

Roadmap - Master of Science (MS) Geophysics

Semester	Credit Hours (Courses)
1	12 CH (4 Compulsory Courses)
2	12 CH (4 Elective Courses)
3	03 CH (Thesis)
4	03 CH (Thesis)
Total Credit Hours	30

Compulsory Courses

Course Code	Course Title	Credit Hours
GEO 503	Advanced Petroleum Geology	3
GEO 548	Advanced Seismic Stratigraphy	3
GEO 540	Advanced Seismic Techniques	3
ESC 701	Research Methodology	3

List of Elective Courses

Course code	Course Title	Credit Hours
GEO 518	3D Seismic Interpretation	3
GEO 517	Seismic Data Analysis	3
GEO 515	Exploration Geophysics	3
GEO 544	Borehole Geophysics	3
GEO 513	Advanced Seismology	3
GEO 543	Advanced Earthquake Seismology	3
GEO 507	Basin Analysis	3
GEO 534	Reservoir Geology	3
GEO 545	Petrophysical Analysis	3
GEO 531	Advanced Structural Geology	3
GEO 508	Stratigraphy and Petroleum Prospects of Pakistan	3
GEO 598	Drilling Operations and Well Site Geology	3
GEO 514	Mining Geophysics	3
GEO 542	Geodesy	3
GEO 549	Near Surface Geophysics	3
GEO 510	Development of Groundwater Resources	3
GEO 528	Groundwater Modeling	3
GEO 530	Advanced Marine Geology	3
ENV 513	Health Safety and Environment	3
GEO 505	Advanced Sedimentology	3
GEO 501	Global Tectonics	3
GEO 597	Applications of GIS in Geosciences	3
GEO 601	Gravity and Magnetic Exploration Methods	3

GEO 602	Electrical Exploration Methods	3
GEO 603	Engineering Geophysics	3
GEO 502	Geophysical Exploration Methods	3
GEO 512	Mineral Prospecting and Exploration	3
GEO 519	Coal Geology	3
GEO 524	Clastic Sedimentology	3
GEO 525	Carbonate Sedimentology	3
ENV 572	Climate Change Adaption and Mitigation	3
ENV 504	Environmental Impact Assessment	3
GEO 516	Applied Environmental Geophysics	3
GEO 604	Machine Learning for Geosciences	3
GEO 605	Applications of Geostatistics in Geosciences	3
GEO 606	Reservoir Geomechanics	3
GEO 607	Unconventional Hydrocarbon Resources	3
GEO 608	Practical Applications of Geosciences Softwares	3
THS 701	MS Thesis	6
Any other relevant course from Geology and Environmental Science disciplines		

COURSE DESCRIPTION

Course Code	GEO 540
Course Title	Advanced Seismic Techniques
Course Outline:	
Gridding Techniques; Spatial-Temporal Velocity Interpolation; Triangulated Velocity Models; Horizon Formation/Structurally Interpolated Velocity Models; Drift Correction; Forward Modeling; Horizon/Window based Seismic Attributes; Horizon Attribute based Seismic Modeling; Hilbert Transform & Complex Trace Analysis; Post Stack Seismic Attributes; Amplitude versus Offset/Angle; Seismic Inversion/Reverse Modeling.	

Course Code	GEO 518
Course Title	3D Seismic Interpretation (3 CH)
Course Outline:	
2D seismic data interpretation, Importance and its limitations. Introduction, Importance, Application of 3D Seismic Interpretation, Practical workflow, Quality control of survey and processing, Seismic data type, SEG-Y data, navigation file, CRS, loading and QC of seismic and well data. Importance and its limitations, Mis-ties computations. Digitization and Map constructions. Calibration of well and seismic data, synthetic seismogram. Identification of reflectors and mapping of horizons and faults. Different types of maps, (Time, thickness, Isopach, time slices, and iso-stratal maps). Velocity analysis and depth conversion. Advance 3D Interpretation techniques; Horizon based seismic trace attributes, AVO Analysis, Seismic Inversion, Direct Hydrocarbon Indicators.	

Course Code	GEO 517
Course Title	Seismic Data Analysis (3 CH)
Course Outline:	
Introduction of Seismic Data Processing; Seismic imaging techniques; Significance of Seismic Data Analysis in hydrocarbon exploration; the basic principles of the methods used in analyzing digital signals for geophysical applications; The latest trend in Seismic Data Analysis; Discrete data analysis with emphasis on seismic problems. Z-transforms, discrete Fourier transforms, digital filtering, Convolution and Deconvolution, autoregressive-moving average models, spectral analysis, missing data, model fitting, and two-dimensional and multi-channel analysis; Migration and its types; Practical experience in computer processing of seismic reflection data and related examples. The latest research articles (from SEG, AAPG, EAGE, First Break etc.) related the subject recommend discussing in class.	

Course Code	GEO 515
Course Title	Exploration Geophysics (3CH)
Course Outline:	
Introduction of Geological and Geophysical techniques; Physical characteristics of the Earth's lithosphere; Applications of geophysical methods, seismic, gravity, magnetic, resistivity, telluric, magnetotelluric, self-potential and GPR methods; Detection and exploration of natural resources; Mapping of natural resources; Limitations in Geophysical methods; Case Studies of Geophysical methods.	

Course Code	GEO 544
Course Title	Borehole Geophysics (3CH)
Course Outline:	
Introduction to Borehole geophysics; Rheology and wave propagation in inhomogeneous and fluid saturated porous materials; Borehole seismic methods; Checkshot, Acquisition, Processing and Analysis; Vertical Seismic Profiling and its types, Acquisition, Processing and Analysis, P and S wave transformations and analysis; Cross well seismic and travel time tomography; Introduction to well logging; Quality control of log data; Log Data Interpretation, Caliper, SP, gamma ray logs, sonic logs, density, neutron, resistivity, NMR and Image logs; Pore Pressure Prediction; Fundamentals of Rock Physics; Core and core analysis.	

Course Code	GEO 513
Course Title	Advanced Seismology (3 CH)
Course Outline:	
Introduction to seismology; Applications of Seismology; Theory of Elasticity; Seismic Energy Sources; Geologic significance from P-wave and S-wave velocity; Wave Propagations; Overview of surface wave methods; Teleseismic Body-Wave; Reflection and Transmission; Seismic Anisotropy; Raypath geometry in Anisotropic Materials; Detection and recording of seismic waves; Stress-Displacement Fields, Equivalent Forces & Moment Tensors; An Introduction to Seismogram Computation; Receiver functions; Travel Time Computations; Seismic site characterization; Seismic zonation,; Estimating phase velocity and subsurface structure; Earthquake Effects and Hazards; Interpretation Techniques; Case studies	

Course Code	GEO 543
Course Title	Advanced Earthquake Seismology (3CH)
Course Outline:	
Seismology, Introduction, its branches and applications; Useful definitions in earthquake seismology; Earthquake Effects and Hazards; Overview of surface wave methods; Principles of microtremor survey method; Geologic significance from P-wave and S-wave velocity; Estimating phase velocity and subsurface structure; Seismic zonation; Seismic site characterization; Peak ground acceleration (PGA); Seismic risk analysis (SRA); Seismic hazard assessment (SRA); Deterministic Seismic Hazard Assessment (DSHA); Probabilistic Seismic Hazard Assessment (PSHA); Research papers and case histories.	

Course Code	GEO 514
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Course Title	Mining Geophysics (3 CH)
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Course Outline:

Mineral prospecting and exploration methods; Mineral deposits, economics, target selection, deposit modeling, exploration technology, environmental issues, program planning; Geochemical prospecting methods; Geochemical behavior of common ore elements; Distribution of detrital material and solutions by streams and glaciers; Dispersion of trace metals from mineral deposits and their discovery; Principles and application of primary dispersion of metallic mineral deposits; Geophysical methods for exploration and mining; Methods for metalliferous mining; Geophysical prospecting; Electromagnetic, Resistivity, Induced Polarization, Self-Potential, Radiometric, Gravity and Magnetic methods applied for metallic mineral deposits; Airborne, electromagnetic surveys; site design; theoretical basis for each technique, the instrumentation used; Working Conditions, data collection, processing and interpretation procedures; Deposition of coal; Seismic methods for identifying coal, iron and copper sulphides; Review of geophysical research conducted in Pakistan; Specified assignments/projects

Course Code	GEO 542
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Course Title	Geodesy (3 CH)
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Course Outline:

Introduction to geodesy; Shape of earth; Topography; Geodetic datum; Geoid; Ellipsoid; Defining the ellipsoid by the numbers; Coordinates; Astronomic, Geodetic and Geocentric; Datums and types of datums; Map projections, from glob to map; Commonly used projections; Cylindrical, Mercator projection and Transverse Mercator; Developable surfaces; Coordinate origin; Perspective projections; Properties of projections; Scale; Standard lines; Small and large scales; Scale factor; Shape and Area; Major and minor lines; Introduction to co-ordinate system; Global systems, Latitude longitude, Height, UTM zones and benefits; Universal polar stereographic net; UPS coordinates; Reference systems; Military grid reference systems, Local systems, National grid systems, Public land survey system. Case history from Pakistan

Course Code	GEO 549
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Course Title	Near Surface Geophysics (3 CH)
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Course Outline:

Introduction to environmental explorations; Principles behind geophysical measuring techniques; Techniques with relation for improved understanding of the near surface geology; Seismic methods; Electrical methods, profiling, vertical sounding, 2D and 3D measurements; Electromagnetic methods, Slingram, VLF, TEM; Ground Penetration Radar; Radiometry and Well Logging; Applications of geophysical methods in contaminant plumes, conduits, fractures, voids, aquifers, buried containers, waste pits, ordnance, landfill delineation.

Course Code	GEO 601
Course Title	Gravity and Magnetic Exploration Methods (3 CH)
<u>Course Outline:</u>	
Introduction; Newtons law of Gravitation; The Geoid, Instruments used in Gravity and magnetic exploration; Survey Techniques employed; Types of Gravity and Magnetic Surveys; Methodology used to carry out Gravity and Magnetic Surveys; Reduction of Gravity and Magnetic data; Corrections used to correct gravity and magnetic data; Regional and Residual separation techniques for gravity and magnetic data; Interpretation of Gravity and Magnetic data and generation of theoretical and field curves; Depth Rules for Gravity and magnetic methods; Estimating the shape and size of the body.	

Course Code	GEO 602
Course Title	Electrical Exploration Methods (3 CH)
<u>Course Outline:</u>	
Electrical resistivity method, Mechanisms of conduction, Ohms law, Archies law, Electrode Configurations (Wenner Configuration, Schlumberger Configuration, Dipole-Dipole Configuration, Pole-Dipole Configuration, Pole-Pole Configuration), Choice of Array, Refraction of Current Path, Electrical Reflection Co-efficient Survey Types, interpretation of Electrical Resistivity Data, Curve Matching Technique to interpret resistivity data, Application of Electrical Resistivity Data; Electric exploration methods, Charge body potential Method, Spontaneous Potential method, Induced Polarization Method, Electromagnetic Method, Telluric Method, Magnetotelluric Method, Principle, Mechanism, Important Consideration, Sources of Noise, Instrumentation, Field Procedure, Survey design, Interpretation, Advantages, Disadvantages, Limitations, Applications.	

Course Code	GEO 502
Course Title	Geophysical Exploration Methods
<u>Course Outline:</u>	
An introduction to the physics of the earth. Theory and application of basic geophysical field techniques including, gravity, magnetic, electrical, electromagnetic, GPS, seismic studies, and satellite remote sensing. The present internal structure and dynamics of the earth and constraints from the gravitational and magnetic fields, seismology, mineral phases and wave propagation in earth materials. The earthquake source in terms of seismic and geodetic signals. Contributions of heat-flow, gravity, paleomagnetic, and earthquake mechanism data to plate tectonics, the driving mechanism of plate tectonics, and the energy sources of mantle convection. Application of the basic principles of physics to the earth sciences, including mechanics of rotating bodies, the two-body problem, tidal theory, oscillations and normal modes, diffusion and heat transfer, wave propagation, electro- and magneto-statics.	

Course Code	GEO 516
Course Title	Applied Environmental Geophysics
<u>Course Outline:</u>	
Introduction to geophysical methods for environmental applications. Fixed and mobile hazards. Applications in contaminant plumes, conduits, fractures, voids, aquifers. buried containers, waste pits, ordnance, landfill delineation. Use of seismic methods, ground penetration radar, electromagnetic methods, tomography and other geophysical methods to environmental problems.	

Course Code	ENV 504
Course Title	Environmental Impact Assessment
<u>Course Outline:</u>	
Introduction: principles, concepts and purposes of IEE and EIA and its significance for the society. Cost and benefits of EIA. Main stages in EIA process. Public consultation and participation in EIA process. Methods and techniques for impact prediction and evaluation. Integration during project life cycle. EIA review and post project analysis. EIA process management. Role of quality assurance and quality control in environmental analysis. EIA Regulations and guidelines in Pakistan.	

Course Code	ENV 572
Course Title	Climate Change Adaption and Mitigation
<u>Course Outline:</u>	
Climate Change, Cause & Effect of Climate Change, Climate Change Policy, Impacts of Climate Change in Pakistan, Green Economy, Carbon Footprint, Technological Development and Changing climate, Climate Change matters, Present rapid warming, Projection of future climate change, Uncertainty in climate change projections, Climate change impacts-reasons for concern, Impacts on natural systems, societal systems, human health and comforts, Reactions and attitudes to climate change: Adaptation, Mitigation options: increased energy efficiency, fuel substitution, nuclear power, hydropower, solar energy, wind power, biomass energy, tidal, wave and geothermal energy, hydrogen economy, changes in infrastructure and behavior.	

Course Code	GEO 519
Course Title	Coal Geology
<u>Course Outline:</u>	
Definition, composition, classification and origin of coal. Litho types and coal macerals. Chemical and petrographical analysis. Application of coal petrography. Depositional environments of coal and coal bearing strata, coalification process, types of coal basin sand their tectonic setting, concepts of cyclic deposition in coal basin, origin of split sand partings in coal seams. Comparison between modern and ancient coal forming environments, structural problems relevant to exploration & mining. Coal utilization and resource evaluation. Methods of coal exploration; geological, geophysical and drilling. Coal bearing sequences of Pakistan. Coal mining and its environmental issues. Lab: Petrography of coal and associated rocks. Preparation a coal pellets. Petrographic methods of coal analysis. Specified assignments/projects.	

Course Code	GEO 608
Course Title	Practical Applications of Geosciences Softwares
Course Outline:	
<p>Introduction to software used in different industry. How to create and manage a project including establishing project boundaries, choosing an X/Y projection. the use of authors, CRS and its types. Culture (geographic layer) input: creating and entering culture data on the base map including formatted and unformatted data entry and the importing of ESRI shape files. Well data input: using file sources such as HIS Energy and ascii formatted data; loading of well locations, deviation surveys, formation tops, log curves, and local and shared Time-Depth information. Using the SEG-Y Viewer to examine 2D and 3D trace header data. 2D and 3D data loading from files and the use of Share/Copy feature for seismic data. Introduction Review basic concepts: Waves; Wavelet; Seismic sections 2D vs. 3D; Seismic display, slice, 2D and 3D view, Volume concept, Slicing the data volume, Dynamic range and data loading, Polarity and colour Character and zero phase, Colour principles, Interpretative value of colour, Interpretation procedure/workflow, Synesthetic seismogram, Structural interpretation, Fault recognition and mapping, Horizon mapping and procedures, Visualization and auto tracking. Direct contouring and the importance of the strike perspective, Maps and its types. Depth conversion and procedures. Composite displays. Advantage and disadvantages of different displays, Subtle structural features. Stratigraphic interpretation. Seismic facies analysis. Internal reflection configuration. External geometry of seismic facies units. Recognition of characteristic shape. Methods of making horizon slices. Unconformity horizon slices; Seismic attribute analysis.</p> <p>Small project based on available data.</p>	

Course Code	GEO 607
Course Title	Unconventional Hydrocarbon Resources (3 CH)
Course Outline:	
<p>Introduction to unconventional hydrocarbon resource; An overview of unconventional hydrocarbon resources in Pakistan; Classification of unconventional hydrocarbon resources; Geologic and geographic occurrences; Recovery technology and economics of unconventional hydrocarbon resources; Characterization of unconventional resources; Exploration; Development; Laboratory methods; Geomechanics; Geochemical methods; Well completion; Hydraulic fracturing; Environmental issues; Seismic and geostatistical estimation methods.</p>	

Course Code	GEO 606
Course Title	Reservoir Geomechanics (3 CH)
Course Outline:	
<p>Introduction to reservoir Geomechanics; Structural Geology, Fault Classification; Stress and strain analysis; Tectonic stress, Review of Earth Stresses; Stresses in various types of basins; Determining initial stress conditions in typical reservoir cases; Mechanical Behavior of Reservoir Rocks, stress-strain-yield properties of reservoir rocks; poorly consolidated sandstones; Diagenetic processes in reservoir rocks; Transport Properties of Reservoir Rocks; Thermal conductivity and expansion properties of rocksand minerals; Effect of high temperatures on clay minerals and hydrous minerals; Permeability vs. effective stresses in porous media; Fractured media. Pore Pressure Prediction.</p>	

Course Code	GEO 605
Course Title	Applications of Geostatistics in Geosciences (3 CH)
Course Outline:	
<p>Introduction to Geostatistics; Computer application in geo-statistics; Collection and editing of data, primary data and secondary data; Measures of central tendency or averages, types of averages, arithmetic mean, median, mode, empirical relation between mean, median and mode; Relative merits and demerits of various averages; Measures of dispersion range, semi-interquartile range or quartile deviation, mean deviation, standard deviation, skewness; Correlation and simple regression, coefficient of correlation, scatter diagram, rank correlation, regression; Geo-statistical analysis, variogram calculation, interpretation, linking variogram behaviour with physical causes (geology, sampling); Extension variances and estimation variances/simple calculations in one and two dimensions; Global reserve/resource estimation; Optimal estimation and introduction to kriging.</p>	

Course Code	GEO 604
Course Title	Machine Learning for Geosciences (3 CH)
Course Outline:	
<p>Introduction to Machine Learning; Types, Supervised, Unsupervised; Model Representation; Cost Function; Supervised learning, Generative/discriminative learning, parametric/nonparametric learning, neural networks, and support vector machines; Gradient Descent; Gradient descent for Linear Regressions; Clustering, dimensionality reduction, kernel methods; Machine learning for seismic interpretation, fault extraction, horizon mapping, surface generation, facies analysis through supervised and unsupervised methods.</p>	

Course Code	GEO 603
Course Title	Engineering Geophysics (3 CH)
Course Outline:	
<p>Introduction to environmental and engineering problems as well as geophysical technique; Relevant physical properties of rocks and soil; Seismic reflection, Optimum window and optimum offset techniques; Field procedure, techniques, and instrumentation; Data correction and interpretation; Seismic refraction, Interpretation techniques such as GRM and others; Electrical Images, 2D Resistivity Modelling; Finite difference method; 2D electrical imaging exploration and multi electrodes, Data collection and interpretation; Introduction to 3D electrical imaging; Relevant topics such as GPR and others; Field examples for environmental, engineering and hydrogeology; Latest research articles related the subject will be discussed in class.</p>	

Course Code	GEO 512
Course Title	Mineral Prospecting & Exploration (3 CH)
<u>Course Outline:</u>	
<p>Mineral prospecting methods. Mineral deposit economics, target selection, deposit modeling, exploration technology, international exploration, environmental issues, program planning, proposal development. Geochemical prospecting methods. Geochemical behavior of common ore elements, development of primary and secondary haloes around ore deposits. Distribution of detrital material and solutions by streams, glaciers, etc. Dispersion of trace metals from mineral deposits and their discovery. Principles and application of primary dispersion to the search for metallic mineral deposits. Secondary dispersion processes (mechanical and chemical) applied to the search for metalliferous mineral deposits. Field methods of analysis for trace amount of metals. Labs consists of analysis and statistical interpretation of data from soils, stream sediments, vegetation, and rock in connection with field problems. Individual special investigations of a laboratory or field problem in exploration geochemistry. The mineralogy of economic deposits. Mineral deposit geology and models. Mineral exploration data and evaluation techniques. Project evaluation</p>	

Course Code	GEO 534
Course Title	Reservoir Geology (3CH)
<u>Course Outline:</u>	
<p>Reservoir rock types, Clastics, carbonates, and non-marine reservoirs; Introduction to deposition of reservoir rocks; Reservoir properties; Depositional and diagenetic controls; Fluid properties and their saturation; Hydrocarbon distribution and fluid contacts; Reservoir zonation and thickness mapping; Reservoir pore spaces configuration; Mapping reservoir heterogeneity; Field observations to understand reservoir; Migration of hydrocarbons from source rock to reservoir; Estimation and calculation of reservoir volumetrics; Material balance and production decline curve methods; Appraisal and development of reservoir basic concepts.</p>	

Course Code	GEO 530
Course Title	Advanced Marine Geology (3 CH)
<u>Course Outline:</u>	
<p>Evolution of ocean basin and marine Environment; Types of marine/ocean basins; Concept of Oceanography; Modern and ancient deep-marine processes; Deposits and environments; Physical and Biological processes in shallow and deep-marine environments; Key Concepts and Techniques in Oceanographic data analysis and Sediment transport processes; Sediments and facies, beds, their sedimentary characteristics and interpreted depositional processes; Deep-water ichnology; Trace-fossil assemblages as palaeo-environmental indicators; Mineral resources of sea; Time-space integration including sedimentary marine deposition; Statistical properties of sediment; Gravity flow deposits; mass transport Deposits; Bed thickness distributions; Sea bed morphology; Sediment drifts and abyssal sediment waves, Contourites; Submarine fans and related depositional systems; Interpretations of sub-environments; Offshore data processing; Integration and dominant geological processes; GIS and remote sensing concepts in marine tomography; Climate processes; Interactions and impacts of climate change.</p>	

Course Code	GEO 528
Course Title	Groundwater Modeling (3 CH)
Course Outline:	
Purpose of groundwater modelling; Conceptual model, conceptualization of aquifer-aquitard systems; Specification of boundary conditions; Hydrological stresses; Design of numerical model, finite-difference solutions of flow problems; Steady versus unsteady model; One layer versus multi-layer model; Lay-out of grids; Stress period/time steps; Model inputs, initial conditions; boundary conditions; Hydrogeological parameters, model calibration procedures and validation, selection of model code; Model prediction, purpose of prediction; Simulation of scenarios; Determination of capture zones; Introduction to MODFLOW; Exercises and case study	

Course Code	GEO 525
Course Title	Carbonate Sedimentology (3CH)
Current Course Outline:	
Carbonate mineralogy and chemistry: structure of aragonite, calcite and dolomite, trace elements and isotopes, Dolomite and dolomitization models: Modern and ancient examples Dolomitization reactions, trace element geochemistry of dolomites, dolomite petrography. Depositional textures and structures: Carbonate constituents, algal stromatolites. Classification of carbonates by Folk and Dunham. Porosity types. Concept of micro facies and micro facies types of Wilson. Major controls on carbonate sedimentation. Depositional processes and facies in carbonate rocks. Carbonate depositional models, platforms, rimmed shelves, ramps, epeiric plat forms and isolated platforms. Cyclicity in carbonates. Modern carbonate environments of Bahamas, Florida and Persian gulf. Carbonated positional systems; Lacustrine, shoreline, peritidal reefs, shallow and deep water. Diagenetic processes: sequences and models.	
Lab. Identification of carbonate sediments in hand specimen and thin sections. Microfacies interpretations Staining and XRD techniques.	

Course Code	GEO 524
Course Title	Clastic Sedimentology (3CH)
Course Outline:	
Texture of clastic sedimentary rocks. Sedimentary structures, their classification, and hydrodynamic conditions. Pealeo current analysis and provenance of elastic rocks. Sedimentary environment sand facies. Continental environments: Deserts, rivers lakes, glaciers and wind. Transitional environments; Delta, estuary, inter deltaic complexes. Marine environments: shelf, slope and deep marine. Diagenesis of clastic rocks.	
Lab. Petrographic study of elastic rocks. Heavy mineral analysis. Recording, plotting and analysis of Paleocurrent data. Field techniques for study of elastic sedimentary rocks.	

Course Code	GEO 531
Course Title	Advanced Structural Geology (3 CH)
Course Outline:	
Structural Geology and Tectonics; Deformation of earth's lithosphere; Theoretical aspects of rock deformation; Quantitative aspects of stress and strain analyses; The broad spectrum of deformation complexities in contractional, extensional and strike-slip regimes at various scales; Rheological properties of the lithosphere; Brittle and plastic deformation processes at the microscale and macroscale; Interaction between climate and tectonic; Practices in exploration software, MOVE; Geometric and kinematic modeling of brittle structures.	

Course Code	GEO 510
Course Title	Development of Groundwater Resources (3 CH)
Course Outline:	
Introduction to Groundwater, types of aquifer, Karez, groundwater resources of Pakistan; An introduction to geophysical and geochemical methods of exploration for planning, and design of regional water resources investigations; Groundwater Exploration, reconnaissance survey, surface investigation methods, subsurface investigations including test drilling, drilling methods, resistivity logging, radiation logging, temperature logging, velocity measurement and other methods; Groundwater Management, groundwater monitoring, observation network, water table fluctuation, selection of sites for the observation network, installation of observation wells and piezometers; Conjunctive use of surface and groundwater; Groundwater recharge; Groundwater balance; Groundwater quality; Case histories in the sustainable management of ground-water resources.	

Course Code	GEO 598
Course Title	Drilling Operations and Well Site Geology (3 CH)
Course Outline:	
Well Planning and its pre-requisites; Drilling of a well (Vertical & Directional); Drilling Rig Types; Components of a drilling Rig and their Operation (Derrick/Mast, Sub-structure, Hoisting, Rotary, Circulatory, Well Control, Bits etc.); Introduction to Drilling Fluids, Their Types & Selection; Casing, Casing Design and casing /cementing operation; Coring, its requirement, Types & Operation; Fishing; Mud Logging and its benefits; Lag Time Calculation; Drill Return (Cuttings) collection/ Sampling; Master Log and recorded parameters with their interpretation; Visual and microscopic analysis of cuttings at well site for lithological identification, porosity measurement, fluorescence/oil shows and formation tops; Chromatographic Analysis and interpretation of Gas Shows; Wireline logging Operations and their quality control; Measurement while drilling and its utilization; Well Testing (DST, MDT etc.); Perforation & Completion of a successfully tested well.	

Course Code	GEO 507
Course Title	Basin Analysis (3CH)
Course Outline:	
Basin formation in various types of geotectonic setting; Basin infill dynamics; Subsidence history and consequences for reservoir and source rock development and the petroleum system; Mechanisms of sedimentary basin formation by stretching, strike-slip, flexure and compression; Effects of mantle dynamics; Basin infill mechanisms and depositional systems; Basin stratigraphy, subsidence and thermal history; Changes of reservoir and petrophysical parameters during burial and tectonic processes; Application to the petroleum system Leading towards the play concept; Sedimentary basins of Pakistan; Sedimentary basin and their formation processes; A review of petroleum systems of Pakistan with respect to basin analysis.	

Course Code	GEO 508
Course Title	Stratigraphy and Petroleum Prospects of Pakistan (3 CH)
Course Outline:	
Introduction to Stratigraphy and Facies analysis; Lithostratigraphy; Biostratigraphy; Controls of sedimentary environments on the development of hydrocarbon and coal resources; Sedimentary basins of Pakistan; Brief review of Stratigraphy of Pakistan; Potential source rocks of Pakistan, Potential reservoir rocks of Pakistan; Trapping mechanism in different sedimentary basins of Pakistan; Unconventional hydrocarbon prospects of Pakistan; Review of case histories for Conventional and Unconventional hydrocarbon prospects of Pakistan.	

Course Code	GEO 505
Course Title	Advanced Sedimentology (3 CH)
Course Outline:	
Concept of facies and the connection between tectonics and deposition; Facies and facies associations of various environment; ancient deposits; Methods of study of sedimentary rocks; Accommodation and shoreline shifts; Sediment mobility under unidirectional, bidirectional and gravitational currents; Bed-form geometry; Spatial distribution; Types of contacts in the clastic sedimentary rock record; Time attributes of stratigraphic surfaces; Concept of hierarchy in the rock record; Depositional systems on large and small scales; Detailed depositional systems, Fluvial systems, Aeolian systems, Estuarine systems, Deltaic system, Shallow-water systems, Deep-water systems; Subsurface reservoir geometry and flow properties; Morphology, Modern analogues; Sedimentary textures; Sedimentary structures and flow regimes in the context of each sub environment; Petroleum system characteristics; Stratigraphic stacking patterns in modern and ancient depositional system.	

Course Code	GEO 548
Course Title	Advanced Seismic Stratigraphy
Course Outline:	
Introduction to sequence and seismic stratigraphy; Philosophy and history of sequence stratigraphy; Fault mechanical stratigraphy; Vail and Galloway sequence theory; Hierarchy and application; Sequence models; Basin development; sediment deposition and accommodation concepts; Geophysical fundamentals; Examples of operational sequences; Basin related depositional systems; Chronostratigraphy construction and interpretation; Sea level curves; Orders of cyclicity; Carbonate and Siliciclastic sequences; System Tracts; Stratigraphic surfaces; Seismic facies; Paleo-environmental analysis; Geohistory reconstruction; Biostratigraphic signature; Sequences in Deep marine, Shallow marine, Shelfal, Deltaic and Neritic Environment; Hydrocarbon traps related geometries; Seismic truncations; Data Integration at seismic, log, core and outcrop scale; Demarcation of stratigraphic surfaces on integrated data sets; Static and dynamic models; Optimizing exploration.	

Course Code	GEO 597
Course Title	Applications of GIS in Geosciences (3 CH)
Course Outline:	
Introduction to the GIS; Data exploration and preparation for GIS studies; Uses of GIS in hydrocarbon exploration, and in geological studies; Spatial Interpolation; GIS in flood management; Terrain Processing; GIS for watershed delineation; Geospatial Analysis, field development and planning; Analyzing Surfaces, spatial analysis for creating contours, hills shades and calculating views shed; Map Algebra, working with No Data values, doing conditional processing, and merging multiple Rasters together.	

Course Code	ESC 701
Course Title	Research Methodology (3CH)
Course Outline:	
Introduction to Research; Research paradigms; Research Design & Methods; Scientific Research; Research Question; Literature Review; Selecting the Research Method (s); Field Surveys; Data Collection; Sampling; Analytical tools; Research Proposal Writing Techniques; Research Presentation Techniques; Thesis manuscript writing; Funding acquisition; Soft skills development.	

Course Code	GEO 545
Course Title	Petrophysical Analysis (3 CH)
Introduction well logs and Petrophysics; Basic Wireline logging methods (electrical, radioactive, nuclear, acoustic and mechanical logs) and logging procedures; Application and use of open hole and cased hole logs for evaluating/estimating the Petrophysical properties of reservoir; Qualitative and Quantitative interpretation of well logs (lithology identification, shale content, porosities measurement fluid saturation, permeability, identification of pay intervals, well correlation based on the log characters/signatures and determination of lateral variations of Petrophysical parameters using well correlation etc.); Identification of Facies and evaluation of Depositional environments using wireline logs; Application of image logs and their analysis; Application of conventional logs in evaluation of unconventional reservoirs (Tight & Self Contained/shale reservoirs); Application of core analysis and its integration in Petrophysical analysis; Software based quick look Petrophysical interpretation in Geographix/Tecklog/Vizdom solutions VGS.	

Course Code	GEO 501
Course Title	Global Tectonics (3 CH)
<u>Course Outline:</u>	
<p>Geological, geochemical and geophysical evidence related to the contemporary concepts of plate tectonics and mantle convection; Kinematics and dynamics of plate motions; Description, evolution and causes of movements between lithospheric plates; Seismicity, geological processes and tectonics of plate boundaries; Wilson cycle in detail. Continental rift and drift; Major tectonic features of the Earth's crust; Tectonics and orogenies; Orogenic belts; Plumes; Plate tectonic evolution and geological processes of ocean basins, sea-floor spreading, magnetic anomalies, subduction zones, island arcs, rises, trenches and transforms; Geochemical and thermal evolution of the Earth; Dynamics of processes and physical properties of the Earth's interior including mantle dynamics and thermal convection; Modern analogues for plate tectonic phenomena; Plate tectonic framework of Pakistan; Implications of plate tectonics; Seismicity and active fault system of Pakistan.</p>	

Course Code	GEO 503
Course Title	Advanced Petroleum Geology
<u>Course Outline:</u>	
<p>Introduction of Petroleum Geology; History of petroleum Exploration; Basic concepts of Geological and Geophysical methods in Petroleum Exploration and Exploitation; Petroleum System & its components; Theories of petroleum source and thermal maturity/generation; Kerogen and its types; Pathways of hydrocarbon/petroleum migration; Accumulation of Hydrocarbon in reservoirs and the nature of traps & seals; Basic Concepts of reservoir types (Clastic, Carbonates, Fractures, Tight & Self-contained) and their properties; Tools used to study reservoir / source/trap for the prospect generation; Practical approach for the prospect generation (geological mapping, geophysical evaluation, analogue data/information & well logs); Biomarkers and Geochemical correlations of reservoir to reservoir / source to reservoir; Risk analysis of geological factors components of a petroleum system; reserve estimation; Case histories of oil/gas fields from any basin of Pakistan or related research papers review.</p>	