water saturation (S_W) of clean formations using (i) Archie's cross-plot, (ii) Hingle plot (iii) Formation factor comparison method (iii) resistivity ratio methods (iv) movable hydrocarbon method: Determination of water saturation (S_W) of shaly formations.

Recommended Books:

1. Standard Metods of Geophysical Formation Evaluation : James K. Hallenburg
2. Practical Formation Evaluation : Robert C. Ransom
3. The geological Interpratation of Well Logs : Malcolm Rider
4. Well Logging for Earth Scientists : Darwin V. Ellis
5. Petrophysics- Theort and Practice of Measuring Reservoir Rock and fluid Transport Properties : Djebbar Tiab and Erle C. Donaldson

GP-402 Physical Oceanography and Marine Geophysics

Unit I Physical Oceanography
Physical properties of seawater and methods of determination, distribution of salinity in the oceans, factors affecting salinity, water masses and water type, TS Diagram, Circulation of currents in major ocean waves. Tides: Dynamical and equilibrium theory of tides. Marine pollution, steps to control marine pollution, Laws of seas, Coastal zone management

Unit II Dynamical Oceanography
Equation of motion in a rotating and translating coordinate system, Coriollis force term and other terms, Non linear term in equation of motion, Brunt Viasala frequency, Geopotential surface and isobaric surface, wind driven ocean circulation, Ekman Solution, Vorticity.

Unit III Marine exploration
Resource potential for offshore areas, Geophysical continental margins, type of continental margins, geophysical evidences for evolution of Atlantic type continental margins, Characteristic geophysical signatures for transitional crust, isostatic 2D gravity anomalies, sea floor magnetic anomalies and their interpretation.

Unit IV
Geophysical studies for active continental margins, Seismicity, volcanism, heat flow studies, seismic surveys along island arc-trench areas, seismic expression for subduction and crustal deformation, paired gravity anomalies over island arc trench areas and their interpretation. Geophysical exploration for continental Margins of India and Andman shelves, brief review on the hydrocarbon exploration for the Indian continental margin.

Reccomended Books:

1. The Earth, Tarbuck and Lutgens
2. Descriptive Physical oceanography, Pickard Lmerv
3. Estuaries- Introduction, Dyer
4. Oceanography, Ross
5. Dynamical Ocenography, Pond and Pickard
6. The Sea, Hill
7. Nettleton, Gravity and Magnetics in Oil prospecting
8. McQuillin and Ardus, Exploring the geology of shelf area

GP-403: SEISMIC PROSPECTING

UNIT-I: FUNDAMENTAL OF PROSPECTING
Motivation for Seismic Prospecting, Oil Exploration, Mining and Engineering Application, Principles and Physical Basis of Seismic prospecting: Types of Elastic Waves, Reflection, Refraction and Transmission Coefficients, Expression for wave velocities, Factors affecting wave velocities in Rocks.

UNIT-II: DATA ACQUISITION

Seismic Sources: Explosive and Non-Explosive Sources, Seismic Refraction Method: Travel Time Equation for Simple one layer case and for variable velocity case. Expressions for dipping layer and faulted bed cases. Gardener delay time method. Hidden layer problems. Field techniques for refraction survey, fan shooting.
Seismic Reflection Method: The travel time equations for horizontally layered medium, Expression for dipping interfaces, Field techniques for reflection survey: Split Spread, End on Spread, Broad side configurations. 2D/3D configurations, Common depth point technique, Presentation formats for Seismograms, Selection of field survey parameters.

UNIT-III: SEISMIC DATA PROCESSING
Data processing sequence, Static and Dynamic Correction, weathering and datum corrections, CDP stacking, Migration and depth section preparation.
Velocity depth determination: Velocity-depth relation for measurements in boreholes, velocity depth relation from surface observations, the T^2-X^2 method, the T-ΔT method, the hyperbola method.
Noise Elimination method: The structure of noise and its classification using frequency and spatial filters(arrays), Multiples identification, Suppression of multiples, VSP.

UNIT-IV: SEISMIC DATA INTERPRETATION
Mapping of Hydrocarbon bearing and water bearing structures, geological interpretation, Structural and Stratigraphic traps, direct detection of hydrocarbons, pattern recognition, Seismic attribute analysis.

Recommended Books:
1. Dobrin, M.B Introduction to Geophysical Prospecting
2. W.M.Telford et al Applied eophysics
3. Keary and Brooks Introduction to Geophysical Exploration
4. Waters, R.H.. Reflection Seismology
5. Robinson Basic Exploration Geophysics
6. Sheriff, R.E Seismic Stratigraphy
7. Nelson, H.R New technologies in Exploration Geophysics
8. Lavergne, M. Seismic Methods
9. Robertson

GP-404: Geophysical Inversion

Unit-I:
Forward problems versus Inverse problems, continuous inverse problem, discrete inverse problem, formulation of inverse problems and their reduction to a matrix problem, linear inverse problems, classification of inverse problems, least squares solution and minimum norm solution, concept of norms, concept of 'a priori' information, constrained linear least squares inversion, review of matrix theory.

Unit-II
Introduction to finite difference method, forward, backward and central difference method, Application of finite difference method for solving Helmholtz equation.
Introduction to finite element method, various steps, simple examples showing application of finite element method.

Unit-III

Model and Data spaces, householder transformation, data resolution matrix, model resolution matrix, eigen values and eigen vectors, singular value decomposition (SVD), generalised inverses, Non-linear inverse problems, Gauss Newton method,, steepest descent (gradient) method, Marquardt-Levenberg method, Earthquake location problem, tomography problem.

Unit-IV

Probabilistic approach of inverse problems, maximum likelihood and stochastic inverse methods, Backus-Gilbert method, Global optimization techniques: genetic algorithm, simulated annealing methods, examples of inverting geophysical data.

Recommended Books:

(1) Geophysical data analysis: Discrete inverse theory: William Menke
(2) Deconvolution & Inversion: V.P. Dimri
(3) Geophysical Data analysis: Understanding Inverse problem theory & Practice: Max A. Meju
(4) Time series analysis and inverse theory for Geophysicists: David Gubbins
(5) Inverse problem theory methods for data fitting and model parameter estimation : I. Tarantola

GP-501: Near Surface Geophysics

Unit-I: Introduction

Man and Environment, Near Surface Geophysics: Introduction, Practitioners and Users, Traditional and Emerging views of Near Surface- Geophysics, Concepts and Fundamentals, Special Challenges associated with near Surface Geophysics. Rock Physics Principles for Near-Surface Geophysics: Description of the Geological Material, Conditions in the Near Surface of the Earth, Density, Electrical Properties, Elastic Wave Velocities.

Unit-II: Geophysical Techniques in Near Surface studies

Review of Seismic, Gravity, Magnetic and Electrical methods, Applications of these methods to Environmental and Engineering studies: Delineation of structural trends, contacts and faults, microgragravity detection of subsurface voids and cavities, detection of Archaeological objects, Mapping of fracture zones, reflection profiling in ground water studies, dam site investigations, evaluation of acquifer potentional, Investigation of waste dump sites.

Unit-III: Ground-Penetrating Radar

Introduction, Electromagnetic Theory, Physical properties, EM wave properties, GPR Instrumentation, Modeling of GPR Responses, Survey Design, Data processing, Interpretation, Case Studies and Pit falls.

Unit-IV:GIS Applications in Near surface Geophysics

Concept of Digital Image in Remote Sensing, Image preprocessing, rectification, enhancements and analysis, Digital Image processing procedures, Band ratioing and NDVI, GIS applications in integrated

ground water resources mapping, site suitability studies and utilities management, GIS applications for engineering, environmental problems, landfill sites and solid waste management,

Recommended Books:

1.Near-Surface Geophysics Edited by Dwain K. Butler
2.Applied Geophysics by W. M. Telford et al.
3.Experiments in Engineering Geology by KVGK Gokhale and D M Rao
4. Geotechnical and Environmental Geophysics Edited by Stanley H.Ward
5. Environmental and Engineering Geophysics, P.V.Sharma

GP-502 NON LINEAR GEOPHYSICS

UNIT-I: NON LINEAR ELASTICITY

Kinematics of Deformation: Deformation gradient tensor, the strain tensors, homogeneous deformations, deformation of surface and volume elements, material and spatial coordinates, analysis of stress, Cauchy and Poila stresses, Cauchy's stress tensor, Cauch's equation of motion, balance laws, Constitutive equations for elasticity.

UNIT-II: NON LINEAR WAVES

Linear Wave equation, dispersion relation, non linear equations, effect of non linearity, difussive waves, dispersive waves, Solotary waves, soliton, Schrondinger equation, relationship between KdV and Schrondinger equation.

UNIT-III NON LINEAR SYSTEM

Geometerical view of Dynamical system, Singular points, Limit cycles, Phase plane trajectories, bifurcation diagram, examples of bifurcation equations, Chaotic dynamics, stochastic description of dynamical system, various types of bifurcation, Catastrophe theory in Geophysics.

UNIT-IV FRACTALS AND MULTIFRACTALS

Self Similarity, Self affinity, Cantor sets, Fractal dimension of geometry, fractal in time series, Box Correlation integral method, counting method, multifractal, Generalized dimension, D_q-q analysis, Application of fractals and multifractal in earthquake studies, gravity and magnetic field methods.

Recommended Books:

1. T.S. Parkar Deformation of Elastic Solids.
2. P.L.Bhatnagar Non Linear waves in one dimensional dispersive systems
3. Derek P.Atherton Stability of Non Linear Systems
4. Nicolis and Nicolis, Irreversible Phenomenons and dynamical system analysis in geosciences
5. B.B.Mandelbrot, The fractal geometry of nature
6. Parker and O.L.Chua Practical Numerical Algorithms for Chaotic System

7. D.L.Turcotte Fractals in Geophysics
8. V.P.Dimri Applications of fractals in Geophysics

GP-506: Computational Seismology

Unit I Strong motion seismology

Concept of strong motion: Characteristics of earthquake strong ground motion, time domain and frequency domain parameters of strong ground motion, strong motion array and recorder, dynamics of vibration, vibration of a single degree of freedom system, earthquake response spectra, Strong motion networks in India

Modelling of strong ground motion: Stochastic modelling technique, Empirical Greens function technique, Semi empirical technique and Composite source modelling technique.

Unit II Attenuation Studies

Wave attenuation: geometrical spreading, scattering and intrinsic attenuation, Quality factor Q and its estimation using frequency domain methods, origin of coda waves, coda-Q and its estimation, estimation of frequency indedependent and frequency dependent Q using strong ground motion, simultaneous estimation of source parameters and Q, concept of 3-D Q and its estimation.

Unit III Engineering seismology

Concept of earthquake hazard, vulnerability and risk, probabilistic versus deterministic approach of estimating earthquake hazard, Regression analysis for estimating peak ground motion, microzonation, site amplification, concept of earthquake resistant design, Indian earthquake hazard scenario.

Unit IV: Selected Topics

Seismic tomography – Methods, regional and local tomography, 3-D velocity analysis, Receiver functions, Seismicity based studies- b-value, fractal/multifractal analysis, seismic quiescence/gaps. Ray tracing, Anisotropy, Time predictable model, GPS based studies in seismology.

RECOMMENDED BOOKS

(1) Quantity Seismology: Aki and Richards
(2) Introduction to seismology: Peter M. shearer
(3) Modern Global Seismology: Lay & Wallace
(4) Earthquake Hazard Analysis: L. Reiter
(5) An introduction to seismology, earthquakes and Earth structure: Stein & Wysession

GP-512: Seismic Data Analysis and Reservoir Geophysics

Unit-I: Introduction

Objectives of Seismic Signal Processing, Seismic Resolution, Basic data processing sequence: CMP sorting, Velocity analysis, residual statics corrections, Normal-Moveout Correction, Moveout stretch, Noise and Multiple Attenuation, f-k filtering, τ-p filtering, Dip-Moveout correction, CMP stacking, post stack processing.

Unit-II: Seismic Deconvolution and Seismic Migration

The convolutional Model, Inverse Filtering, Optimum Wiener filters, Predictive deconvolution in practice, The problem of nonstationarity: Time-Variant deconvolution, gated Wiener deconvolution, Homomorphic deconvolution, Minimum and Maximum Entropy Deconvolution, Inverse Q Filtering, Fresnel Zone, Seismic Migration: Mathematical foundation of migration, Migration using wave equation and finite difference techniques, Pre and Post stack time and depth migration

Unit-III: Seismic Modeling

The role of Seismic Modeling, Concept and example of Physical Models, Seismic Modeling Approaches, Forward Seismic Modeling, Inverse Seismic Modeling, Application of GLI technique, Modeling pitfalls.

Unit-IV: Reservoir Geophysics

Reservoir Management, Geophysical Method for Reservoir Surveillance, Analysis of AVO, Acoustic Impedance Estimation, 4-D Seismic Method, 4-C Seismic Method.

Recommended Books:

1. Seismic Data Analysis, Vol. I&II, ÖZYILMAZ.
2. Reservoir Geophysics, Robert E.Sheriff.
3. Seismic Modeling of Geologic Structures, Stuart W.Fagin.
4. Introduction to Seismic Inversion Method, Brian H.Russell

Department of Geophysics Kurukshetra University Kurukshetra

Model questions for Paper_I

1. 'The cross over distance is less than critical distance.' The statement is:
(a) true (b) false (c) may or may not be true (d) none of these
2. Deconvolution of two sequences in time domain is equivalent to:
(a) multiplication in frequency domain (b) addition in frequency domain
(c) division in frequency domain (d) none of these
3. The SP method of Geophysics is of which type:
(a) artificial source (b) natural source (c) both (d) none of these
1 gal = _____ gravity units
(a) 10 (b) 10^2 (c) 10^3 (d)10^4
4. The shape time-distance curve for the seismic refraction is:
(a) straight line (b) parabola (c) hyperbola (d) quadratic
5. The shape time-distance curve for the critically refracted wave is:
(a) straight line (b) parabola (c) hyperbola (d) quadratic
6. The non-recursive filter is of:
(a) IUSR type (b) FUSR type (c) both of these (d) none of these
7. The Recursive filter is of:
(a) IUSR type (b) FUSR type (c) both of these (d) none of these
8. Which of the following is natural source geophysical method:
(a) IP method (b) Electrical method (c) Gravity method (d) Seismic method
9. The model resolution matrix for the linear inverse problem d = Gm (d: data vector; m: model parameter vector) is given by (G^{-g} : generalized inverse)
(a) GG^{-g} (b) $G^{-g}G$ (c) $G^{-1}G^{-g}$ (d) G/G^{-g}
10. The data resolution matrix for the linear inverse problem d = Gm (d: data vector; m: model parameter vector) is given by (G^{-g} : generalized inverse)
(a) GG^{-g} (b) $G^{-g}G$ (c) $G^{-1}G^{-g}$ (d) G/G^{-g}

Model questions for Paper_II

Q.No. 1. Describe the difference between profiling and sounding in electrical resistivity survey. What are the configurations used for these? Explain
Q.No. 2. Describe the difference between least square and damped least square solution of a linear inverse problem? Illustrate the method to solve an over determined linear inverse problem.
Q.No. 3 (a) . What is digital filtering? Discuss direct and canonical realization of a digital filter.
(b) Discuss the applications of Geophysical methods in imaging the subsurface
Q.No. 4 (a) What is difference between DFT and FFT ? Discuss applications of FFT in seismology.
(b) Illustrate the decimation in time algorithm to compute FFT of a given sequence.