ANNEXURE-E

INSTITUTE OF GEOLOGY, UNIVERSITY OF THE PUNJAB LAHORE

COURSES AND SYLLABI

FOR

M.PHIL IN APPLIED GEOLOGY (GEOPHYSICS)

DURATION: 2 YEARS

COURSE WORK: 24 CREDIT HRS

THESIS WORK: 06 CREDIT HRS

Course Code:	Course Title	Credit hrs
FIRST SEMESTER		
GEOL-501	**REGIONAL GEOLOGY (CORE-SUBJECT)**	**03**
GEOL: 539	**GEOPHYSICAL MODELLING**	**03**
GEOL: 540	**GEOPHYSICAL DATA PROCESSING**	**03**
GEOL: 541	**ADVANCED SEISMIC INTERPRETATION**	**03**
SECOND SEMESTER		
GEOL-505	**RESEARCH METHODOLOGY AND TECHNICAL WRITING (CORE-SUBJECT)**	**03**
GEOL: 542	**EXPLORATION GEOPHYSICS (GRAVITY, MAGNETIC, ELECTRICAL AND ELECTROMAGNETIC METHODS)**	**03**
GEOL: 543	**ROCK PHYSICS**	**03**
GEOL: 544	**ADVANCED SEISMIC STRATIGRAPHY**	**03**
GEOL: 545	**WELL SEISMIC AND BORE HOLE GEOPHYSICS**	**03**
GEOL: 546	**RESERVOIR GEOPHYSICS**	**03**

INSTITUTE OF GEOLOGY UNIVERSITY OF THE PUNJAB, LAHOURE

COURSES & SYLLABI

FOR

M.PHIL IN APPLIED GEOLOGY (GEOPHYSICS)

Duration: **2 Years (4 Semesters)**

Course Work **24 Credit hours**

Thesis Work **06 Credit hours**

FIRST SEMESTER

GEOL-501: REGIONAL GEOLOGY (CORE-SUBJECT, 03 Credit Hours)

The geology of Himalayas, Karakuram and Hindukush ranges. The geology and stratigraphy of the Salt Range, Sulaiman Range and Kirthar Range. The Katawaz Basin. The Makran and adjacent regions. The Chagai and adjacent regions. Ophiolites of the region. The Deccan traps and hot spots. The Geology of Indian Plate.

Books Recommended

1. Geology and tectonics of Pakistan by Kazmi, A.H., Jan, M.Q. (1997), Graphic Publishers, Karachi
2. Geodynamics of Pakistan, by A.Farah and K.DeJong, 1979, Elite Publishers, Karachi, Proceedings of the International Committee on Geodynamics.
3. Geology of Pakistan by Bender and Raza, 1995, Gebruder Borntraeger, Berlin.
4. Reconnaissance Geology of Part of West Pakistan, HSC, 1960.
5. Stratigraphy of Pakistan, S.M. Ibrahim Shah, 1997, GSP Memoir.
6. Stratigraphy of Pakistan, S.M. Ibrahim Shah, 2008, GSP Memoir (2nd Edition).
7. Stratigraphy of Pakistan, by Kazmi and Abbassi, 2008.

GEOL-539 GEOPHYSICAL MODELLING (03 Credit hrs)

Basics of computer programming, Numerical derivative methods, Numerical integration methods, Numerical iterative methods, Newton–Raphson method, Gaussian function, Fourier Transform, Z Transform and their inverses, Finite difference, Finite element, Finite volume, 1D and 2D wave propagation models in homogeneous and heterogeneous media, Numerical modelling of deformation in rocks, Image processing,

Lab:

Computer programs in FORTRAN 77, FORTRAN 90 and MATLAB; Numerical modelling of wave propagation in homogeneous and heterogeneous elastic and porous media; Computer programs for image processing

Reference Books:

1. D. R. Durran, 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-540 GEOPHYSICAL 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

Lab:

Exercises on Fourier Transform, Inverse Fourier Transform, Z Transform; Applications of Fourier and Hilbert Transforms in exploration; Curve fitting exercises; Computation of Auto and Cross correlations of discrete time series of geophysical data; Development of digital filters and applying them to geophysical data by programming;. Signal processing of real geophysical data using various processing softwares

Reference Books:

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

GEOL-541 ADVANCED SEISMIC INTERPRETATION (03 Credit hrs)

Fundamentals of theory, Integrated interpretation, Basics concepts, Seismic displays, Data reading, Signal identification, Horizontal and vertical resolution, Characterisitcs 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

Lab:
Structural and stratigraphic interpretation of real 2D and 3D data, Wavelet extraction, synthetic seismogram generation, Well tie, Construction of time structure and depth structure maps, isopach maps, Identification of plays, Geophysical modelling

Reference Books:

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

SECOND SEMESTER

GEOL-505: RESEARCH METHODOLOGY AND TECHNICAL WRITING (CORE-SUBJECT 03 Credit Hours)

Background and philosophy of research: concept of research, types of research, elements of research. Types of data for research. Various stages of research, research methods and methodology. Research proposal, selection of a research topic and problems, literature survey, reference collection, hypothesis, mode of approach, actual investigation, results and conclusion, presenting an oral scientific seminar, writing a report, research paper and thesis. Layout of a research report PhD thesis/ M.Phil dissertation. Plagiarism and its professional consequences.

GEOL-542 EXPLORATION GEOPHYSICS (GRAVITY, MAGNETIC, ELECTRICAL AND ELECTROMAGNETIC METHODS) (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; Electrical properties of rocks; Introduction to Electrical and electromagnetic methods of geophysical prospecting, Principles of Resistivity methods, Instruments for Resistivity methods; Resistivity field surveys in Wenner and Schlumberger configurations; Resistivity Data analysis 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.

Lab:

Determination of average density of surface rocks from gravity data; Exercises on reduction to pole of magnetic data, diurnal correction, Preparation of gravity and magnetic anomaly contour maps from field data; Regional – residual separation methods in gravity and magnetic methods; Construction of gravity and magnetic profiles on some simple geometrical models; Interpretation of gravity and magnetic anomalies obtained over different geological structures
Computation of resistivity profiling with a two-electrode and four-electrode spread over a vertical contact; Graphical and analytical construction of Vertical Electric Sounding (VES) curves; Application of curve matching techniques and interpretation of VES curves. Calculation of Electric field due to a point and dipole sources; Computations on Coulomb Forces and Electric field intensity; Analysis and interpretation of VLF EM, Transient Electromagnetic (TEM), Magnetotelluric (MT) data sets; Computer programming for data processing of geomagnetic deep sounding data.

<u>Reference Books:</u>

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. W.M. Telford, L.P.Geldart, and R.E.Sheriff, Applied geophysics, Cambridge Univ. Press 1990.
4. M.B.Dobrin, and C.H. Savit, Introduction to geophysical prospecting, McGraw Hill, 1988.
5. E. S. Robinson and C. Coruh, Basic Exploration Geophysics, J. Wiley and Sons, 1988.
6. B.S.R. Rao and I.V.R. Murthy, Gravity and Magnetic Methods of prospecting, Arnold – Henniman Publishing company, New Delhi, 1978
7. L.L. Nettleton, Gravity and Magnetics in Oil Prospecting, McGraw-Hill, 1976.

8. J. A. Edminister, Schaum's Outline on Electromagnetics 2nd Edition, Tata McGraw-Hill Book Co., 2004.
9. M.B. Dobrin, and C.H. Savit, Introduction to Geophysical Prospecting, McGraw Hill, 1988.
10. Electromagnetic induction methods, SEG Vols 1-3, Society of Exploration. Geophysicists, 1988.
11. T. Rikitake, R. Sato and Y. Hagiwara, Applied Mathematics for Earth Scientists, Terra Scientific Publishing Company, Tokyo, 1987.

GEOL-543 ROCK PHYSICS (03 Credit hrs)

Fundamentals and Principles of Rock Physics, their Scope and Utility, Concepts of Elasticity, Plasticity and Viscosity, Rock Permeability, Porosity, Elastic Properties of the Fluids, Seismic Wave Propagation, Rock Structures Evaluation, Rock Properties Model. 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, Triaxial Deformation or Rock, Damage Mechanics of Rock and Crack Propagation, State of Stress under Tectonic Load, Rock Tomography, Time dependency of rock deformations, 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

Lab.

Velocity-density cross-plotting exercise in FORTRAN, fluid substitution modelling in MATLAB and FORTRAN, rock physics parameters extraction from seismic data, seismic wave propagation modelling in FORTRAN, Ray tracing exercise in MATLAB, synthetic seismogram generation exercises in MATLAB

<u>Reference Books:</u>

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-544 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

Lab:

Exercises: Rock Physics exercises using specialized software. Interpretation of seismic sections and delineation of key surfaces and systems tracts. Wheeler Diagrams.

<u>Reference Books:</u>

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-545 WELL SEISMIC AND BORE HOLE GEOPHYSICS (03 Credit hrs)

Basics, 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, 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

Lab:

VSP data acquisition parameter analysis, VSP processing, VSP interpretation, Well to surface seismic exercises, well tie, Lithology identification from wireline logs, Well log interpretation exercise, reservoir estimation exercises

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.
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-546 RESERVOIR GEOPHYSICS (03 Credit hrs)

Basics and principles, Formation fluids characterizations, Types and nature of petroleum fluids, 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 peterophysical 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

Lab:

Exercises using different softwares (MATLAB, OpendTect, Kingdom), AVO analysis and interpretation of real seismic data, Identification of fluid's type and saturation using seismic attributes, Use of spectral decomposition in seismic interpretation, Cross plotting of different seismic attributes

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.