CURRICULUM
OF
GEOLOGY
FOR
BS/MS
(Revised 2013)

HIGHER EDUCATION COMMISSION
ISLAMABAD
CURRICULUM DIVISION, HEC

Prof. Dr. Mukhtar Ahmad  Executive Director
Mr. Fida Hussain  Director General (Acad)
Mr. Rizwan Shaukat  Deputy Director (Curri)
Mr. Abid Wahab  Assistant Director (Curri)
Mr. Riaz-ul-Haque  Assistant Director (Curri)

Composed by Zulfiqar Ali, HEC Islamabad
PREFACE

The curriculum, with varying definitions, is said to be a plan of the teaching-learning process that students of an academic programme are required to undergo. It includes objectives and learning outcomes, course contents, scheme of studies, teaching methodologies and methods of assessment of learning. Since knowledge in all disciplines and fields is expanding at a fast pace and new disciplines are also emerging; it is imperative that curricula be developed and revised accordingly.

University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII vide Section 3, Sub-Section 2 (ii), Act of Parliament No. X of 1976 titled “Supervision of Curricula and Textbooks and Maintenance of Standard of Education”. With the repeal of UGC Act, the same function was assigned to the Higher Education Commission (HEC) under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities, R&D organizations, councils, industry and civil society by seeking nominations from their organizations.

In order to impart quality education which is at par with international standards, HEC NCRCs have developed unified templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering in 2007 and 2009.

It is hoped that this curriculum document, prepared by the respective NCRC's, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC (www.hec.gov.pk).

(Fida Hussain)
Director General (Academics)
CURRICULUM DEVELOPMENT PROCESS

STAGE-I
CURRI. UNDER CONSIDERATION
COLLECTION OF REC
CONS. OF CRC.
PREP. OF DRAFT BY CRC
ORIENTATION COURSES
IMPLE. OF CURRI.
BACK TO STAGE-I

STAGE-II
CURRI. IN DRAFT STAGE
APPROVAL OF 1ST DRAFT BY EXP. OF COL./UNIV
FINALIZATION OF DRAFT BY CRC
APPRAISAL OF 1ST CURRI. by CRC
PREP. OF DRAFT BY CRC
PREP. OF FINAL CURRI.
INCORPORATION OF REC. OF V.C.C.
IMPLE. OF CURRI.
PRINTING OF CURRI.
PRINTING OF CURRI.
REVIEW

STAGE-III
FINAL STAGE
COL./UNIV
PREP. OF FINAL CURRI.
QUESTIONNAIRE

STAGE-IV
STAGE-IV
FOLLOW UP STUDY
COMMENTS

Abbreviations Used:
CRC.  Curriculum Revision Committee
VCC.  Vice Chancellor’s Committee
EXP.  Experts
COL.  Colleges
UNI.  Universities
PREP.  Preparation
REC.  Recommendations
INTRODUCTION

A final meeting of the National Curriculum Revision Committee (NCRC) in Geology was held at HEC, Regional Centre, Peshawar from 7-9 May, 2013 to review the draft curriculum of 4-year professional BS and 2-year MS in Geology in the light of HEC unified framework/template for integrated curricula in basic, social, applied and natural sciences. The following participants attended the meetings:

**Dr. Mirza Shahid Baig**  
Convener  
Fulbright Meritorious  
University Professor  
Institute of Geology  
University of Azad Jammu and Kashmir (AJ&K)  
Muzaffarabad, Azad Kashmir.

**Dr. Syed Abid Hussain**  
Member  
Professor  
Faculty of Engineering  
Takatoo Campus, BUITEMS,  
Airport Road, Baleli, Quetta-87330.

**Dr. Irshad Ahmad**  
Member  
Professor  
National Center of Excellence in Geology  
University of Peshawar,  
Peshawar.

**Prof. Dr. Sajjad Ahmad**  
Member  
Chairman  
Department of Geology,  
University of Peshawar,  
Peshawar.

**Dr. Nazir Ahmad**  
Member  
Associate Professor  
Institute of Geology  
University of the Punjab  
Lahore.

**Dr Imdadullah Siddiqui**  
Member  
Associate Professor  
Centre for Pure and Applied Geology  
University of Sindh  
Jamshoro, Sindh.
Dr. Sheikh Saeed Ahmad  
Assistant Professor  
Department of Geology  
Fatima Jinnah Women University  
Mall Road, Rawalpindi.

Mr. Khalid Aziz  
GM Training/R&D  
Pakistan Gems and Jewelry Development Company  
M-3, Mezzanine Floor  
Hotel Regent Plaza  
Main Shahrah-e-Faisal  
Karachi.

Mr. Muhammad Ishaq Saqi  
Senior Manager Exploration  
PPL, House No. 59/A,  
Ismail Zabeeh Road  
F/8-4, Islamabad.

Dr. Asghar Ali  
Manager Exploration (GR Labs)  
OGDCL, Islamabad.

Dr. Naseem Aadil  
HEC Foreign Professor  
Department of Geological Engineering  
University of Engineering and Technology (UET)  
G. T. Road, Lahore-54890.
Minutes of the meeting

The NCRC meeting started with the recitation of the Holy Quran. Mr. Zaheer Ahmad Awan, Director, HEC Regional Centre, Peshawar welcomed the participants on behalf of the Chairman, Higher Education Commission, Dr. Javed Leghari.

In the beginning of the meetings, Mr. Zaheer Ahmad Awan, Director, HEC Regional Centre, Peshawar highlighted the role of Higher Education Commission for the development of curricula. He briefed the members of the committee about the revision of curricula regularly at specific intervals to improve for imparting better quality education compatible nationally and internationally and useful for the industry and society. He pointed out the need to review/revise the curricula for 4- year professional BS and 2-year MS in Geology as standard for all the HEC recognized institutions and universities and facilitate students to continue higher education abroad and able to compete internationally.

Mr. Abid Wahab, Assistant Director (Curriculum), acted as meetings coordinator and facilitated all the technical sessions and logistics. Mr. Abid, in the preliminary meeting, requested the participants to select a Convener for the NCRC meeting for the geology curriculum revision. Prof. Dr. Mirza Shahid Baig, Institute of Geology, University of Azad Jammu and Kashmir (AJK), Muzaffarabad was unanimously selected as Convener and Prof. Dr. Naseem Aadil, Department of Geological Engineering, University of Engineering and Technology (UET), Lahore as Secretary. Prof. Dr. Mirza Shahid Baig and Prof. Dr. Naseem Aadil thanked the members for expressing confidence in them. In the final meeting, the same convener and secretary were requested to conduct the meeting.

In the preliminary meeting, the Committee, after three days discussion, prepared the revised draft curricula for 4-year BS and scheme of study for 2-year MS in Geology. In the final meeting, the Committee, after thorough discussions on the initial draft for three days, recommended the final draft for implementation in the universities and other degree awarding institutions.
ELIGIBILITY CRITERIA FOR ADMISSION IN 4-YEAR PROFESSIONAL BS DEGREE PROGRAM IN GEOLOGY

Intermediate Science (or Equivalent) with minimum 50% marks from the following groups:

1. Pre-Medical Group
2. Pre-Engineering Group
3. Other Groups (studied at least two subjects from Chemistry, Physics and Mathematics)
4. Three years Diploma in Associate Engineering (DAE)-equivalent to FSc

SCHEME OF STUDY FOR 4-YEARS BS IN GEOLOGY

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<td>English I</td>
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<td>Introduction to Geology</td>
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<td>Introduction to Paleontology</td>
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<td>Stratigraphy</td>
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<td>Geostatistics</td>
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<td>Petrography</td>
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<td>Geological Fieldwork-II</td>
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<td>Structural Geology</td>
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<td>Sedimentary Petrology</td>
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<td>Geol. 505</td>
<td>Micropaleontology</td>
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<td>Geol. 508</td>
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<td>Petroleum Geology</td>
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<td>Geol. 510</td>
<td>Engineering Geology</td>
<td>2+1</td>
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<td>Geol. 511</td>
<td>Metamorphic Petrology</td>
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<td>Geol. 512</td>
<td>Geological Fieldwork – III</td>
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<tr>
<td>Geol. 601</td>
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<td>Geol. 602</td>
<td>Economic Geology</td>
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<td>Geol. 603</td>
<td>Environmental Geology</td>
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<td>Hydrogeology</td>
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<tr>
<td>Geol. 607</td>
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<tr>
<td>Geol. 608</td>
<td>Reading and Conference / Independent Study</td>
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<td>Geol. 609</td>
<td>Thesis</td>
<td>0+6</td>
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<tr>
<td>Geol. 610</td>
<td>Internship/Practical Training</td>
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<td>Geol. 611</td>
<td>Comprehensive Oral Exam/Grand Viva Voce</td>
<td>S/U*4 Based</td>
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Note:
1. The recommended minimum credit hours for the completion of BS should not be less than 130 credit hours as required by HEC.
2. Internship (S/U based) is recommended in public/private sector organizations during/after the last four semesters, whenever possible. The allocation of the thesis topic and acquisition of data with the consultation of concerned supervisor shall start from beginning of VII semester.
3. Thesis will be open defence.
4. S/U’ means satisfactory (S = 50% marks) and Unsatisfactory (U = less than 50% marks).
5. Elective courses will be selected by relevant thesis supervisor.
6. Subject/s will be offered subject to availability of resource and resource person.
7. A two to three months field training camp must be arranged in summer/winter vacations by concerned departments with the help of HEC in different provinces. The field training camp is compulsory requirement for BS Geology degree.

LIST OF GROUPS AND ELECTIVE COURSES

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<tr>
<th>Groups</th>
<th>Elective Course</th>
<th>Credit Hour</th>
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<td>Group-I Mineralogy and Petrology</td>
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<td>Igneous Petrogenesis</td>
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<td>Group-II Paleontology and Stratigraphy</td>
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<td>Invertebrate Paleontology</td>
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<td>Palynology and Paleonbotany</td>
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<td>Group-III Economic Geology</td>
<td>Ore Deposits</td>
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<td>Metallgeny and Plate Tectonics</td>
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<td>Group-IV Engineering Geology</td>
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<td>Soil Mechanics</td>
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| Petroleum Geosciences | Engineering Geology II | 2+1     
|               | Sequence Stratigraphy II | 2+1     
|               | Petroleum Engineering | 2+1     
|               | Reservoir Geology | 2+1     
|               | Organic Geochemistry | 2+1     
|               | Petroleum Geology of Pakistan | 2+1     
|               | Geological and Geophysical Software Applications | 2+1     
|               | Logging and Log Interpretation | 2+1     
|               | Seismic Interpretation | 2+1     
|               | Basin Modeling | 2+1     |
| Group-VI | Applied Geophysics                                      |         |
|            | Seismic Stratigraphy | 2+1     
|            | Earthquake Seismology | 2+1     
|            | Geomagnetism and Paleomagnetism | 2+1     
|            | Electrical and Radiometric Exploration Methods | 2+1     
|            | Bore-Hole Geophysics | 2+1     
|            | Seismic prospecting | 2+1     
|            | Gravity and Magnetic Methods | 2+1     
|            | Rock Physics | 2+1     |
| Group-VII | Geochemistry                                      |         |
|            | Thermodynamics | 2+1     
|            | Geochemical Exploration | 2+1     
|            | Stable Isotope Geochemistry | 2+1     
|            | Radio Isotope Geochemistry | 2+1     
|            | Low Temperature Geochemistry | 2+1     
|            | High Temperature Geochemistry | 2+1     |
| Group-VIII | Sedimentology                                      |         |
|            | Clastic Sedimentology | 2+1     
|            | Carbonate Sedimentology | 2+1     
|            | Basin Modeling | 2+1     
|            | Quaternary Geology | 2+1     
|            | Clay Mineralogy | 2+1     |
| Group-IX  | Hydrogeology                                      |         |
|            | Hydrology | 2+1     
|            | Groundwater Investigations | 2+1     
|            | Groundwater Engineering | 2+1     
|            | Hydrochemistry and Ground Water Pollution | 2+1     |
| Group-X   | Industrial Mineralogy                              |         |
|            | Industrial Mineralogy-I | 2+1     
|            | Industrial Mineralogy-II | 2+1     
|            | Instrumental Techniques | 2+1     
|            | Clay Mineralogy | 2+1     
|            | Mineral Economics | 2+1     
|            | Mineral Deposits of Pakistan | 2+1     |
| Group-XI  | Marine Geology                                   |         |
|            | Marine Geology | 2+1     
|            | Oceanography | 2+1     
<p>|            | Marine Geochemistry | 2+1     |</p>
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<td>Group-III Structure, Tectonics and Neotectonics</td>
<td>Structural Geology II</td>
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<td>Metamorphic Structures</td>
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<td>Applied Structural Techniques</td>
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<td>Tectonics of Pakistan</td>
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<td>Seismotectonics</td>
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<td>Quaternary Geology</td>
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<td>Earth Quake Seismology</td>
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<td>Geological and Geophysical Software Applications</td>
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<td>GROUP-IV Coal Geology</td>
<td>Metalogeny and Plate Tectonics</td>
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<td>Coal, Environment and Clean Coal Technology</td>
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<td>Coal Geology</td>
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<td>Mining Geology</td>
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<td>GROUP-V GEOTECHNICAL ENGINEERING</td>
<td>Earthquake Engineering and Risk Assessment</td>
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<td>Ground Water System</td>
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<td>Excavation and Tunneling</td>
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<td>Engineering Geology II</td>
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<td>Rock Mechanics</td>
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<td>Soil Mechanics</td>
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DETAIL OF COURSES
FOR 4 YEARS BS IN GEOLOGY

Geol. 301: Introduction to Geology (3 credit hours)

Objectives:
This course is designed to acquire the knowledge about the basic concepts of geology. This will help the students to get knowledge about various types of rocks and minerals and the processes of their formation.

Course Contents:
Introduction and scope of geology; importance and relationship with other sciences; history and philosophy of geology; Earth as a member of the solar system; its origin, age, composition and internal structure; introduction to plate tectonics, Isostasy; mountain building processes; earthquakes and volcanoes; weathering and erosion; introduction, identification and classification of rocks and minerals; sedimentary, igneous and metamorphic structures; introduction to fossils in sedimentary rocks; introduction to folds, faults, joints, cleavage, foliation, lineation and unconformities; Geological Time Scale; Law of Superposition, present is key to the past and Law of Faunal Succession; concept and techniques of geological dating, relative and absolute dating; evolution of life on earth; use of Brunton Compass and GPS, etc.

Recommended Books:
Objectives:
This course is designed to acquire the knowledge about the formation of various landforms on the surface of the earth. This will help the students to understand the processes by which the various types of structures developed on the earth surface due to erosional and depositional processes.

Course Contents:
Geomorphological processes; weathering and erosion; glaciers and their erosional and depositional landforms; geological work of wind and associated features; erosional and depositional work of surface and subsurface water; valley and base-level development and its types; drainage pattern, stream meandering and development of flood plains; the erosional and depositional work of sea; development of coastal landforms; geomorphic cycles and associated landforms produced by tectonics and volcanic activity; introduction to tectonic geomorphology; introduction to topographic maps; aerial photographs and satellite imageries.

Labs: Identification of geomorphic features by using topographic maps, relief maps and interpretation of 3D relief diagrams on computer.

Recommended Books:
7. Geomorphology by Chorley, R.J., 1984, Methuen.
Geol. 303: **Geological Fieldwork-I**  (2 credit hours)

**Objectives:**
This preliminary field trip is for identification of rock types and geomorphic features which will help the students to understand in identifying various types of criteria to recognize rocks and other geological and geomorphological features in the field.

**Labs:** Field based exercises. During the first two years students will perform about two weeks of fieldwork. It will lead to become familiar with major rocks and basic geological mapping techniques. Each field trip will be followed by report writing and Viva Voce / Evaluation.

**Recommended Books:**

Geol. 401: **Introduction to Paleontology**  (3 credit hours)

**Objectives:**
This course is designed to acquire the knowledge about the various types of fossils and their significance. This will help the students to understand various morphological features of fossils; their classification, identification and distribution in geologic time.

**Course Contents:**
Introduction to fossils and their significance; modes of fossilization, study of morphology, range and broad classification of major invertebrate phyla i.e. coelenterata, brachiopoda, mollusca, arthropoda (trilobite) and echinodermata (echinoidea); introduction to micro fossils; introduction to paleobotany; introduction and classification of major vertebrates i.e. mammals, amphibians, reptiles and picies; introduction to micropaleontology i.e. foraminifera, briozone, ostrocodes and conodonts etc. Index fossils; introduction to major invertebrate and microfossils of Pakistan.

**Labs:** Megascopic identification and description of fossils up to genus level related to phyla studied.

**Recommended Books:**

**Geol. 402: Stratigraphy**

**(3 credit hours)**

**Objectives:**
This course is designed to acquire the knowledge about the various stratigraphic successions formed during different geologic time. This will help the student to understand the stratigraphic set up of various regions, especially Pakistan.

**Course Contents:**
Principles of stratigraphy; laws of superposition and faunal succession; geological time scale with divisions; classification and nomenclature of stratigraphic units: lithostratigraphic, biostratigraphy and chronostratigraphic units; contacts; litho-and-biofacies; principle of stratigraphy correlation; Stratigraphy code of Pakistan; outline of stratigraphy of Pakistan; principles of biostratigraphy and biostratigraphy zones; biostratigraphy techniques and procedures; biostratigraphy of Pakistan.

**Labs:** Preparation of stratigraphic columns and their correlation, facies maps, isopach, stratigraphic map,

**Recommended Books:**
Geol. 403  Geostatistics  (3 credit hours)

Objectives:
This unit is designed to provide students with an introduction to the geostatistical techniques used in estimation from spatial data. Applications will be mainly in the areas of mining, petroleum, soil science and environmental management.

Course Contents:
Descriptive statistics and exploratory data analysis, random variable; moments; probability distributions; normal and lognormal distributions, random function model, modeling spatial continuity; experimental variograms covariance functions; correlograms and madograms; variogram and covariance function models; isotropy and anisotropy, estimation methods: simple kriging (ordinary

Labs: Calculating a range of descriptive statistics and carry out a variety of methods for exploratory data and variance) analysis; use variograms and covariance functions to model spatial continuity; understand the random function model for the analysis of spatial data; carry out simple and ordinary kriging.

Books Recommended:

Geol. 404:  Mineralogy  (3 credit hours)

Objectives:
This course is designed to acquire the knowledge about the physical and optical properties of various rock forming minerals and related phase diagrams. This will help the students in learning how various silicate and non-silicate minerals can be identified and how these are formed during different P-T conditions.

Course Contents:
Classification of minerals; study of internal structure; polymorphism and isomorphism; crystal systems; crystal chemistry; paragenesis, physical and optical properties of the common silicate and non-silicate mineral groups; introduction to X-Ray diffractometry and universal stage and their application; phase equilibrium studies; one component; binary and ternary system;
introduction to mineralogy and crystallography; elements of symmetry; crystal notation; study of normal classes of crystallographic systems.

Labs: Megascopic and microscopic identification of common rock forming minerals; construction and interpretation of phase diagrams from given experimental data; lab work related to XRD and Universal stage.

Recommended Books:

Geol. 405: Petrography (3 credit hours)

Objectives:
This course is designed to help the students to identify the minerals in sedimentary, igneous and metamorphic rocks using polarizing microscope and also classifying the rocks on the basis of rock texture and mineral composition.

Course Contents:
Introduction to polarizing microscope; optical properties of opaque and non-opaque minerals in plane polarized light and under crossed nicol including metallic under reflected light; description of optical properties of common rock forming minerals; mineralogy and common texture of igneous, sedimentary and metamorphic rocks.

Labs: Identification and description of common minerals; study of rocks and minerals in thin section, texture and composition; classification of rocks using different techniques, volume estimates and other elementary petrographic techniques.
Recommended Books:

Geol. 406: Geological Fieldwork-II (2 credit hours)
Objectives:
The second year field work will be performed for about two weeks. This course is designed to identify various types of rocks, field stratigraphy, fossils, structural features and landforms in the field. This will help the students to understand various types of criteria to recognize rocks and other geological features in the field.

Labs: Field based exercises; the students will become familiar with major rocks, field stratigraphy, fossils, structures, section measurement and basic geological mapping techniques. Each field trip will be followed by report writing and Viva Voce / Evaluation

Recommended Books:

Geol. 407: Structural Geology (3 credit hours)
Objectives:
This course is designed to acquire the knowledge about the deformational structures and their kinematics in the crust. This will help in understanding the deformational mechanism of various types of rocks and the mapping of resultant structures.

Course Contents:
Stress: concepts, classes, ellipsoid; Mohr circle of stress; Strain: concept, types of strain, measures of strain, ellipse and ellipsoid, stress-strain diagram; factors controlling the mechanical behavior of rocks; Folds: geometry,
classification based on geometry, morphology, angle, bed thickness, variation and vergence etc. The mechanics of fold formation; drag fold and types; Faults: terminology, slip and separation, criteria for recognition of fault and active fault, classification of thrust/reverse, normal and strike-slip faults; kinematics of folds and faults; Joints: terminology, geometry and classification; Foliation: terminology, classification and relationship with bedding; Lineation: terminology and classification; contacts; unconformity: concept, classification, recognition and significance; tectonites; primary structures and facing based on primary structures; introduction to structural balancing technique and application of structural geology in exploration

**Labs:** Map exercises and construction of geological cross-sections; orthographic projections (geometrical exercises); basic balance cross-sections, stereographic projections and use of structural computer software.

**Recommended Books:**

**Geol. 408: Igneous Petrology**

**Objectives:**
This course is designed to acquire the knowledge about the origin of magma and the role of magmatic and metamorphic process in the formation of igneous rocks. This will help the students in understanding the classification of various igneous rocks and their genesis in different tectonic settings.

**Course Contents:**
Composition, origin, differentiation and evolution of magma; classification of igneous rocks; mineralogy and petrology and occurrence of the following series: tholeiitic and alkali-olivine basalt; basalt–andesite series; study of granites, granodiorite, syenite, carbonatite, mafic and ultramafic rocks and ophiolites; lamprophyres; facies analysis of volcanic rocks; mode of occurrences and types of extrusive rocks; texture and structure of igneous rocks; economic importance of igneous rocks.
Labs: Megascopic and microscopic identification and description of igneous rocks. Discrimination diagrams.

Recommended Books:
1. Igneous and Metamorphic Petrology by Best, M. G., 2002, Black Well.

Geol. 501: Geotectonics (3 credit hours)

Objectives:
This course is designed to acquire the knowledge about the various types of plate boundaries, their kinematics and dynamics. This will help the students to understand the mountain building activity and changes that occurred on the earth with the passage of time.

Course Contents:
Concept of geosyncline and sedimentary basins; sea floor spreading, oceanic ridges and trenches; continental rifts; intra-oceanic islands; hot spot and mantle plumes; continental drift and reconstruction; concept of plate tectonics; historical perspective; mechanism of plate tectonics; plates and plate boundaries; relative and absolute plate motions; extensional, compressional and transpressional tectonics; subduction zones; transform and transcurrent faults; introduction to neo-tectonics and related hazards, application of geotectonics in natural resource explorations.

Labs: Specified assignments/projects.

Recommended Books:
2. Economic Geology and Geotectonics, Donald Harvey Tarling, 1981, Wiley
Geol. 502: Sedimentary Petrology (3 credit hours)

Objectives:
This course is designed to acquire the knowledge about various types of sedimentary rocks and their diagenesis. This will help the students to understand the classification and depositional system of the sedimentary rock.

Course Contents:
Introduction to sedimentology; origin, transportation and deposition of sediments; texture of sedimentary rocks and their statistical parameters; sedimentary structures, their classification, morphology, significance and paleocurrent analysis; classification and description of sedimentary rocks; provenance of sediments; diagenesis; concepts of sedimentary facies and facies associations; physico-chemical controls of the sedimentary environments; diagnostic features of glacial, eolian, fluvial, lagoonal, lacustrine, deltaic, tidal, turbidites and marine environments; tectonic controls of sedimentation.

Labs: Grain size analysis of sediments and sedimentary rocks; megascopic and microscopic study of sedimentary rocks for classification; use of ternary diagrams, discrimination diagrams for tectonic setting, separation and identification of heavy minerals; study of primary sedimentary structures and their uses in facing or top bottom. Rose diagrams and paleocurrent analysis.

Recommended Books:
Geol. 503: Geophysics (3 credit hours)

Objectives:
This course is designed to acquire the knowledge about the seismic waves, seismic refraction, gravity, magnetic and electrical prospecting. This will help the students in learning the basic techniques in geophysics and the students will also work on the seismic images and interpretation of subsurface structures.

Course Contents:
Definition and relation of geophysics with other sciences; classification and brief description of various branches of geophysics such as seismic reflection and refraction techniques; magnetism; geoelectricity; tectonophysics; gravimetry; geothermy and geodesy; geophysical data acquisition, processing and interpretation; applications of geophysical techniques for exploration of mineral deposits, oil, gas, subsurface water and engineering works; introduction to earthquake seismology and geodynamics of earth.

Labs: Analysis and interpretation of geophysical data; generation of time contour map, time depth conversion and generation of depth contour map.

Recommended Books:
Geol. 504:  Field Geology  (3 credit hours)

Objectives:
This course is designed to understand the geological mapping techniques in the field. This will help the students in learning the use of field equipments and data acquisition and preparation of geological maps and cross-sections.

Course Contents:
Introduction of topographic and geological maps; methods and techniques of surface and subsurface geological mapping; introduction to instruments for geological mapping; interpretation of geological maps with reference to outcrop patterns; correlation techniques; field description of igneous, metamorphic and sedimentary rocks; modes of geological illustration including structural contour, isopach and lithofacies maps, block and fence diagrams; scan line survey; preparation of geological maps and cross sections; awareness and compliance of Health and Safety Environment (HSE) particularly during geological work.

Labs: Uses of field instruments; field data acquisition and interpretation; section measurement and preparation of cross section; structural balancing; geological fieldwork and report writing of an assigned area.

Recommended Books:

Geol. 505:  Micropaleontology  (3 credit hours)

Objectives:
This course is designed to understand the micro-fossils found in geological formations and Tertiary biostratigraphy rock units in Pakistan.

Course Contents:
Introduction to foraminifera, bryozoa, conodonts, algae, pollen and spores; microfossils and nanoplanktons; principles of biostratigraphy and biostratigraphic zones; biostratigraphic techniques and procedures; Tertiary biostratigraphy with special reference to Pakistan

Labs: Basic micropaleontological and biostratigraphic techniques; morphological and taxonomic studies of selected/index microfossils.
**Recommended Books:**

**Geol-506: Introduction to GIS and RS**  (3 credit hours)

**Objectives:**
This course is designed to introduce principles, concepts and applications of Geographic Information Systems (GIS) and Remote Sensing (RS): a decision support tool for planners and managers of spatial information and to obtain information on the earth from deci-meter level to km level locally and globally.

**Course Contents:**
Introduction to Geographical Information System; data types, data models and structures; data sources and capturing techniques; displaying and manipulating spatial information, vector data preparation, GPS Survey; introduction to the concept of RS, electromagnetic spectrum, atmospheric interaction; Technology of Remote Sensing (Orbits, Satellites, Sensors and Platforms); applications of Remote Sensing, satellite image processing cycle, image enhancement, data fusion and mosaicing and information extraction (classification and vectorization)

**Labs:** Introduction to ArcGIS, Exploring GIS Dataset in ArcCatalog, Working on vector data in ArcGIS (Scanning, Digitization and Editing), Integrating GPS data in GIS Environment, Applications of GIS, ERDAS Imagine - Environment, Noise Corrections, Geometric Corrections, Radiometric Corrections.

**Recommended Books:**

Geol. 507: Sequence Stratigraphy (3 credit hours)

Objectives:
This course is designed to acquire the knowledge about various types of stratigraphic sequences and their relation with the sea level changes. This will help the students to learn about the formation of various sedimentary rock sequences during geologic time.

Course Contents:
Introduction, history, concept and significance of sequence stratigraphy; data sources: seismic reflections, outcrops, well logs, core; seismic facies; sea level changes, their causes and effects; accommodation, eustatic and relative sea curve; hierarchy of sequence stratigraphic elements; types of sequences and systems tracts; applications to hydrocarbon exploration and basin analysis

Labs: Interpretation of seismic reflections; picking up/identification of sequence boundaries, system tracks and seismic facies.

Recommended Books:
Geol. 508: Geochemistry (3 credit hours)

Objectives:
This course is designed to acquire the knowledge about the distribution of elements in minerals and rocks and their dispersion in different environments. This will help the students in learning the geochemical characteristic of various rocks and their role in mineral exploration.

Course Contents:
Development of geochemistry as a discipline; composition of meteorites; origin and cosmic abundance of elements; geochemical structure of the earth; geochemical classification of elements; polymorphism and pseudomorphism; geochemical cycle; mobility and dispersion of elements under different geochemical environments; introduction to geochemistry of igneous, metamorphic and sedimentary rocks; geochemical anomalies and their application in mineral exploration; introduction to geochemical analytical techniques; introduction to organic geochemistry, organic matter, types, and its importance in petroleum industry.

Labs: Processing and interpretation of geochemical data. Ternary diagrams interpretation.

Recommended Books:
1. Introduction to Geochemistry by Krauskopf, K.B., 1967, McGraw-Hill.

Geol. 509: Petroleum Geology (3 credit hours)

Objectives:
This course is designed to acquire the knowledge about the processes involved in the formation, migration and accumulation of petroleum in the rocks and drilling and well logging techniques for petrophysical evaluation and production of oil and gas. This will help the students to learn about the global occurrences of oil and gas with special emphasis on Pakistan so that they can effectively use their knowledge in the exploration and development of the country’s energy resources.
Course Contents:
Introduction and history of hydrocarbon exploration; the nature and classification of petroleum hydrocarbons, their origin, migration and accumulation, traps, seal and cap rocks; source rock-evaluation; kerogene and its types; reservoir rocks characterization, reservoir fluid, reservoir conditions and dynamics; tight reservoirs; exploration petroleum cycle in Pakistan; prospect and exploration in frontiers areas; introduction to drilling operations, well site geology and mud logging; well failure/success analysis; petroleum prospect risk analysis; nonconventional hydrocarbons, introduction to play fairways and petroleum system.

Labs: Preparation of, various types of subsurface maps, e.g. isopach, isochore and isoliths etc. Preparation of fence diagrams. Identification of pay zone, analysis of pyrolysis data and correlation diagrams. Visits to well/drilling sites.

Recommended Books:

Geol. 510: Engineering Geology (3 credit hours)

Objectives:
This course is designed to acquire the knowledge about the rock mechanics and their role in the construction of huge structure. This will help the students in learning various techniques of determination of physical and geotechnical parameters of soils and rocks for construction of buildings and foundations.
Course Contents:
Introduction to the engineering geology and its application; weathering, physical and chemical; earthquakes, causes and intensity scale; rock mass classification; geotechnical studies of rocks and soils; geological factors and strength of rocks; chemical and mechanical behavior of rocks; geotechnical investigation; uses of sedimentary, igneous and metamorphic rocks as construction material; Building Code of Pakistan; dam and tunnel engineering; common engineering problems and their remedial measures.

Labs: Sieve analysis, slake durability, moisture, void ratios, porosity, angle of repose, and other geotechnical properties of soils. Uniaxial and Triaxial Testing; tensile, compressive and shear tests of rocks.

Recommended Books:
1. Practical Engineering Geology by Steve Hencher – 2012.Amazon
10. Geology for Engineers by Blyth, F.G.H. and De Freites, M.H., 1960, Butter and Tonner Ltd.

Geol. 511: Metamorphic Petrology (3 credit hours)

Objectives:
This course is designed to expose the students to the solid state transformation of pre-existing igneous, metamorphic and sedimentary rocks into metamorphic rocks. The students will get familiar with metamorphic processes and the resulting textures and structures in the rocks.

Course Contents:
Introduction to metamorphism; types, grades, zones and facies of metamorphism; metamorphic diffusion and differentiation; study of thermal and regional metamorphism of igneous, argillaceous, calcareous and arenaceous rocks; metamorphism in relation to plate tectonics; study of textures and structures of metamorphic rocks; metamorphism and deformation; history and dating of metamorphic rocks; differentiation between metamorphism and
metasomatism; paired metamorphic belts. Himalayan and pre-Himalayan metamorphism in Pakistan.

**Labs:** Petrographic and hand specimen identification of metamorphic textures, structures, and metamorphic history of rocks. ACF and AKF ternary diagrams and petrogenesis.

**Recommended Books:**
1. Igneous and Metamorphic Petrology by Best, M.G., 2002, Black Well.

**Geol. 512: Geological Fieldwork-III** (2 credit hours)

**Objectives:**
The duration of field work will be about two weeks and is designed to identify various types of rocks, stratigraphic features, fossils, primary and secondary structures and landforms in the field. Exercise will include the construction of profiles and cross sections, out crop sketches, scan line survey and geological mapping techniques.


**Recommended Books:**
Objectives:
This course is designed to acquire the knowledge about the tectono-stratigraphy of Pakistan with special emphasis on the tectonic elements and minerals and fuel deposits. This will help the students to learn about the interaction of regional plates and blocks such as Indian Plate, Arabian Plate, Karakoram Plate, and Afghan Block through geological times and their influence on the stratigraphy and mineral deposits of Pakistan.

Course Contents:
Physiographic and tectonic divisions and their descriptions; geology and stratigraphy of the Indian plate, Karakoram plate, Afghan block and Arabian plate; Waziristan, Kohistan, Chagai and Ras Koh magmatic Arcs; sedimentary basins of Pakistan; Makran subduction complex, Chaman transform zone, arcs, oroclines and suture zones; Tertiary Himalayan and pre-Himalayan orogenic events; Late Precambrian to Early Cambrian Hazaran orogeny, regional metamorphism (Himalayan and pre-Himalayan);, main episodes of magmatism and their relations to tectonics. Economic mineral and fuel deposits of Pakistan.

Field Visits: Fieldwork across the Indian plate, Himalayan collision zone, Kohistan Island Arc and Eurasian plate to study the geology and tectonics of Pakistan.

Recommended Books:
Geol. 602: Economic Geology (3 credit hours)

Objectives:
This course is designed to acquire the knowledge about the formation of various types of economic mineral deposits and their significance. This will help the students to understand the processes which are involved in the genesis of various ores deposits, hydrocarbons, gemstones and other industrial minerals.

Course Contents:
Introduction to economic minerals and rocks and their classification; grade and reserve estimation of deposits; introduction to ore microscopy; environment and processes of formation of economic mineral deposits: magmatic segregation, hydrothermal solution, metasomatism, sedimentation, evaporation, residual and mechanical concentration and metamorphism; relationship of mineral deposits to plate tectonic settings; introduction of geological exploration/prospecting; brief description of economic minerals such as fuel minerals, gemstones, copper, lead, zinc, iron, gold, chromite, manganese, salt, gypsum, bauxite, sulphur, barite, fluorite, clays, phosphorite, building and dimension stones, industrial rocks and minerals, radioactive minerals and rocks with special reference to Pakistan.

Labs: Identification and description of economic minerals, microscopic studies and lab exercises on grade and reserve estimation from provided data.

Recommended Books:
3. Introduction to mineral exploration by Charles and Micheal. 2006, Black well.
Academic Press.
15. Magmatic Sulfide Deposits: Geology, Geochemistry and Exploration by Naldrett, AJ., 2004

Geol. 603: Environmental Geology

(3 credit hours)

Objectives:
This course is designed to acquire the knowledge about the role of geology in the environmental degradation. This will help the students to learn how the various geological processes and related human activities are involved in contaminating our ecosystem.

Course Contents:
Introduction to environmental geology; management of natural resources; global climatic changes; environmental controls for erosion, desertification and coastal degradation; introduction to environmental impact assessment and initial environmental examination; environmental impact of mining, dams, reservoirs, highways, their assessment and controls; geological hazards such as floods, landslides, earthquakes, tsunamis, volcanoes, glaciers and shoreline processes and their remedial measures; industrial pollution, solid and liquid waste disposal, groundwater contaminations, river lake and marine pollution and their impact on human health; clean sources of energy, introduction to acid mine drainage.

Labs: Sampling and analysis of air, water, soil and rocks, geochemical analysis. Exercises can be done on published data.

Recommended Books:
Geol. 604: Hydrogeology  (3 credit hours)

Objectives:
This course is designed to acquire knowledge about the exploration of groundwater resources and their management. This will help the students to learn how to manage and conserve water resources, how to overcome the acute shortage of water supply and also how to maintain its purity for meeting the present demand as well as the demand of the future generation.

Course Contents:
The hydrologic cycle. Aquifer system and types; occurrence and movement of groundwater; hydrologic properties of rocks and their measurements, fluctuation of groundwater levels and causes; recharge and discharge of ground water; groundwater exploration by geological, hydro-geological and geophysical methods and remote sensing techniques; well hydraulics, tube well drilling techniques, designing, development; flow-net analysis and pumping tests; water logging and causes of water table declination; groundwater chemistry, salinity, quality analysis and deterioration of water quality. Groundwater resources of Pakistan.

Labs. Preparation of water table and piezometric surface maps. Flow-net analysis; study and preparation of hydro-geologic maps; graphical presentation of published chemical data of groundwater.

Recommended Books:
2. Hydrogeological Conceptual Site Models: Data Analysis and Visualization by Neven Krešić, Alex Mikszewski. 2012. CRC Publishers Taylor and Francis group, USA.
15. Field Hydrogeology by Brassington, R., 1988, John Wiley and Sons.

Geol. 605: Elective (3 credit hours)
Geol. 606: Elective (3 credit hours)
Geol. 607: Elective (3 credit hours)

Geol. 608 Reading and Conference/Independent Study (1 credit hour)

This course is based on assignment given to students for literature review and thesis writing proposals.

Geol. 609: Thesis (6 Credit hours)
Geol. 610: Internship/Practical Training (S/U* Based)

Geol. 611: Comprehensive Oral Exam/Grand Viva voce (S/U* Based)
Semester VII and VIII (List of Elective Courses)

GROUP-I: MINERALOGY AND PETROLOGY

Objectives:
The courses for this group of specialization have been designed to offer advanced level courses covering various aspects of mineralogy and petrology of igneous, sedimentary and metamorphic rocks. These courses will enable the students to fully understand (1) the mineralogical and chemical characteristics of various types of rocks, (2) the magmatic processes for the formation of igneous rocks and (3) the concept of metamorphic facies and zones. After completing these courses the students will be able to carry out their independent research on the mineralogical and petrological aspects of all rock type.

This group comprises of following courses:
1. Geochemistry II
2. Igneous Petrogenesis
3. Metamorphic Petrology II
4. Sedimentary Petrology II
5. Mineralogy II

1. Geochemistry II (3 credit hours)

Course Contents:
Geochemistry of igneous, sedimentary and metamorphic rocks; modal analysis for classification, chemical characterization and identification of minerals; classification and distribution of elements in the earth crust; introduction to analytical geochemistry; causes for geochemical diversity in the igneous rocks; geochemical characteristics of igneous rocks as petrogenetic indicators; processes which modify the composition of primary magmas; geochemical characteristics of different magma series; geothermometry and geobarometry; metasomatic processes and environment.

Labs: Characterization of igneous rocks on the basis of their (a) modal and (b) chemical composition; calculation of normative composition from the major element chemistry of igneous rocks; the use of major and trace element composition of igneous rocks as a means to determine their paleotectonic setting; graphical representation of metamorphic mineral parageneses (ACF and AKF diagrams); protolith of a variety of metamorphic rocks on the basis of their major and trace element geochemistry; the use of mineral chemical data for estimating pressure-temperature conditions of metamorphism.

Recommended Books:
11. Magmatic Sulfide Deposits: Geology, Geochemistry and Exploration by Naldrett, A.J., 2004

2. **Igneous Petrogenesis** (3 credit hours)

Course Contents:
Mantle-magma systems and source of magma; physico-chemical factors in magmatic evolution; petrogenesis of igneous rocks; petrogenic provinces: basaltic provinces, granite-granodiorite provinces and mafic-ultramafic complexes; tectonism-magmatism relationship; magmatism at convergent and divergent plate boundaries; intracontinental hot spots; intraplate magmatism; magmatism related to collisional environments and island arcs; ophiolites; volcanic chains and island arcs. Igneous rock associations.

Labs: Petrographic study of rock suits. Modal analyses and discriminate diagrams.

Recommended Books:

3. Metamorphic Petrology-II (3 credit hours)

Course Contents:
Basic characteristics of metamorphic reactions and role of fluids; concept of iso-grades and iso-reaction grades; very low grade and ocean floor metamorphism; contact and regional metamorphism; metamorphic facies series; P-T gradients, mineralogical characteristics of individual facies; progressive and retrogressive metamorphism of pelites, basic rocks and carbonates; high grade metamorphism, anatexis and migmatites; tectonics of regional metamorphic belts; paired metamorphic belts; metamorphic structure of continental crust; metasomatic processes.

Labs: Construction and interpretation of ACF and AKF diagrams; petrographic study of various rocks suites; mineral and mineral phase equilibria and P-T conditions.

Recommended Books:
2. Igneous and Metamorphic Petrology by Hyndman, D.W., 1972, McGraw-Hill.
5. Metamorphism and Plate Tectonics Regimes by Ernst, W.G. 1975, Dowden, Hutchinson and Ross, Inc.

4. Sedimentary Petrology-II (3 credit hours)

Course Contents:
Classification of sedimentary rocks, sedimentary environments; diagenesis of clastic, nonclastic and other sedimentary rocks; fabric, framework, geometry, texture and composition; study of heavy minerals; provenance of sedimentary rocks.

Labs: Study of texture, mineral composition and diagenesis of various types of
sedimentary rocks in hand specimens and thin sections; heavy mineral separation and analysis.

**Recommended Books:**

5. **Mineralogy-II (3 credit hours)**

**Course Contents:**
Physical and chemical properties of minerals; relationship between the structure, chemistry and properties of silicates, carbonates, oxides, sulphides, and phosphates; mechanisms of mineral nucleation and crystal growth; importance of kinetics in mineral formation; interpretation of mineral analysis.

Measurement of mineral triple junction angles; description of grain boundaries and their implication for the development of rock textures; triangular and X-Y plots; mineralogical evaluation for the assessment and performance of industrial rocks and minerals.

**Labs:** Microscopic identification of the common rock forming minerals in thin section, using transmitted and reflected light microscopy.

**Recommended Books:**
GROUP-II: PALEONTOLOGY AND STRATIGRAPHY

Objectives:
Advance level courses have been designed in this group of specialization. These courses will enable the students to fully understand (1) the morphology of various types of vertebrate and invertebrate fossils, (2) the microfossils and micro-organism and their role in sedimentary depositional system, (3) the deposition of various sedimentary sequences during geologic time and (4) the role of palynology and paleobotany in petroleum industry. After completing these courses the students will be able to carry out their independent research on establishing the stratigraphy of an area.

This group comprises the following courses:
1. Stratigraphy II
2. Micropaleontology II
3. Invertebrate Paleontology
4. Vertebrate Paleontology
5. Palynology and Paleobotany

1. Stratigraphy II (3 credit hours)

Course Contents:
Lithostratigraphy, facies analysis; evolutionary concepts in biostratigraphy: diachronism evolution and biochronology; Tectonostratigraphy: interpretation of complex deformed terrains; principles and practices in event stratigraphy, cyclostratigraphy, seismic and sequence stratigraphy; stratigraphic applications of isotope geochemistry; global standard stratigraphy: chronostratigraphy; Interpretation of Stratigraphic record: facies analysis, sea level changes, paleoenvironment and paleoclimates, Use of satellite imageries for stratigraphic interpretation.

Labs: Specified Assignments/projects.

Recommended Books:

2. **Micropaleontology-II** (3 credit hours)

**Course Contents:**
General techniques of collection and preparation of samples; Morphological, taxonomic, stratigraphical and paleoecological studies of Foraminifera, Ostracoda, Chitinozoa, Micropalankton, Pollen, Spores and Miscellaneous group. Study of Nano fossils. Importance and applications of micropaleontology.

**Labs:** Sampling and laboratory techniques; microscopic examination and identification of microfossils from Pakistan; preparation of thin sections of larger foraminifera and their identification.

**Recommended Books:**
2. Elements of Micropaleontology by Bignot, G., 1985, Graham and Trotman.

3. **Invertebrate Paleontology** (3 credit hours)

**Course Contents:**
Organic evolution and fossil record through ages; detail classification, evolution and geographical distribution of important invertebrates; Phyla like Brachiopoda, Molluska, coelenterata, Orthopoda and Echinodermeta etc.

**Labs:** Description and identification of invertebrate fossils up to species level.

**Recommended Books:**
1. Invertebrate and Evaluation by Clarkson, E.N.K., 1986, Allen and Unwin.
4. **Vertebrate Paleontology** (3 credit hours)

**Course Contents:**
Vertebrate life through ages; study of major groups of vertebrate fossils. Evolution of some well-known selected Fishes, Amphibians, Reptiles, Dinosaurs and Mammals. Study of vertebrate fauna of Pakistan.

**Labs:** Description and identification of vertebrate fossils.

**Recommended Books:**

5. **Palynology and Paleobotany** (3 credit hours)

**Course Contents:**
Introduction, methods of study, techniques of collection and preparation of palynomorphs; types and functions of spores; Pollen and spores morphology, development of homospores; Suprageneric classification of triletespores; distribution of palynomorphs during various geological periods with special reference to Pakistan; scope and application of palynology in petroleum industry; study of nano fossils. Introduction, aims and objectives of paleobotany. Taxonomy of fossils and study of various groups of fossil plants. Paleobotany as fossil fuels.

**Labs:** Identification of Gondwanic and other flora from Pakistan.

**Recommended Books:**
GROUP-III: ECONOMIC GEOLOGY

Objectives:
Advance level courses have been designed in this group of specialization. These courses will enable the students to fully understand (1) the processes of formation of various types of magmatic, hydrothermal, sedimentary, metamorphic and metasomatic ore deposits, (2) the ore reserves calculation and their economic evaluation and extraction, (3) the coalification processes and coal utilization and evaluation, (4) the techniques of mineral exploration, (5) the plate tectonics and its role in the formation of metallic mineral deposits and (6) the identification and evaluation of gems and gemstones. After completing these courses the students will be able to carry out their independent research on the characterization and genesis of various types of mineral deposits and their economic evaluation.

This group comprises the following courses:
1. Ore Deposits
2. Mineral Exploration
3. Coal Geology
4. Mining Geology
5. Metallogeny and Plate Tectonics
6. Fundamental Gemology
7. Descriptive Gemology
8. Mineral Deposits of Pakistan
9. Mineral Economics

1. Ore Deposits (3 credit hours)

Course Contents:
Magmatic deposits: The ultramafic-mafic Cr-Ni-PGE deposits, the mafic-ultramafic Fe-Ni-Cu sulphide deposits, the quartz monzonite-granodiorite, Cu-Mo sulphide deposits and the anorthosite-gabbro Fe-Ti deposits. Porphyry type deposits and ores associated with carbonatites; hydrothermal vein deposits, iron and manganese concentration of sedimentary affiliation; stratiform and stratabound sulphides deposits; ores formed by metamorphic and metasomatic processes; tectonic setting and mineralization.

Labs: Identification of ores in hand specimens. Ore microscopy and case studies.

Recommended Books:
2. **Mineral Exploration** (3 credit hours)

**Course Contents:**

Field exploration techniques; mineral potential of Pakistan; reserve identification and estimation; grade analysis; risk assessment and economic evaluation; geochemical exploration: principles of geochemical dispersion, choice of media for sampling, field methods and sampling theory, analytical methods and quality control, and data interpretation, geochemical and metallogenic provinces; geochemical survey of rock, soil, water and stream sediments for mineral exploration.

Geophysical exploration: principal geophysical techniques, including magnetic, electromagnetic, electrical, radiometric, gravity and seismic methods as applied to mineral exploration.

**Labs:** Case studies and exercises on geochemical and geophysical data interpretation.

**Recommended Books:**

2. Statistics and Data Analysis in Geology, by Davis, J.C., 1986, John Willey and Sons.
3. **Coal Geology**  
(3 credit hours)

**Course Contents:**
Definition, composition; classification and origin of coal; lithotypes and coal minerals; chemical and petrographical analysis; application of coal petrography; depositional environments of coal and coal bearing strata, coalification process, types of coal basins and their tectonic setting, concepts of cyclic deposition in coal basin, origin of splits and partings in coal seams; comparison between modern and ancient coal forming environments; structural problems relevant to exploration and mining; coal utilization and resource evaluation; methods of coal exploration: geological, geophysical and drilling; coal bearing sequences of Pakistan; coal mining and its environmental impacts.

**Labs:** Petrography of coal and associated rocks; preparation of coal pellets, petrographic methods of coal analysis; specified assignments/projects. Reserve estimation and quality assessment exercises based on published data.

**Recommended Books:**
5. Principles and Applications of Coal Petrology SEPM Short Course No.8 by Crelling, J.C. and Dutcher, R.R., 1980, Society of Economic Paleontologists and Mineralogists Indian University at Bloomington.
7. International Handbook of Coal Petrology by International Committee for Coal Petrology, 1985, University of Newcastle Upon Tyne.

4. **Mining Geology**  
(3 credit hours)

**Course Contents:**
Terminology related to mining; mining survey techniques; surface and subsurface mining methods; opening of mines; structural controls in mining; correlation of surface and subsurface data; spatial relationship of seams; surface and underground mapping methods; calculation of ore grade and tonnage; gases
in mines and spontaneous combustion; rock pressure and support; collapses in mines and their safety/remedial measures; mine-refuse disposal management; ore grade control in mining; impact of mining on environment and their remedies and rehabilitation; introduction to mining explosives; coring, core logging and data interpretation; the effects of gasses and radioactive isotopes on miners health. Miner’s diseases, their monitoring and remedial measures.

**Labs:** Bore-hole data interpretation. Ore grade and tonnage/reserve estimation.

**Recommended Books:**
3. Techniques in Mineral Exploration by Reedman, J.H., 1979, ASP.

**5. Metalogeny and Plate Tectonics**

*(3 credit hours)*

**Course Contents:**
Introduction to ore deposits; ore forming processes, plate tectonic, geology and ore deposits; ore deposits models; metal deposits of oceanic–type crust. Intercontinental, intracontinental hotspots and anogenic magmatic metallic deposits; deposits of the early and advanced stage rifting; deposits of forearc, backarc, passive and active margin and other deposits; metal deposits in relation to collisional events; ophiolite deposits; tectonic related mineralization in Pakistan. Metalogenic deposits of Pakistan.

**Labs:** Specified assignments/projects related to metalogenic provinces of Pakistan

**Recommended Books:**

6. **Fundamental Gemology**  
(3 credit hours)

**Course Contents:**

Gems; basic properties, hardness scale, nature of light, laws of reflection and refraction, refractive indices, refractometers. Polarized light and uses of polariscope. Pleochroism, dichroscope, electrical, magnetic and thermal properties of minerals. Specific gravity and methods of determinations.

Colour and causes of colour in gemstones; gemological instrument, special optical properties, chatoyancy, asterism, luminescence play of colors and labradorescence. Inclusions and study of inclusions. Emission and absorption spectroscopy and spectrosopes.

Classification of gemstones, systematic description of crystallography, physical properties, optical properties, absorption spectra, chemical properties, special gemological features, diagnostic features, occurrences of gemstones and gemstones of Pakistan.

**Labs:** Uses of various instrument needed in gemstones identification; identification of rough and cut gemstones by physical and optical properties.

**Recommended Books:**
7. **Descriptive Gemology** (3 credit hours)

**Course Contents:**

Synthetic gemstones; history of synthesis, methods of manufacturing, methods of differentiation between natural and synthetic gemstones; imitation gemstones like glass, plastic etc.

Gemstone treatment and their identifications; methods of gemstone enhancement; doublets, triplets and foil backs and their detections; dyeing and irradiation; heat treatment principles and practice, types of furnaces; various types of diffusion and other types of enhancement, latest development in gemstone enhancement.

Detail study of all gemstone families: Diamond, Corundum, Beryl, Topaz, Tourmaline, Spinel, Quartz and other gems species; study and identification of synthetics and treated gemstones.

Outline of methods used for gem cutting, styles of gem cutting and polishing, principles, philosophy and economics of evaluation; color grading of gemstones; origin of gemstones, world gems deposits and gems deposits of Pakistan; brief introduction to mining methods and processing techniques; brief introduction to advance quantitative and qualitative analytical techniques and equipment.

**Labs:** Identification of natural, synthetic and artificial gemstones.

**Recommended Books:**

8. **Mineral Deposits of Pakistan**  
(3 credit hours)

**Course Contents:**

Introduction to ore forming processes and environments of mineralization; plate tectonics and mineralization; metallogenetic provinces of Pakistan. Metallic mineral deposits (copper, copper-gold-silver, PGE, iron, chromite, bauxite, lead-zinc, antimony, manganese) deposits of Pakistan; fuel minerals (coal, radioactive minerals). Introduction to petroleum and gas deposits of Pakistan; gemstones of Pakistan; mineral specimens and decorative stones of Pakistan; dimension stones of Pakistan. Ceramic minerals (clay minerals, silica sand, K/Na feldspars, nepheline syenite); cement raw materials (limestone, gypsum, laterite etc.); miscellaneous industrial minerals (rock phosphate, barite, asbestos, magnesite, mica, ochre, soapstone, dolomite etc.)

**Labs:** Visits to various mineral deposits.

**Recommended Books:**


9. **Mineral Economics**  
(3 credit hours)

**Course Contents:**

Financial evaluation of ore reserves/ore resources; mineral prospecting and exploration cost; calculation/verification of ore grade and tonnage; capital cost, mine development cost and operartive cost; basis of revenue calculation; taxation system; risk analysis and management; development decisions based on economic evaluation, financial requirements, cash flow and internal rate of return (IRR), payback period; mineral policy; mining rules and regulations; project financing. Minerals world trade/marketing; mineral exchange working; introduction to PC-I AND PC-II (Planning Commission, Govt. of Pakistan).

**Labs:** Exercises to develop economic models for mineral deposit mining and assignments/projects on published data.

**Recommended Books:**

1. International Mineral Economics by Goecht, W., Zant, II and Eggert, R.C., 1988,
GROUP-IV: ENGINEERING GEOLOGY

Objectives:
Advance level courses have been designed in this group of specialization. These courses will enable the students to fully understand (1) the rocks and soils mechanics and their role in construction industry, (2) the earthquake related seismicity and intensity, (3) the geological and geophysical surveys, (4) the infrastructure development and (5) the techniques for evaluation of building materials. After completing these courses the students will be able to carry out their independent research on the site development for construction.

This group comprises the following courses:
1. Rock Mechanics
2. Soil Mechanics
3. Seismotectonics
4. Engineering Geology II

1. Rock Mechanics (3 credit hours)

Course Contents:
Fabric and mechanical nature of rocks; determination of rock quality for engineering purposes; stress strain behaviors of different rocks; rock mass strength theories of failure; types of fracture; rock deformation in compression; factors controlling mechanical behaviors of rocks; excavation methods in rocks; distribution of stresses around underground excavations; use of photo elasticity in rock mechanics. Measurement of stresses in situ; wave propagation in rocks; dynamic models.

Labs: Specified assignments/projects on uniaxial and triaxial strength.

Recommended Books:
2. **Soil Mechanics** (3 credit hours)

**Course Contents:**
Introduction and concept of soil mechanics; soil formation and its classification, survey and sampling with its important engineering properties like soil grading, moisture contents, void ratios, density, permeability, shearing strength, bearing capacity, consolidation and settlements.

**Labs:** Index properties of soil; determination of soil density, permeability, unconfined shearing and compressive strength of soil and Attenberg’s limits.

**Recommended Books:**

3. **Seismotectonics** (3 credit hours)

**Course Contents:**
Introduction to seismology; seismology and interior of earth, progress of seismology; application of seismology; global mosaic of earthquakes, earthquake effects, depth of earthquake, tectonic pattern, types of seismic waves in earthquake shaking; causes of earthquakes, size of an earthquake, stimulation of earthquake by water; seismicity related with different plate boundaries: convergent plate boundaries, divergent plate boundary, transforms plate boundary and intraplate setting.

Seismicity and tectonics: thin-skinned tectonics, thick-skinned tectonics and flake tectonics. Seismotectonics of Himalayas, Hindukush, Zagros, Alps and Cordillera orogenic belts. Seismotectonics of basin and range province of USA.

Damage observations and earthquake intensity; determination of focal depth, location of epicenter, earthquake source mechanism and fault plane solution, seismicity and seismic zoning maps, earthquake prediction and modification, seismic site investigation and surveillance, geodetic evaluation; model test in earthquake engineering; seismotectonics study for engineering structures, nuclear plants, highways, dams, bridges, buildings, waste disposal and slope instability.

**Labs:** Specified assignments/projects on determination of g-values and response spectra.
**Recommended Books:**
15. Physical geology exploring the earth by Wincander, R., 2001, A Division of Thomson Learning Canada.

**4. Engineering Geology II** (3 credit hours)

**Course Contents:**
Rock and soil mechanics and its application in civil engineering; study of geological factors in relation to the construction of buildings and foundations, roads, highways, excavation and tunneling, mine openings, dams and bridges; construction materials; slope stability analysis, hazard assessment, mass movement, their causes and prevention; application of geophysical methods for site investigation; construction in earth-quake zone; dams and their kinds geological investigations for selecting a site for a dam; landslides, classification, geometry, causes and preventive methods; ground water and character of ground water; case histories of important engineering projects (small and mega) in Pakistan.
Labs: Specified assignments/projects.

Recommended Books:

GROUP-V: PETROLEUM GEOSCIENCES

Objectives:
Advance level courses have been designed in this group of specialization. These courses will enable the students to fully understand (1) the formation, migration and accumulation of hydrocarbons, (2) the sequence stratigraphy and importance of trace fossils, (3) techniques of geological, geophysical and geochemical prospecting for hydrocarbons, (4) the hydrocarbon reserves estimation and risk analysis (5) the clay minerals and their role in petroleum industry, (6) the geochemical assessment of source rock for hydrocarbons and (7) the hydrocarbon resources of Pakistan. After completing these courses the students will be able to carry out their independent research on the hydrocarbons characterization, exploration and economic evaluation.

This group comprises the following courses:
1. Sequence Stratigraphy II
2. Petroleum Engineering
3. Reservoir Geology.
5. Petroleum Geology of Pakistan
6. Geological and Geophysical Software applications
7. Logging and log Interpretation
8. Seismic Interpretation
9. Basin Modeling (For course contents, see Group-VIII)

1. Sequence Stratigraphy II (3 credit hours)

Course Contents:
Concepts of sequence stratigraphy; sequence hierarchy and composite sequences; various approaches of sequence stratigraphy, clastic and carbonate sequence stratigraphy; time stratigraphy, genetic sequence stratigraphy, fluvial
sequence stratigraphy, sequence stratigraphy in wireline log and core data sets; application of sequence stratigraphy in tectonically active basins; importance of trace fossils in sequence stratigraphy. Fundamentals of seismic stratigraphy; concepts and models of various depositional systems; seismic reflections in response to strata surfaces and unconformities; seismic sequence analysis; integration of seismic data with geology; seismic facies analysis; reflection character analysis; geologic interpretation and evaluation for reservoirs, source rocks and seals for structural and stratigraphic traps.

**Labs:** Interpretation and seismic reflection patterns. Surface and seismic facies and identification of sequences. Core analysis and wire line logs, key surfaces, their recognition and significance.

**Recommended Books:**
2. Sea-level Changes an Integrated Approach by Wilgus, B.S. and others, SEPM.
10. The Geology of Stratigraphic Sequences by Miall, AD., 1997

### 2. Petroleum Engineering (3 credit hours)

**Course Contents:**
Introduction to rig components, drilling methods and operations; types of bits; drilling fluids, composition and function; cementation and casing operations; coring operations; mud and wireline logging; well testing and completion; well production operations; evaluation and analysis of well data i.e. well cutting, cores, logs and production data; secondary and enhanced oil recovery, common drilling problems and preventive measures, HSE at well site.

**Labs:** Study of mass properties of rocks, wire line logs, cores, well cuttings, DST and MDT pressure data.
**Recommended Books:**

**3. Reservoir Geology**

(3 credit hours)

**Course Contents:**

Petrophysical evaluation; reservoir rock types: elastic, carbonates and non-marine reservoirs. Reservoir properties, depositional and diagenetic controls; fluid properties and their saturation; hydrocarbon distributing and fluid contacts; reservoir zonation and thickness mapping reservoir pore spaces configuration; mapping reservoir heterogeneity; reservoir estimation and calculation of reservoir volumetric, material balance and production, decline curve methods; appraisal and development of reservoir basic concepts.

**Labs:** Porosity and permeability distribution maps, reservoir facies distribution map, isopach maps, isochore maps, log correlation map

**Recommended Books:**
4. Organic Geochemistry (3 credit hours)

Course Contents:
Introduction to organic geochemistry; organic matters, its types and composition; conversion of organic matter to hydrocarbon; composition of biogenic matters; geochemical conditions for the accumulation and formation of hydrocarbons; generation and composition of petroleum hydrocarbons and coal; geochemical assessment of source rocks; geochemical assessment of primary and secondary migration; application of different geochemical prospecting and exploration methods; geochemistry of formation fluids; Fingerprinting / biomarker study / Oil-source / oil-oil correlation

Labs: Determination of TOC, maturity indicators, pyrolysis, van krevelen diagram, GS, GS-MS.

Recommended Books:
5. **Petroleum Geology of Pakistan**  
(3 credit hours)

**Course Contents:**
History of petroleum exploration; new trends for petroleum exploration; tectonic framework; sedimentary basins and their evolution and distribution; tectonics, depositional settings and lithostratigraphic divisions of the rocks of various geological periods; facies development and their association in depositional basins such as Indus, Baluchistan and offshore regions; evaluation of petroleum potentials of different basins; structural styles and petroleum play in the basins of Pakistan; geothermal gradients and their maturity; productive and potential oil and gas reservoirs and source rocks and their distribution in the basins. Play Fairways and Petroleum System in basins; case studies.

**Labs:** Case histories of oil and gas fields of Pakistan.

**Recommended Books:**
8. Selected technical proceedings of PAPG and SPE meetings

6. **Geological and Geophysical Software Applications**  
(3 credit hours)

**Objectives:**
The use of advanced computer software will help the students to keep pace with the increased use of computers in the field of geosciences; It will enhance the capability of the students to visualize the geologic features in DD environments and integration of seismic and geologic data.

**Course Contents:**
Fold and thrust belts and concepts of cross-section balancing. Drawing digital topographic map, extracting profile line from digital topographic date along traverse of known length and geographic location, use of the Digital Elevation Model, transferring contacts from the map to the sections, plotting dip/strike data
on the map and projecting it to the section. Drawing structural geological cross-section, studying cross-section in DD environment. Cross-section Balancing in 2D, converting 2D information into 3D Model, structural contouring of the 3D Model, restoration of Model in 3D, integrating the well data in the 3D Model, integrating the seismic data in 3D model, generating 3D Model from seismic data, plotting geochemical data in 2D and 3D graphs. Data plotting in IUGS Classification diagrams.

**Recommended Books:**
2. Tutorials of MOVE software, version 2013
3. Tutorials of Global Mapper 13
4. Tutorials of Petrel.

7. **Logging and Log Interpretation** (3 credit hours)

**Course Contents:**
Introduction, logging environment (Pressure/ temperature), lithology interpretation from different types of log e.g. gamma ray and spectral gamma ray logs, resistively logs, sonic or acoustic logs, density and photoelectric log, the neutron log, sequences and depositional environments from logs, determination of value of shale and movable hydrocarbons, CBL, FMI caliber log.

**Labs:** Quantitative uses of logs, e.g. porosity/ permeability calculation, hydrocarbons/ water saturation, shale volume calculation.

**Recommended Books:**

8. **Seismic interpretation** (3 credit hours)

**Course Contents:**
Basic Principles of the seismic method and seismic interpretation 2D and 3D seismic reflection data: Introduction, structural and stratigraphic, interpretation, reservoir, identification and evaluation, horizon and formation attributes visualization, exercises in structural and stratigraphic interpretation of 2D and 3D seismic data. Vertical seismic profiling, interactive, interpretation of 2D and 3D seismic on work station.

**Labs:** Interpretation of various seismic sections, use of software to solve these problems.
Recommended Books:

GROUP-VI: APPLIED GEOPHYSICS

Objectives:
Advance level courses have been designed in this group of specialization. These courses will enable the students to fully understand (1) the concepts and models of various depositional systems, (2) the seismic facies analysis, (3) the seismic zonations of Pakistan, (4) the palaeomagnetism and its application, (5) the radiometric dating techniques, (6) the electrical, gravity and magnetic techniques in geophysics. After completing these courses the students will be able to carry out their independent research on the application of geophysical techniques in hydrocarbon exploration.

This group comprises the following courses:
  1. Seismic Stratigraphy
  2. Earthquake Seismology
  3. Geomagnetism and Paleomagnetism
  4. Electrical and Radiometric Exploration Methods
  5. Bore-Hole Geophysics
  6. Seismic Prospecting
  7. Gravity and Magnetic Methods
  8. Rock Physics

1. Seismic Stratigraphy (3 credit hours)

Physical principles and basic theory; seismic waves; types of seismic methods; velocities of seismic waves in rocks and factors influencing these velocities; surveying techniques; seismic energy sources; instruments; data acquisition and processing techniques; interpretation; applications and case histories.

Fundamentals of seismic stratigraphy; concepts and models of various depositional systems; seismic reflections in response to strata surfaces and
unconformities; seismic sequence analysis; integration of seismic data with geology; seismic facies analysis; reflection character analysis; geologic interpretation and evaluation for reservoirs, source rocks and seals for structural and stratigraphic traps.

Labs: Specified assignments on data processing, analysis and interpretation.

Recommended Books:

2. Earthquake Seismology (3 credit hours)

Mathematical analysis of seismological processes on the basis of elastic wave theory; seismic waves and their analysis in earthquake seismology; frequency, magnitude, energy of an earthquake and their relationship; source parameters and their determination; composite fault plane solutions of earthquakes and their determination; geographical distribution of important earthquakes; earthquakes and their relationship to the tectonics of the area.

Labs: Specified problems on data processing, analysis, fault solutions and interpretation.

Recommended Books:
1. The Interior of the Earth, its Structure, Constitution and Evaluation by Bott, M.H.P., 1982, Edward Arnold.
2. Introduction to Seismology by Bath, M. 1979, Birkhauser Verlag, Basal.
3. Geomagnetism and Paleomagnetism  (3 credit hours)

Fundamentals of geomagnetism; magnetic properties of rocks; description of magnetic field of the earth; paleomagnetic sampling; measurement of NRM; magnetic cleaning techniques and field tests of paleomagnetic stability; paleointensity analysis; palaeomagnetism and its applications.

Labs: Specified assignments/projects.

Recommended Books:

4. Electrical and Radiometric Exploration Methods  (3 credit hours)

Fundamentals of current flow in the earth; electrode arrangements and field procedures; instruments; processing and interpretation of resistivity data; field procedure, data acquisition and interpretation of self-potential, induced polarization and electromagnetic methods; study of case histories.

Physical principles and basic theory; radioactivity of rocks; radioactive dating methods; field surveys and instruments; data processing and interpretation; application of radiometric methods in exploration of minerals and energy resources

Labs: Specified problems on data acquisition, processing and interpretation.

Recommended Books:

5. **Borehole Geophysics**

   (3 credit hours)

Introduction; basic theory of geophysical methods; petrophysics and formation evaluation; different types of logging techniques, instrumentation and their field application; log analysis and interpretation; application of borehole geophysics for lithological, environmental, water resources, geotechnical, mineral and hydrocarbon studies. Borehole logging; VSP, Case histories

**Labs:** Specified assignments on data acquisition/processing and interpretation.

**Recommended Books:**

6. **Seismic Prospecting**

   (3 credit hours)

Planning for 2D and 3D seismic surveys and concepts of recording parameters; types of seismic surveys; onshore and offshore seismic surveys; Methodology of seismic data acquisition, seismic equipment, types of seismic energy sources and recording equipment, acquisition methods, quality control of data during acquisition and processing, field processing, Work flow for various basic and advanced processing techniques, seismic mapping and interpretation of 2D and 3D seismic data; well seismic (VSP), Forward seismic Modeling, Ray tracing, synthetic seismograms generation, AVO for lithology and DHI, Applications in Exploration and Production.

**Labs:** Specified assignments/projects.
**Recommended Books:**

**Gravity and Magnetic Methods**

(3 Credit hours)

Physical principles and basic theory; instrumentation; planning of the survey and evaluation of errors; different survey methodologies; rock densities/rock susceptibilities and their measurements Lrostasy; data acquisition, processing; interpretation and mapping to identify gravity/magnetic anomalies; regional fields and residual anomalies, derivatives, continuation of the field, two and three-dimensional modeling; applications in petroleum industry and case histories.

**Labs:** Specified problems on data acquisition; processing and interpretation.

**Recommended Books:**

**8. Rock Physics**

(3 credit hours)

**Course Contents:**

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, porous media, fluid substitution model and rock properties model. In-situ stress measurement, pore pressure, effective
pressure, fluid migration, seismic signature, isotropy and anisotropy, velocity dispersion and attenuation, causes of velocity dispersion and attenuation, fluid distribution patterns into the pores, rock physics as interpretation tool and Empirical relations between different rock physics parameters,

**Labs:** Velocity–density cross–plotting exercise, fluid substitution Modeling, Rock Physics parameter extraction from seismic data, seismic wave propagation modeling, Ray tracing exercise in MATLAB, Synthetic seismogram generation exercises in MATLAB.

**Recommended Books:**

**GROUP-VII: GEOCHEMISTRY**

**Objectives:**
Advance level courses have been designed in this group of specialization. These courses will enable the students to fully understand (1) the basic concepts of thermodynamics, (2) the geochemical techniques applied in mineral exploration, (3) the isotopes and their role in source rock characterization and dating, (4) the elemental distribution in sedimentary rocks, (5) geochemical characteristics of igneous and metamorphic rocks and their petrogenesis. After completing these courses the students will be able to carry out their independent research related to the petrogenetic and paleotectonic history of various types of rocks and geochemical exploration of mineral deposits.

**This group comprises the following courses:**
1. Thermodynamics
2. Geochemical Exploration
3. Stable Isotope Geochemistry
4. Radio Isotope Geochemistry
5. Low Temperature Geochemistry
6. High Temperature Geochemistry
1. Thermodynamics (3 credit hours)

Course Contents:
Introduction and definitions of thermodynamic properties such as system, components, entropy, enthalpy and chemical potential; laws of thermodynamics; Gibbs’s energy and equilibrium; Henry’s law; osmosis and osmotic pressure; ideal and real solutions; solid solutions; the phase rule with examples of different mineral associations; the ionization of weak electrolytes; chemical equilibrium of gas and general solution reactions; calculation of entropy changes in reversible and irreversible process and determination of P-T conditions.

Labs: Exercises on the entropy, enthalpy, chemical potential and laws of thermodynamics.

Recommended Books:
3. Thermodynamics in Geology by Fraser, D.G. 1979, D. Riedel Publishing Company.

2. Geochemical Exploration (3 Credit hours)

Course Contents:
Basic principles for geochemical exploration; geochemical dispersion, geochemical mobility and association of elements; classification of mineral deposits; types of geochemical anomalies in bed-rock, residual and over burden, drainage sediments and natural waters; orientation surveys; role of path finder elements in mineral exploration; geochemical data acquisition methods; decay pattern in stream sediments; statistical interpretation of geochemical data; geochemical methods and selection of sediments in mineral exploration with emphasis on litho stream sediments and soil survey; geochemical evaluation and appraisal of ore deposits, surface geochemical surveys for petroleum explorations.

Labs: Preparation of histogram, frequency diagrams and geochemical maps.
Recommended Books:

3. Stable Isotope Geochemistry (3 credit hours)

Course Contents:
Principles of stable isotopes geochemistry; stable isotopes in the atmosphere and hydrosphere; stable isotope variations in various types of rocks and weathering and diagenetic processes; carbon and sulphur-isotope studies of organic matter; fossil fuels and related materials, applications in burial and tectonic evolution

Labs: Data oriented exercises; Discrimination diagrams and interpretation; mass spectrometry of stable isotopes.

Recommended Books:
4. Radioactive Isotope Geochemistry (3 credit hours)

Course Contents:

Radioactive decay: introduction, decay mechanisms (beta, positron, electron capture, alpha), fission, rates of radioactive decay, half life, decay series and secular equilibrium, applications of natural radioactivity and units of radioactivity; an introduction to isotopic dating methods and radiogenic isotope as tracers of geological processes: introduction, K-Ar, Ar$^{40}$-Ar$^{39}$, Rb-Sr, Sm-Nd, U-Th-Pb (concordia, discordia, zircons, isochrons), extinct radionuclides, fission tracks, cosmogenic nuclides and C$^{14}$ dating, heterogeneity of the earth’s mantle, Nd and Sr isotope compositions of the ocean. Laser probe isotope geochemistry and dating techniques.

Labs: Data oriented exercises; discrimination diagrams and interpretation; mass spectrometry of radioactive nuclides.

Recommended Books:

5. **Low Temperature Geochemistry** (3 credit hours)

**Course Contents:**
Factors affecting element distribution in sedimentary rocks; chemical weathering and rock decomposition; sequence of mineral alteration; various stages of weathering; differential loss of elements during weathering environments/agents of chemical weathering; general nature of weathering reactions such as solution and hydration, weathering of carbonates; oxidation, hydrolysis of silicates; the system CaCo3-CaMgCo3 (sediments and diagenesis; evaporites and their formation; oxidation and reduction in sedimentation of iron, manganese and sulphur; other oxidation and reduction processes; organic material in sediments such as carbon and its compounds, organic matter in black shales; carbon compounds as reducing agents.

**Labs:** Calculation of gains and losses during weathering. Characterization of sedimentary rocks on the basis of their chemistry; the use of geochemical data on sedimentary rocks as a guide to source rock composition, weathering condition and environment of deposition.

**Recommended Books:**
7. Geochemistry of hydrothermal ore deposits by Barnes, H.L.,1979, John Wileyand Sons.
6. **High Temperature Geochemistry** (3 credit hours)

**Course Contents:**
Geochemical characteristics of igneous rocks as petrogenetic indicator; binary variation diagrams and fractionation indices, triangular variation diagrams; geochemical characteristics of primary magmas; processes which modify the composition of primary magmas; convection and mixing in magma chambers, fractional crystallization, crystal contamination, zone refining, liquid immiscibility, gaseous transfer processes; geochemical characteristics of different magma series.

Distribution of elements in metamorphic rocks; behavior of trace elements during the metamorphism of pelitic rocks; geochemistry of granulite facies rocks and problems of their origin; graphical presentation of metamorphic mineral paragenesis (ACF and AKF diagrams). Metasomatism, its types and transfer of material.

**Labs:** Characterization of igneous rocks on the basis of their model and chemical composition. Calculation of normative composition from the major element chemistry of igneous rocks. The use of major and trace element composition of igneous rocks as a means to determine their palaeotectonic setting. The use of mineral chemical data for estimating pressure temperature conditions of metamorphism (data oriented exercises).

**Recommended Books:**
GROUP-VIII:  SEDIMENTOLOGY

Objectives:

Advance level courses have been designed in this group of specialization. These courses will enable the students to fully understand (1) the sedimentary processes, structures and textures, classifications, compositions of carbonates, arenaceous, argillaceous and rudaceous rocks, (2) Diagenetic processes and their effects on physio-chemical properties of rocks. (3) the sedimentary basin development in relation to plate tectonics (geosynclines to tectonic basins), (4) the sedimentary basins and quaternary deposits of Pakistan and (5) the quaternary geology and related nano-tectonics and after completing these courses the students will be able to carry out their independent research related to the texture, composition and diagenesis of various types of sedimentary rocks.

This group comprises the following courses:

1. Clastic Sedimentology
2. Carbonate Sedimentology
3. Basin Modeling
4. Quaternary Geology
5. Clay Mineralogy

1. Clastic Sedimentology  (3 credit hours)

Course Contents:


 Labs: Petrographic study of clastic rocks and heavy mineral analysis; recording, plotting and interpretation of data for paleocurrent analysis, Rose Diagram; field techniques for study of clastic sedimentary rocks.

Recommended Books:


2. **Carbonate Sedimentology**  
   (3 credit hours)

**Course Contents:**

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 microfacies and microfacies types of Wilson; major controls on carbonate sedimentation; depositional processes and facies in carbonate rocks; carbonate depositional models, platforms, rimmed shelves, ramps, epicontinental platforms and isolated platforms; cyclic in carbonates; modern carbonate environments of Bahamas, Florida and Persion Gulf; carbonate depositional systems; lacustrine, shore line, peritidal reefs, shallow and deep water; diagenetic processes and sequences and models.

**Labs:** Identification of carbonate sediments in hand specimen and thin sections; staining; microfacies interpretations and XRD techniques.
Recommended Books:

3. Basin Modeling (3 credit hours)

Course Contents:
Sedimentary Basins and its classification, mechanism for formation of sedimentary basins, types of basins i.e. divergent and convergent plate margin basins; foreland, forearc and backarc basins; transform margins; rift and pull apart basins; basins associated with sutures; cratonic basins and others; sedimentation and plate tectonics, clastic and nonclastic petrofacies; factors controlling basin stratigraphy and tectonic mechanism. Eustatic and relative sea level changes; causes and response; tectonic vs. eustatic controls; sedimentary basins of Pakistan. Concept of 1D, 2D, 3D and 4D basin modeling for petroleum exploration; burial history curve, geothermal gradient, heat flow, maturity levels of source rocks; expansion and migration into traps.

Labs: Stratigraphy columns and their correlation; textural data interpretation; paleocurrent data interpretation; basin mapping methods; clastic petrofacies analysis; interpretation of depositional basins and source area.

Recommended Books:
5. **Quaternary Geology**  

(3 credit hours)

**Course Contents:**

The Quaternary period: Character, duration, development and climatic changes; soil characteristics; soil stratigraphy; morphological evidence and landforms; Quaternary environments; Pleistocene glaciations and sea level changes; lithological evidence of environments; types of sediments; isotopes in deep-sea sediments; biological evidence; plant fossils and animal remains; dating methods; Quaternary stratigraphy and correlation; Quaternary geology, geochronology and neotectonics; Quaternary deposits of Pakistan and its importance (alluvial, fluvial, colluvial, lacustrine, glacial and eoline deposits)

**Labs:** Sampling techniques; assignments on specified topics/field visits to study Quaternary geology.

**Recommended Books:**

2. Quaternary Geology and Environment by Jean, A.M. 2002, Publisher Springer.
10. Late Quaternary Geology of India and See level changes by Noraxema, A.C., 2002, Geological Society of Indian.

6. **Clay Mineralogy**

**Course Contents:**

Introduction, structure and classification of clay minerals; introduction to analytical methods for clay separation and their identification; origin and diagenesis; clay minerals during diagenesis and low grade metamorphism; paleothermometry; geological significance in petroleum industry; depositional environments; clay minerals and sedimentation; significance of clay minerals in soils, drilling fluid and reservoirs; industrial applications. Economic clay deposits of Pakistan

**Labs:** Sample preparation for analysis; identification of clay minerals; data oriented exercises.
Recommended Books:

GROUP-IX: HYDROGEOLOGY

Objectives:
Advance level courses have been designed in this group of specialization. These courses will enable the students to fully understand (1) the ground water modeling techniques and management, (2) the techniques for ground water exploration, (3) the ground water engineering and (4) the ground water chemistry and contamination. After completing these courses the students will be able to carry out their independent research related to ground water modeling, aquifer identification and contamination of ground water.

This group comprises the following courses:
1. Hydrology
2. Groundwater Investigations
3. Groundwater Engineering
4. Hydrochemistry and groundwater pollution

1. Hydrology (3 credit hours)

Course Contents:
Hydrological cycle; surface and groundwater occurrences; recharge and discharge, catchment area and its distribution, surface water flow, Darcy law, hydraulic conductivity, groundwater flow, effect of geology in groundwater flow, water storage types of aquifer, methods of estimating recharge and discharge; physical and mathematical description of groundwater problems; flow nets, tube wells, drains and ditches; consideration of time-variant flow and steady-state flow; field and laboratory measurements of hydraulic properties of different geological materials; groundwater modeling techniques and resource management; soil water balance and water budget estimate of aquifers.

Labs: Measurement of hydrogeologic properties of water-bearing formations; practical applications of mathematical ground water model.
Recommended Books:
5. Physical and Chemical Hydrogeology by Domenico and Schwartz, 1996, John Willey and Sons.

2. Groundwater Investigation (3 credit hours)

Course Contents:
Groundwater exploration techniques, geological and hydrogeological maps, aerial photographs and satellite imageries; use of various geophysical methods in groundwater exploration; the application of surface geophysical surveying to groundwater problems including identification of aquifer geometry, aquifer properties and water quality; principles and application in hydrogeology of well logging techniques.

Labs: Field survey and interpretation of available data.

Books Recommended:

3. Groundwater Engineering (3 credit hours)

Course Contents:
Groundwater problems in site selection and construction of dams and other huge structures; geotechnical logging and grouting techniques; groundwater table and its flow into excavations; the principles and applications of dewatering; the effect of groundwater on soil and rock strength; deep aquifers testing and groundwater flow analysis into underground workings; hydrogeology of mining areas; the analysis of ground subsidence related to groundwater obstruction. Groundwater engineering hazards and its remedial measures
Labs: Case studies related to dam site and tunnels.

**Recommended Books:**

**Hydrochemistry and Groundwater Pollution**

(3 credit hours)

**Course Contents:**
Properties and constituents of water; laws of chemistry related to water and its reaction with the aquifer matrix; principles and processes controlling composition of natural water; water-quality standards (EPA), methods of water sampling and analysis; presentation, evaluation and interpretation of water analysis data (piper and trilinear diagram, stiff pattern); sources, nature and effects of groundwater contamination; mass transport of solutes and chemical processes occurring in aquifers; septic tanks and cesspools, landfills, chemical spills and leaking underground tanks, nuclear waste, groundwater contaminations prevention and remedies; monitoring wells, water treatment and techniques for the removal of physical biological and chemical contaminants; saline intrusions in coastal and estuarine sediments.

Labs: Groundwater sampling for chemical analysis; graphic presentation of chemical analysis data; preparation of subsurface hydrochemical maps; identification of the source and extent of contamination.

**Recommended Books:**

**GROUP-X: INDUSTRIAL MINERALOGY**

**Objectives:**
Advance level courses have been designed in this group of specialization. These courses will enable the students to fully understand (1) the physical and chemical properties of industrial rocks and minerals, (2) the kinematics of the mineral formation, (3) the beneficiation processes of various industrial minerals and rocks, (4) the behavior of material under specific conditions and (5) the instrumental techniques for industrial mineral identification. After completing...
these courses the students will be able to carry out their independent research on the technological development and value addition of industrial minerals.

This group comprises the following courses:
1. Industrial Mineralogy-I
2. Industrial Mineralogy-II
3. Instrumental Techniques
4. Clay mineralogy (For course contents, see Group-VIII)
5. Mineral Economics (For course contents, see Group-III)
6. Mineral Deposits of Pakistan (For course contents, see Group-III)

1. Industrial Mineralogy I (3 credit hours)

Course Contents:
Physical and chemical properties of minerals; relationship between the structure, chemistry and properties of carbonates, sulphates, silica minerals, feldspars, clay minerals, nepheline, serpentine, amphiboles, micas, olivine and phosphates. Mechanisms of mineral nucleation and crystal growth; importance of kinetism in mineral formation.

Interpretation of mineral analysis, recalculation of a mineral analysis in terms of fixed number of anions and where appropriate cations; plotting a phase diagram from experimental data; interpretation of phase diagrams including the SiO2-SiO2, Al2O3-SiO2-Al2O3-K2O-SiO2, CaO-MgO-SiO2, Al2O3-CaO; drawing of isothermal sections through ternary phase diagram and their relevance; plotting data on triangular diagrams; measurement of mineral triple junction angles, description of grain boundaries and their implication for the development of rock textures; use of a variety of computer programs, including spreadsheets, calculate mineralogical parameters; triangular and X-Y plots; relating mineralogical information to the assessment and performance of industrial rocks and minerals.

Labs: Microscopic identification of common rock forming minerals in thin section, using transmitted and reflected light microscopy; identification of common ceramic, refractory and slag minerals in thin section

Recommended Books:
2. **Industrial Mineralogy-II** (3 credit hours)

**Course Contents:**
The geological setting, mineralogy, physical and chemical properties, beneficiation, search methods and uses of the following: sands and gravels, hard rock aggregates, dimension stone, slate, limestone and dolomite, magnesite, clays (common clay/shale, kaolin, bentonite, and fuller's earth), silica sand, dunite and serpentine, feldspars, nepheline syenite; natural abrasive raw materials, gypsum, anhydrite, chromite, barite and gemstones including diamond; mineralogy and chemistry of raw materials for cement, glass, agriculture, chemical and refractories; industrial minerals and their environmental impacts; risk assessment and economic evaluation. Economic potential of industrial minerals in Pakistan.

**Labs:** Interpretation of geological maps in terms of their industrial rock and mineral potential; use of resource map of various types to suggest potential areas of worth, reserve estimation; risk analysis (exercises based on supplied data).

**Recommended Books:**

3. Instrumental Techniques (3 credit hours)

Course Contents:
Theory of x-ray diffraction (XRD) for mineral identification; x-ray fluorescence (XRF), atomic absorption, neutron activation and mass spectrometer techniques for elemental analysis; methods of sample preparation; software programme; calibration curve for quantitative analysis and identification of minerals by XRD and JCPDS card files; theory and practical aspects of DTA (differential thermal analysis) and TG (thermogravimetric) analyzer.

Physical properties: Particle size measurements, sieving, sedimentation, density/SG, automated methods (coulter counter); surface area measurements; gas absorption, BET equation, permeability; color specifications; CIE system and their importance to industry.

Labs: Determination of liquid and plastic limit of clays; froth floatation and scrubbing of sands; separation of clays by hydrocyclone; viscosity measurement by Bookfield viscometer.

Recommended Books:
6. Laboratory Handbook of Petrographic Techniques by Hutchison, C.S., 1974, John Willey and Sons.

GROUP-XI: MARINE GEOLOGY (3 credit hours)

Objectives:
Advance level courses have been designed in this group of specialization. These courses will enable the students to fully understand (1) the classification of marine environment, (2) what dynamic processes shape the surface of the earth under the ocean surface. (2) the sea level changes through time and
sedimentation processes, (3) the coastal landforms and delta development, (4) the physiographic features and management of offshore environment of Arabian sea, (5) the role of geology in evolution of coastal zones and morphodynamics. After completing these courses the students will be able to carry out their independent research in the field of oceanography.

This group comprises the following courses:

1. Marine Geology
2. Oceanography
3. Marine Geochemistry
4. Geology of Arabian Sea

1. **Marine Geology**

   **Course Contents:**
   Development of marine geology, contribution of deep sea drilling project (DSDP) and ocean drilling program (ODP); hypsometry, topographic features of the ocean; plate tectonics and sea floor spreading, major ocean basins, gulls and seas; geology of continental margins, estuaries, deltas, barrier islands and coral reefs; sediment types and distributions, shelf sedimentation, oxygen and strontium isotope, deep sea sedimentation; methods and instrumentation in marine geology; worldwide sea level changes through time. Introduction to marine geology of Pakistan.

   **Labs:** Exercises of marine charts, navigation and bathymetry, acoustic seismic profiling, geography of the marine environments, sea floor spreading and plate tectonics and marine sediments.

   **Recommended Books:**
2. **Oceanography** *(3 credit hours)*

**Course Contents:**
Chemical and physical nature of seawater; temperature, salinity and density of sea water; oceanic heat budget; mixing processes in the oceans; light and sound in the ocean; gases in seawater; oceanic circulation: surface circulation and thermohaline circulation, ENSO and Indian monsoon; coastal and ocean upwelling, upwelling zones and ocean sedimentary record; ocean waves and tides; sea level changes, coastal oceanography: shorelines and estuaries, continental shelf and its water; sources of marine energy: waves, tides, current and OTEC. Oceanographic tools and technology; the law of the sea.

**Labs:** Solar radiation and heat balance, seawater temperature and salinity, water masses and temperature–salinity diagrams, surface currents, tides, waves, shallow water waves and coastal processes.

**Recommended Books:**

3. **Marine Geochemistry** *(3 credit hours)*

**Course Contents:**
The geochemical cycle and the composition of ocean water; the transport of material to ocean, nutrients, organic carbon and carbon cycle in seawater; trace elements in the ocean, residence time and reactivity of elements; the composition of oceanic suspended matter; the geochemistry of marine sediments, sediment interstitial waters and diagenesis; organic matter production, accumulation and preservation; marine carbonates; isotopes in marine geochemistry; chemical characteristics of hydrothermal vent fluids;
geochemistry of ferromanganese deposits in the ocean; geochemical proxies and global environmental history; pollution in the sea; geochemical models.

**Labs:** Exercises dealing with determination of salinity, residence time and reactivity of major elements, calculation of chemical fluxes, paleoproductivity, interpretation of geochemical proxies; geochemical analysis of marine sediments

**Recommended Books:**

**4. Geology of Arabian Sea** (3 credit hours)

**Course Contents:**
Geological evolution of Arabian Sea; geology of the coastal regions of Arabian Sea; physiographic and structural features of Arabian Sea; geodynamics and sedimentation of Makran and Indus continental margins; geology of the Indus delta and Indus fan systems; geology of DSDP and ODP-well sites from Arabian Sea; seismic stratigraphy of the northern Arabian Sea; mineralogy and geochemistry of Arabian Sea sediments; Sea level changes, oxygen minimum zone variations and its influence on Arabian Sea sediments; sedimentary record of climatic variations and Himalayan orogeny; offshore hydrocarbon and mineral resource prospects. Case study of drilled wells.

**Labs:** Selected exercises based on National and International Geological Research Cruises data of Arabian Sea.
**Recommended Books:**

**GROUP-XII: ENVIRONMENTAL GEOSCIENCES**

**Objectives:**
Advance level courses have been designed in this group of specialization. These courses will enable the students to fully understand (1) the geological hazards and their management, (2) global warming, (3) the soil and water chemistry, (4) the anthropogenic and geologic sources of contamination, (5) the environmental impact assessment and management. After completing these courses the students will be able to carry out their independent research related to the degradation of ecosystem through natural and industrial pollution.

**This group comprises the following courses:**
1. Environmental Geology II
2. Soil and Water Resources
3. Environmental Hazards
4. Hydrological Systems and Environments
5. Environmental Impact Assessment and Management
6. Natural Resource Management
7. Occupational Health and Safety

1. **Environmental Geology II**
   
   **(3 credit hours)**

   **Course Contents:**
   Environmental management (effective management for exploitation of geology resources with the impact that this may cause on environment; appropriate waste disposal strategies to minimize the problems of contamination and pollution); recognition of natural hazards and identifying their causes and providing their mitigation; environmental controls for erosion, desertification coastal degradation; environmental impact of mining, dams, reservoir, highways their assessment and control; understanding the geological environments in major construction and engineering projects; national environmental quality standards (NEQS); initial
environmental examination (IEE) and environmental impact assessment (EIA); international convention and protocols for environmental protection; Environmental Protection Agency (EPA); Case Studies

Labs: Case studies based on EIA reports.

Recommended Books:
4. LAL’S commentary on Water and Air Pollution with environment, Revised by Mc Mehta, 4th edition, Vol 1and2, 2007 Delhi Law house Delhi , India

2. **Soil and Water Resources** (3 credit hours)

Course Contents:
Soil and its classification; types; soil erosion, landform and land use; predicting and controlling soil erosion; soluble salts in soils; aerosol particulate matter; hydrological system and agriculture; source of water resource and its types; natural water resources and policy making; hydrological cycle; frozen water reserves; global warming and surface water resources; surface water storage and ecological system; ground water movement; water logging and salinity.

Labs: Case studies based on Soil and water analysis.

Recommended Books:

3. **Environmental Hazards** (3 credit hours)

Course Contents:
Information on river flooding and flood control; effects on agro-economy, slope stability in hilly areas; types of landslides; their causes and remedial measures; methods of analysis of slopes; landslide inventory mapping, information on landslides and their effects on socio-economic conditions; study of case
histories in Pakistan and abroad; snow avalanches; subsidence mechanism and related problems; earthquake and tsunami hazards; hazardous minerals in mining; solid and liquid waste management; safety and health standards; legislations; regulations and controls; effect on global environment; Hazards of nuclear waste assessment and its remedies

Labs: Case studies based on slope stability and mining activities.

Recommended Books:

4. Hydrological Systems and Environments (3 credit hours)

Course Contents:
Surface and groundwater resources, precipitation, evaporation, erosion and silting in catchment areas and reservoirs (dams); surface and groundwater contamination and their sources; effect of mineralogy, mining activities, industrial effluents; heavy metal concentration; contamination due to chemicals and sewage systems; decomposable organic matter and pollutant agents (industrial and agricultural fertilizers etc.); dissolved gases, minerals and suspended impurities in surface and groundwater; biological contamination (viral, bacterial, protozoa and helminthes).

Labs: Case studies based on EIA reports and visits to the industrial sites.

Recommended Books:

5. Environmental Impact Assessment and Management (3 credit hours)

Course Contents:
Reclamation of agricultural land, landfill and land use, socio-economic uplift, underground drainage system, installation of tube wells and canal lining, vegetation, rock bolting, grouting; identification of environmental hazards and evaluation of risks, slope and flood control instrumentation gauges, extensometers and tilt meters etc. disposal of industrial and radioactive wastes; environmental impact assessment with special reference to Pakistan; effect of earthquakes on environment and its assessment and management.

Labs: Case studies based on Environmental Impact Assessment with special reference to Pakistan.
Recommended Books:
1. Solid Waste Management by Grever, V., 2000, Oxford and IBH (Ltd.).

6. Natural Resource Management (3 credit hours)

Course Contents:
Introduction to natural resources and their sustainable management; requirements of a management plan; forest types and methodologies of watershed management; existing status of rangeland management; existing situation of wildlife at national level; wildlife census; threats faced by wildlife; available water resources and threats; effective management plan; fisheries management, existing situation of agricultural sector; agricultural products and their share in GDP; problems faced by agricultural sector; agricultural policy and management options.

Labs: Case histories and case studies of natural parks of Pakistan; visit to natural parks, identification of park problems, managing and sustaining natural parks, establishing, designing, and managing natural reserves, ecological restoration.

Recommended Books:
1. Principle of Environmental Science (Inquiry and Applications) by William P. Cunningham and Mary Ann Cunningham.

7. Occupational Health and Safety (3 credit hours)

Course Contents:
Introduction, concepts, importance and principles of occupational health and safety; cost of accidents; hazards and risk at work place; plants and mines safety and safe work practices; fire fighting techniques; emergency response protocols; spill response protocols; risk assessment approaches; occupational health and safety management system 18001; occupational health and safety in Pakistan; labor code of Pakistan.
Labs: Visits to various industries for hazard identification, evaluation, assessment and mitigation in order to reduce the damage; internship in various industries for learning practical approach of occupational health and safety.

Recommended Books:

GROUP- XIII: STRUCTURE, TECTONICS AND NEOTECTONICS

Objectives:
Advance level courses have been designed in this group of specialization. These courses will enable the students to fully understand (1) the deformational structures and their kinematics in the crust, (2) the fabric development in metamorphic rocks, (3) the projections and structural analysis, (4) the cross-sectional balancing, (5) the Himalayan orogeny, (6) the tectonic zonation of Pakistan and (7) the neotectonics behavior of various structural features. After completing these courses the students will be able to carry out their independent research in the field of structural geology and tectonics.

This group comprises the following courses:
1. Structural Geology II
2. Metamorphic Structures
3. Applied Structural Techniques
4. Tectonics of Pakistan
5. Neotectonics
6. Seismotectonics (For course contents, see Group-IV)
7. Quaternary Geology (For course contents, see Group-VIII)
8. Earthquake Seismology (For course contents, see Group-VI)
9. Geological and Geophysical software applications (For course contents, see Group-V)

1. Structural Geology II (3 credit hours)

Course Contents:
Stress and strain; planar and linear fabrics: analyses of fabrics, axial plane foliations/cleavages and their types and origin, transposed foliations, lineation types and origin; fabrics as kinematics indicators; structures in folded rocks: fold morphology and classifications, mechanisms of folding, strain and small scale structures in folds, superposed folding; fault geometry and morphology: classification of fault systems, geometry of 1) extensional, 2) strike slip and 3) thrust fault systems; fractures and joints: mechanical analyses of fractures;
ductile and brittle shear zones; sense of shear indicators, strain markers, strain measurement methods, geometric and genetic classification of joints, analyses of joints in uniformly dipping strata and in folded rocks; tectonites; structural techniques and retrodeform sections.

**Labs:** Structural map exercises; balanced cross-sections; fault plane solutions; stereographic exercises; structural software exercises.

**Recommended Books:**
8. Appropriate Structural Computer Software.

2. **Metamorphic Structures** *(3 credit hours)*

**Course Contents:**
Microstructures in deformed and metamorphosed rocks; crystal defects, crystal plasticity, dislocations; annealing recrystallization, recovery, primary and secondary recrystallization, dynamic recrystallization, stress induced recrystallization, strain induced recrystallization and associated microstructures; driving forces for dynamic recrystallization; dynamic recrystallization by subgrain rotation and grain boundary migration; controls on migration rates. Ductile shear zones; mylonites, terminology; microstructures, planar and linear ductile fabric and kinematic indicators; petrofabrics: factors controlling fabric development, fabric representation-pole and inverse pole figures, orientation distribution functions; measuring techniques, pressure solution and metamorphic differentiation; cataclastic deformation; sense of shear indicators; strain markers; strain analysis.

**Labs:** Microscopic studies of metamorphic textures and structures.

**Recommended Books:**

3. **Applied Structural Techniques** (3 credit hours)

**Course Contents:**

Structural techniques: measurement of attitude and location, contour maps, attitude and dimension calculations, stereographic projections, stereographic poles and rotations; calculation of layer attitudes in drill holes, equal area projections and structural analyses; practical strain measurements of 1) initially circular and elliptical markers, 2) lines and 3) angles, methods and representation of strain state; progressive displacement and progressive deformation, interpretation of geological maps; analyses of fracture array geometry; constructing profiles and block diagrams; balanced cross section techniques; Kinematic analysis and indicators.

**Labs:** Exercises based on course contents.

**Recommended Books:**


4. **Tectonics of Pakistan** (3 credit hours)

**Course Contents:**

Concept of Rodania, Pangea and Gondwana supercontinents; Permian separation of Afghan, Pamirs, Karakoram, Lahasa microcontinents, closure of Palaeotethys and accretion tectonics at Eurasia’s southern margin; early cretaceous split and northward flight of India, closure of northern Neotethys and collision tectonics of the Shyok Suture; Himalayan orogeny; constraints on the timing of India-Eurasia collision; resultant physiography, structures, metamorphism, climatic changes; tectonic zonation of Pakistan: each zone to be studied in terms of its geomorphology, tectonics, stratigraphy, metamorphism,
magmatism and mineral deposits. Karakoram plate; Kohistan-Ladakh Island Arc Terrane; the Himalayas: internal and external zones; Swat, Besham, Hazara, Kaghan (Nanaga Parbat) blocks; the Hill ranges (Samana, Kalachitta, Margala, Galiats). Kohat-Potwar plateaus and the Salt Ranges; the boundary faults and related tectonics: MMT, MCT, PANJAL THRUST, MBT, MFT. Afghan-India collision zone: Indus, Kurram-Waziristan- Muslim Bagh-Bela Ophiolite/Melange belt. Sulaiman-Kirthar thrust-fold belt; Katawaz basin; Makran accretionary prism; Raskoh-Chagai Arc Terrane. Indus platform and foredeep; offshore Pakistan: the Indus delta. Syntaxes and orocline of Pakistan; Precambrian to Recent tectonics of Pakistan; Tertiary Himalayan urogeny and Late Proterozoic to early Cambrian Hazaran orogeny. Makran Subduction, Arabian Sea tectonics, tectonics of passive margin of Indian plate

Field Visits: The field work in tectonic zones of Pakistan.

Recommended Books:
5. Neotectonics (3 credit hours)

Course Contents:
Active tectonics and neotectonics: definitions, active faults and criteria for identifying active faulting; direct measurements of tectonic movements; direct measurement with geodetic networks; triangulation of sites with reference to satellites; global positioning systems; geology and earthquakes; earthquake seismology; paleoseismology; trenching and seismic trenching; Quaternary dating methods; tectonic geomorphology; offset geological-geomorphological features (paleoseismic indicators, changes in elevations of coast lines, stream offsets, slope retreat, terraces, incised meander); fault scarp morphology; neotectonics behavior of faults and folds; hazards of active tectonics: earthquakes and mass movements; remote sensing and satellite imageries applications in neotectonics and related hazards; active tectonics and nuclear waste disposal; neotectonics of Pakistan and Himalayas.

Recommended Books:
GROUP-XIV     COAL GEOLOGY

Objectives:
Pakistan is rich in coal resources but country is severally effected by energy crises. Keeping in view country’s energy crises, a course on coal geology is introduced.

This group comprises the following courses:
1. Metalogeny and Plate Tectonics
2. Exploration and Exploitation of Coal
3. Coal, Environment and Clean Coal Technology
4. Coal Geology (For course contents, see Group-III)
5. Mining Geology (For course contents, see Group-III)

1. Metalogeny and Plate Tectonics  (3 credit hours)

Course Contents:
Introduction to ore deposits; ore forming processes, plate tectonic, geology and ore deposits; ore deposits models; metal deposits of oceanic–type crust; intracontinental hotspots and anorganic magmatism; deposits of the early and advanced stage rifting; deposits of principal arc; deposits of arc related rifts; other arc related deposits; metal deposits in relation to collisional events; tectonic related mineralization in Pakistan.

Labs: Specified assignments/projects related to metalogenic provinces of Pakistan/field visits.

Recommended Books:

2. **Exploration and Exploitation of Coal** (3 credit hours)

**Course Contents:**
Field techniques; outcrop mapping, remote sensing; open pit and underground mining methods; open hole drilling, core drilling, portable drilling, core and open whole logging; in situ and non in situ coal sampling methods and analysis; coal exploitation and data collection; geotechnical properties, coal resources and coal reserves; hydrological characteristics of coal and coal bearing sequences; collection and handling of hydrogeological data; surface and subsurface waters; dewatering of open pit mines; dewatering of underground mines, water quality and groundwater rebound; physical properties of coal bearing sequences, surface geophysical methods: density, seismic velocity, seismic reflection coefficients; electrical methods, seismic survey, gravity, electrical and radiometric methods; types of geophysical borehole logging.

**Labs:** Outcrop mapping, field sampling, observation of drilling techniques; application of geophysical techniques in coalfield; study of geophysical logs.

**Recommended Books:**

3. **Coal, Environment and Clean Coal Technology** (3 credit hours)

**Course Contents:**
Coal mining and contamination of water; spoil dumping; dust suspension and subsidence; coal miners diseases; international and national environmental regulations; clean coal technology: coal as alternate source of energy; gas in coal, coaland methane; underground coal gasification technology; coal liquefaction technology; coal as an oil-prone source rock.

**Labs:** Identification of cleats and pores in coal with Scanning Electronic Microscope (SEM), Identification of minerals with XRD.

**Books Recommended:**
GROUP-XV: GEOTECHNICAL ENGINEERING

Objectives:
Advance level courses have been designed in this group for specialization in geotechnical engineering (geological engineering) with an aim to meet the demands of country in the future. These courses will enable the students to fully understand (1) properties of rocks and soils and their role in construction industry, (2) risk assessment due to earthquake related seismicity and its intensity and (3) earthquake resistant infrastructure development. After completing these courses the students will be able to carry out the independent on site investigations for the construction of huge concrete structures.

This group comprises the following courses:
1. Earthquake Engineering and Risk Assessment
2. Groundwater Systems
3. Excavation and Tunneling
4. Engineering Foundation
5. Dam engineering
6. Rock Mechanics (For course contents, see Group-IV)
7. Soil Mechanics (For course contents, see Group-IV)
8. Engineering Geology II (For course contents, see Group-II)

1. Earthquake Engineering and Risk Assessment
   (3 credit hours)

Course Contents:
Earthquake and its causes with reference to world and Pakistan; distribution and relationship with plate tectonics; mathematical analysis of seismological processes on the basis of elastic wave theory; seismic waves and their analysis in earthquake seismology; frequency, magnitude, energy of an earthquake and their relationship; source parameters and their determination; composite fault plane solutions of earthquakes and their determination; earthquakes and their relationship to the tectonics of the area; application of seismic zones for building code in earthquake prone area; risk analysis, hazards and remedial measures.

Labs: Calculation of g-value, PGA analysis; Specified problems on data processing, analysis, fault solutions and interpretation.
Recommended Books:
2. Introduction to Seismology by Bath, M., 1979, Birkhauser Verlag, Basal.

2. Groundwater Systems

Course Contents:
Hydrological cycle; recharge and discharge, catchment area and its distribution, Darcy law, hydraulic conductivity, groundwater flow, water storage types of aquifer, methods of estimating recharge and discharge; physical and mathematical description of groundwater problems; flow nets, consideration of time-variant flow and steady-and non steady state flow; field and laboratory measurements of hydraulic properties of different geological materials; groundwater modeling techniques and resource management; principles and processes controlling composition of natural water; water-quality standards (EPA); groundwater contaminations prevention and remedies; monitoring wells, water treatment and techniques for the removal of physical, biological and chemical contaminants; saline intrusions in coastal and estuarine sediments.

Labs: Measurement of hydrogeologic properties of water-bearing formations; practical applications of mathematical ground water model; Groundwater sampling for chemical analysis; graphic presentation of chemical analysis data; preparation of subsurface hydrochemical maps; identification of the source and extent of contamination.

Recommended Books:
3. **Excavation and Tunneling**  

**Course Contents:**
Introduction to excavation and tunneling; major tasks of engineering geologists; ground behavior; geotechnical site investigation; exploration during tunnel construction; prediction of rock mass conditions and behavior; theory of rock drilling and rock blasting; mechanical rock excavation methods; sealing/grouting, operation and maintenance of underground constructions; environmental issues of rock engineering; excavations and tunneling under difficult conditions; tunnels and excavation designs; tunneling through TBM, geological problems and remedial. Important case studies in Pakistan and Kashmir.

**Field Visits:** Visits to excavation and tunneling sites in Pakistan and Kashmir.

**Books Recommended:**
4. **Engineering Foundation**

**Course Content:**

Stress distribution in soils, site investigation, planning of boring, boring methods, sampling, in-situ (field) tests, settlement of structures, initial (elastic) settlement, consolidation settlement, allowable settlement, settlements of footings on granular and cohesive soils, bearing capacity of soils, design of shallow foundations, types of shallow foundations, rigid design of shallow foundations on cohesionless and cohesive soils, use of in-situ tests in foundation design, retaining structures, excavations, review of earth pressure theory, earth retaining systems, cantilevers and gravity retaining walls, anchored walls, reinforced earth walls, design of retaining structures, pile foundations, classification of piles, types of piles, bearing capacity of a single pile in cohesionless and cohesive soils, design of pile groups and settlement of pile groups.

**Recommended Books:**


5. **Dam Engineering (3 credit hours)**

**Course Contents:**

History of dam; types of dams by structure, size and use, construction material; construction elements; power generation plant; spillways; dam creation; common purposes; site investigation, location; impact assessment; environmental impact; human social impact; economics; dam failure. Dam design after geological, structural and geotechnical investigation/Common problems and remedial measures in dam engineering. Case studies of known earth fill and concrete dams of Pakistan.

**Field Visits:** Field visits to Dams of Pakistan.

**Recommended Books:**

2. Engineering Soundbite: Ethical Issues from the St. Francis Dam Failure, Paul Guyer, Guyer Partners, 2011
COMP. 401: Computer Applications in Geology  (3 credit hours)

Objectives:
The course is designed to acquire knowledge about the use of computer to carry out various assignments: 1) To learn basics of the operating systems, some of the commonly used software and programs in geology. The statistics applied to geology and geophysics; use of internet, establishing a workplace network, to learn basic computer hardware, preliminary information about the computer encoding systems and various kind of file formats. 2) Learn applied geology, geophysics and structural computer programs.

Course Contents:
Learn basic programs (word, excel, Illustrator, PowerPoint), basic programming and numerical analysis (using MATLAB); basic geographical information systems and visualization; some of the field equipment; basic knowledge related to Computer hardware (CPU, memory, motherboard and bus, power supply, monitor, video card, hard drive, ports (ethernet, parallel, serial, USB), CD, zips, etc. System run programs (drivers, Operating systems like Windows, Unix, Mac and Linux, other software used in industries Geographix, Petrel, Petromod, Kingdom Sweet. Computer encoding (Digital, Analogue), various kinds of scripts like MATLAB, ASCII, EBCDIC, and UNICODE; basics of networking. Use of common geological, structural and geophysical computer programs.

Labs: Basic exercises on geological, structural and geophysical computer programs.

Recommended Books:
2. An Introduction to Computing Infrastructure: Hardware and Operating Systems, John Williams, 1996, Que E and T.
8. Use common geological, geophysical and structural programmes.
Mgt 401: Principles of Management (3 credit hours)

Objectives:
Provides an overview of management history and theory, schools of management thought, the functions and processes of management and the environment within which the modern manager (students) operates.

Course Contents:
This course is designed to develop an understanding of how modern management theory evolved. To analyze and discuss planning, organizing, controlling, decision making, communication, motivation, leadership, human resource development within a group, information, systems, social responsibility and management of the future. To promote group interaction through class discussion and to develop oral and written communication skills, to articulate and defend one's position. The course encompasses all the above into a coherent picture to forecast the future directions, challenges and to understand the ethical issues within the field of management.

Recommended Books:
ELIGIBILITY FOR ADMISSION IN 2-YEAR MS PROGRAMME

Four years education in Geology/Earth Sciences/Relevant Subjects after FSc. with minimum 50% marks will be compulsory for admission in 2-year MS programme.

SCHEME OF STUDIES FOR 2-YEAR MS IN GEOLOGY

Duration: 2-Year (4-Semesters)
Course work: 24 Credit Hours
Thesis: 6 Credit Hours
Reading Conference 1 Credit Hour
Comprehensive Oral Exam/Grand Viva Voce  "S/U Based

1st Semester: 12 Credit Hours course work

2nd Semester: 12 Credit Hours course work

3rd Semester: Research for thesis including field and laboratory work
   1. Reading conferences
   2. Submission of thesis synopsis for approval as per rules of the institutes / university

4th Semester: Data compilation, thesis writing and open public defense.
   Final defense of thesis will be carried until at least one international paper is submitted / published in HEC Recognized Journal

   *S/U based; Satisfactory (S = 50% marks) and unsatisfactory (U less than 50% marks).

LIST OF SUBJECTS

A. The following subjects are suggested for the MS Geology course work.

Geol. 701 Advanced Geochemistry
Geol. 702 Igneous Petrogenesis
Geol. 703 Metamorphic Petrogenesis
Geol. 704 Advanced Mineralogy
Geol. 705 Geothermometry and Geobarometry
Geol. 706 Advanced Stratigraphy
Geol. 707 Micropalaeontology
Geol. 708 Invertebrate Palaeontology
Geol. 709 Vertebrate Palaeontology
Geol. 710 Palynology and Paleobotany
Geol. 711 Mineral Prospecting and Exploration
Geol. 712 Coal Geology
Geol. 713 Metallogeny and Plate Tectonics
Geol. 714 Coal Petrology
Geol. 715 Process Mineralogy
Geol. 716 Mineral Deposit Evaluation and Economics
Geol. 717 Rock Mechanics
Geol. 718 Soil Mechanics
Geol. 719 Seismotectonics
Geol. 720 Engineering Geology
Geol. 721 Petroleum Geology
Geol. 722 Sequence Stratigraphy
Geol. 723 Petroleum Engineering and Geophysical Methods
Geol. 724 Reservoir Geology
Geol. 725 Organic Geochemistry
Geol. 726 Petroleum Geology of Pakistan
Geol. 727 Seismic Methods and Seismic Stratigraphy
Geol. 728 Earthquake Seismology
Geol. 729 Geomagnetism
Geol. 730 Paleomagnetism
Geol. 731 Radiometric Methods
Geol. 732 Electrical Methods
Geol. 733 Bore-hole Geophysics
Geol. 734 Geophysical Data Processing
Geol. 735 Gravity and Magnetic Methods
Geol. 736 Engineering Seismology
Geol. 737 Thermodynamics
Geol. 738 Geochemical Exploration
Geol. 739 Isotope Geochemistry
Geol. 740 High Temperature Geochemistry
Geol. 741 Low Temperature Geochemistry
Geol. 742 Clastic Sedimentology
Geol. 743 Carbonate Sedimentology
Geol. 744 Sedimentary Petrology
Geol. 745 Basin Analysis
Geol. 746 Quaternary Geology
Geol. 747 Clay Mineralogy
Geol. 748 Applied Sedimentology
Geol. 749 Techniques in Sedimentology
Geol. 750 Advanced Hydrology
Geol. 751 Groundwater Investigations
Geol. 752 Groundwater Engineering
Geol. 753 Groundwater Planning and Management
Geol. 754 Hydrochemistry and Groundwater Pollution
Geol. 755 Modeling in Groundwater
Geol. 756 Industrial Mineralogy
Geol. 757 Technology of Industrial Minerals and Rocks
Geol. 758 Mining Geology and Mineral Economics
Geol. 759 Physical and Chemical Oceanography
Geol. 760 Advanced Marine Geology
Geol. 761 Coastal Geomorphology
Geol. 762 Geology of Arabian Sea
Geol. 763 Advanced Environmental Geology
Geol. 764 Soil and Water Resources
Geol. 765 Environmental Hazards
Geol. 766 Hydrological Systems and Environment
Geol. 767 Environmental Impact Assessment and Management
Geol. 768 Plate Tectonics
Geol. 769 Advanced Structural Geology
Geol. 770 Metamorphic Structures
Geol. 771 Applied Structural Techniques
Geol. 772 Tectonics of Pakistan
Geol. 773 Neotectonics
Geol. 774 Gemology
Geol. 775 Advanced Geomorphology
Geol. 776 Glacial Geology
Geol. 777 Remote Sensing
Geol. 778 Geographic Information System
Geol. 779 Mining Geophysics
Geol. 780 Geochronology
Geol. 781 Research Methodology
Geol. 782 Advanced Instrumentation
Geol. 783 Volcanology
Geol. 784 Tectonic Geomorphology
Geol. 785 Active tectonics
Geol. 786 Paleoseismology
Geol. 787 Seismic trenching
Geol. 788 Geobotany
Geol. 789 Applications of Archeology in Active Tectonics
Geol. 790 Quaternary Geochronology
Geol. 791 Soil Stratigraphy
Geol. 792 Geodesy
Geol. 793 Pegmatites and Gem Stones
Geol. 794 Geophysical modeling
Geol. 795 Organic Biomarkers
Geol. 796 Isotope Geology
Geol. 797 Quaternary Environments
Geol. 798 Quaternary Glaciology
Geol. 799 Medical Geology
Geol. 800 Military Geology

Note: The details of course content and assigned credit hours will be decided by the concerned universities/institutes through their concerned forums. The design courses should be advance, literature and research oriented to meet the International Standards according to HEC criteria.
RECOMMENDATIONS

In addition to recommendations made by current committee during its preliminary meeting of December 17-19, 2012 and previous NCRC of 2009, following additional recommendations are made for implementation of these schemes in the country:

1. HEC should facilitate establishing Pakistan Geological Council in line with PEC to register, monitor and regulate the geological profession in the country to enhance the quality of academics and services.

2. The lack of research material of geologic discipline is hampering the research activities due to costly research literature including journals/material/software available through internet facility. The HEC funded geoscience lab and research centers should be established in north and south regions to promote geoscience research activities in the country. A centralized geoscientific database should be established not only to integrate geologic knowledge but also to attract foreign investment in the country. Students and academics from respective region will utilize this facility for their projects.

3. Labs should be equipped to meet the need of postgraduate for their research projects. In addition, field equipments must be provided for field survey.

4. Field Vehicles and sufficient funds must be provided to implement the field programs.

5. Comprehensive oral exam/grand viva voce should be made mandatory for completion of degree programs.

6. Internship for 4-year BS must be made ensured with cooperation and financial support of HEC through various ministries in their relevant departments/organizations.

7. Financial support should be provided to final year students for their field projects on the recommendation of academic institutions. All public and private institutions are ensured to arrange funds for field work and quality research in the country.

8. In addition to regular fieldworks, Summer Field Camp should be organized by HEC under the supervision of professional field geologists from the academia.
9. To enhance quality applied research for the development of industry in the country, a close linkage should be established between academia and both national and international companies and institutions. In this regard, the HEC should facilitate the establishment of a Liaison office to coordinate between academia and industry.

10. The BS 4year professional degree in geology is a professional degree and must be treated at par with other professional degrees.

11. The HEC should provide at least two scholarships to each public university to fund thesis/dissertation to outstanding students recommended by the department.

12. Considering severe energy crises (Oil, Gas and Coal) in the country, the HEC should facilitate for Creating Energy Research Fund (ERF) through petroleum industry to address energy crises in the country. Furthermore, HEC should encourage industries to establish “Chairs” in public and private universities to coordinate between industry and academia.
Eng. 301: English I (Functional English) (3 credits)

Objectives:
Enhance language skills and develop critical thinking.

Course Contents:

Basics of Grammar
Parts of speech and use of articles
Sentence structure, active and passive voice
Practice in unified sentence
Analysis of phrase, clause and sentence structure
Transitive and intransitive verbs
Punctuation and spelling

Comprehension
Answers to questions on a given text

Discussion
General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

Listening
To be improved by showing documentaries/films carefully selected by subject teachers

Translation Skills
Urdu to English

Paragraph Writing
Topics to be chosen at the discretion of the teacher

Presentation Skills
Introduction

Note: Extensive reading is required for vocabulary building.
Recommended Books:

1. **Functional English**
   a) Grammar

   b) Writing

   c) Reading/Comprehension

   d) Speaking

**Eng. 302: Communication Skills (English II) (3 credits)**

**Objectives:**

Enable the students to meet their real life communication needs.

**Course Contents:**

- **Paragraph Writing**
  Practice in writing a good, unified and coherent paragraph

- **Essay Writing**
  Introduction

- **CV and Job Application**
  Translation skills
  Urdu to English

- **Study Skills**
  Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension

- **Academic Skills**
  Letter/memo writing, minutes of meetings, use of library and internet
Presentation Skills
Personality development, emphasis on content, style and pronunciation

Analytical Skills and Professional Ethics

Note: Documentaries to be shown for discussion and review.

Recommended Books:

Communication Skills

a) Grammar

b) Writing

c) Reading
2. Reading and Study Skills by John Langan
3. Study Skills by Riachard Yorky.

Eng 401: English III (Technical Report Writing) (3 credits)

Objectives:

Enhance language skills and develop critical thinking, follow the USGS guidelines for professional writing skills.

Course Contents:

Essay Writing
Descriptive, narrative, discursive, argumentative

Academic Writing
How to write a proposal for research paper/term paper
How to write a research geological research report/professional paper/term
paper (emphasis on style, content, language, form, clarity, consistency, geological contents)

Technical Report Writing

Progress Report Writing

Note: Extensive reading is required for vocabulary building.

Presentation Skills

Recommended Books:

Technical Writing and Presentation Skills (USGS guidelines for professional geowriting)

a) Essay Writing and Academic Writing
      (particularly suitable for discursive, descriptive, argumentative and report writing).


b) Presentation Skills

c) Reading
   Cain; Stephen Ruffus and Maurice Scharton. (A reader which will give students exposure to the best of twentieth century literature,
   without taxing the taste of engineering students).
Pakistan Studies (Compulsory) (2 credits)

Objectives:

- Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
- Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

Course Outline:

1. Historical Perspective
   b. Factors leading to Muslim separatism
   c. People and Land
      i. Indus Civilization
      ii. Muslim advent
      iii. Location and geo-physical features.

2. Government and Politics in Pakistan
   Political and constitutional phases:
   a. 1947-58
   b. 1958-71
   c. 1971-77
   d. 1977-88
   e. 1988-99
   f. 1999 onward

3. Contemporary Pakistan
   a. Economic institutions and issues
   b. Society and social structure
   c. Ethnicity
   d. Foreign policy of Pakistan and challenges
   e. Futuristic outlook of Pakistan

Books Recommended

Annexure – C

Isl. St. /Eth. 401: Islamic Studies/Ethics (Compulsory) (2 credits hours)

Objectives:

This course is aimed at:
1 To provide Basic information about Islamic Studies
2 To enhance understanding of the students regarding Islamic Civilization
3 To improve Students skill to perform prayers and other worships
4 To enhance the skill of the students for understanding of issues related to faith and religious life.

Course Content:

Introduction to Quranic Studies
1) Basic Concepts of Quran
2) History of Quran
3) Uloom-ul-Quran

Study of Selected Text of Holly Quran
1) Verses of Surah Al-Ba‘ra Related to Faith (Verse No-284-286)
2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
3) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
5) Verses of Surah Al-Inam Related to Ihkam(Verse No-152-154)

Study of Selected Text of Holly Quran
1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.)
2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
3) Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)

Seerat of Holy Prophet (S.A.W) I
1) Life of Muhammad Bin Abdullah ( Before Prophet Hood)
2) Life of Holy Prophet (S.A.W) in Makkah
3) Important Lessons Derived from the life of Holy Prophet in Makkah

Seerat of Holy Prophet (S.A.W) II
1) Life of Holy Prophet (S.A.W) in Madina
2) Important Events of Life Holy Prophet in Madina
3) Important Lessons Derived from the life of Holy Prophet in Madina

Introduction To Sunnah
1) Basic Concepts of Hadith
2) History of Hadith
3) Kinds of Hadith
4) Uloom-ul-Hadith
5) Sunnah and Hadith
6) Legal Position of Sunnah

Selected Study from Text of Hadith

Introduction to Islamic Law and Jurisprudence
1) Basic Concepts of Islamic Law and Jurisprudence
2) History and Importance of Islamic Law and Jurisprudence
3) Sources of Islamic Law and Jurisprudence
4) Nature of Differences in Islamic Law
5) Islam and Sectarianism

Islamic Culture and Civilization
1) Basic Concepts of Islamic Culture and Civilization
2) Historical Development of Islamic Culture and Civilization
3) Characteristics of Islamic Culture and Civilization
4) Islamic Culture and Civilization and Contemporary Issues

Islam and Science
1) Basic Concepts of Islam and Science
2) Contributions of Muslims in the Development of Science
3) Quranic and Science

Islamic Economic System
1) Basic Concepts of Islamic Economic System
2) Means of Distribution of wealth in Islamic Economics
3) Islamic Concept of Riba
4) Islamic Ways of Trade and Commerce

Political System of Islam
1) Basic Concepts of Islamic Political System
2) Islamic Concept of Sovereignty
3) Basic Institutions of Govt. in Islam

Islamic History
1) Period of Khlaft-E-Rashida
2) Period of Ummayyads
3) Period of Abbasids
Social System of Islam
1) Basic Concepts Of Social System Of Islam
2) Elements Of Family
3) Ethical Values Of Islam

Recommended Books:
1) Hameed ullah Muhammad, “Emergence of Islam”, IRI, Islamabad.
2) Hameed ullah Muhammad, “Muslim Conduct of State”.
3) Hameed ullah Muhammad, ‘Introduction to Islam’.
4) Mulana Muhammad Yousaf Islahi,”.
COMPULSORY MATHEMATICS COURSES FOR BS (4 YEARS) 
GEOLOGY 

Math. 301: Mathematics I (Algebra) (3 credit hours)

Prerequisite(s): Mathematics at secondary level

Objectives:

Prepare the students, not magering in mathematics, with the essential tools of algebra to apply the concepts and the techniques in their respective disciplines.

Course Content:

Preliminaries: Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions.

Matrices: Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer’s rule.

Quadratic Equations: Solution of quadratic equations, qualitative analysis of roots of a quadratic equations, equations reducible to quadratic equations, cube roots of unity, relation between roots and coefficients of quadratic equations.

Sequences and Series: Arithmetic progression, geometric progression, harmonic progression.

Binomial Theorem: Introduction to mathematical induction, binomial theorem with rational and irrational indices.

Trigonometry: Fundamentals of trigonometry, trigonometric identities.

Recommended Books:
Math 302: Mathematics II (Calculus) (3 credit hours)

Prerequisite(s): Mathematics I (Algebra)

Objectives:

Prepare the students, not majoring in mathematics, with the essential tools of calculus to apply the concepts and the techniques in their respective disciplines.

Course Outline:

Preliminaries: Real-number line, functions and their graphs, solution of equations involving absolute values, inequalities.
Limits and Continuity: Limit of a function, left-hand and right-hand limits, continuity, continuous functions.

Derivatives and their Applications: Differentiable functions, differentiation of polynomial, rational and transcendental functions, derivatives.
Integration and Definite Integrals: Techniques of evaluating indefinite integrals, integration by substitution, integration by parts, change of variables in indefinite integrals.

Books Recommended:
Chem. 301: Chemistry 1 (3 Credit hours)

Objectives:
Prepare the students with tools of chemistry to apply the concepts and the techniques in their respective discipline.

Course Content:
Phase rule for one and two component system and Distribution laws; first and second laws of thermodynamics with applications; brief introduction to nuclear chemistry: nuclear fission and fusion, nuclear reactors, uses of isotopes and radioisotopes; Metallurgy: major steps involved in metallurgy of iron, copper, nickel, chromium, gold and platinum. metallurgy raw materials; cement preparation; solutions: types, Eubulioscopic constant, distribution law and various properties of solutions; Complexometric Methods: titration and its various types, concept of mono, di and plydentateligoinds.

Labs: Qualitative analysis of a mixture containing four radicals; Refractive Index of various liquids.

Recommended Books:
3. See also relevant updated books.

Chem. 302: Chemistry II (3 credit hours)

Objectives:
Prepare the students with tools of chemistry to apply the concepts and the techniques in their respective discipline.

Course Content:
Gravimetric and volumetric method of analysis; chromatography, TLC, PC, CC ion exchange procedure and application of all these techniques; solvent extraction, classification, important terms involved, types of extraction and factor influencing the extraction system; electro analytical method; basic principles and elementary techniques; conductometer; potentiometry; PH and EH measurement; atomic absorption techniques, neutron activation technique and mass spectrometry.
Labs: volumetric analysis; calorimetric analysis of Ni, Fe and Mn; PH and EH measurements; atomic absorption, neutron activation and mass spectrometry analyses.

Recommended Books:
3. See also relevant updated books.

Phy. 301: Physics I (3 credits)

Objectives:

Prepare the students with tools of physics to apply the concepts and the techniques in their respective discipline.

Course Content:

Vector: Vector notation, vector addition, vectors in the Cartesian coordinate system, scalar product (of two vectors) vector product (of two vectors), scalar of triple product, vector triple product, gradiset of a scalar, divergence of a vector, divergence theorem and Stock’s theorem; **conservation of energy**: concept of conservation laws, conservation of energy, worked and kinetic energy, power, conservation forces, rotational energy, potential energy in an electric and gravitational field; dynamics of rigid bodies, center of mass, conservation of angular momentum, equation of motion of rotating body, moment of inertia, perpendicular axes and parallel axis theorems; calculation of moment of inertia for a disc and solid sphere; Euler’s theorem, Gyroscope cortolis forces; **Inverse Square Law of forces**: Newton laws, ficltioris forces, Newton law of Universal Gravitation b/w point mass and solid spheres, Kepler’s laws, satellite in circular orbit escape velocity;

Electrostatics: electro charges as source of electric flux, Gauss’s theorem, Electrostatic potential, Poisson’s equation, Laplace Equation Potential due to: (a) Point Charge (b) dipole capacity of spherical condenser, dielectrics.

Labs: Surface tension by capillary rise; value of ‘g’ by compound pendulum; modulus of rigidity by Maxwell’s Needle method; use of sextant and measurement of longitude.

Recommended Books:
3. See also updated relevant books.
Objectives:

Prepare the students with tools of physics to apply the concepts and the techniques in their respective discipline.

Course Content:

Magnetism: Explanation of dia, pura and ferromagnetism on atomic structure of an atom, magnetic circuit, relation b/w susceptibility and permeability, Hysteresis determination of B-H curve using a Ballistic galvanometer, Magnetic Shell and Ampere’s law and method of measuring magnetic field; Current Electricity: Magnetic flux density B. Amper’ s law and calculation of B due to current in (a) Long Straight, (b) Solenoid, (c) Toriod, Biot and Sarvat’s law and calculation of B, unit of current carrying conductor in a magnetic field, theory and construction of moving coil and magnetic galvanometer; definition of different system of units C.G.S Electrostatic and C.G.S Electro-magnetic system of units, practical units, Gavssion System of units; Optics: Reflection and refraction, Sertent wave theory, Interference, Biprism and Michelin interferometer determination of wave length and thickness by using Michelin’s interfero - meter, diffraction, diffraction by single and double and “N” slits; Radio Activity: Natural radio activity, mature and charge of alpha, Beta and Gama rays, radioactive series, laws of radioactive decay, Half life and artificial radio activity and transuranic elements.

Labs: Conservation of pointer galvanometer into a voltmeter & in ammeter; Frequency of A.C supply; Low resistance by carry foster bridge; B-H curve by Magnetometer; Measurement of H.

Recommended Books:
3. See also updated books.