

**INSTITUTE OF GEOLOGY, UNIVERSITY OF THE PUNJAB  
LAHORE**

**COURSES AND SYLLABI  
FOR  
PhDAPPLIED GEOLOGY (GEOPHYSICS)**

**COURSE WORK:                    18CreditHrs**

<b>Course Code:</b>	<b>Course Title</b>	<b>Credit hrs</b>
<b>GEOL: 760</b>	<b>Numerical Methods In Research</b>	<b>03</b>
<b>GEOL: 761</b>	<b>Seismic Data Processing</b>	<b>03</b>
<b>GEOL: 762</b>	<b>Seismic Data Interpretation</b>	<b>03</b>
<b>GEOL: 763</b>	<b>Research Methodology</b>	<b>03</b>
<b>GEOL: 764</b>	<b>Exploration Geophysics I (Gravity, Magnetic)</b>	<b>03</b>
<b>GEOL: 765</b>	<b>Exploration Geophysics Ii (Electrical, Electromagnetic, Gpr Methods)</b>	<b>03</b>
<b>GEOL: 766</b>	<b>Advanced Rock Physics</b>	<b>03</b>
<b>GEOL: 767</b>	<b>Advanced Seismic Stratigraphy</b>	<b>03</b>
<b>GEOL: 768</b>	<b>Well Seismic</b>	<b>03</b>
<b>GEOL: 769</b>	<b>Borehole Geophysics</b>	<b>03</b>
<b>GEOL: 770</b>	<b>Advanced Reservoir Geophysics</b>	<b>03</b>
<b>GEOL: 771</b>	<b>Engineering Geophysics</b>	<b>03</b>
<b>GEOL: 772</b>	<b>Thermodynamics Of Petroleum Fluids</b>	<b>03</b>
<b>GEOL: 773</b>	<b>Seismic Hazard Analysis</b>	<b>03</b>
<b>GEOL: 774</b>	<b>Solid State Geophysics</b>	<b>03</b>

# INSTITUTE OF GEOLOGY UNIVERSITY OF THE PUNJAB, LAHOURE

## COURSES & SYLLABI

### FOR

### PhD (GEOPHYSICS)

#### **GEOL: 760 NUMERICAL METHODS IN RESEARCH (03 Credit hrs.)**

Basics of computer programming, Numerical derivative methods, Numerical integration methods, Numerical iterative methods, Numerical methods as a tool in scientific research, Iterative methods: Newton Raphson iterative method – Secant Method; Interpolation: Newton's forward and backward difference formulae; Differentiation and Integration: Numerical differentiation with interpolation polynomials – Numerical Integration by Trapezoidal and Simpson's rule- Ramberg integration. Fourier Transform, Z Transform and their inverses, Finite difference, Finite element, Finite volume, 1D, 2D, 3D modelling of geological bodies, Numerical modelling of deformation in rocks, Image processing,

#### **Reference Books:**

1. D. R. Durrant, 1999, Numerical methods for wave equations in geophysical fluid dynamics, Springer.
2. Tarantola, 2005, Inverse Problem Theory and Methods for Model Parameter Estimation, Society for Industrial and Applied Mathematics.

#### **GEOL: 761 SEISMIC DATA PROCESSING (03 Credit hrs)**

Introduction to the importance of signal processing in Geophysics, Fundamentals of signal processing, Impulse response and convolution, Transform domain analysis, Fourier Transforms and Fourier Series, Properties of Fourier Transforms and Fourier Series, Discrete Time Fourier Transform (DTFT), Z transform, Basic data processing sequences, Noises and multiple attenuation, Coherent noises, Random noises, Different types of multiples, Gain application, Amplitude balancing, Preprocessing, Auto correlation and cross correlation, Sampling and Reconstruction, Geometrical spreading correction, Trace balancing, Processing algorithms for marine seismic data (2D and 3D), Processing of land seismic data (2D and 3D), Convolution and Deconvolution, Filtering, Velocity analysis and static correction, NMO, Residual static correction, Migration: Principles and algorithms, time migration, Depth migration, Applications of signal processing in Exploration Geophysics

#### **Reference Books:**

1. R. N. Bracewell, 1999, The Fourier Transform and its applications, McGraw-Hill Science/Engineering/Math, 3rd edition.
2. J. F. Clearbout, 1985, Fundamentals of Geophysical Data Processing with applications to Petroleum Prospecting, Blackwell Scientific Publications.
3. R.E. Sheriff, and L.P. Geldart, 1995, Exploration Seismology, Cambridge University Press.
4. W.M. Telford, L.P. Geldart, and R.E. Sheriff, 1990, Applied Geophysics, Cambridge University Press.
5. M.B. Dobrin, and C.H. Savit, 1988, Introduction to Geophysical Prospecting, McGraw Hill, New York.
6. E. A. Robinson, and S. Trietel, 1980, Geophysical Signal Analysis, Prentice Hall, Englewood Cliffs, New Jersey.

### **GEOL: 762 SEISMIC DATA INTERPRETATION (03 Credit hrs)**

Fundamentals of theory, Integrated interpretation, Basics concepts, Seismic displays, Data reading, Signal identification, Horizontal and vertical resolution, Characteristics of seismic events, Amplitude, frequency, phase, resolution, Structural interpretation of 2D and 3D seismic data, Stratigraphic interpretation of 2D and 3D seismic data, Quantitative interpretation, Qualitative interpretation, Amplitude interpretation, Seismic reservoir mapping, Applications, Fault analysis, Basin modelling, Traps identification

#### **Reference Books:**

1. M.B. Dobrin, and C.H. Savit, 1988, Introduction to Geophysical Prospecting, McGraw Hill, New York.
2. M. Bacon, R. Simm, and T. Redshaw, 2003, 3-D seismic interpretation, Cambridge Press.
3. P. Avseth, T. Mukerji, and G. Mavko, 2005, Quantitative seismic interpretation: Applying rock physics tools to reduce interpretation risk. Cambridge University press.
4. R.E. Sheriff, and L.P. Geldart, 1995, Exploration Seismology, Cambridge University Press.
5. A.R. Brown, 2004, Interpretation of three-Dimensional seismic data, SEG investigations in geophysics, No. 9.
6. W.M. Telford, L.P. Geldart, and R.E. Sheriff, 1990, Applied Geophysics, Cambridge University Press.

### **GEOL: 763 RESEARCH METHODOLOGY (03 Credit hrs)**

Research methods – Identification of the Problem – Determining the mode of attack-literature survey – Mode of approach of actual investigation – Abstraction of a research paper – Drawing inferences from data - Qualitative and Quantitative analysis, Plagiarism check, Internet and its applications – e-journals- Assessing the status of the problem – Results and Conclusions – Presenting a Scientific seminar – Publication of Research paper - Art of writing a Thesis/Paper, preparation of presentation

### **GEOL: 764 EXPLORATION GEOPHYSICS I (GRAVITY, MAGNETIC) (03 Credit hrs)**

Gravitational field of the Earth, Potential field equations and derivation, Densities of rocks and their determination, Gravity instruments for Geophysical exploration, Gravity effect over different types of geological structures, Anomalies of gravity field – Free-Air, Bouguer and Isostatic anomaly; Processing of Gravity data; Geophysical interpretation of gravity anomalies; Delineation of gravity anomaly parameters using signal processing tools; Shape of Earth; Moments of inertia, Geoid, Isostasy, Earth rotation, Earth structure; Exploration for resources; Geodetic measurements of crustal motion . Principles of magnetic methods; Instruments for magnetic measurements for geophysical Exploration; Principles of various magnetic instruments; Relation between gravity and magnetic methods; Magnetic effect over different types of geological structures, Data Processing of field magnetic observations; Delineation of magnetic anomaly parameters using signal processing tools; Introduction to airborne magnetic surveys

#### **Reference Books:**

1. R.J. Lillie, Whole Earth Geophysics: An introductory book for geologists and geophysicists, Prentice Hall, 1998.
2. I.V. Radhakrishnamurthy, Gravity and Magnetic Interpretation in Exploration Geophysics, Geol. Soc. India Publication, Bangalore, 1998.
3. B.S.R. Rao and I.V.R. Murthy, Gravity and Magnetic Methods of prospecting, Arnold – Henniman Publishing company, New Delhi, 1978
4. L.L. Nettleton, Gravity and Magnetics in Oil Prospecting, McGraw-Hill, 1976.

**GEOL: 765    EXPLORATION GEOPHYSICS II (ELECTRICAL,  
ELECTROMAGNETIC, GPR METHODS)                    (03 credit hrs)**

Electrical and electromagnetic properties of rocks and minerals; Introduction to Electrical methods, Principles of Resistivity methods, Instruments for Resistivity methods; Resistivity Data analysis , modelling and Interpretation; Induced Polarization and Self-potential methods, Electromagnetic theory; Electromagnetic spectrum, Principles of Electromagnetic induction in the Earth, Coulomb Forces and Electric Field Intensity, Gauss's Law and Electric Flux, Volume and Surface Integrals, Gauss Divergence Theorem, Stokes Theorem, Laplace Equation, Vector and Scalar Potentials, Ampere's Law and the Magnetic Field.

Applications of ground penetrating radar (GPR) in Applied Geophysics, Principle of GPR, GPR data processing, analysis and interpretation.

**Reference Books:**

1. W.M. Telford, L.P.Geldart, and R.E.Sheriff, Applied geophysics, Cambridge Univ. Press 1990.
2. M.B.Dobrin, and C.H. Savit, Introduction to geophysical prospecting, McGraw Hill, 1988.
3. E. S. Robinson and C. Coruh, Basic Exploration Geophysics, J. Wiley and Sons, 1988.
4. J. A. Edminister, Schaum's Outline on Electromagnetics 2nd Edition, Tata McGraw-Hill Book Co., 2004.
5. M.B. Dobrin, and C.H. Savit, Introduction to Geophysical Prospecting, McGraw Hill, 1988.
6. Electromagnetic induction methods, SEG Vols 1-3, Society of Exploration Geophysicists, 1988.
7. T. Rikitake, R. Sato and Y. Hagiwara, Applied Mathematics for Earth Scientists, Terra Scientific Publishing Company, Tokyo, 1987.

**GEOL: 766    ADVANCED ROCK PHYSICS (03 Credit hrs)**

Fundamentals and Principles of Rock Physics, their Scope and Utility, Concepts of Elasticity, Plasticity and Viscosity, Elastic Properties of the Fluids, Seismic Wave Propagation, Rock Structures Evaluation, Rock Properties Model. Fluid substitution models, Gassamnn,s fluid substitution, In-Situ Stress Measurement, Role of Fractures in Seismic behaviour, Pore pressure, Fluid Migration, Permeability model for fracture Rock, Scaling properties of fluid flow in fracture rock, Constitutive model, Seismic signature, Logging of Fracture reservoir, Role of stresses in modulating fractures, Correlation between Static and Dynamic Model, Rock Anisotropy and its Causes, Influence of Stress on Seismic Anisotropy, Detection and Quantification of Seismic Anisotropy, Velocity dispersion and attenuation, Fluid distribution patterns into the pores, Rock physics as interpretation tool, Empirical relations between different rock physics parameters, Forward seismic modelling, Ray tracing, synthetic seismograms generation, Applications in Exploration & Production

**Reference Books:**

1. M. Gary, T. Mukherjee, and J. Dvorkin, The Rock Physics, Hand Book, Cambridge University Press, 2000.
2. P. Avseth, T. Mukerji, and G. Mavko, 2005, Quantitative seismic interpretation: Applying rock physics tools to reduce interpretation risk. Cambridge University press.
3. N. Barton, 2007, Rock quality, seismic velocity, attenuation and anisotropy, Taylor & Francis/Balkema.
4. Y. Gu'eguen, and M. Bout'eca, 2004, Mechanics of Fluid-Saturated Rocks, Elsevier.

### **GEOL: 767    ADVANCED SEISMIC STRATIGRAPHY (03 Credit hrs)**

Concepts & Principles of Sequence Stratigraphy Tool Box, Seismic Stratigraphy as a tool in Sequence Stratigraphy, Methodology/workflow, Rock Physics and seismic stratigraphy, Seismic resolution & log-to-seismic tie, 2D Forward Modeling and Inversion, Pitfalls in Seismic Stratigraphy, Systems Tracts. Type-1 & -2 sequences signatures on seismic and well logs, Chronostratigraphic Charts (Wheeler diagrams), construction, interpretation & use, 3D Seismic geomorphology, Applications in Exploration & Production (Reservoir Characterization, Inversion and Porosity Maps. AVO for Lithology and DHI, Reservoir Compartments, 4D seismic and Enhanced Recovery planning, GDE maps of reservoir, Seal and source in Play Fairway and Common Risk Segment (CRS) mapping

#### **Reference Books:**

1. P.C.H. Veeken, 2007, Seismic stratigraphy, basin analysis and reservoir characterization, volume 37, Elsevier.
2. G. D. Williams, A.Dobb, 1993, Tectonics and Seismic Sequence Stratigraphy, The Geological Society London.
3. R.M. Slatt, 2006, Stratigraphic reservoir characterization for petroleum geologists, geophysicists, and engineers, Handbook of petroleum exploration and production, Elsevier.
4. O. Catuneanu, 2006, Principles of sequence stratigraphy, Elsevier.

### **GEOL: 768    WELL SEISMIC (03 Credit hrs)**

Fundamentals of well seismic, Vertical well seismic, VSP data acquisition, zero-offset VSP, offset VSP, walkaway VSP, walk-above VSP, salt-proximity VSP, shear-wave VSP, and drill-noise or seismic-while-drilling, Well seismic tools, Well seismic data processing, Correlation with surface seismic, Cross-well seismic, Interpretation, Synthetic VSP generation

#### **Reference Books:**

1. Mari, J.L., and Coppens, F., 2003, Well Seismic Surveying, Institute Francais du Petrole Publications.
2. Hardage, B.A., 1985, Vertical seismic profiling, Part A: principles, Geophysical Press, London.
3. Hardage, B.A., 1985, Vertical seismic profiling, Part B: advanced concepts, Geophysical Press, London.

### **GEOL: 769    BOREHOLE GEOPHYSICS (03 Credit hrs)**

Fundamental of borehole geophysics, Well logging and geology, Formation evaluation, Archie's formulae, Borehole environment, Invasion profiles, Principles, methods and application of logging tools including Spontaneous polarization, Resistivity, Microresistivity, Induction, Sonic, Density, Litho-density, Neutron, Pulsed neutron, Natural Gamma ray, Gamma ray spectrometry, Cement bond, Variable density, Caliper, Dipmeter, Formation microscanner and imager. Well log interpretation, Applications, correlation of log data with seismic

#### **Reference Books:**

4. Ellis, D. V., J.M. Singer, 2008, Well logging for earth scientists, Springer.
5. Schlumberger Manual Log Interpretation Principles/Applications, Vol. 1 & 2, Schlumberger Education Services, New York, 1989.
6. Tiab, D., and E.C. Donaldson, 2004, Petrophysics: Theory and practice of measuring reservoir rocks and fluid transport properties, Elsevier.
7. Crain's Petrophysical Handbook, <http://www.spec2000.net/lcmain.htm>

## **GEOL: 770    ADVANCED RESERVOIR GEOPHYSICS (03 Credit hrs)**

Application in exploration Geophysics, Formation fluids characterizations, Amplitude versus offset (AVO) analysis, Processing of multi-component data, AVO interpretation, Advanced seismic attributes analysis, Acoustic impedance, Elastic impedance, Spectral decomposition, Colour inversion, Reservoir characterization, Integration of geophysical attributes and petrophysical properties,  $V_P/V_S$  and poisson's ratio, Applications in Exploration and production, Reservoir estimation, 4D seismic monitoring, Future prediction of reservoir behaviour, Seismic facies Analysis

### **Reference Books:**

1. Methods and Applications in Reservoir Geophysics, Investigations in Geophysics Series No. 15, 2010 Society of Exploration Geophysicists.
2. W.L. Abriel, 2008, Reservoir Geophysics: Applications, Society of Exploration Geophysicists.
3. P. Avseth, T. Mukerji, and G. Mavko, 2005, Quantitative seismic interpretation: Applying rock physics tools to reduce interpretation risk. Cambridge University press.
4. O., Yilmaz, 2002, Seismic data analysis, Processing, inversion and interpretation of seismic data, volume II, Society of Exploration Geophysicists.
5. M. R. Riazi, 2005, Characterization and Properties of Petroleum Fractions, ASTM 100 Barr Harbor.

## **GEOL: 771    ENGINEERING GEOPHYSICS (03 Credit hrs)**

Fundamental and introduction of engineering geophysics, Engineering properties of rocks, soils and minerals, Geophysical methods and their applications in engineering, seismic refraction method, principle, data acquisition, processing and interpretation of refraction, Exploration Geophysics of the shallow subsurface, uses of GPR, radioactive, VLF methods for engineering, how to design, specify and execute a basic survey, applications to the built environment using high resolution ground penetrating radar and ultrasonic methods to determine construction and condition, geologic hazards, geotechnical, material properties, landslide and slope stability.

### **Reference Books:**

1. An Introduction to Applied and Environmental Geophysics by John Reynolds.
2. Exploration Geophysics of the Shallow Subsurface, 1992, H. R. Burger, w/ Macintosh computer software, Prentice Hall, 489 pp
3. Field Geophysics by J. Milsom
4. Waltham T., Foundations of Engineering Geology, 2nd Edition, Taylor & Francis, (2001).
5. Applied Geophysics for Geologists and Engineers, 1981, by D.H. Griffiths and R.F. King. 2<sup>nd</sup> Edition , Pergamon Press, 230pp.
6. Looking into the Earth by P. Kearey and A. Khan.
7. An Introduction to Geophysical Exploration by Kearey, Brooks, and Hill
8. Principles of Applied Geophysics by D.S. Parasnis
9. Environmental and Engineering Geophysics, 1997, by Sharma, P. V., 1997., Cambridge University Press, 475pp
10. Introduction to Geophysical Prospecting by Dobrin and Savit  
Applied Geophysics by W.M. Telford, L.P. Geldard and R.E. Sheriff

## **GEOL: 772    THERMODYNAMICS OF PETROLEUM FLUIDS (03 Credit hrs)**

Fundamental laws of thermodynamics, Types and nature of petroleum fluids, Petroleum fluid composition, thermodynamical properties of petroleum fluids, effects of temperature, pressure, and composition on the volumetric properties of formation fluids, isothermal compressibilities, adiabatic compressibilities, Black oil model, reduced properties of

petroleum fluids, equation of state and its use for the computation of volumetric properties of fluids, phase behaviour of petroleum mixtures

**Reference Books:**

**GEOL: 773 SEISMIC HAZARD ANALYSIS (03 Credit hrs)**

Fundamental of hazard analysis, Computer-assisted seismogram analysis and source parameter determination, Risk Estimation, effect of earthquakes on structural design, Representations of Seismic Hazard, Data completeness, Recurrence Relationships, Gutenberg-Richter recurrence law Mmax Estimation, Predictive relationships, Deterministic Seismic Hazard Analysis, Probabilistic Seismic Hazard Analysis, Applicability of DSHA and PSHA, Summary of uncertainties, Uncertainty in the Hypocentral Distance, Uniform hazard spectrum (UHS), Attenuation models, Simulation of Strong Ground Motion, Forward modeling in strong ground motion seismology, impact of hazards on construction.

**Reference Books:**

**GEOL: 774 SOLID STATE GEOPHYSICS (03 Credit hrs)**

Fundamentals and introduction to physics of the solid state earth, emphasis on Earth's structure from seismic observations, heat flow, the physics of rocks under high pressures and high temperatures, Geothermal energy processes and sources, extraction of geothermal energy, equation of state, seismological, thermal and compositional models, Thermal conduction earth's heat flow density

Heat conduction equation -1-D with/without heat production, Surface temperature variation (propagation dependence on depth and time) Heat transport, Heat flow measurement, Oceanic and continental heat flow, Global heat flow map.

**Reference Books:**

(Prof. Dr. M. SaeedFarooq)  
Director