Curriculum

Centre for Earth & Space Sciences

University of Swat

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BOARD OF STUDIES

1st Meeting Held on:
3rd July, 2018

BS Geology (4 Years)

(Session 2014-18 and Onward)

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MEMBERS OF THE BOARD OF STUDIES

List of Board of Studies Members for the Centre for Earth & Space Sciences, University of Swat

S.No	Name	Convener/Member
1	In-Charge, Centre for Earth and Space Sciences, University of Swat.	**Convener**
2	Dr. Sajjad Ahmad, Professor/ Chairman Department of Geology, University of Peshawar.	**Member**
3	Mr. Gohar Rehman, Assistant Professor Department of Geology, University of Peshawar.	**Member**
4	Dr. Amin ur Rashid, Assistant Professor Department of Applied Physical & Material Sciences, University of Swat.	**Member**
5	Dr. Kifayatullah, Assistant Professor Department of Computer & Software Technology,University of Swat.	**Member**
6	Mr. Asad Muhammad, Lecturer Department of Geology, University of Malakand.	**Member**
7	Mr. Babar Azam Khan, Lecturer GPG Jehanzeb College, Saidu Sharif, Swat.	**Member**
8	Mr. Shaukat Ali, Associate Professor Govt. AKL Post Graduate College, Matta Swat.	**Member**
9	Mr. Alamzeb Khan, Assistant Professor Govt. AKL Post Graduate College, Matta Swat.	**Member**

CENTRE FOR EARTH & SPACE SCIENCES
Aspiring for Quality Education with Relevance
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Dated: 12 November, 2018

1st BOARD OF STUDIES MEETING

(MINUTES OF THE MEETING)

The 1st meeting of the "Board of Studies" of the Centre for Earth & Space Sciences was held on the 3rd July, 2018 at 11:00 AM, at the Green Hills Hotel, Sector F, Kanju Township. The meeting was chaired by the In-Charge, Centre for Earth & Space Sciences, Mr. Adnan Khan. The meeting was formally started with the recitation of the Holy Quran by Dr. Kifayat Ullah, Assistant Professor; Department of Computer & Software Technology, University of Swat.

The following members of the Board of Studies attended the meeting.

1	In-Charge Adnan Khan Centre for Earth and Space Sciences, University of Swat.	Convener
2	Dr. Sajjad Ahmad, Professor/ Chairman Department of Geology, University of Peshawar.	Member
3	Mr. Gohar Rehman, Assistant Professor Department of Geology, University of Peshawar.	Member
4	Dr. Amin ur Rashid, Assistant Professor Department of Applied Physical & Material Sciences, University of Swat.	Member
5	Dr. Kifayatullah, Assistant Professor Department of Computer & Software Technology, University of Swat.	Member
6	Mr. Asad Muhammad, Lecturer Department of Geology, University of Malakand.	Member
7	Mr. Babar Azam Khan, Lecturer GPG Jehanzeb College, Saidu Sharif, Swat.	Member
8	Mr. Shaukat Ali, Associate Professor Govt. AKL Post Graduate College, Matta, Swat.	Member
9	Mr. Alamzeb Khan, Assistant Professor Govt. AKL Post Graduate College, Matta, Swat.	Member

Mr. Adnan Khan welcomed the members of the Board of studies. He told that, it was a great honor for the University of Swat that the leading experts of their fields are here for the contribution to the academic development of the Centre. He thanked the honorable members for taking time out of their busy schedules and coming all the way from different parts to participate in the meeting. He also thanked Dr. Kefayat Ullah, Department of Applied Physical & Material Sciences for their help and support in arranging this meeting.

Mr. Adnan Khan briefed the members about the Centre and the Curricula adopted to improve the quality of Geology education. The members of the board were satisfied and praised the working and improvement of the Centre.

The members of the Board of Studies gave the following recommendations for the smooth working of the Centre:

The Board approved the following Agenda Items

Item No. 1: BS-Program in Geology **Annexure-A**

To approve mission, vision and objectives of the Department and BS Geology Program

Decision:

The Board unanimously recommended mission, vision and objectives of the Department and BS Geology Program.

Item No.2: Scheme of Studies & Courses for BS-Program **Annexure- B & C**

To approve the scheme of studies and courses for BS Geology Program for the sessions 2014-18, 2015-19, 2016-20 & 2017-21 and onwards.

Decision:

a- The Board unanimously recommended the HEC revised Curriculum 2013 for the BS-Geology program for the sessions 2014-18, 2015-19, 2016-20 & 2017-21.

b- The board also recommended the current scheme of studies and courses for the session 2018-22 and onwards.

Item No. 3: Field Works in different Semesters

To approve Geological Field trips to different geological sites of Pakistan during BS Geology Program.

Decision:

The Board unanimously recommended the following geologically important sites to be visited during the Program, especially Salt Range was emphasized which should be visited in any of the semesters.

Semester-II

Field: 1- River System & Rocks identification of Swat & Malakand Area

Semester-IV
Field: 1- Chillas & Gilgit field- Minimum 5 days
Field: 2- Nizampur Basin – One day

Semester-VI
Field: 1- Salt Range Field, District Mianwali – Minimum 5 days
Field: 2- Nowshehra Field- One day

Semester-VIII
Field: 1- Oil Companies, Dames, Tunnels etc- 2 days *(if possible).*

Item No. 4: Award list for Field Works

To approve the award list for field works (attached at Annexure-F) during BS Geology Program

Decision:

The Board unanimously recommended the award list for field works during BS Geology Program.

General Recommendations:

The following general recommendations have been suggested and approved by the board of studies members for the improvement of teaching practices at the Centre for Earth & Space Sciences.

1. Dr. Sajjad Ahmad proposed that Research & Field work should be mandatory during the Program.
2. Mr. Gohar Rehman suggested to increase the Credit Hours for Semester VIII up to 15.
3. Dr. Sajjad Ahmad also recommended that the course coding should be according to the HEC or as per the University policy.
4. Mr. Shaukat Ali proposed that English-IV should be included in the Curriculum.
5. Dr. Sajjad Ahmad recommended that the subject Structure Geology should also be divided into "Structural Geology & Structural Methods" courses.

Adnan Khan/ In-Charge,
Centre for Earth & Space Sciences
University of Swat

Dr. Sajjad Ahmad

Mr. Gohar Rehman

Dr. Kifayat Ullah

Mr. Asad Muhammad

Mr. Shaukat Ali

Mr. Alamzeb Khan

Dr. Amin Ur Rashid

Mr. Babar Azam Khan

28/11/2018

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Members of the BOS
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Adnan Khan/ In-Charge,
Centre for Earth & Space Sciences
University of Swat

Annexure-A

INTRODUCTION

The Centre for Earth & Space Sciences has been made functional in the University of Swat in the year of 2014and started BS Geology program. During the admissions of the first Batch for the session of 2014-2018, the Department enrolled 40 students in BS Geology. It is four year program of eight semesters, each semester running for sixteen weeks. The degree is awarded to students on their successful completion of a minimum 132 credit hours, including six credits for the project, with a CGPA of at least 2.0. The coursesof BS Geology has been designed to train professional Geologist by imparting high quality education in the field of Geology. The students are trained with skills to apply the concepts, principles and best practices in Oil & Gas sectors as well as in mining departments and other mineral explorations.

MISSION OF THE DEPARTMENT

The Centre for Earth & Space Sciences has a mission to provide state of the art teaching and research facilities to produce professional graduates at the highest national and international levels for academic institutions, Oil Companies and Mineral exploration/mining. We also aim to provide a research based environment by establishing laboratories equipped with sophisticated research facilities and establishing strong collaborations with other renowned institutions.

VISION OF THE DEPARTMENT

Building on the existing strengths, the Centre for Earth & Space Sciences is bridging a link between the academia and industry. Such kind of link will help in the academia and professional growth of the students and the faculty members.

MISSION OF THE BS-GEOLOGY PROGRAM

Currently the Centre for Earth & Space Sciences is offering BS (4 year) program. This degree program is aimed to promote the scientific knowledge about the earth and its mineral resources. We also want to enhance our student's knowledge and skills required to embark on careers as geologists in energy, mineral resources and environmental consulting or to pursue them in their studies in more specialized areas of geology.

PROGRAM OBJECTIVES

According to the curriculum and academic calendar, following are the main objectives BS-Geology program.

- Primary function of the Centre is on campus teaching along with variousfieldworks of geologically important sites of the country.
- To provide high quality learning environment that is challenging and professional.
- To promote the scientific knowledge about the earth and its mineral resources.
- To link the academia and industry for the academic and professional growth of students and faculty members.

The objectives are well-defined and support the mission statements of the department and BS-Geology program.

EXPECTED OUTCOMES OF THE BS GEOLOGY DEGREE PROGRAM

Graduates of the Geology Program will be able to:

1. Explain the importance of Geology and its applicability in various relevant fields.
2. Gain a broad fundamental geological knowledge including rock, mineral and fossil identification.
3. Perform field-based research and produce accurate geologic maps and subsurface modeling.
4. Aware them to analyze data and to solve various geological problems.

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. F.Sc
2. Other Groups (studied Chemistry, Physics and Mathematics)
3. Three years Diploma in Associate Engineering (DAE)-equivalent to F.Sc

Annexure-B

HEC CURRICULUMOF BS GEOLOGY FOR SESSION 2014-18, 2015-19, 2016-20 & 2017-21

SCHEME OF STUDY

Semester I	Course	Credit Hour	Total
Chem. 301	Chemistry I	2+1	3
Eng. 301	English I	3+0	3
Geol. 301	Introduction to Geology	2+1	3
Math. 301	Mathematics I	3+0	3
Phy. 301	Physics I	2+1	3
Pak. St. 301	Pakistan Studies	2+0	2
Total			**17**

Semester II	Course	Credit Hour	Total
Chem. 302	Chemistry II	2+1	3
Eng. 302	Communication Skills (English II)	3+0	3
Geol. 302	Geomorphology	2+1	3
Math. 302	Mathematics II	3+0	3
Phy. 302	Physics II	2+1	3
Geol. 303	Geological Fieldwork I	0+2	2
Total			**17**

Semester III	Course	Credit Hour	Total
Comp. 401	Computer Applications in Geology	2+1	3
Geol. 401	Introduction to Paleontology	2+1	3
Geol. 402	Stratigraphy	2+1	3
Geol. 403	Geostatistics	2+1	3
Geol. 404	Mineralogy	2+1	3
Isl. St./Eth. 401	Islamic Studies/Ethics	2+0	2
Total			**17**

Semester IV	Course	Credit Hour	Total
Eng. 401	Tech. Report Writing (English III)	3+0	3
Geol. 405	Petrography	2+1	3
Geol. 406	Geological Fieldwork-II	0+2	2
Geol. 407	Structural Geology	2+1	3
Geol. 408	Igneous Petrology	2+1	3
Mgt. 401	Principles of Management	3+0	3
Total			**17**

Semester V	Course	Credit Hour	Total
Geol. 501	Geotectonics	2+1	3
Geol. 502	Sedimentary Petrology	2+1	3
Geol. 503	Geophysics	2+1	3
Geol. 504	Field Geology	2+1	3
Geol. 505	Micropaleontology	2+1	3
Geol. 506	Introduction to GIS and RS	2+1	3
Total			**18**

Semester VI	Course	Credit Hour	Total
Geol. 507	Sequence Stratigraphy	2+1	3
Geol. 508	Geochemistry	2+1	3
Geol. 509	Petroleum Geology	2+1	3
Geol. 510	Engineering Geology	2+1	3
Geol. 511	Metamorphic Petrology	2+1	3
Geol. 512	Geological Fieldwork – III	0+2	2
Total			**17**

Semester VII	Course	Credit Hour	Total
Geol. 601	Geology of Pakistan	3+0	3
Geol. 602	Economic Geology	2+1	3
Geol. 603	Environmental Geology	2+1	3
Geol. 604	Hydrogeology	2+1	3
Geol. 605	Elective course	2+1	3
Geol. 606	Elective course	2+1	3
Total			**18**

Semester VIII	Course	Credit Hour	Total
Geol. 607	Elective Course	2+1	3
Geol. 609	Thesis	0+6	6
Geol. 610	Internship/Practical Training	S/U*[2] Based	
Geol. 611	Comprehensive Oral Exam/Grand Viva Voce	S/U*[4] Based	
Total			**9**

Annexure-C

LAYOUT OF BS GEOLOGY(4-YEAR)

Compulsory Courses (the student has no choice)		**Foundation Courses**		**Major Courses**	
15 Courses		**9 Courses**		**22 Courses**	
43 Credit Hours		**24 Credit Hours**		**69 Credit Hours**	
Subject	**Cr. Hr**	**Subject**	**Cr. Hr.**	**Subject**	**Cr. Hr.**
Chemistry I	3(2-1)	Introduction to Geology	3(2-1)	Mineralogy	3(2-1)
Chemistry II	3(2-1)	Geological Fieldwork- I	2(0-2)	Structural Geology	3(2-1)
English I (Functional English)	3(3-0)	Geological Fieldwork-II	2(0-2)	Petrography	3(2-1)
English II (Communication Skills)	3(3-0)	Geological Fieldwork – III	2(0-2)	Geotectonics	3(2-1)
English III (Technical Report Writing)	3(3-0)	Field Geology	3(2-1)	Sedimentary Petrology	3(2-1)
English-IV	3(3-0)	Geomorphology	3(2-1)	Geophysics	3(2-1)
Mathematics I (Algebra)	3(3-0)	Stratigraphy	3(2-1)	Igneous Petrology	3(2-1)
Mathematics II (Calculus)	3(2-1)	Introduction to Paleontology	3(2-1)	Micropaleontology	3(2-1)
Physics I	3(2-1)	Introduction to GIS and RS	3(2-1)	Sequence Stratigraphy	3(2-1)
Physics II	3(3-0)			Geochemistry	3(2-1)
Principles of Management	3(2-1)			Engineering Geology	3(2-1)
Geostatistics	3(2-1)			Metamorphic Petrology	3(2-1)
Computer Applications in Geology	2(2-0)			Geology of Pakistan	3(3-0)
Pakistan Studies	2(2-0)			Economic Geology	3(2-1)
Islamic Studies/Ethics				Environmental Geology	3(2-1)
				Hydrogeology	3(2-1)
				Petroleum Geology	3(2-1)
				Structural Methods	3(2-1)
				Elective Course	3(2-1)
				Elective Course	3(2-1)
				Elective Course	3(2-1)
				Thesis/Research Project	6(0-6)
Total Cr. Hrs	**43**		**24**		**69**

Total Credit Hours for BS Geology Program: 136

SCHEME OF STUDIES FOR (4YEAR) BS-GEOLOGY PROGRAM

1st year

Semester-I

Course Code	Course	Credit Hour	Total
CHE-101	Chemistry I	2+1	3
ENG-102	English I (Functional English)	3+0	3
GEOL-103	Introduction to Geology	2+1	3
MAT-104	Mathematics I (Algebra)	3+0	3
PHY-105	Physics I	2+1	3
PS-106	Pakistan Studies	2+0	2
Total			**17**

Semester-II

Course Code	Course	Credit Hour	Total
CHE-151	Chemistry II	2+1	3
ENG-152	English II (Communication Skills)	3+0	3
GEOL-153	Geomorphology	2+1	3
MAT-154	Mathematics II (Calculus)	3+0	3
PHY-155	Physics II	2+1	3
GEOL-156	Geological Fieldwork- I	0+2	2
Total			**17**

2nd year

Semester-III

Course Code	Course	Credit Hour	Total
GEOL-201	Computer Applications in Geology	2+1	3
GEOL-202	English III (Tech. Report Writing)	3+0	3
GEOL-203	Stratigraphy	2+1	3
GEOL-204	Geostatistics	2+1	3
GEOL-205	Mineralogy	2+1	3
ISL-206	Islamic Studies/Ethics	2+0	2
Total			**17**

Semester-IV

Course Code	Course	Credit Hour	Total
ENG-251	English-IV	3+0	3
GEOL-252	Introduction to Paleontology	2+1	3
GEOL-253	Geological Fieldwork-II	0+2	2
GEOL-254	Structural Geology	2+1	3
GEOL-255	Petrography	2+1	3
MGT-256	Principles of Management	3+0	3
Total			**17**

3rd year

Semester-V

Course Code	Course	Credit Hour	Total
GEOL- 301	Geotectonics	2+1	3
GEOL- 302	Sedimentary Petrology	2+1	3
GEOL- 303	Geophysics	2+1	3
GEOL- 304	Igneous Petrology	2+1	3
GEOL- 305	Micropaleontology	2+1	3
GEOL- 306	Introduction to GIS and RS	2+1	3
Total			**18**

Semester-VI

Course Code	Course	Credit Hour	Total
GEOL- 351	Sequence Stratigraphy	2+1	3
GEOL- 352	Geochemistry	2+1	3
GEOL- 353	Field Geology	2+1	3
GEOL- 354	Engineering Geology	2+1	3
GEOL- 355	Metamorphic Petrology	2+1	3
GEOL- 356	Geological Fieldwork – III	0+2	2
Total			**17**

4th year

Semester-VII

Course Code	Course	Credit Hour	Total
GEOL – 401	Geology of Pakistan	3+0	3
GEOL- 402	Economic Geology	2+1	3
GEOL- 403	Environmental Geology	2+1	3
GEOL- 404	Hydrogeology	2+1	3
GEOL- 405	Petroleum Geology	2+1	3
GEOL- to be selected from Elective courses	Elective course	2+1	3
Total			**18**

Semester-VIII

Course Code	Course	Credit Hour	Total
GEOL- to be selected from Elective courses	Elective Course	2+1	3
GEOL- - to be selected from Elective courses	Elective Course	2+1	3
GEOL-451	Structural Methods	2+1	3
GEOL- 452	Internship/Practical Training/Geological Fieldwork	S/U*[2] Based	
GEOL- 498	Thesis/Research Project	0+6	6
Total			**15**

Note:

1. The recommended minimum Credit Hours for the completion of BS- Geology is 130 as required by HEC.
2. Total Credit Hours of the BS-Geology after amendment in HEC revised Curriculum – 2013, has been increased upto136.
3. 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.
4. Thesis will be open defense.
5. S/U* means satisfactory (S = 50% marks) and Unsatisfactory (U = less than 50% marks).
6. Elective courses will be selected by relevant thesis supervisor.
7. Subject/s will be offered subject to availability of resource and resource person.

LIST OF GROUPS AND ELECTIVE COURSES

Groups	Course Codes	Elective Course	CreditHours
Group-I Mineralogy and Petrology	GEOL-406	Geochemistry II	2+1
	GEOL-407	Igneous Petrogenesis	2+1
	GEOL-408	Metamorphic Petrology-II	2+1
	GEOL-409	Sedimentary Petrology-II	2+1
	GEOL-410	Mineralogy II	2+1
Group-II Paleontology and Stratigraphy	GEOL-411	Palynology and Paleonbotany	2+1
Group-III Economic Geology	GEOL-412	Ore Deposits	2+1
	GEOL-413	Mineral Exploration	2+1
	GEOL-414	Mineral Deposits of Pakistan	2+1
Group-IV Engineering Geology	GEOL-415	Rock Mechanics	2+1
	GEOL-416	Soil Mechanics	2+1
	GEOL-417	Engineering Geology II	2+1
Group-V Sedimentology	GEOL-418	Basin Modeling	2+1
	GEOL-419	Carbonate Sedimentology	2+1
Group-VI Industrial Mineralogy	GEOL-453	Industrial Mineralogy-I	2+1
Group-VII Environmental Geosciences	GEOL-454	Natural Resource Management	2+1
Group-VIII Structure, Tectonics and Neotectonics	GEOL-455	Structural Geology II	2+1
	GEOL-456	Metamorphic Structures	2+1
	GEOL-457	Applied Structural Techniques	2+1
	GEOL-458	Tectonics of Pakistan	3+0
	GEOL-459	Earth Quake Seismology	2+1
	GEOL-460	Geological and Geophysical Software Applications	2+1
Group-IX Petroleum Geosciences	GEOL-461	Petroleum Engineering	2+1
	GEOL-462	Petroleum Geology of Pakistan	2+1
	GEOL-463	Logging and Log Interpretation	2+1
Group-X Applied Geophysics	GEOL-464	Electrical and Radiometric, Exploration Methods	2+1
	GEOL-465	Bore-Hole Geophysics	2+1
	GEOL-466	Seismic prospecting	2+1

GEOL-103: 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.

Learning outcomes:
Upon completion of this course students will have learnt about the various geological processes in and on the Earth and its application to the past history of the earth. "Present is the key to the past". Students will also understand how the three major rock types (igneous, sedimentary and metamorphic) form, identification of minerals, rocks and crystal shapes of the normal class of the crystal system.

Course Contents:

Week-1: Introduction and scope of geology; importance and relationship with other sciences;
Week-2: History and philosophy of geology;
Week-3: Earth as a member of the solar system; its origin, age, composition.
Week-1: Internal structure of Earth; Introduction to plate tectonics,
Week-4: Isostasy; mountain building processes;
Week-5: Earthquakes and volcanoes:
Week-6: Weathering and erosion; Introduction,
Week-7: Identification and classification of rocks and minerals;
Week-8: Sedimentary Rocks,

Presentations, Quizzes and Assignments

Week-9: Igneous Rocks:
Week-10: Metamorphic structures;
Week-11: Introduction to fossils in sedimentary rocks;
Week-12: Introduction to folds, Faults
Week-13: Joints, cleavage, foliation, Lineation and unconformities;
Week-14: Geological Time Scale; Law of Superposition, present is key to the past and Law of Faunal Succession;
Week-15: Concept and techniques of geological dating, relative and absolute dating;
Week-16: Evolution of life on earth; use of Brunton Compass and GPS, etc.

Presentations, Quizzes and Assignments

Recommended Books:

1. Physical Geology (13th Edition) by Charles Plummer, David Mc Geary, Diane Carlson, Lisa Hammersley, 2009, McGraw-Hill
2. Laboratory Manual in Physical Geology (9th Edition) , Richard M. Busch, 2011, American Geological Institute, Pearson Education
3. Physical Geology, By Plummer, (14th Edition), Charles (Carlos) Plummer, Diane Carlson, Lisa Hammersley, 2012 McGraw-Hill
4. Principles of Physical Geology by Holmes, A., 1978, Nelson.
5. Foundation of Structural Geology by Park, R. G., 1983, Blackie.
6. Elementary Exercises upon Geological Maps by Platt, J. I., 1961, Thomas Murby and Co.
7. An Introduction of Geological Structures and Maps by Bennison, G.M., 1997, Edward Arnold.
8. Physical Geology by Plummer, McGeay and Carlson, 2005.
9. How Does Earth Work: Physical Geology and Process of Science by Smith, G. and Pun, A., 2006, Prentice Hall.

GEOL-153: Geomorphology **(3 Credit hours)**

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.

Learning Outcomes:

At the conclusion of the course, students will be able to:
Describe the morphology of the landscape and related processes in areas influenced by fluvial, glacial, periglacial, aeolian, coastal, and arid systems. Understanding the significance of processes involved in weathering and mass wasting.

Course Contents:

Week-1: Geomorphological processes
Week-2: Weathering and its various types
Week-3: Erosion and its various types
Week-4: Glaciers and their erosional landformsand depositional landforms
Week-5: Glaciers depositionallandforms and depositional landforms
Week-6: Geological work of wind and associated features
Week-7: Erosional and depositional work of s u r f a c e a n d s u b s u r f a c e water
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Drainage pattern and its various types
Week-10: Valley and base-level development
Week-11: Various types of valleys and base level development
Week-12: Associated landforms produced by tectonics and volcanic activity
Week-13: Introduction to tectonic geomorphology
Week-14: Introduction to topographic maps
Week-15: Aerial photographs and satellite imageries
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Geomorphology: The Mechanics and Chemistry of Landscapes, Robert S. Anderson, Suzanne P. Anderson, 2010, Cambridge University Press
2. Landscapes and Geomorphology: A Very Short Introduction, Andrew Goudie, Heather Viles, 2010, Oxford University Press.
3. Process Geomorphology by Ritter, Kochel and Miller, 2002, the McGraw-Hill Company.
4. Tectonic Geomorphology, Douglas W. Burbank, Robert S. Anderson, 2000, John Wiley and Sons.
5. Principles of Geomorphology by Thornbury, W.D., 1991, John Wiley and Sons.
6. Geomorphology of Earth Surface Processes and Form by Aharma, V.K., 1986, McGraw-Hill.
7. Geomorphology by Chorley, R.J., 1984, Methuen.
8. Image Interpretation in Geology by Drury, S.A., 1986, Allen and Unwin.

GEOL-156: 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.

Learning Outcome:
Students will be able to recognise various rock types exposed in different areas. They will have the first-hand knowledge of rocks and structures in the mountainous areas.

Labs: Field based exercises. During the first two years students will performabout 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:

1. Field Geology by Lahee, F. H. 1961, McGraw-Hill.
2. Geology in the Field by Compton, R.R. 1985, John Wiley and Sons.
3. Basic Geological Mapping by Barnes, J.W. and Lisle, R.J., 2004, John Wiley and Sons.

GEOL-201: 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 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 file formats. 2) learn applied to geology, geophysics and structural computer programs.

Learning Outcomes:
Upon completion of this course students will learn about the basics of the computer and will be able to use computer for report writing, presentations, map designing through various geological softwares, computation and Internet.

Course Contents:
Week-1: Learn basic programs (word, excel, illustrator, PowerPoint)
Week-2: Coral Draw
Week-3: Basic geographical information systems and visualization
Week-4: Some of the field equipment,
Week-5: Basic knowledge related to computer hardware
Week-6:CPU, memory, motherboard and BUS, Power supply, monitor, video card, hard drive
Week-7: ports (Ethernet, parallel, serial, USB, CD, Zips etc
Week-8: *Presentations, Quizzes and Assignments.*

Week-9: System run programs (drivers, operating systems like Windows, Unix, Mac and Linux
Week-10: Other softwares used in industries Geographix, Petrel,
Week-11: Computer encoding (Digital, Analogue)
Week-12: Various kinds of scripts like Matalib,ASCII, EBCDIC
Week-13:UNICODE basics of network
Week-14: Use of common geological, structural and geophysical computer programs
Week-15: Practical exercise on the available software packages
Week-16: *Presentations, Quizzes and Assignments.*

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

Recommended Books:

1. Basic category theory for computer scientist, C. Benjumin Piercce, 1991.
2. An introduction to computing infrastructure: Hardware and operating systems, John Williams, 1996, Que EandT.
3. Introduction to computers, Peter Norton, 2004, Technology education.
4. Introduction to Computers, Gary B. Shelly, Steven M. Freund, Misty E. Vermaat, edition 8, 2010, Technology Education.
5. An introduction to operating systems-Concepts and practices, Pramod Chandra P. Bhatt, 2004, PHI Learning Pvt. Ltd.
6. Introduction to computers, Rajmohan Joshi, 2009.
7. Computer networks, Andrew S. Tanenbaum, 5th Edition, 2010.
8. Use common geological, geophysical and structural programmes.

GEOL-203: 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.

Learning outcomes:
The student will be able to, workout the stratigraphy of a particular area. Understand the rock-type and stratigraphic set-up of various sedimentary basins of Pakistan.

Course Contents:

Week-1: Principles of Stratigraphy
Week-2: Laws of Superposition and Faunal Succession
Week-3: Geological Time Scale with Divisions; Classification and Nomenclature of Stratigraphic Units
Week-4: Lithostragraphic, Biostratigraphy and Chronostratgraphic Units
Week-5: Contacts; Litho and Biofacies
Week-6: Principle of Stratigraphy Correlation
Week-7: Preparation of Stratigraphic Columns and their Correlation, FaciesMaps,Isopach Stratigraphic Map.
Week-8: *Presentations, Quizzes and Assignments.*

Week-9: Stratigraphy Code of Pakistan
Week-10: Outline of Stratigraphy of Pakistan
Week-11: Outline of Stratigraphy of Pakistan.
Week-12: Principles of Biostratigraphy and Biostratigraphy Zones
Week-13: Biostratigraphy Techniques and Procedures
Week-14: Biostratigraphy of Pakistan
Week-15: Sedimentary Basin of Pakistan
Week-16: *Presentations, Quizzes and Assignments.*

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

Recommended Books:

1. Principles of Stratigraphy by Weller, J. M., 1962, Harper Brothers.
2. Stratigraphy of Pakistan by Shah, S. M. I. (Ed), 1977, GSP Memoir 12, Geological Survey of Pakistan, Quetta.
3. Principles of Sedimentology and Stratigraphy by Boggs, S., 2001, Prentice Hall.
4. Stratigraphic Code of Pakistan, Geological Survey of Pakistan, 1962, Memoirs of GSP, V. IV, Part-I.
5. The Geology of Stratigraphic Sequences by Miall, A. D., 1997, Springer.
6. Applied Stratigraphy by EAM Koutsoukos., 2005. Springer.
7. Stratigraphy and Historical Geology of Pakistan by Kazmi, A. H and Abbasi, I.A., 2008, Graphic Publishers, Karachi, Pakistan.
8. Stratigraphy of Pakistan by Geological Survey of Pakistan, 2008, GSP Memoir 22, Geological Survey of Pakistan, Quetta.

GEOL-204: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.

Learning outcomes:
The students will learn the basic approach in conducting a variogram analysis, directional analysis (Rose Diagram and variogram surface) and variogram modeling. They will also learn the mathematical and statistical principles behind Kriging and Co-kriging.

Course Contents:

Week-1: Descriptive statistics
Week-2:exploratory data analysis,
Week-3: -Do-
Week-4:random variable; moments;
Week-5: -Do-
Week-6:probability distributions;
Week-7:normal and lognormal distributions,
Week-8: *Presentations, Quizzes and Assignments.*
Week-9:random function model,
Week-10:modeling spatial continuity;
Week-11:experimental variograms covariance functions;
Week-12: -Do-
Week-13:correlograms and madograms;
Week-14:variogram and covariance function models;
Week-15:isotropy and anisotropy, estimation methods: simple kriging (ordinary
Week-16: *Presentations, Quizzes and Assignments.*

Labs: Calculating a range of descriptive statistics and carry out a variety ofmethods 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:

1. Geostatistical Estimation: kriging, S. Rouhani, in Rouhani et al. (1996).
2. Modeling Spatial Variability using Geostatistical Simulation, A. J. Des-Barats, in Rouhani et al., 1996.
3. Goovaerts, P. 1997, Geostatistics for Natural Resources Estimation, Oxford University Press.
4. Olea, R.,1999, Geostatistics for Engineers and Earth Scientists, Kluwer.
5. Armstrong, M.,1999, Basic Linear Geostatistics, Springer.
6. Clark, I., and Harper, W., 2000, Practical Geostatistics 2000. Ecosse Geostatistical Sales, Alloa, Scotland.

GEOL-205: 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.

Learning outcomes:
After the completion of this course, students will beable to interpret rocks types in thin sections under microscope and Rock-Classification based on their mineral composition and to understand the internal structures and composition of major mineral groups such as silicates, oxides and radioactive minerals.

Course Contents:

Week-1: Introduction to mineralogy and crystallography, Minerals and its classification

Week-2: Crystals, internal structures of crystals, Crystals system and crystals chemistry
Week-3: Polymorphism and isomorphism
Week-4: Structure classification of silicates
Week-5: Physical properties, structure, detailed chemistry and paragenesis of the various silicates and non-silicates. Olivine group, Garnet group, Alumino-silicate polymorphs. Humite group
Week-6: Alumino-silicate polymorphs, Epidote group, Zircon, sphene, mullite,
Week-7: Topaz, Tourmaline group, beryl, cordierite;
Week-8: *Presentations, Quizzes and Assignments.*

Week-9: Chain silicates Pyroxene group including details regarding the different compositional series and individual members belonging to the group
Week-10: Amphibole group including classification and details of the different compositional series and individual members within the group
Week-11: Sheet silicates Micas (inluding both di- and tri-octahedral subgroups)
Week-12: Talc, serpentine, chlorite, Feldspathoids (including nepheline, leucite and sodalite groups);
Week-13: Framework silicates Feldspars (including alkali feldspars and plagioclase series)
Week-14: Brief description of common oxides including spinel group, sulphides, hydroxides, sulphates, carbonates and phosphates
Week-15: Introduction to X-Ray diffractometry, phase equilibrium studies; one component; binary and ternary system.
Week-16: *Presentations, Quizzes and Assignments.*

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

Recommended Books:

1. Principles of Mineralogy by William, H.B., 1990, Oxford University Press.
2. Optical Mineralogy by Kerr, P.F., 1959, McGraw-Hill.
3. Minerals and Rocks by Klein, C., 1989, John Wiley and Sons.
4. A Colour Atlas of Rocks and Minerals in Thin Section by Mackenzie, W.S. and Adams, A.E. 1996, John Wiley and Sons.
5. Atlas of Rock-Forming Minerals in Thin Section by Mackenzie, W.S., Donaldson, C.H. and Guilford, C.P., 1980, John Wiley and Sons.
6. An Introduction to Rock Forming Minerals by Deer, W.A., Howie, R.A. and Zussman, J., 1992, Longman.

GEOL-252: 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.

Learning Outcomes:
Upon successful completion of the course, students will be able to, identify common sedimentary rocks and structures, and interpret and describe the depositional environments in which they form and identify common fossil organisms and describe their habitat as well.

Course Contents:
Week-1: Introduction and classification of major vertebrates i.e. mammals, amphibians, reptiles and Pisces; Introduction to fossils and their significance;
Week-2: Modes of fossilization, study of morphology, range and broad classification of major invertebrate phyla i.e coelenterate;
Week-3: Phylum Brachiopoda,
Week-4: -do-
Week-5: Mollusca;
Week-6: -do-
Week-7: -do-
Week-8: *Presentations, Quizzes and Assignments.*

Week-9: Echinodermata (echinoidea);
Week-10: -do-
Week-11: Introduction to micro fossils;
Week-12: Introduction to micropaleontology i.e. foraminifera, bryozoan,
Week-13: Ostrocodes and conodonts etc.
Week-14: Introduction to paleobotany;
Week-15: Index fossils; introduction to major invertebrate and microfossils of Pakistan.
Week-16: *Presentations, Quizzes and Assignments.*

Labs: Mega scopic identification and description of fossils up to genus level related to phyla studied.

Recommended Books:

1. Invertebrate Fossils by Moore, R. C., Lalicker, C. G. and Fischer, A. G., 1952, McGraw-Hill.
2. Principles of Paleontology by Raup, D.M. and Stanley, S.M., 1985, W.H. Freeman and Co.
3. Vertebrate Paleontology by Romer, A.S., 1966, University Chicago Press.
4. Invertebrate Paleontology and Evolution by Clakson, E.N.K., 1998, Blackwell Publishing.
5. Genetics, Paleontology and Macroevolution by Levinton, J.S., 2001, Cambridge University Press.

GEOL-255: 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.

Learning outcomes:
At the end of the course, studentwill be able to interpret rocks types in thin sections under microscope and Rock-Classification based on their mineral composition

Course Contents:

Week-1: Introduction to polarizing microscope;
Week-2: Optical properties of opaque and non-opaque minerals
Week-3: Properties in plane polarized light.
Week-4: Properties in crossed nicols/light, Extinction and its types.
Week-5: Uniaxial & Biaxial minerals
Week-6: Uniaxial and Biaxial interference figures
Week-7: Description of optical properties of common rock forming minerals
Week-8: -do-
Week-9: *Presentations, Quizzes and Assignments*

Week-10: Mineralogy and common texture of igneous rock
Week-11: -do-
Week-12: Mineralogy and common texture of metamorphic rocks
Week-13: -do-
Week-14: Mineralogy and common texture ofsedimentary rocks
Week-15:-do-
Week-16: *Presentations, Quizzes and Assignments.*

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

Recommended Books:

1. Optical Mineralogy by Kerr, P. F., 1959, McGraw-Hill.
2. Minerals and Rocks by Klein, C., 1989, John Wiley and Sons.
3. Igneous and Metamorphic Petrology by Best, M. G., 1982, W. H. Freeman and Co.
4. Minerals in Thin Sections by Perkins, D., 2000, Prentice Hall.
5. Petrography of Igneous and Metamorphic Rocks by Philpotts, A.R., 1989, Prentice Hall.
6. Atlas of Rock-Forming Minerals in Thin Section by MacKenzie, W. S. Guilford, C. P., 1980, John Wiley and Sons.
7. Introduction to Optical Mineralogy by Nesse, W. D., 2003, Oxford University Press.
8. An Atlas of Minerals in Thin Section by Schulze, D. J., 2003, CD-RM, Oxford University Press.

GEOL-253: 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.

Learning outcomes:
The students will be able to understand the basic principals of geological surveying.

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:

1. Field Geology by Lahee, F.H. 1961, McGraw-Hill.
2. Geology in the Field by Compton, R. R. 1985, John Wiley and Sons.
3. Basic Geological Mapping by Barnes, J. W. and Lisle, R. J., 2004, John Wiley and Sons.

GEOL-254: Structural Geology **(3 credit hours)**

Objectives:

To acquire the knowledge of the basics about deformational structures, and their kinematics, dynamic and descriptive analyses:

Learning Outcomes:

After completion of this course the students will be able to identify and map the deformational structures in the field and synthesis their kinematics and dynamics.

Course Contents:

Week-1: Stress: concepts, classes
Week-2: Ellipsoid; Mohr circle of stress;
Week-3: Strain: concept, types of strain
Week-4: Measures of strain, ellipse and ellipsoid,
Week-5: Stress-strain diagram
Week-6: Factors controlling the mechanical behavior of rocks;
Week-7: Folds: geometry,classification based on geometry
Week-8: *Presentations, Quizzes and Assignments.*

Week-9: Fold morphology, angle, bed thickness, variation and vergence etc.
Week-10: Faults: terminology, slip and separation, criteria for recognition of fault and active fault,
Week-11: Classification of thrust/reverse
Week-12: Normal and strike-slip faults
Week-13: Joints: terminology, geometry and classification;
Week-14: Contacts; unconformity: concept, classification
Week-15: Recognition and significance;
Week-16: *Presentations, Quizzes and Assignments*

Labs: Attitude of planes, Attitude of lines, Stereographic projections, Interpretation of topographic maps, Exercises on geologic maps.

Recommended Books:

1. Structural Geology of Rocks and Regions, George H. Davis, Stephen J. Reynolds, Charles F. Kluth, 2011, John Willy and Sons.
2. Structural Geology, Haakon Fossen 2010, Cambridge University Press.
3. Structural Geology: An Introduction to Geometrical Techniques, Donal M. Ragan, 2009, Cambridge University Press.
4. Foundation of Structural Geology by Park, R. G., 1983, Blackie.
5. Structural Geology of Rocks and Regions by Davis, G. H. and Reynolds, S. J., 1996, John Wiley and Sons.
6. Laboratory Exercise Book in Structural Geology by Ghauri, A. A. K., 1989, National Centre of Excellence in Geology, University of Peshawar.
7. An Introduction to Geological Structures and Maps by Bennisen, G. M., 1975, Edward Arnold.
8. Structural Geology by Twiss, R. J. and Moores, E. M., 1995, W. H. Freeman and Co.

GEOL-304: Igneous Petrology (3 credit hours)

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.

Learning outcomes:
Student should be able to classify igneous rocks according to their genesis and place various igneous rocks in their Tectonic position.

Course Contents:
Week-1: Composition, origin, differentiation and evolution of magma.
Week-2: Classification of igneous rocks
Week-3: Texture and structure of igneous rocks
Week-4: Rock series: tholeiitic and alkali-olivine basalt
Week-5: Basalt–andesite series
Week-6: Study of granites, granodiorite,
Week-7: Syenite and carbonatite,
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Mafic and ultramafic rocks, Ophiolites
Week-10: Origin, mineralogy and classification of lamprophyres
Week-11: Nephelinesyenite and related soda-rich rocks
Week-12: Facies analysis of volcanic rocks;
Week-13: Mode of occurrences of igneous bodies
Week-14: Extrusive rocks and its types
Week-15: Economic importance of igneous rocks.
Week-16: *Presentations, Quizzes and Assignments*

Labs: Megascopic and microscopic identification and description of igneousrocks. Discrimination diagrams.

Recommended Books:

1. Igneous and Metamorphic Petrology by Best, M. G., 2002, Black Well.
2. Petrology of Igneous and Metamorphic Rocks by Hyndmann, D. W., 1995, McGraw-Hill.
3. Igneous Petrogenesis by Wilson, M., 1989, Unwin Hyman.
4. Petrology: Igneous, Sedimentary and Metamorphic by Blatt, H., Tracy, R. and Owens, D., 2005, W. H. Freeman and Co.
5. Introduction to Igneous and Metamorphic Petrology, Winter, J. D., 2001, Prentice Hall.
6. Igneous Rocks: A Classification and Glossary: Recommendations of the IUGS Sub-commission, Maitre, R. W., Le Bas, M. J., Streckeisen, A., Zanettin, B. and Bonin, B. (eds.), 2005.

MGT-256: Principles of Management (3 credit hours)

Objectives:
This course aims at broadening the perspective of the students to understand management of an organization including various managerial functions and giving them insight into various managerial skills.

LearningOutcomes:
After studying this course the students will have a clear understanding about the management of an organization including various managerial functions. This course will also give them an insight into various managerial skills. Basic concepts, tools of analysis and terminologies used in microeconomics & Macro Economics

Week 1: Definition of Management, nature and purpose, Management Skills,
Week 2: Technical, Human, Conceptual, Design**,** Productivity, effectiveness and efficiency**,**
Week 3: Managing science or art, elements of science, scientific approach**,** Functions of managers, planning, organizing, leading, staffing, controlling
Week 4: Fredrick Taylor, Taylor's major concern, Taylor's principles**,** Fayol's operational management**,**
Week 5: Fayol's 14 principles**,** Hawthorne studies, behavior management
Week 6: Nature and purpose of planning**,** Definition**,** Nature, contribution to purpose and objectives, primacy, pervasiveness, efficiency,
Week 7: Types of plans, mission, objectives, strategies, policies, procedures**,** Steps in planning process**,** MBO-process, setting preliminary objectives,
Week 8: clarify roles, subordinate objectives**,** Benefits of MBO**,** Weakness of MBO

Presentations, Quizzes and Assignments

Week 9: Formal and informal organization**,** Span of management**,** Factors determining effective span**,** Structure, logic and purpose of organizing
Week 10: By time, by function, by geography, by customer, by product, Human resource management,
Week 11: Definition of staffing, Selection process, techniques and instruments, Selection process,
Week 12: interviews, tests, assessment centers, limitations, Socializing new employees
Week 13-14: Leadership, Definition, Leadership behavior and styles, Linkert's four system approaches, Managerial grid
Week 15-16: Steps in control process, establishment of standards, measurement of performance, Corrections of deviations

Presentations, Quizzes and Assignments

Recommended Books:

1. Heinz Weihrich, Harold Koontz: "*Management- a global perspective*" 10th Edition. McGraw Hill Series (Jan 1986)
2. Joseph M. Putty: "*Management- a functional approach*"

GEOL-301: 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.

Learning Outcomes:
After completing this course the students will be able to understand the characteristic rock association and structures found in different types of plate settings.

Course Contents:
Week-1: Continental drift and reconstruction
Week-2:Concept of plate tectonics;
Week-3: Plates and plate boundaries;
Week-4: Mechanism of plate tectonics;
Week-5: Plate Motions, Relative and absolute plate motions;
Week-6: Sea floor spreading
Week-7: Oceanic ridges and trenches;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Continental rifts; intra-oceanic islands;
Week-10: Hot spot and mantle plumes;; historical perspective;
Week-11: Extensional, compressional and transpressional tectonics;
Week-12: Subduction zones;
Week-13: Transform and transcurrent faults;
Week-14: Introduction to neo-tectonics and related hazards.
Week-15: Application of geotectonics in natural resource explorations.Concept of geosyncline and sedimentary basins.
Week-16: *Presentations, Quizzes and Assignments*

Labs: Specified assignments/projects.

Recommended Books:

1. Plate Tectonics: Continental Drift and Mountain Building, Wolfgang Frisch, Martin Meschede, Ronald C. Blakey, 2010, Springer
2. Economic Geology and Geotectonics, Donald Harvey Tarling, 1981, Wiley
3. An Introduction to Seismology, Earthquakes, and Earth Structure. Stein, Seth; Wysession, Michael (2009). Chichester: John Wiley and Sons.
4. Plate Tectonics – Geodynamics, Turcotte, D. L.; Schubert, G. 2002, Cambridge University Press Tectonics by Moores, E. M. and Twiss, R. J., 1995, W. H. Freeman and Co.
5. Global Tectonics by Keary, P. and Vine, F. J., 1996, Blackwell.
6. Plate Tectonics: How it Works by Cox, A. and Hort, R. B., 1986, Blackwell.
7. The Evolving Continents by Windley, B. F., 1984, John Wiley and Sons.

GEOL-302: 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.

Learning Outcomes:

The students will be able to understand,

a) Basin mechanisms, Environment of deposition and Sedimentary rock deposits in various depositional settings.
b) understand formation and internal fabric sedimentary rocks.
c) Classification of Sedimentary rocks
d) Classification & depositional system

Course Contents:

Week-1: Introduction to sedimentology and importance of sedimentology
Week-2: Origin,transportation and deposition of sediments
Week-3: Texture of sedimentary rocks and their statistical parameters
Week-4: introduction to sedimentary structures, their classification, morphology, significance and paleocurrent analysis; biogenic sedimentary structures
Week-5: Primary inorganic sedimentary structures, predepositional structures
Week-6: Syndeposional dsedimentary strcuctues
Week-7: Postdepositional sedimentary structures and miscellaneous structures
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Concept of sedimentary facies and facies association and introduction to sedimentary environment
Week-10: Diagenetic features of the glacial and fluvial environment
Week-11: Diagenetic features of the eolian and lacustrine environment
Week-12: Diagenetic features of the deltaic, lagoonal, tidal and turbidites
Week-13: Classification and description of sedimentary rocks;
Week-14: Classification and description of sedimentary rocks
Week-15: Classification and description of sedimentary rocks and
Week-16: *Presentations, Quizzes and Assignments*

Labs: Grain size analysis of sediments and sedimentary rocks; megascopicand 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:

1. Sand and Sandstone by Pettijohn, F. J., Potter, P. E. and Siever, R., 1972, Springer-Verlag.
2. Principles of Sedimentology by Friedman, G. M. and Sanders, J. E., 1978, John Wiley and Sons.
3. Depositional Sedimentary Environments by Reineck, H. E. and Singh, I. B., 1980, Springer-Verlag.
4. Carbonate Sedimentology by Tucker, M. E. and Wright, V. P., 1990, Blackwell.
5. Sedimentary Environment and Facies by Reading, H. G., 1986, Blackwell.
6. Applied Sedimentology by Selly, R. C., 1988, Chapman and Hall.
7. Petrology of Sedimentary Rocks by Boggs Jr. S., 1992, Merril Publishing Co.
8. Principles of Sedimentology and stratigraphy by Boggs, Jr. S., 2012, 5th Edition, Pearson Publishing Co.

GEOL-303: 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.

Learning Outcomes:
At the end of this course the students will have the basic knowledge of geophysics and will be able to work on the seismic images and interpret subsurface structures.

Course Contents:
Week-1: Definition and relation of geophysics with other sciences
Week-2: Classification and brief description of various branches of geophysics such as seismic reflection and refraction techniques
Week-3: Geomagnetism and Geoelectricity
Week-4: Tectonophysics and Gravimetry
Week-5: Geothermy and geodesy; geophysical data acquisition, processing and interpretation
Week-6: Geophysical data acquisition, processing and interpretation
Week-7: Applications of geophysical techniques for exploration of mineral deposits, oil and gas
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Applications of geophysical techniques for exploration of subsurface water and engineering works
Week-10: Introduction to earthquake seismology and geodynamics of earth.
Week-11: Introduction to earthquake seismology and geodynamics of earth.
Week-12: Analysis and interpretation of geophysical data
Week-13: Generation of time contour map
Week-14: Time depth conversion and generation of depth contour map
Week-15: Earth quack seismology
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Whole Earth Geophysics: An Introductory Textbook for Geologists and Geophysicists, Robert J. Lillie, 2008, Prentice Hall.
2. Tectonics - Recent Advances, 2012, Evgenii Sharkov, InTech
3. Introduction to Applied Geophysics by Burger R. H., Sheehan, A. and Jones, C. 2000, W. W. Norton
4. Applied Geophysics by Telford, W. M., Geldart, C. P., Sheriff, R. E. and Keys, D. A., 1976, Cambridge University Press.
5. Introduction to Geophysics by Garland, G. D., 1971, W. B. Saunders Co.
6. Seismic Exploration by Al-Sadi, H. N., 1980, Birkhauser Verlag.
7. Introduction to Geophysical Prospecting by Dobrin, M.B. and Savit, C. H., 1988, McGraw-Hill.
8. An Introduction to Geophysical Exploration by Kearey, P., and Brooks, M., 1991, Osney Mead.
9. Basic Exploration Geophysics by Robinson, E.S. and Coruh, C., 1988, John Wiley and Sons.
10. Geophysical Methods in Geology by Sharma, P.V., 1987, Elsevier.

GEOL-353: 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 equipment and data acquisition and preparation of geological maps and cross-sections.

Learning Outcomes:
At the end of this course the students will have the basic knowledge of how to collect data in the field and to prepare geological maps and cross sections.

Course Contents:
Week-1: Introduction of topographic and geological maps; methods and techniques of surface and subsurface geological mapping
Week-2: Introduction to instruments for geological mapping
Week-3: Interpretation of geological maps with reference to outcrop patterns
Week-4: Correlation techniques
Week-5: Field description of igneous, metamorphic and sedimentary rocks
Week-6: Modes of geological illustration
Week-7: Structural contour, isopach and lithofacies maps
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Block and fence diagrams
Week-10: Scan line survey
Week-11: Awareness and compliance of Health and Safety Environment (HSE) particularly during geological work
Week-12: Uses of field instruments field data acquisition and interpretation
Week-13: Section measurement and preparation of cross section
Week-14: Preparation of geological maps and cross sections
Week-15: Field sampling in sedimentary terrain and constructing of lithostratigraphic log
Week-16: *Presentations, Quizzes and Assignments*

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:

1. Elements of Field Geology by Himus, G. W. and Sweeting, G. S., 1968., University Tutorial Press Ltd.
2. Field Geology by Lahee, F.H., 1961, McGraw-Hill.
3. Geology in the Field by Compton, R. R., 1985, John Wiley and Sons.
4. Introduction to Field Geology. Bevier, M. L., 2006. McGraw-Hill Ryerson.

GEOL-305: 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.

Outcomes:

The students will be able to interpret Depositional system of major sedimentary Basins by studying microfossils.Also the students will able to do the detailed biostratigraphy of sedimentary strata.

Course Contents:
Week-1: Introduction and scope of Micropaleontology;
Week-2: Foraminifera and their morphology;
Week-3: Classification of Foraminifera;
Week-4: Brief description of important groups of foraminifera;
Week-5: Applications of foraminifera;
Week-6: General techniques of collection and preparation of foraminifera;
Week-7: Radiolarians, their morphology and classification;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Ostracodes, their morphology and classification;
Week-10: Conodonts, their different morphological types and classification;
Week-11: Pollen and spores;
Week-12: Introduction to Nano planktons;
Week-13: Principles of biostratigraphy and biostratigraphic zones
Week-14: Biostratigraphic techniques and procedures;
Week-15: Tertiary biostratigraphy with special reference to Pakistan;
Week-16: *Presentations, Quizzes and Assignments*

Labs: Basic micropaleontological and biostratigraphic techniques; morphologicaland taxonomic studies of selected/index microfossils.

Recommended Books:

1. Microfossils by Brasier, M. D., 1980, Allen and Unwin.
2. Invertebrate fossils by Fischer, G. A. and Moore, R. C., latest Ed., McGraw Hill.
3. Introduction to marine micropaleontology by Haq and Boersman, 1980, Elsevier.
4. Paleontology by Tucker, V. C.T and Noeld, E. W., 1985, Pergaman Press.
5. Plankton Stratigraphy by Balli and Saunders, 1986, Oxford University Press.

GEOL-306: 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.

Learning Outcomes:
After completion of this course students will have the basic concepts and applications of Geographic Information Systems (GIS) and Remote Sensing (RS):

Course Contents:
Week-1: Introduction to Geographic Information System (GIS)
Week-2: Data types uses in the GIS environment
Week-3: Data models and structures
Week-4: Data sources and capturing techniques
Week-5: Displaying and manipulating spatial information
Week-6: Vector data preparation in the GIS
Week-7: Field survey and data acquisition using GPS
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Introduction to the concept of RS
Week-10: An overview to the electromagnetic spectrum, atmospheric interaction
Week-11: Technology of Remote Sensing (Orbits, Satellites, Sensors and Platforms);
Week-12: Applications of Remote Sensing in Earth Sciences
Week-13: Satellite image processing cycle
Week-14: Image enhancement techniques
Week-15: Data fusion and mosaicking and information extraction (classification and vectorization)
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Remote Sensing by Siamak Khorram, Frank H. Koch, Cynthia F. Van der Wiele.2012.Springer.
2. Introduction to geographic information systems by Kang-Tsung Chang. 2010. McGraw-Hill Publishers.
3. GIS: Fundamentals, Applications and Implementations by Elangovan. 2006. McGraw-Hill Publishers.
4. Remote Sensing of the Environment by John R. Jensen. 2009. Amazon publishers
5. Matt Duckham, Michael F. Goodchild, Michael F. Worboys, 2003, Foundations of Geographic Information Science, Tylor and Francis, New York, USA.
6. Michael N. Demers 2002, Fundamentals of Geographic Information System, John Wiley and Sons, Inc., Singapore.
7. Kang-Tsung Chang, 2002, Introduction to Geographic Information Systems, McGraw- Hill Company, New York, U.S.A.
8. W. G. Rees, 2001, Physical Principles of Remote Sensing Cambridge University Press, United Kingdom. ISBN: 0521669480.
9. Asanta Shrestha and Birendra Bajracharya, 2000, GIS for Beginners, By ICIMOD, Kathmandu, Nepal.

GEOL-351: 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.

Learning Outcomes:
The students will be able to understand, Basin mechanisms, environment of deposition and Sedimentary rock deposits in various depositional settings.

Course Contents:
Week-1: Introduction, history and significance of sequence stratigraphy
Week-2: Concepts and principles of sequence stratigraphy, Basin forming processes and basin margin concepts
Week-3: Concept of relative sea level, Eustasy and accommodation space
Week-4: Order of cyclicity and global correlation and sediment supply
Week-5: Basin architecture analysis and sequence stratigraphic surfaces
Week-6: Hierarchy of sequence stratigraphic elements; Sequence and types of sequence
Week-7: Introduction to systems tracts and types of systems tracts, low stand systems tract
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Transgressive systems tract, High stand systems tract
Week-10: Shelf-margin systems tract and introduction to high resolution sequence stratigraphy
Week-11: Parasequence, parasequence set and parasequence stacking pattern
Week-12: Seismic stratigraphy and seismic reflections concept
Week-13: Seismic facies analysis and identification of sequence stratigraphic surfaces and systems tracts on seismic data
Week-14: sequence stratigraphy of outcrop and core data and introduction to well logs
Week-15: Types of well logs and introduction to Chronostratigraphic charts
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Silici-clastic Sequence Stratigraphy in Well Logs, Cores and Outcrops by Van Wagoner, J.C., et al., 1990, AAPG Meth Expl. Ser. No.7.
2. Sea-level Changes an Integrated Approach by Wilgus, B.S., et al., 1988. SEPM.
3. Seismic Stratigraphy: Application to H-carbon Exploration by Payton, C.W., 1977, AAPG Mem. 26.
4. Sequence Stratigraphy and Facies Association by Posamentier, H.W., et al., 1993, Blackwell.
5. Sequence Stratigraphy by Emery, D. and Myers, K.J., 1996, Oxford, Blackwell.

GEOL-352: 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.

Learning Outcomes:
The students will be able to understand, the knowledge about the distribution of elements in minerals and rocks and their environments. Students will also learn the geochemical characteristic of various rocks and their role in mineral exploration.

Course Contents:

Week-1: Development of geochemistry as a discipline;

Week-2: Origin and cosmic abundance of elements

Week-3: Composition and types of meteorites

Week-4: Geochemical structure of the earth

Week-5: Geochemical classification of elements;

Week-6: Polymorphism andiso-structural minerals

Week-7: Pseudomorphism and its types;

Week-8: *Presentations, Quizzes and Assignments*

Week-9: Geochemical cycle; mobility and dispersion of elements under different geochemical environments;

Week-10: Introduction to geochemistry of igneous rocks

Week-11: Introduction to geochemistry of metamorphic rocks

Week-12: Introduction to geochemistry of sedimentaryrocks;

Week-13: Geochemical anomalies and their application in mineral exploration;

Week-14: Introduction to geochemical analytical techniques;

Week-15: Introduction to organic geochemistry, organic matter, types, and its importance in petroleum industry.

Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Introduction to Geochemistry by Krauskopf, K.B., 1967, McGraw-Hill.
2. Principles of Geochemistry by Mason. B., 1966, John Wiley and Sons.
3. Geochemistry in Mineral Exploration by Rose, A.W., Hawkes, H.H. and Webb, J.S., 1983, Whitstable Litho Ltd.
4. Inorganic Geochemistry by Henderson, P., 1982, Pergamon Press Ltd. Geochemistry by Brownlow, A.H., 1996, Prentice Hall.
5. Geochemistry by Beaumont, E.A., and Foster, N.H., 1988, AAPG Special Bulletin, Publication No.8.
6. Geochemistry. Pathways and Processes by McSween, H. Y., Jr, Richardson, S.M. and Uhle, M. E., 2003, Columbia University Press, New York.

GEOL-405: 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.

Learning Outcomes:
In this course the students will understand that how petroleum generates and how we explore it. After completion this course, the student will be able to do the basin analysis of prospect area to explore the petroleum.

Course Contents:
Week-1: Introduction and history of hydrocarbon exploration;
Week-2: The nature and classification of petroleum hydrocarbons,
Week-3: Origin of petroleum;
Week-4:kerogene and its types;
Week-5: Diagenesis and their different stages;
Week-6: Total Organic Carbons (TOC) and their procedure of determination;
Week-7: Rock-Eval pyrolysis and Vitrinite reflectance;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Reservoir characterization,Reservoir fluid, reservoir conditions and dynamics; tight reservoirs;
Week-10: Petroleum Traps;
Week-11: Migration of petroleum;
Week-12: Exploration petroleum cycle in Pakistan; prospect and exploration in frontiers areas;
Week-13: Introduction to drilling operations,Well site geology and mud logging;
Week-14: Petroleum prospect risk analysis; nonconventional hydrocarbons and well failure/success analysis;
Week-15: Introduction to play fairways and petroleum system.
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Elements of Petroleum Geology, Richard C. Selley, 1998, Acad. Press
2. Hydrocarbon Exploration and Production: Frank Jahn, Mark Cook and Mark Graham, 1998, Elsevier.
3. Wellsite Geological Techniques for Petroleum Exploration: Methods and Systems of Formation Evaluation, Bhagwan Sahay, Awadesh Rai, Manoj Ghosh, 1988, Oxford and IBH Pub. Co.
4. Petroleum Geology by North, F.K., 1985, Allen and Unwin.
5. Geology of Petroleum by Leverson, A.I., 1970, W.H. Freeman and Co.
6. Geology and Tectonics of Pakistan by Kazmi, A.H. and Jan, M.Q., 1997, Graphic Publishers.
7. Geology of Pakistan by Bender, F.K. and Raza, H.A., (eds.) 1995, Gebruder Borntraeger.
8. Hydrocarbons from Coal by Law, B.E., and Rice, D.D., 1993, AAPG Studies in Geology # 38
9. Principles of Petroleum Development Geology by London, R.C., 1996, Prentice Hall.
10. Petroleum Geology of the North Sea: Basic Concepts and Recent Advances by Glennie, K.W., 1998. Marston Book Services Ltd.

GEOL-354: 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.

Learning Outcomes:
Upon the completion of this course, the students will learn about the rock mechanics and their role in the construction of huge structure and will also know about geotechnical parameters of soil and rocks.

Course Contents:
Week-1: Introduction to the engineering geology and its application
Week-2: Weathering, physical and chemical
Week-3: Earthquakes, causes and intensity scale
Week-4: Rock mass classification
Week-5: Chemical and mechanical behavior of rocks
Week-6: Geotechnical studies of rocks and soils
Week-7: Geological factors and strength of rocks
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Geotechnical investigation
Week-10: Uses of sedimentary, igneous and metamorphic rocks as construction material
Week-11: Building Code of Pakistan
Week-12: Dam, geotechnical investigation and types of dam
Week-13: Tunnel, geotechnical investigation and there types
Week-14: Common engineering problems and their remedial measures
Week-15: Factors effecting strength of the rocks and petrographic control
Week-16: *Presentations, Quizzes and Assignments*

Labs: Sieve analysis, slake durability, moisture, void ratios, porosity, angleof 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
2. Engineering Geology: Principles and Practice by David George Price, Michael de Freitas – 2008.Springer.
3. Foundations of Engineering Geology by Waltham, T, 2002.
4. Engineering Geology by Goodman, R.E., 1993, John Wiley and Sons.
5. Rock Slope Stability Analysis by Gian Paolo Giani. 1992. Amazon.
6. Engineering Geology by F G Bell – 2007. Buttersworth.
7. Measuring Engineering Properties of Soil by Wray, W.K., 1986, Prentice, Hall.
8. Fundamentals of Engineering Geology by Bell, F.A.G., 1983, Butter, Worth.
9. Engineering Geology by Beavis, F.C., 1985, Blackwell.
10. Geology for Engineers by Blyth, F.G.H. and De Freites, M.H., 1960, Butter and Tonner Ltd.
11. Geology and Engineering by Legget, R.F., 1962, McGraw-Hill.

GEOL-355: 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.

Learning Outcomes:

Student should be able to classify metamorphic rocks according to the grade of metamorphism.

Course Contents:
Week-1: Introduction to metamorphism and their types;
Week-2: Agents of metamorphism;
Week-3: Groups of metamorphic rocks;
Week-4: Study of thermal and regional metamorphism of igneous, argillaceous, calcareous and arenaceous rocks;
Week-5: Grades of metamorphism;
Week-6: Zonesof metamorphism;
Week-7: Concept of metamorphic facie and their classification;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Metasomatism and their different types;
Week-10: Metamorphic diffusion and differentiation;
Week-11: Study of textures and structures of metamorphic rocks;
Week-12: Metamorphism and deformation;
Week-13: Metamorphism in relation to plate tectonics and Paired metamorphic belts.
Week-14: History and dating of metamorphic rocks;
Week-15: Himalayan and pre-Himalayan metamorphism in Pakistan.
Week-16: *Presentations, Quizzes and Assignments*

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.
2. Petrology of Igneous and Metamorphic Rocks, by Hyndmann, D.W., 1995, McGraw-Hill.
3. Petrology: Igneous, Sedimentary and Metamorphic by Blatt, H., Tracy, R. and Owens, D., 2005, W.H. Freeman and Co.
4. Metamorphism and Plate Tectonic Regimes by Ernst, W.G, 1975, Hutchison and Ross, Inc.
5. Metamorphic Petrology by Turner, F.J., 1981, McGraw Hill.

GEOL-356: 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.

Learning outcomes:
The students will be able to understand the basic principles of geological surveying and will know about the construction of profiles and cross sections, out crop sketches, scan line survey and geological mapping techniques.

Labs: Field based exercises. Observation and plotting of geologicalinformation on topographic sheet. Study of geomorphic features. Measurement of stratigraphic sections. Recognition of structural features. Study of fossils, primary and secondary structures. Field description of sedimentary, igneous and metamorphic rocks. Report writing based on geological mapping of an assigned area and fieldwork Viva Voce and Evaluation.

Recommended Books:

1. Elements of Field Geology by Himus, G.W. and Sweeting, G.S., 1968., University Tutorial Press Ltd.
2. Field Geology by Lahee, F.H. 1987, McGraw-Hill.
3. Geology in the Field by Compton, R.R. 1985, John Wiley and Sons.
4. Basic Geological Mapping by Barnes, J.W. and Lisle, R.J., 2004, John Wiley and Sons.

GEOL-401: Geology of Pakistan (3 credit hours)

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.

Learning outcomes:
After completing this course students will be able to know about the basic knowledge of various major and minor plates and their influence on the stratigraphy and mineral deposits of Pakistan.

Course Contents:
Week-1: Physiographic and tectonic divisions and their descriptions
Week-2: Geology and stratigraphy of the Indian plate, Karakoram plate, Afghan block and Arabian plate
Week-3: Waziristan, Kohistan, Chagai and RasKoh magmatic Arcs
Week-4: Sedimentary basins of Pakistan
Week-5: Makran subduction complex, Chaman transform zone and
Week-6: Arcs, oroclines and suture zones
Week-7: Pre-Himalayan orogenic events
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Late Precambrian to Early Cambrian Hazaran orogeny
Week-10: Himalayan division
Week-11: Regional metamorphism (Himalayan and pre-Himalayan
Week-12: Regional metamorphism (Himalayan and pre-Himalayan
Week-13: Main episodes of magmatism and their relations to tectonics
Week-14: Economic mineral and fuel deposits of Pakistan
Week-15: Economic mineral and fuel deposits of Pakistan
Week-16: *Presentations, Quizzes and Assignments*

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:

1. Geodynamics of Pakistan by Farah, A. and DeJong, K.A. (eds.), 1979, Geological Survey of Pakistan.
2. Geology of Himalaya, Karakuram, Hindukush in Pakistan by Tahirkheli, R.A.K., 1982, Geol. Bull., University of Peshawar.
3. Precambrian to early Paleozoic Orogenesis in the Himalaya, Baig, M.S., and Lawrence, R.D., 1987, Kashmir Journal of Geology, V.5, p.1-22.
4. Evidence for late Precambrian to early Cambrian orogeny in northwest Himalaya, Pakistan. Baig, M.S., Lawrence, R.D, and Snee, L.W., 1988, Geological Magazine, London, V. 125, No. 1, p. 83-86.
5. Timing of pre-Himalayan orogenic events in the northwest Himalaya: 40 Ar/ 39 Ar constraints. Kashmir Journal of Geology, Baig, M.S., Snee, L.W., La Fortune, R.J., and Lawrence, R.D., 1989, V. 6and7, p. 29-40.
6. Geochronology of pre-Himalayan and Himalayan tectonic events, northwest Himalaya, Pakistan,

Baig, M.S., 1991, Kashmir. Kashmir Journal of Geology, V.8 and 9, p. 197.
7. Geology of Himalaya by Gansser. A., 1964, John Wiley and Sons.
8. Reconnaissance Geology of West Pakistan, 1961, Hunting Survey, Report.
9. Geology and Tectonics of Pakistan by Kazmi, A.H. and Jan, M.Q., 1997, Graphic Publishers.
10. Stratigraphy and Historical Geology of Pakistan by Kazmi, A.H and Abbasi, I.A.,2008, Graphic Publishers, Karachi, Pakistan

GEOL-402: 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.

Learning Outcomes:

Upon completion of this course the students will be able to understand the different types of ore deposits, their association in different environments and the basic principal of mineral exploration and exploitation techniques.

Course Contents:

Week-1: Introduction to economic minerals and rocks and their classification;
Week-2: Environment and processes of formation of economic mineral deposits: magmatic segregation, hydrothermal solution, metasomatism, sedimentation, evaporation, residual and mechanical concentration and metamorphism;
Week-3: Detail description ofChromite and Carbonatite deposits and their examples from Pakistan.
Week-4: Detail description of Iron Ore deposits and their examples from Pakistan
Week-5: Brief description of economic minerals such as fuel minerals, gemstones, building and dimension stones.
Week-6: Placer deposits and their examples from Pakistan.
Week-7: Introduction of geological exploration/prospecting;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Relationship of mineral deposits to plate tectonic settings;
Week-10: Brief description of economic minerals such as copper,lead, zinc, iron, gold, manganese;
Week-11: Salt, gypsum, bauxite, sulphur, barite, fluorite, clays, phosphorite, building an dimension stones,
Week-12: Introduction to ore microscopy;
Week-13: Industrial rocks and minerals;
Week-14: Grade and reserve estimation of deposits;
Week-15: Radioactive minerals and rocks with special reference to Pakistan.
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Metals and Society: An Introduction to Economic Geology by Arndt, and C. Ganino – 2012, Springer.
2. Economic Geology: Principles and Practice by Walter L. Pohl – 2011, John Wiley and Sons.

3. Introduction to mineral exploration by Charles and Micheal. 2006, Black well.
4. Hand book of mineral and coal exploration in British Colombia by Aime and MABC.2009, Springer.
5. Directory of Mineral Deposits of Pakistan by Zaki, A., 1969, Geological Survey of Pakistan.
6. Ore Deposits by Park, C.F. and MacDiarmid, R.A., 1970, W. H. Freeman and Co.
7. Economic Mineral Deposits by Jenssen, M.L. and Bateman, A.M., 1972, John Wiley and Sons.
8. Mineral Prospecting Manual by Chausier, J.B., 1987, North OxfordAcademic Press.
9. An Introduction to Ore Geology by Evans, A.M., 1987, Blackwell.
10. Atlas: Economic Mineral Deposits by Dixan, C.J., 1979, Chapman Lordin and Hall.
11. Metallogeny and Mineral Deposits of Pakistan by Kazmi, A.H. and Abbas, S.G., 2001, Orient Petroleum Inc.
12. Handbook of Exploration Geochemistry, Govett , G.J.S. (ed.), 1995, Elsevier
13. Ore Deposit Geology by Edward, R. and Atkinsons, K., 1986, Chapman and Hall.
14. Introduction to Mineral Exploration, 2nd edition, by Moon, C.J., Whateley, M.K.G. and Evans, A.M. (Editors). 2006**,** Blackwell Publishing, Oxford.
15. Magmatic Sulfide Deposits: Geology, Geochemistry and Exploration by Naldrett, AJ., 2004

GEOL-403: 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.

Learning Outcomes:
Students attending this course will be able to, understand earthquakes and their types and causes, Volcanoes and related hazards, Flooding and their causes, related hazards and mitigation and about Landslides.

Course Contents:
Week-1: Introduction to environmental geology; management of natural resources
Week-2: Global climatic changes and their effects.
Week-3: Environmental controls for erosion, desertification and coastal degradation.
Week-4: Introduction to environmental impact assessment and initial environmental examination.
Week-5: Environmental impact of mining, dams, their assessment and controls.
Week-6: Environmental impact of reservoirs, highways, their assessment and controls.
Week-7: Geological hazards such as floods and their types, ,
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Landslides and their types, volcanoes and their types
Week-10: Earthquakes, tsunamis processes and their remedial measures .
Week-11: Glaciers and shoreline processes and their remedial measures, industrial pollution and their various types..
Week-12: Concept of solid and liquid waste disposal,groundwater contaminations
Week-13: River lake and marine pollution and their impact on human health
Week-14: Clean sources of energyand their types.
Week-15: Introduction to acid mine drainage, Presentations.
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Geology and the Environment by Bernard W. Pipkin, D. D. Trent, Richard Hazlett. 2010. Yolande Cossio. USA.
2. Environmental geology: handbook of field methods and case studies Klaus. Knödel, Gerhard Lange, Hans-Jürgen. Voigt. 2007, Springer, New York.
3. Environmental Geology by Montgomery, C.W., 2005, McGraw-Hill.
4. Radio Propagation and Remote Sensing of the Environment by Armanel, N.A., Polyakove, V.M., 2005, CRC Press.
5. Lab Manual for Environmental Geology by Harvey Blatt – 2012. Worth Publishers Environmental Geology by Keller, E.A., 2000, Prentice Hall, Publishing Co. New Jersey, US.
6. Applied Chemical Groundwater Hydrology by Mazore, E., 1988, McGill.
7. Earthquake Risk and Damage by Liu, B.C., 1981, Westview.

GEOL-404: 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.

Learning Outcomes:

Students attending this course will be able how to explore ground water resources and their management and will also know how to conserve water resources.

Course Contents:

Week-1: Introduction to hydrogeology, the hydrologic cycle.
Week-2: Aquifer system and its types;
Week-3: Occurrence and movement of groundwater;
Week-4: Hydrologic properties of rocks
Week-5: Measurements, fluctuation of groundwater levels and causes
Week-6: Recharge and discharge of ground water;
Week-7: Groundwater exploration by geological, hydro-geological methods;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Groundwater exploration bygeophysical methods and remote sensing techniques;
Week-10: Well hydraulics,
Week-11: Tube well drilling techniques, designing, development; flow-net analysis and pumping tests
Week-12: Water logging and causes of water table declination
Week-13: Groundwater chemistry, salinity,
Week-14: Quality analysis and deterioration of water quality.
Week-15: Groundwater resources of Pakistan.
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Hydrogeology: objectives, methods, applications by Ric Gilli, Eric Gilli, Christian Mangan , 2012, CRC Publishers Taylor and Francis Group, USA.
2. Hydrogeological Conceptual Site Models: Data Analysis and Visulization by Neven Krešić,

AlexMikszewski.2012. CRC Publishers Taylor and Francis group,USA.
3. Fundamentals of Hydrology by Tim Davie. 2012. Rourledge for Taylor and Francis group,USA.
4. Elementary Hydrogeology by Singh. 2010. Prentice Hall, USA.
5. Hydrogeology Lab Manual by Lee. 2010. Prentice Hall, USA.
6. Hydrogeology, Principles and Practice by Geofluids, S.Q.L., 2005, Blackwell Synergy.
7. Introduction to Hydrogeology by Geofluids, H., 2003, Blackwell Synergy.
8. Groundwater Hydrology by Todd, D.K., 1995, John Wiley and Sons.
9. Groundwater Resource Evaluation by Walton, W.C., 1970, McGraw-Hill.
10. Introduction to Groundwater by Michael, P. 1985, George Allen and Unwin.
11. Applied Hydrogeology by Fetter, C.W., 1994, MacMillan Pub. Co.
12. Groundwater by Ragunath, H.M., 1992, Wiley Eastern Ltd.
13. Groundwater Hydrology by Bouwer, H., 1988, McGraw-Hill.
14. Hydrology and Groundwater Resources of NWFP by Kruseman, G.P., 1988, WAPDA.
15. Field Hydrogeology by Brassington, R., 1988, John Wiley and Sons.

GEOL-451: Structural Methods (3 Credit Hours)

Objectives:
To get familiar with the advance level understanding of various structural elements found in the earth crust and types of illustration used in structural analysis.

Learning Outcomes:
After completion of this course the students will be able to conduct structural analysis in different types of terrains and will be able to prepare different type of surface and subsurface maps and cross sections

Course Contents:

Week-1: Fundamental classes of fold, Kinematic analysis of fold, Major structure associated with Folding

Week-2: Regional tectonic Fold mechanism, Cross section and map view of Fold Constructing profiles and Block diagrams of Folding

Week-3: Constructing profiles and Block diagrams of Folding, Busk and Dink Method for Fold, Profile Construction

Week-4: -do-

Week-5: Shear Fractures and its Importance

Week-6: Joint surface analysis, Patterns of Intersection and termination of joints

Week-7: Termination of joints and Systematic study of joints.

Week-8: *Presentations, Quizzes and Assignments.*

Week-9: Foliation and Types of Foliation, Lineation and Types of Lineation

Week-10: Cleavage and types of Cleavage, Geometric relationship of Cleavages; Tectonites and type of Tectonites, Linear structures

Week-11: Definition, Distinction and recognition of Fault, Classification of fault based on slip and separation

Week-12: Thrust Tectonics, Thrust System, Decollement and detachment

Week-13: Ramp Flat geometry, Duplex structure and Types of Duplex Structure

Week-14: Normal Faults, Strike slip Faults, Various Normal Fault Geometrics

Week-15:introduction to structural balancing technique and application of structural geology in exploration

Week-16: *Presentations, Quizzes and Assignments*

Labs: Map exercises and construction of geological cross-sections; orthographicprojections (geometrical exercises); b a s i c b a l a n c e c r o s s - s e c t i o n s, stereographic projections and use of structural computer software.

Recommended Books:

9. Structural Geology of Rocks and Regions, George H. Davis, Stephen J. Reynolds, Charles F. Kluth, 2011, John Willy and Sons.
10. Structural Geology, Haakon Fossen 2010, Cambridge University Press.
11. Structural Geology: An Introduction to Geometrical Techniques, Donal M. Ragan, 2009, Cambridge University Press.
12. Foundation of Structural Geology by Park, R. G., 1983, Blackie.
13. Structural Geology of Rocks and Regions by Davis, G. H. and Reynolds, S. J., 1996, John Wiley and Sons.
14. Laboratory Exercise Book in Structural Geology by Ghauri, A. A. K., 1989, National Centre of Excellence in Geology, University of Peshawar.
15. An Introduction to Geological Structures and Maps by Bennisen, G. M., 1975, Edward Arnold.
16. Structural Geology by Twiss, R. J. and Moores, E. M., 1995, W. H. Freeman and Co.

GEOL-____: Elective **(3 credit hours)**

GEOL-____: Elective **(3 credit hours)**

GEOL-____: Elective **(3 credit hours)**

GEOL-498: Thesis/Research Project **(6 Credit hours)**

Objectives:
The students will be assigned projects in any discipline of geology of their interest. Individual or group of students will work under the supervision a faculty member and will learn how to prepare workflow of a given project and basic procedure of report writing.

Learning Outcomes:
At the end of this exercise each student will have the skills of preparing project reports assigned to him in any geological organization.

GEOL-452: Internship/Practical Training/Geological field work (S/U* Based)

ELECTIVE COURSES

GROUP-I: MINERALOGY AND PETROLOGY

Objectives:

The courses for this group of specialization have been designed to offer advance 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.

Learning Outcomes:

After the completion of this course, students will be able to interpret rocks types in thin sections under microscope and Rock-Classification based on their mineral composition.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. GEOL-406: Geochemistry II (3 credit hours)

Course Contents:

Week-1: Geochemistry of igneous Rocks,

Week-2: Geochemistry of sedimentary

Week-3: Geochemistry of metamorphic rocks;

Week-4: Modal analysis for classification, chemical characterization and identification of minerals;

Week-5: -do-

Week-6: Classification and distribution of elements in the earth crust;

Week-7: Introduction to analytical geochemistry (X-Ray fluorescence spectrometry, Atomic absorption);

Week-8: *Presentations, Quizzes and Assignments*

Week-9: Introduction to analytical geochemistry (Inductive coupled micro spectrometry, LA ICPMS)

Week-10: Causes for geochemical diversity in the igneous rocks;

Week-11: Geochemical characteristics of igneous rocks as petrogenetic indicators;

Week-12: Geochemical process which modify the composition of primary magmas;

Week-13: Geochemical characteristics of different magma series;

Week-14: Geothermometry and geobarometry;

Week-15: Metasomatic processes and environment.

Week-16: *Presentations, Quizzes and Assignments*

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:

1. Igneous and Metamorphic Petrology by Best, M.G., 1982, W. H. Freeman and Co.
2. Petrogenesis of Metamorphic Rocks by Butcher, K. and Frey, M., 1994. Springer-Verlag.
3. The Interpretation of Igneous Rocks by Cox, K.G., Bell, J.D. and Pankhurst, R. J., 1979. George Allen and Unwin.
4. Petrology of the Igneous Rocks by Hatch, F.H., Wells, A.K. and Wells, M.K., 1975, Murby.
5. Introduction to Geochemistry by Krauskopf, K.B., 1982, McGraw-Hill.
6. Petrology by Nockolds, S.R., Knox, R.W. O'B. and Chinner, G.A., 1978, Cox and Wyman.
7. Using Geochemical Data: Evaluation, Presentation and Interpretation by Robinson, 1993, Longman.
8. Geochemistry by Wedepohl, K.H., 1967, Holt, Rinenhart and Winston.
9. Igneous Petrogenesis by Wilson, M., 1989, Academic Press.
10. Geochemistry, by Brownlow, A.H., 1996, Prentice Hall.
11. Magmatic Sulfide Deposits: Geology, Geochemistry and Exploration by Naldrett, AJ., 2004
12. Geochemistry. Pathways and Processes by Mcsween, H. Y., jr, Richardson, S.M. and Uhle, M. E., 2003, Columbia University Press, New York.
13. Quantitative Geochemistry by Zou, H., 2007

2. GEOL-407:Igneous Petrogenesis **(3 credit hours)**

Course Contents:

Week-1: Mantle-magma systems and source of magma;
Week-2: Physico-chemical factors in magmatic evolution;
Week-3: Petrogenesis of igneous rocks;
Week-4: Petrogenic provinces: basaltic provinces,
Week-5: Granite-granodiorite provinces
Week-6: Mafic-ultramafic complexes;
Week-7: Tectonism-magmatism relationship;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Magmatism at convergent and divergent plate boundaries;
Week-10: Intracontinental hot spots;
Week-11: Intraplate magmatism;
Week-12: Magmatism related to collisional environments and island arcs;
Week-13: Ophiolites;
Week-14: Volcanic chains and island arcs.
Week-15: Igneous rock associations.
Week-16: *Presentations, Quizzes and Assignments*

Labs:Petrographic study of rock suits. Modal analyses and discriminatediagrams.

Recommended Books:

1. Igneous Petrology by Hill, A., 1987. Longman Scientific and Technical.
2. Petrology: Igneous, Sedimentary and Metamorphic by Ehlers, E.G. and Blatt, H.W.H., 1982, W. H. Freeman and Co.
3. Petrology: Igneous and Metamorphic Rocks by Hyndman, D.W., 1972, McGraw-Hill.
4. Igneous and Metamorphic petrology by Best, M.G., 1982, W.H., 1982, W. H. Freeman and Co.
5. Igneous and Metamorphic Petrology by Turner, F.J. and Verhoogen, J. 1960, McGraw-Hill.
6. Igneous Petrogenesis by Wilson, M., 1989, Unwing Hyman.
7. Igneous Petrogenesis by Carmichael, I.S.E., Turner, F.J. and Verhoogen, J., 1974, McGraw-Hill.
8. Igneous Petrology by McBirney, A.R., 1984, Freeman Cooper and Co.
9. Introduction to Igneous and Metamorphic Petrology by Winter, J.D, 2001. Prentice Hall.

3. GEOL-408: Metamorphic Petrology-II (3 credit hours)

Course Contents:

Week-1: Basic characteristics of metamorphic reactions and role of fluids;
Week-2: Concept of iso-grades and iso-reaction grades;
Week-3: Very low grade and low grade metamorphism
Week-4: Ocean floor metamorphism
Week-5: Contact and regional metamorphism;
Week-6: Metamorphic facies series; P-T gradients,
Week-7: Mineralogical characteristics of individual facies;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Progressive and retrogressive metamorphism of pelites,
Week-10: Progressive and retrogressive metamorphism of basic rocks
Week-11: Progressive and retrogressive metamorphism of carbonates;
Week-12: High grade metamorphism, anataxis and migmatites;
Week-13: Tectonics of regional metamorphic belts;
Week-14: Paired metamorphic belts; metamorphic structure of continental crust;
Week-15: Metasomatic processes.
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Petrology: Igneous, Sedimentary and Metamorphic by Ehlers, E.G. and Blatt, H.W.H., 1982, W. H. Freeman and Co.
2. Igneous and Metamorphic Petrology by Hyndman, D.W., 1972, McGraw-Hill.
3. Igneous and Metamorphic Petrology by Best M.G., 1982, W. H. Freeman and Co.
4. Metamorphic petrology by Turner, F.J., 1981, McGraw-Hill.
5. Metamorphism and Plate Tectonics Regimes by Ernst, W.G. 1975, Dowden, Hutchisnson and Ross, Inc.
6. Petrology of the Metamorphic Rocks by Mason, R., 1981, George Allen and Unwin/Thomas Murby.
7. Introduction to Igneous and Metamorphic Petrology by Winter, J.D., 2001, Prentice Hall.

3. GEOL-409: Sedimentary Petrology-II (3 credit hours)

Course Contents:

Week-1: Classification of sedimentary rocks and introduction to Clastic sedimentary rocks
Week-2: Diagenesis of Clastic sedimentary rocks like Conglomerates and classification of conglomerates
Week-3: Description of breccias and types of breccia
Week-4: Description and diagenesis of Sandstone,
Week-5: classification of sandstone and Description of siltstone,claystone,Mudstone and shale
Week-6: Introduction to Non clastic sedimentary rocks like limestone and dolostone
Week-7: Diagenesis of limestone and classification of limestone
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Description of dolostone,chert and evaporates and coal
Week-10: Sedimentary environemts like fluvial and desert environment
Week-11: Glacial environment and lacustrine environment
Week-12: Lagoonalenvironment, eusturay environment
Week-13: Deltaic environment and tidal environment
Week-14: Shallow marine and deep marine environments
Week-15: Framework, geometry, texture and composition; study of heavy minerals; provenance of sedimentary rocks.
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Principles of Sedimentology and Stratigraphy by Boggs, S., 2001, Prentice Hall.
2. Sedimentary Geology by Prothero, D., Schwab, F., 1996, W.H. Freeman and Co.
3. Sequence Stratigraphy by Emery, D. and Myers, K.J., 1996, Blackwell.
4. Sedimentary Petrology, An Introduction by. Tucker, M.E., 1981, Blackwell.
5. Sedimentary Rocks by Pettijohn, F. J., 1975, Harper and Row.
6. Sedimentary Petrology by Tucker, M. E., 1990, Blackwell.

5. GEOL-410: Mineralogy-II (3 credit hours)

Course Contents:

Week-1: Physical and chemical properties of minerals;
Week-2: Relationship between the structure, chemistry and properties of silicates (Olivine group, Garnet group, Monticellite).
Week-3: Beryl, tourmaline, zircon, staurolite, corderite
Week-4: Relationship between the structure, chemistry and properties of carbonates,
Week-5: Relationship between the structure, chemistry and properties of oxides,
Week-6: Relationship between the structure, chemistry and properties of sulphides,
Week-7: Relationship between the structure, chemistry of phosphates;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Mechanisms of mineral nucleation and crystal growth;
Week-10: Importance of kinetics in mineral formation;
Week-11: Interpretation of mineral analysis.
Week-12: Measurement of mineral triple junction angles;
Week-13: Description of grain boundaries and their implication for the development of rock textures;
Week-14: Microscopic identification of the common rock forming minerals in thinsectionWeek-**Week-15:** Triangular and X-Y plots; mineralogical evaluation for the assessment and performance of industrial rocks and minerals.
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Mineralogy for Students by Battey, M. H., 1981, Longman.
2. Mineralogy by Berry and Masson, 1983, W. H. Freemen and Co.
3. Mineralogy by Perkins, D., 2002, Prentice Hall.
4. Minerals in Thin Sections by Perkins, D., 2000, Prentice Hall.
5. Petrology of Igneous an d Metamorphic rocks by Philpotts, A.R., 1989, Prentice Hall.
6. Atlas of Rock Forming Minerals in Thin section by Mackenzie, W.S., Guilford, C.P., 1980, John Wiley and Sons.
7. Introduction to Rock Forming Minerals by Deer, W.A., Howie, R.A., and Zussman, J., 1992, Longman.

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.

Learning Outcomes:
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. Palynology and Paleobotany

1. GEOL-411: Palynology and Paleobotany (3 credit hours)

Course Contents:

Week-1: Introduction;
Week-2:methods of study of pollen and spores;
Week-3:techniques of collection and preparation of palynomorphs;
Week-4:types and functions of spores;
Week-5: Pollen and spores morphology;
Week-6:development of homospores;
Week-7: Classification of pollen and spores
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Suprageneric classification of triletspores;
Week-10:distribution of palynomorphs during various geological periods with special reference to Pakistan;
Week-11:scope and application of palynology in petroleum industry;
Week-12:study of nano fossils.
Week-13:aims and objectives of paleobotany.
Week-14: Taxonomy of fossils and study of various groups of fossil plants.
Week-15: Paleobotany as fossil fuels.
Week-16: *Presentations, Quizzes and Assignments*

Labs: Identification of Gondwanic and other flora from Pakistan.

Recommended Books:

1. Microfossils by Braiser, M.D., 1980, Allen and Unwin.
2. Introduction to Marine Paleontology by Haque and Boersman, 1980, Elsevier.
3. Paleobotany by Stewart, W. N., 1983, Cambridge Press.
4. Principles of Paleobotany by William, C. D., Latest Ed, Ronall Press.

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.

Learning outcomes:
Upon completion of this course the students will be able to understand the different types of ore deposits, their association in different environments and the basic principal of mineral exploration and exploitation techniques. Ore reserve calculation and their economic significance. Students will also be able to understand identification of gems and gemstones and 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. Mineral Deposits of Pakistan

1. GEOL-412: Ore Deposits (3 credit hours)

Course Contents:

Week-1: Magmatic deposits: The ultramafic-mafic Cr-Ni-PGE deposits;
Week-2:the mafic-ultramafic Fe-Ni-Cu sulphide deposits,
Week-3:the quartz monzonite-granodiorite,
Week-4: Stratiform and Podiform Chromite deposits,
Week-5: Carbonatite deposits,
Week-6: Cu-Mo sulphide deposits and the anorthosite-gabbro Fe-Ti deposits.
Week-7: Porphyry type deposits;
Week-8: *Presentations, Quizzes and Assignments*

Week-9:hydrothermal vein deposits,
Week-10: Sedimentary Iron Ores,
Week-11:iron and manganese concentration of sedimentary affiliation;
Week-12:stratiform and stratabound sulphides deposits;
Week-13:ores formed by metamorphic and metasomatic processes;
Week-14: Placer deposits,
Week-15:tectonic setting and mineralization.
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Ore Deposits Geology by Edwards, R. and Atkinson, K., 1986, Chapman and Hall.
2. An Introduction to Ore Geology by Evans, A.M., 1980, Blackwell.
3. Mineral Deposits and Global Tectonic Settings by Mitchell, A.H.J. and Garson, M.S., 1981, Academic Press.
4. Mineral Deposits in Relation to Plate Tectonics by Sawkins, F.J., 1984, Springer-Verlag.
5. Ore Petrology by Stanton, R.L., 1972, McGraw-Hill. Metallogeny and Plate Tectonics by Strong, D.F. (ed.), 1976, Geol. Assoc. Canada.

2. GEOL-413: Mineral Exploration (3 credit hours)

Course Contents:

Week-1: Field exploration techniques;
Week-2: Mineral potential of Pakistan;
Week-3: Reserve identification and estimation;
Week-4: Grade analysis; risk assessment and economic evaluation;
Week-5: Geochemical exploration:
Week-6: Principles of geochemical dispersion, choice of media for sampling,
Week-7: Field methods and sampling theory,
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Analytical methods and quality control, and data interpretation,
Week-10: Geochemical and metallogenicprovinces
Week-11: Geochemical survey of rock, soil, water and stream sediments for mineral exploration.
Week-12: Case studies and exercises on geochemical and geophysical data interpretation.
Week-13: Geophysical exploration: principal geophysical techniques, including magnetic, electromagnetic methods as applied to mineral exploration.
Week- 14: Electrical, radiometric methods as applied to mineral exploration.
Week-15: Gravity and seismic methods as applied to mineral exploration.
Week-16: *Presentations, Quizzes and Assignments*

Labs: Case studies and exercises on geochemical and geophysical datainterpretation.

Recommended Books:

1. Economic Evaluation in Exploration, by Friedrich, W.W., 1986, Springer-Verlag.
2. Statistics and Data Analysis in Geology, by Davis, J.C., 1986, John Willey and Sons.
3. Geological Problem Solving with Lotus 123 for Exploration and Mining.
4. Geology, by George, S. Koch, G.S Jr., 1990, Pergamon Press.
5. Geochemistry in Mineral Exploration by Rose, A.W., Hawkes, H.E. and Webb, J.S., 1983, Whitstable Litho Ltd.
6. Geochemical Exploration by Joyce, A.S., 1984, Australian Mineral Foundation.
7. Mineral Prospecting Manual by Chaussier, J.B. and Morer, J., 1987, North Oxford Academic.
8. Exploration and Mining Geology by Peters, W.C., 1978, John Wiley and Sons.
9. Techniques in Mineral Exploration by Reedman, J.H., 1979, Applied Science Publishers.
10. Exploration Methods: Course Notes by Claverino, J., Dawney, R. and Stephenson, P., 1994, Australian International Assistance Bureau.
11. Evaluation of Mineral Reserves by Journal, A.G., 2004, Oxford University Press.
12. Introduction to Mineral Exploration, 2nd edition, by Moon, C.J., Whateley, M.K.G. and Evans, A.M. (Editors). 2006, Blackwell Publishing, Oxford.

8. GEOL-414: Mineral Deposits of Pakistan (3 credit hours)

Course Contents:

Week-1: Introduction to ore forming processes and environments of mineralization;
Week-2: Plate tectonics and mineralization;
Week-3: Metalogenic provinces of Pakistan.
Week-4: Metallic mineral (copper, copper-gold-silver, PGE, iron, chromite, bauxite, lead-zinc, antimony, manganese) deposits of Pakistan;
Week-5: Fuel minerals (coal, radioactive minerals) of Pakistan.
Week-6: Introduction to petroleum and gas deposits of Pakistan;
Week-7: Petroleum producing areas of Pakistan;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Gemstones of Pakistan;
Week-10: Construction and building stones of Pakistan;
Week-11: Mineral specimens and decorative stones of Pakistan;
Week-12: Dimension stones of Pakistan;
Week-13: Ceramic minerals (clay minerals, silica sand, K/Na feldspars, nepheline syenite);
Week-14: Cement raw materials (limestone, gypsum, laterite etc.);
Week-15: Miscellaneous industrial minerals (rock phosphate, barite, asbestos, magnesite, mica, ochre, soapstone, dolomite etc.);
Week-16: *Presentations, Quizzes and Assignments*

Labs: Visits to various mineral deposits.

Recommended Books:

1. Kazmi, A. H., and Jan, M. Q., 1997. Geology and Tectonics of Pakistan. Graphic Publishers, Karachi, Pakistan.
2. Kazmi, A. H., and Snee, L. W., 1989. Emeralds of Pakistan: Geology, gemology and genesis. Van Nostrand Reinhold, New York, USA.
3. Ahmad Z., 1969. Directory of Mineral Deposits of Pakistan. Records of the Geological Survey of Pakistan, Quetta, Pakistan.
4. Bender, F.K. and Raza, H.A., 1995. Geology of Pakistan. Borntraeger, Berlin.
5. Kazmi, A. H., and Siddiqi, R. A., 1996. Significance of the Coal Resources of Pakistan. Geological Survey of Pakistan and U. S. Geological Survey.

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.

Learning Outcomes:

Upon completion of these courses the students will be able to know about the rock and soil mechanics. Their knowledge will be able them to carry out their independent research on the site investigation, infrastructure development and evaluation of construction materials.

This group comprises the following courses:

1. Rock Mechanics
2. Soil Mechanics
3. Engineering Geology II

1. GEOL-415: Rock Mechanics (3 credit hours)

Course Contents:

Week-1: Fabric and mechanical nature of rocks.
Week-2: Determination of rock quality for engineering purposes.
Week-3: Stress strain behaviors of different rocks
Week-4: Rock mass strength
Week-5: Theories of rock mass failure
Week-6: Types of fracture in rock mass
Week-7: Rock deformation in compression
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Factors controlling mechanical behaviors of rocks
Week-10: Excavation methods in rocks.
Week-11: Distribution of stresses around underground excavations
Week-12: Use of photo elasticity in rock mechanics
Week-13: Measurement of stresses in situ
Week-14: Wave propagation in rocks.
Week-15: Dynamic models of rock mechanics
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Rock Mechanics for Underground Mining by Brady, B.H.G. and Brown, E.T., 1985, Allen and Unwin.
2. Engineering Geology by Beavis, F.C., 1985, Blackwell.
3. Structural and Geotechnical Mechanics by Newwark, N.M., latest Ed., Prentice Hall.
4. Engineering Geology and Rock Mechanics by Duncan, N., 1969, Leonar Hill.

2. GEOL-416: Soil Mechanics (3 credit hours)

Course Contents:

Course Contents:

Week-1: Introduction and concept of soil mechanics
Week-2: Soil formation and its classification
Week-3: Survey and soil sampling
Week-4: Important soil engineering properties
Week-5: Methodology and Technique for measuring soil engineering properties
Week-6: soil gradation and sieve analysis
Week-7: Soil classification scheme, AASHTO and UCS system
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Soil physical properties include moisture contents, void ratios, density and permeability
Week-10: phase system of soil i.e. three phase and two phase system.
Week-11: Soil mechanical properties such as shearing strength, bearing capacity, consolidation and settlements
Week-12: application of soil in construction site
Week-13: Seismic response and associated Hazards with soil foundation
Week-14:case histories of important engineering projects foundation on soil.
Week-15: Industrial utilization of soil
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Problems in Engineering Soils by Capper, P.L. and Cassie W.E. and Geddes, J.D., latest Ed., John Wiley and Sons.
2. Engineering Geology by Beavis, F.C., 1985, Black well Scientific Publications.
3. Structural and Geotechnical Mechanics by Newwark, N.M., latest Ed., Prentice Hall.
4. Engineering Geology and Rock Mechanics by Duncan, N., latest Ed., Leonar Hill.

4. GEOL-417: Engineering Geology II (3 credit hours)

Course Contents:

Week-1: Rock mechanics and its application in civil engineering
Week-2: Study of geological factors in relation to the construction of buildings and foundations
Week-3: Study of geological factors in relation to the construction road, highways, excavation and tunneling, mine openings, dams and bridges
Week-4: Construction materials
Week-5: Slope stability analysis
Week-6: Application of geophysical methods for site investigation
Week-7: Hazard assessment
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Construction in earth-quake zone
Week-10: Geological investigations of dam site and their types
Week-11: Characterization of landslides their geometry, causes and preventive methods
Week-12: soil mechanics and its application in construction
Week-13: ground water and character of ground water
Week-14:case histories of important engineering projects (small and mega) in Pakistan
Week-15: Building, dimension and aggregate assessment of various rocks
Week-16: *Presentations, Quizzes and Assignments*

Labs: Specified assignments/projects.

Recommended Books:

1. Principles of Engineering Geology by Attewell, P. B. and Farmer, I. W., latest Ed., John Willey and Sons.
2. Engineering Geology by Beavis, F.C., 1985, Blackwell Scientific Publications.
3. Principles of Engineering Geology by Johnson, R.B. and Degraff, J. V., latest Ed., John Willey and Sons.
4. Fundamentals of Engineering Geology by Bell, F.A.G., 1983, Butter Worth.
5. Engineering Geology by Goodman, R.E., 1993, John Wiley and Sons.
6. Foundations of Engineering Geology by Waltham, T, 2002.
7. A Geology for Engineers (7^{th} edition) By F.G.H Blyth PhD 1984.

GROUP-V: 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

Learning outcomes:
After completion of course students will be able to understand sedimentary structure and classification of different sedimentary rocks. The students will also 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. Basin Modeling
2. Carbonate Sedimentology

GEOL-418: Basin Modeling (3 credit hours)

Course Contents:
Week-1: Sedimentary Basins and its classification;
Week-2: Mechanism for formation of sedimentary basins;
Week-3: Types of basins i.e. divergent and convergent plate margin basins; foreland, forearc and back arc basins;
Week-4: Types of basins: transform margins; rift and pull apart basins;
Week-5: Basins associated with sutures; cratonic basins and others;
Week-6: Sedimentation and plate tectonics;
Week-7: Clastic and non-clastic petrofacies;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Factors controlling basin stratigraphy and tectonic mechanism;
Week-10: Eustatic and relative sea level changes; causes and response; tectonic vs. eustatic controls;
Week-11: Sedimentary basins of Pakistan;
Week-12: Concept of 1D, 2D, 3D and 4D basin modeling for petroleum exploration;
Week-13: Burial history curve, geothermal gradient, heat flow;
Week-14: Maturity levels of source rocks;
Week-15: Expansion and migration into traps;
Week-16: *Presentations, Quizzes and Assignments*

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:

1. Basin analysis: Principles and Applications by Allen, P.A. and Allen, J.R. 1990 Blackwell Scientific Publications Foreland Basins by Allen, P.A. and Homewood. P and William G.D., 1986, Blackwell Scientific Publications.
2. Sedimentary Basin Evolution, Facies and Sediment Budget by Einsle, G., 1992.
3. Sedimentary Environment and Facies by Reading, H.G., 1986, Blackwell Scientific

Publications.
4. Geology and Tectonics of Pakistan by Kazmi, A.H. and Jan, Q., 1997, Graphic Publishers.
5. Geology of Pakistan by Bender and Raza, (ed.) 1995, Gebruder Borntraeger.
6. Sedimentary Petrology by Tucker, M.E., 1991, Blackwell Publications.
7. Principles of sedimentary Basin Analysis by Andrew D. Mial, 1990, Springer-Verlag, New York Inc.
8. Stratigraphy and Historical Geology of Pakistan by Kazmi, A.H and Abbasi, I.A., 2008, Graphic Publishers, Karachi, Pakistan

2. GEOL-419: Carbonate Sedimentology (3 credit hours)

Course Contents:

Week-1: Carbonate mineralogy and chemistry, structure of aragonite, calcite and dolomite;
Week-2: Trace elements and isotopes, dolomite and dolomitization models: modern and ancient examples.;
Week-3: Dolomitization reactions, trace element geochemistry of dolomites, dolomite petrography;
Week-4: Depositional textures and structures: carbonate constituents, algal stromatolites;
Week-5: Classification of carbonates by Folk and Dunham; porosity types;
Week-6: Concept of microfacies and microfacies types of Wilson;
Week-7: Microfacies types of Burchett and Wright for carbonate ramps**.**
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Major controls on carbonate sedimentation;
Week-10: Depositional processes and facies carbonate rocks;
Week-11: Carbonte depositional models, platforms, rimmed shelves, ramps, epieric platforms and isolated platforms; cyclicity in carbonates;
Week-12: Modern carbonate environments of Bahamas, Florida and Persion Gulf;
Week-13: Carbonate depositional systems; lacustrine, shore line, peritidal reefs;
Week-14: Shallow and deep water carbonate depositional systems;
Week-15: Diagnetic processes and sequences and models;
Week-16: *Presentations, Quizzes and Assignments*

Labs: Identification of carbonate sediments in hand specimen and thinsections; staining; microfacies interpretations and XRD techniques.

Recommended Books:

1. Carbonate Sediments and their Diagenesis by Bathurst, R.G., latest Ed., Elsevier.
2. Marine Carbonate by Milliman, J.D., 1974, Springer-Verlag.
3. Carbonate Depositional Environment by Scholle, P.A. Bebout, D.G. and Moore, C.H., AAPG Mem.
4. Carbonate Sedimentology by Tucker, M.E. and Wright, V.P., 1990, Blackwell Scientific Publications.
5. Carbonate Depositional Environments by Scholle, P.A.,, Bebout, D.G. and Moore, C.H., 1993, Mem. Am. Assoc. Petrol. Geol.

GROUP-VI: 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.

Learning Outcomes:
Aftercompletingthese 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

1. GEOL-453: Industrial Mineralogy - I (3 credit hours)

Course Contents:

Week-1: Physical and chemical properties of minerals;
Week-2: Relationship between the structure, chemistry and properties of carbonates, sulphates, **Week-3:** Silica minerals, feldspars, clay minerals, nepheline,
Week-4: Serpentinite, amphiboles, micas, olivine and phosphates.
Week-5: Mechanisms of mineral nucleation and crystal growth; importance of kinetism in mineral formation.
Week-6: 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;
Week-7: Interpretation of phase diagrams including the SiO2-SiO2, Al2O3-SiO2-Al2O3-K2O- SiO2, CaO-MgO-SiO2, Al2O3-CaO;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Drawing of isothermal sections through ternary phase diagram and their relevance; **Week-10:** Plotting data on triangular diagrams;
Week-11: Measurement of mineral triple junction angles,
Week-12: Description of grain boundaries and their implication for the development of rock textures;
Week-13: Use of a variety of computer programs, including spreadsheets, calculate mineralogical parameters;
Week-14: triangular and X-Y plots;
Week-15: Relating mineralogical information to the assessment and performance of industrial rocks and minerals.
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Mineralogy for Students by Battey, M.H., 1981, Longman.
2. Process Mineralogy of Ceramic Materials by Baumgart, W., Dunham, A.C. and Amstutz, G.C., 1988, Enke, Stuttgart.
3. Crystal structures of clay minerals and their X--ray Identification by Brindley, G.W. and Brown, G., 1980, Mineralogical Society.

4. An Introduction to the Rock-Forming Minerals by Deer, W.A., Howie, R.A. and Zussman, J., 1992, Longman.
5. A practical introduction to optical mineralogy by Gribble, C.D. and Hall, A.J., 1985, George Allen and Unwin.
6. Applied Mineralogy by Jones, M.P. 1987, Graham and Trotman.
7. X-ray diffraction and the identification and analysis of clay mineral by MOORE, D.M. and Reynolds, Jr., R.C., 1989, Oxford University Press.
8. An introduction to Metamorphic Petrology by Yardley, B.W.D., 1989, Longman.
9. Minerals and rocks for industry by Ahmad, Z. and Siddiqi, R.A., 1992, Geological survey of Pakistan, Quetta.

GROUP-VII: 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.

Learning Outcomes:
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. Natural Resource Management

6. GEOL-454: Natural Resource Management (3 credit hours)

Outcomes:

The outcome of this course is to develop an understanding of the environmental problems and ethical issues facing humans and the environment and to gain acquire knowledge and skills about health and safety protocols when working with chemical standards and reagents.

Course Contents:

Week-1: Introduction to natural resources and their sustainable management;
Week-2: Requirements of a management plan;
Week-3:forest types and methodologies of watershed management;
Week-4:existing status of rangeland management;
Week-5:existing situation of wildlife at national level;
Week-6:wildlife census;
Week-7:threats faced by wildlife;
Week-8: *Presentations, Quizzes and Assignments*
Week-9:available water resources and threats;
Week-10:effective management plan;
Week-11:fisheries management,
Week-12:existing situation of agricultural sector;
Week-13:agricultural products and their share in GDP;
Week-14:problems faced by agricultural sector;
Week-15:agricultural policy and management options.
Week-16: *Presentations, Quizzes and Assignments*

Labs: Case histories and case studies of natural parks of Pakistan; visit tonatural 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. 2006, Cunningham and Mary Ann Cunningham.
2. Living in the Environment by Miller Jr. G.T (12th edition, 2002).
3. Natural Resource Conservation by Trivedi, P.R. (1st edition, 2004)
4. Crop Production by Nazir, S. (1st Edition, 1999)

GROUP- VIII: STRUCTURE, TECTONICS ANDNEOTECTONICS

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.

Learning Outcomes:
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. Earthquake Seismology (For course contents, see Group-VI)
6. Geological and Geophysical software applications (For course contents, see Group-V)

1. GEOL-455: Structural Geology II (3 credit hours)

Course Contents:
Week-1: Introduction,Stress and strain;
Week-2: planar and linear fabrics: analyses of fabrics, axial plane foliations/cleavages and their types and origin,
Week-3: transposed foliations, lineation types and origin;
Week-4: fabrics as kinematics indicators;
Week-5: structures in folded rocks: fold morphology and classifications,
Week-6: mechanisms of folding,
Week-7: strain and small scale structures in folds,superposed folding;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: fault geometry and morphology: classification of fault systems,
Week-10: geometry of 1) extensional, 2) strike slip and 3) thrust fault systems;
Week-11: fractures and joints**:** mechanical analyses of fractures;
Week-12: ductile and brittle shear zones;
Week-13: sense of shear indicators, strain markers, strain measurement methods,
Week-14: geometric and genetic classification of joints,
Week-15: analyses of joints in uniformly dipping strata and in folded rocks; tectonites; structural techniques and retrodeform sections

Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Structural Geology by Hatcher, R. D., 1995, Prentice Hall.
2. Structural Geology of Rocks and Regions by Davis, G. H. and Reynolds, S. J., 1996, Wiley
3. Structural Geology by Twiss, R. J. and Moores, E. M., 1992, Freeman.
4. An Outline of Structural Geology by Hobbs, B.E., Means, W. D. and Williams, P. F., 1976, John Willey and Sons.
5. Principals of Structural Geology by Suppe, J., 1985, Prentice Hall.
6. The Techniques of Modern Structural Geology. V.I Stress and Strain by Ramsay J.G. and Huber, M.I., 1983, Academic Press.
7. The Techniques of Modern Structural Geology. V.II Folds and Fractures by Ramsay J.G. and Huber, M.I., 1987, Academic Press.
8. Appropriate Structural Computer Software.

2. GEOL-456: Metamorphic Structures (3 credit hours)

Outcomes:

After completion this course the students will be able to understand that how different metamorphic textures and structures develop in metamorphic rocks. They will also be able to link the observed metamorphic structures to their genesis.

Course Contents:

Week-1: Microstructures in deformed and metamorphosed rocks;
Week-2: crystal defects, crystal plasticity, dislocations;
Week-3:annealing recrystallization, recovery,
Week-4:primary and secondary recrystallization;
Week-5:dynamic recrystallization, stress induced recrystallization;
Week-6:strain induced recrystallization and associated microstructures;
Week-7:driving forces for dynamic recrystallization;
Week-8: *Presentations, Quizzes and Assignments*

Week-9:dynamic recrystallization by subgrain rotation and grain boundary migration;controls on migration rates;
Week-10: Ductile shear zones; mylonites, terminology; microstructures, planar and linear d uctile fabric and kinematic indicators;
Week-11:petrofabrics: factors controlling fabric development,
Week-12:fabric representation-pole and inverse pole figures, orientation distribution functions;
Week-13:measuring techniques, pressure solution and metamorphic differentiation;
Week-14: Metamorphic textures;
Week-15: Cataclastic deformation;sense of shear indicators;
Week-16: *Presentations, Quizzes and Assignments*

Labs: Microscopic studies of metamorphic textures and structures.

Recommended Books:

1. Structural Analyses of Metamorphic Tectonites by Turner, F.J a n d Weiss, L. E., latest Ed., 1963, McGraw-Hill.
2. The Study of Fabrics of Geological Bodies by Sander, B., latest Ed., 1966, Pergamon Press.
3. Metamorphic Textures by Spry, A. H., latest Ed., 1969, Pergamon Press.
4. The Techniques of Modern Structural Geology. V.I Stress and Strain by Ramsay J.G. and Huber, M.I., 1983, Academic Press.
5. The Techniques of Modern Structural Geology. V.II Folds and Fractures by Ramsay J.G. and Huber, M.I., 1987, Academic Press

3. GEOL-457: Applied Structural Techniques (3 credit hours)

Course Contents:

Week-1: Structural techniques: measurement of attitude and location,
Week-2: contour maps, attitude and dimension calculations,
Week-3:stereographic projections,
Week-4:stereographic poles and rotations;calculation of layer attitudes in drill holes.
Week-5:equal area projections and structural analyses;
Week-6:practical strain measurements of 1) initially circular and elliptical markers, 2) lines and 3) angles,
Week-7:methods and representation of strain state;
Week-8: *Presentations, Quizzes and Assignments*

Week-9:progressive displacement and progressive deformation.
Week-10:interpretation of geological maps;
Week-11:analysis of fracture array geometry;
Week-12:constructing profiles and block diagrams;
Week-13:balanced cross section techniques;
Week-14: Kinematic analysis and indicators.
Week-15: Folds orientation, projection techniques, dip isogons, and fold classification using layer thickness variation.
Week-16: *Presentations, Quizzes and Assignments*

Labs: Exercises based on course contents.

Recommended Books:

1. Applied Subsurface Geological Mapping by Tearpook, D. J. and Bischke, R. E., 1991, Prentice Hall.
2. Basic Methods of Structural Geology by Marshak, S. and Mitra, S., 1988, Prentice Hall.
3. The Techniques of Modern Structural Geology by Ramsay, J. G. and Huber, M. I., 1983, Volume 1: Strain Analyses. Academic Press.
4. The Techniques of Modern Structural Geology by Ramsay, J. G. and Huber, M. I., 1987, Volume II: Folds and Fractures. Academic Press.
5. Structural Geology, an Introduction to Geometric Techniques by Ragan, D. M, 1985, John Willey and Sons).
6. Principals of Structural Geology by Suppe, J. 1985, Prentice Hall.

4. GEOL-458: Tectonics of Pakistan (3 credit hours)

Outcomes:

After completion this course the students will be understand that how the different continents were separated and how the different mountain systems develop in Pakistan.

Course Contents:

Week-1: Concept of Rodania, Pangea and Gondwana supercontinents;
Week-2: Permian separation of Afghan, Pamirs, Karakoram, Lahasa microcontinents,
Week-3:closure of Palaeotethys and accretion tectonics at Eurasia's southern margin;
Week-4:early cretaceous split and northward flight of India, closure of northern Neotethys and collision tectonics of the Shyok Suture;
Week-5: Himalayan orogeny; constraints on the timing of India-Eurasia collision; resultant physiography, structures,metamorphism, climatic changes;

Week-6: tectonic zonation of Pakistan: each zone to be studied in terms of its geomorphology, tectonics, stratigraphy
Week-7: Karakoram plate; Kohistan-Ladakh Island Arc Terrene;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: 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;
Week-10: the boundary faults and related tectonics: MMT, MCT, PANJAL THRUST, MBT, MFT.
Week-11: Afghan-India collision zone: Indus, Kurram-Waziristan- Muslim Bagh-Bela Ophiolite/Melange belt.
Week-12: Sulaiman-Kirthar thrust-fold belt; Katawaz basin; Makran accretionary prism; Raskoh-Chagai Arc Terrane.
Week-13: Indus platform and foredeep; offshore Pakistan: The Indus delta.
Week-14: Syntaxes and orocline of Pakistan; Precambrian to Recent tectonics of Pakistan;Tertiary Himalayan orogeny and Late Proterozoic to early Cambrian Hazaran orogeny.
Week-15: Makran Subduction, Arabian Sea tectonics, tectonics of passive margin of Indian plate
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Geology and Tectonics of Pakistan by Kazmi, A. H. and Jan, M. Q., 1997, Graphic Publishers.
2. Precambrian to early Paleozoic Orogenesis in the Himalaya, Baig, M.S., and Lawrence, R.D., 1987, Kashmir Journal of Geology, V.5, p.1-22.
3. Evidence for late Precambrian to early Cambrian orogeny in northwest Himalaya, Pakistan. Baig, M.S., Lawrence, R.D, and Snee, L.W., 1988, Geological Magazine, London, V. 125, No. 1, p. 83-86.
4. Timing of pre Himalayan orogenic events in the northwest Himalaya: 40 Ar/ 39 Ar constraints. Kashmir Journal of Geology, Baig, M.S., Snee, L.W., La Fortune, R.J., and Lawrence, R.D., 1989, V. 6and7, p. 29-40.
5. Geochronology of pre-Himalayan and Himalayan tectonic events, northwest Himalaya, Pakistan, Baig, M.S., 1991, Kashmir. Kashmir Journal of Geology, V.8 and 9, p. 197**.**
6. Geology of Pakistan by Bender and Raza, (ed.) 1995, Gebruder Borntraeger.
7. Geodynamics of Pakistan Farrah, A, and DeJong, K., 1979, Geological Survey of Pakistan.
8. Himalayan Tectonics by Treloar P. J. and Searle, M. P., 1998, Geological Society London, Special Publication. Tectonics of Nanga Parbat and the Western Himalayas by Khan, M. A., Trelaor, P. J., Searle, M. P., and Jan, M. Q. 2000. Geological Society, London, Special Publications.
9. Geology and evolution of the Indian plate by Naqvi, S.M., 2005, Capital Publishing Company. New Delhi, India
10. Stratigraphy and Historical Geology of Pakistan by Kazmi, A.H and Abbasi, I.A., 2008, Graphic Publishers, Karachi, Pakistan.

5. GEOL-459: Earthquake Seismology (3 Credit Hours)

Week-1: Introduction to earthquake seismology
Week-2: mathematical analysis of seismological processes on the basis of elastic wave theory
Week-3: seismic waves and their analysis in earthquake seismology;
Week-4: causes of earthquakes
Week-5: earthquake location measurement
Week-6: earthquake magnitude measurement;
Week-7: source parameters and their determination;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Seismometers;
Week-10: energy of an earthquake and their relationship;
Week-11: composite fault plane solutions of earthquakes and their determination;
Week-12: geographical distribution of important earthquakes;
Week-13: earthquakes and their relationship to the tectonics of the area.
Week-14: earthquake prediction;
Week-15: Seismic risk assessment

Week-16: *Presentations, Quizzes and Assignments*

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

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. An Introduction to the Theory of Seismology by Bullen, K.E. and Bolt, B.A., 1985, Cambridge University Press.
4. Quantitative Seismology by Aki, K. and Richards, P.G. 1980, W.H. Freeman and Company.
5. Seismic Waves and Sources by Ben-Menaham, A. and Singh, S.S. 1981, Springer-Verlag.

GROUP-IX: 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.

Learning Outcomes:
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. Petroleum Engineering
2. Petroleum Geology of Pakistan
3. Logging and log Interpretation

1. GEOL-461: Petroleum Engineering (3 credit hours)

Outcomes:
After completion of this course the students will be able to understand the following will be able to work as a well site Geologist.

Course Contents:

Week-1: Introduction to rig components,
Week-2: drilling methods and operations;
Week-3:types of bits;
Week-4:drilling fluids,composition and function;

Week-5:porosity and permeability measurements
Week-6:cementation and casing operations;
Week-7:coring operations;
Week-8: *Presentations, Quizzes and Assignments*

Week-9:mud and wireline logging;
Week-10:well testing and completion;
Week-11:well production operations;
Week-12: evaluation and analysis of well data i.e. well cutting, cores, logs and production data;
Week-13: Natural Driving Mechanisms of petroleum;
Week-14:secondary and enhanced oil recovery techniques,
Week-15:common drilling problems and preventive measures,HSE at well site.
Week-16: *Presentations, Quizzes and Assignments*

Labs: Study of mass properties of rocks, wire line logs, cores, well cuttings, DSTand MDT pressure data.

Recommended Books:

1. Introduction to Geophysical Prospecting by Dobrin, M.D. and Savil, C.H., 1988, McGraw-Hill.
2. Geophysical Methods by Robbert, E.S., 1989, Prentice Hall.
3. Petroleum Engineering, Drilling and Well Completions by Gatlin, C., Latest Ed., Prentice – Hall.
4. Drilling of Oil and Gas by Sereda, N.G. and Solvyon, E.M., latest Ed., Wells Mir Publications.
5. Well Log Formation Evaluation by Merkel, R.H., 1986, AAPG course notes #14.

2. GEOL-462: Petroleum Geology of Pakistan (3 credit hours)

Outcomes:

After completion of this course the students will be able to understand the to explore the source and reservoir rocks of Pakistan.

Course Contents:

Week-1: History of petroleum exploration;
Week-2: new trends for petroleum exploration;tectonic framework;
Week-3:sedimentary basins and their evolution and distribution;
Week-4: Potential source and reservoir rocks of sedimentary basins of Pakistan;
Week-5:depositional settings and lithostratigraphic divisions of the rocks of various geological periods;
Week-6:facies development and their association in depositional basins such as Indus,
Week-7: Baluchistan and offshore regions;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: evaluation of petroleum potentials of different basins;
Week-10:-Do-
Week-11:structural styles and petroleum play in the basins of Pakistan;
Week-12: geothermal gradients and their maturity;
Week-13: productive and potential oil and gas reservoirs and source rocks and their distribution in the basins
Week-14: Play Fairways and Petroleum System in basins;
Week-15:case studies.
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Geodynamic of Pakistan by Farah, A., and Dejong K.A., 1979, Geological Survey of Pakistan.
2. Marine Geology and Oceanography of Arabian Sea and Coastal Pakistan by Haq, B.U. and Milliman, G.D., 1984, Jan Nostrand Reinhold Co.
3. Petroleum Geology of Pakistan by Kadri, I.B., 1995, Pakistan Petroleum Limited.
4. Petroleum Source Rocks of Pakistan by Raza H.A. 1991, Int. Petroleum Seminar, Sp. Publ.
5. Petroleum for Future by Raza, H.A. and Sheikh, A.M., 1988, (HDIP),
6. Geology and Tectonics of Pakistan by Kazmi, A.H. and Jan, Q., 1997, Graphic Publishers.
7. Geology of Pakistan by Bender and Raza, 1995, Gebruder Borntraeger.
8. Selected technical proceedings of PAPG and SPE meetings
9. Stratigraphy and historical geology of Pakistan by Kazmi, A.H and Abbasi, I.A., 2008, Graphic Publishers, Karachi, Pakistan

3. GEOL-463: Logging and Log Interpretation (3 credit hours)

Course Contents:

Week-1: Introduction to logging, significance of logs
Week-2: Logging environment (Pressure/ temperature), and classification of logging
Week-3: Description of gamma ray log and lithology interpretation from gamma ray log
Week-4: Description of resistivity log and lithology interpretation from gamma ray log
Week-5: Description of Neutron log and lithology interpretation from neutron log
Week-6: Description of density and photoelectric log,
Week-7: lithology interpretation from density and photoelectric log
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Description of acoustic log, lithology interpretation from acoustic log
Week-10: Description of caliber log,
Week-11: Description of spontaneous potential log
Week-12: Determination of sequences and environments from gamma ray log and resistivity log
Week-13: Determination of sequences and environments from neutron log and density log
Week-14: Determination of sequences and environments from acoustic and caliber log
Week-15: Determination of value of shale and movable hydrocarbons, CBL,
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. M.H Rider, 1999, Geological Interpretation of Well Logs, 2nd Edition, Whittles publishing services.
2. Charles Gibbson, and George Asquith, 1982, Basic Well Log analysis for Geologist (Methods), American Association of Petroleum Geologists.

GROUP-X: 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 palaeomagnitism and its application, (5) the radiometric dating techniques, (6) the electrical, gravity and magnetic techniques in geophysics

Learning Outcomes:
After completion of this course the students will understand various concept of depositional system, paleomagnetism and different geophysical techniques and will also be able to carry out their independent research on the application of geophysical techniques in hydrocarbon exploration.

This group comprises the following courses:

1. Electrical and Radiometric Exploration Methods
2. Bore-Hole Geophysics
3. Seismic Prospecting

1. GEOL-464: Electrical and Radiometric Exploration Methods (3 credit hours)
Week-1: Introduction
Week-2: Fundamentals of current flow in the earth;
Week-3: electrode arrangements and field procedures;
Week-4: instruments;
Week-5: processing and interpretation of resistivity data;
Week-6: field procedure,
Week-7: data acquisition and interpretation of self-potential,
Week-8: *Presentations, Quizzes and Assignments*

Week-9: data acquisition and interpretation of induced polarization and electromagnetic methods;
Week-10: study of case histories.
Week-11: Physical principles and basic theory;
Week-12: radioactivity of rocks;radioactive dating methods;
Week-13: field surveys and instruments;
Week-14: data processing and interpretation;
Week-15: application of radiometric methods in exploration of minerals and energy resources
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. Introduction to Geophysical Prospecting by Dobrin, M.B. and Savit, C. H. 1988, McGraw Hill.
2. An Introduction to Geophysical Exploration by Kearey, P. and Brooks, M., 1991, Osney Mead.
3. Basic Exploration Geophysics by Robinson, E. S. and Coruh, C., 1988, John Wiley and Sons.
4. Geophysical Methods in Geology by Sharma, P.V., 1987, Elsevier Scientific Publishing Company.
5. Field Geophysics by Milson, J., 1989, Open University Press.
6. Radon Mapping in the Search for Uranium by Telford, W.M., 1982, In; Fitch, A.A. (ed.) Developments in Geophysical Exploration Methods. Applied Science.
7. Introduction to Geophysical Prospecting by Dobrin, M.B. and Savit, C. H., 1988, McGraw Hill, New York.
8. Applied Geophysics by Telford, W. M., Geldart, C.P., Sheriff, R.E. and Keys, D.A., latest Ed., Cambridge University Press, London.
9. Field Geophysics by Milson, J. 1989, Open University Press, Milton Keynes.

10. Interpretation Theory in applied Geophysics by Grant, F.S. and West, G.F., latest Ed., McGraw-Hill, New York.
11. Kearey, P., Brooks, M., and Hill, I., 2002. An Introduction to Geophysical Exploration, 3rd Ed., Blackwell Scientific Publications, London.

2. GEOL-465: Borehole Geophysics (3 credit hours)

Week-1: Introduction;
Week-2: basic theory of geophysical methods;
Week-3: petrophysics and formation evaluation;
Week-4: different types of logging techniques,
Week-5: instrumentation and their field application;
Week-6: log analysis and interpretation;
Week-7: application of borehole geophysics for lithological studies;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: application of borehole geophysics for environmental studies;
Week-10: application of borehole geophysics for water resources
Week-11: application of borehole geophysics for geotechnical
Week-12: application of borehole geophysics for mineral and hydrocarbon studies
Week-13: Borehole logging;
Week-14: Vertical seismic profile (VSP),
Week-15: Case histories
Week-16: *Presentations, Quizzes and Assignments*

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

Recommended Books:

1. An Introduction to Geophysical Exploration by Kearey, P., Brooks, M., and Hill, I., 2002, 3rd Ed., Blackwell Scientific Publications, London.
2. Geophysics in Mineral Exploration: Fundamentals and Case Histories Geology by Lowe, C., Thomas, M.D., and Morris, W.A., (Eds) 1999, Association of Canada, Short Course Notes Volume 14, Sudbury.
3. An Introduction to Applied and Environmental Geophysics by Reynolds, J.M. 1997, Wiley, New York.
4. Sharma, P.V., 1997, Environmental and Engineering Geophysics, Cambridge University Press.
5. Applied Geophysics, 2nd Ed. by Telford, W.M. Geldart, L.P. and Sherriff, R.E., 1990, Cambridge University Press, Cambridge.
6. Geotechnical and Environmental Geophysics, Vol. I-III by Ward, S.H. (ed), 1990, Society of Exploration Geophysicists, Tulsa, Okla.
7. Drilling Practices Manual by Moone, P.L., 1986, Pen Well.

3. GEOL-466: Seismic Prospecting (3 credit hours)

Week-1: Planning for 2D and 3D seismic surveys and concepts of recording parameters;
Week-2: types of seismic surveys;
Week-3: onshore and offshore seismic surveys;
Week-4: Methodology of seismic data acquisition,
Week-5: seismic equipment, types of seismic energy sources and recording equipment,
Week-6: acquisition methods, quality control of data during acquisition and processing,

Week-7: field processing, Work flow for various basic and advanced processing techniques,
Week-8: *Presentations, Quizzes and Assignments*

Week-9: seismic mapping and interpretation of 2D and 3D seismic data;
Week-10: well seismic (VSP),
Week-11: Forward seismic Modeling, Ray tracing,
Week-12: synthetic seismograms generation,
Week-13: AVO for lithology and DHI,
Week-14: seismic prospecting for construction
Week-15: Applications in Exploration and Production.
Week-16: *Presentations, Quizzes and Assignments*

Labs: Specified assignments/projects.

Recommended Books:

1. Statistics for Geoscientists: Techniques and applications by Pal, S.K., 1998. Concept Publishing Company.
2. Statistics and Data Analysis in Geology by Davis, J.C., 198 6 , John Wiley.
3. Geomathematics by Agterberg, F.P., 1974, Elsevier Scientific.
4. Spectral Analysis in Geophysics by Bath, M., latest Ed., Elsevier.
5. Fundamental of Geophysical Data Processing by Claerbout, J.F., latest Ed., McGraw-Hill.
6. Introduction to Digital Filtering in Geophysics by Kulhanek, O., 1976, Elsevier.

COMPULSORY COURSES

Eng-102: English I (Functional English) (3 credit hours)

Objectives:
Enhance language skills and develop critical thinking.

Learning outcomes:
After studying this course contents, students will be able to communicate and enhance their mental faculties. They will easily express themselves in written and in spoken English.

Course Contents:

Week-1: Basics of Grammar
Parts of speech and use of articles
Week-2: Sentence structure, active and passive voice
Week-3: Practice in unified sentence
Week-4: Analysis of phrase, clause and sentence structure
Week-5: Transitive and intransitive verbs
Week-6: Punctuation and spelling
Week-7: Comprehension
Answers to questions on a given text
Week-8: *Presentations, Quizzes and Assignments*

Week-9: 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)
Week-9: Listening
To be improved by showing documentaries/films carefully selected by subject teachers
Week-10: Translation Skills
Urdu to English
Week-11: Paragraph Writing
Topics to be chosen at the discretion of the teacher
Week-12: -Do-
Week-13: Presentation Skills
Introduction
Week-14: -Do-
Week-15: -Do-
Week-16: *Presentations, Quizzes and Assignments*

Note: Extensive reading is required for vocabulary building.

Recommended Books:

1. **Functional English**

a) Grammar

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492
2. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506

b) Writing

1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.

c) Reading/Comprehension

1. Reading. Upper Intermediate. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.

d) Speaking

Eng-152: English II (Communication Skills) (3 credit hours)

Objectives:
Enable the students to meet their real life communication needs.

Learning outcomes:
Studying this course contents will help and guide students to achieve their goals in practical life and job orientations. They will make progress in real life situation face by them.

Course Contents:

Week-1: Paragraph Writing
Week-2: Practice in writing a good, unified and coherent paragraph
Week-3: Essay Writing
Introduction
Week-4: -Do-
Week-5: CV and Job Application
Week-6: -Do-
Week-7: Translation skills
Urdu to English
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Study Skills
Skimming and scanning,
Week-10: intensive and extensive, and speed reading,
Week-11: summary and précis writing and comprehension

Week-12: Academic Skills
Letter/memo writing, minutes of meetings, use of library and internet
Week-13: Presentation Skills
Personality development, emphasis on content, style and pronunciation
Week-14: -Do-
Week-15: Analytical Skills and Professional Ethics
Week-16: *Presentations, Quizzes and Assignments*

Note: Documentaries to be shown for discussion and review.

Recommended Books:

Communication Skills

a) Grammar

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.

b) Writing

1. Writing. Intermediate by Marie-Chrisitine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).

c) Reading

1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
2. Reading and Study Skills by John Langan
3. Study Skills by Riachard Yorky.

ENG: 202: English III (Technical Report Writing) (3 credits hours)

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

Learning outcomes:
While studying this course contents students will become sharp and broad minded. They will be able to write good research proposal, articles needed or required in academic environment**.**

Course Contents:

Week-1: Essay Writing
Week-2: Descriptive
Week-3: narrative
Week-4: discursive
Week-5: argumentative
Week-6: Academic Writing
How to write a proposal for research paper/term paper
Week-7: -Do-
Week-8: *Presentations, Quizzes and Assignments*

Week-9: How to write a research geological research report/professional paper/term paper (emphasis on style, content, language, form, clarity, consistency, geological contents)
Week-10: -Do-
Week-11: Technical Report Writing
Week-12: -Do-
Week-13: Progress Report Writing
Week-14: -Do-
Week-15: *Presentations, Quizzes and Assignments*
Week-16: -Do-

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

1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).

2. College Writing Skills by John Langan. Mc=Graw-Hill Higher Education. 2004.

3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.

b) Presentation Skills

c) Reading

The Mercury Reader. A Custom Publication. Compiled by norther Illinois University. General Editiors: Janice Neulib; Kathleen Shine 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).

ENG-251: English-IV **(3creditshours)**

Objectives:

To develop critical thinking and reasoning of students and their analytical approach towards readings.

LearningOutcomes:

To be human is to think, and critical thinking is thinking about thinking, which is not common to everyone. Studying this course students approach towards readings becomes analytical and profound.

Course Contents:

Week 1-2: Read Academics text critically

Week 3-4: Write well organized academic text e.g. assignments, examination answers

Week 5-6: Write narrative, descriptive, argumentative essays and reports (assignments)

Contents:

Week 7: Critical Reading Advanced reading skills and strategies building on Foundations of English I & II courses in semesters I and II of a range of text types e.g. description, argumentation, comparison and contrast.

Week-8: *Presentations, Quizzes and Assignments*

Week 9-10: Advanced Academic Writing Advanced writing skills and strategies building on English I & II in semesters I and II respectively

Week 11-12: Writing summaries of articles, report writing

Week 13-14: Analysis and synthesis of academic material in writing

Week 15: Presenting an argument in assignments/term-papers and examination answers

Week-16: *Presentations, Quizzes and Assignments*

Recommended Books:

1. Aaron, J. 2003. The Compact Reader. New York: Bedford.

2. Axelrod, R. B and Cooper, C. R. 2002. Reading Critical Writing Well: A Reader and Guide.

3. Barnet, S. and Bedau, H. 2004. Critical Thinking, Reading and Writing: A Brief Guide to Writing. 6 th Ed.

4. Behrens & Rosen. 2007. Reading and Writing Across the Curriculum.

5. Gardner, P. S. 2005. New Directions: Reading, Writing and Critical Thinking.

6. George, D. and Trimbur, J. 2006. Reading Culture: Context for Critical Reading and Writing. 6th Ed.

7. Goatly, A. 2000. Critical Reading and Writing: An Introductory Course. London: Taylor & Francis.

8. Grellet, F., Writing for Advanced Learners of English. CUP.

9. Jordan, K. M. and Plakans, L. 2003. Reading and Writing for Academic Success.
10. Jordon, R. R. 1999. Academic Writing Course. CUP. 11.
Smith, L. C. 2003. Issues for Today: An Effective Reading Skills Text 12. Withrow, J., Effective Writing.

PS-106: Pakistan Studies (Compulsory) **(2 credits hours)**

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.

LearningOutcomes:

After studying this course the students will have a clear vision about historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan. They will have also adequate knowledge about the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

Course Outline:

1. **Historical Perspective**

Week-01: a) Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-i-Azam Muhammad Ali Jinnah.
Week-02: b) Factors leading to Muslim separatism
Week-03: 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:
Week-04: a) 1947-58
Week-05: b) 1958-71
Week-06: c) 1971-77
Week-07: d) 1977-88
Week-08: *Presentations, Quizzes and Assignments*

Week-09: e) 1988-99
Week-10: f) 1999 onward

3. **Contemporary Pakistan**

Week-11: a) Economic institutions and issues
Week-12: b)Society and social structure
Week-13: c)Ethnicity
Week-14: d)Foreign policy of Pakistan and challenges
Week-15: e)Futuristic outlook of Pakistan
Week-16: *Presentations, Quizzes and Assignments*

Books Recommended

1. Burki, Shahid Javed. *State and Society in Pakistan,*The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000.
3. S.M. Burke and Lawrence Ziring. Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots and Development.* Lahore, 1994.
5. Wilcox, Wayne.*The Emergence of Banglades.*, Washington: American Enterprise, Institute of Public Policy Research, 1972.
7. Mehmood, Safdar. *Pakistan Kayyun Toota*, Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd. Amin, Tahir. *Ethno - National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development.* Kent England: WmDawson and sons Ltd, 1980.

9. Zahid, Ansar. *History and Culture of Sindh.* Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan,* Vol. I, II and III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan.* Boston: Houghton Mifflin, 1967.
12. Aziz, K.K. *Party, Politics in Pakistan,* Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective.* Islamabad: National Commission on Historical and Cultural Research, 1993.

ISL-206: 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.

Learning outcomes:

Studying this course will provide the students basic information about Islamic Studies, understanding about Islamic Civilization and will enhance the skill of the students for understanding of issues related to faith and religious life.

Course Content:

Week-1: Introduction to Quranic Studies

1) Basic Concepts of Quran
2) History of Quran
3) Uloom-ul -Quran

Week-2: Study of Selected Text of Holly Quran

1) Verses of Surah Al-Baqra 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)

Week-3: Study of Sellected 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)

Week-4: 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

Week-5: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

Week-06: Important Lessons Derived from the life of Holy Prophet in Madina

Week-07: 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

Week-08: *Presentations, Quizzes and Assignments*

Week-09: Selected Study from Text of Hadith

Week-10: 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

Week-11: 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

Week-12: Islam and Science

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

Week-13: 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

Week-14: Political System of Islam

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

Week-15: Islamic History

1) Period of Khlaft-E-Rashida
2) Period of Ummayyads
3) Period of Abbasids

Week-16: Social System of Islam

1) Basic Concepts Of Social System Of Islam
2) Elements Of Family 3) Ethical Values Of Islam

Presentations, Quizzes and Assignments

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,".
5) Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" leaf Publication Islamabad, Pakistan.
6) Ahmad Hasan, "Principles of Islamic Jurisprudence" Islamic Research Institute, International Islamic University, Islamabad,1993.
7) Mir Waliullah, "Muslim Jrisprudence and the Quranic Law of Crimes" Islamic Book Service, 1982.
8) H.S. Bhatia, "Studies in Islamic Law, Religion and Society" Deep and Deep Publications New Delhi, 1989.
9) Dr. Muhammad Zia-ul-Haq, "Introduction to Al Sharia Al Islamia" Allama Iqbal Open University, Islamabad, 2001.

MAT-104: Mathematics I (Algebra) **(3 credit hours)**

Prerequisite(s): Mathematics at secondary level

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

LearningOutcomes:
Studying these course students will be expected toknow the fundamental theorem of calculus and be able to use it for evaluating various problems regarding calculus in hand.

Course Content:
Week-1: Preliminaries: Real-number system, complex numbers,
Week-2:introduction to sets, setoperations,
Week-3: functions, types of functions.
Week-4: Matrices: Introduction to matrices, types, matrix inverse,
Week-5:determinants, system oflinear equations,
Week-6: Cramer's rule.
Week-7: Quadratic Equations: Solution of quadratic equations
Week-8: *Presentations, Quizzes and Assignments*

Week-9:qualitative analysis of rootsof a quadratic equations,
Week-10: equations reducible to quadratic equations, cube roots of unity,
Week-11: relation between roots and coefficients of quadratic equations.
Week-12: Sequences and Series: Arithmetic progression, geometric progression, harmonicprogression.
Week-13: Binomial Theorem: Introduction to mathematical induction, binomial theorem withrational and irrational indices.
Week-14: Trigonometry: Fundamentals of trigonometry,
Week-15: trigonometric identities.
Week-16: *Presentations, Quizzes and Assignments*

Recommended Books:

1. Dolciani MP, Wooton W, Beckenback EF, Sharron S, *Algebra 2 andTrigonometry*, 1978, Houghton and Mifflin,Boston (suggested text).
2. Kaufmann JE, College *Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston
   Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6^{th} edition), 1986, PWS-Kent Company, Boston.

MAT-154: 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.

Learning Outcomes:
Upon completion of the course, the student will be able to: interpret various concepts of calculus like function from an algebraic, numerical, graphical and verbal perspective and extract information relevant to the phenomenon modeled by the various Calculus concepts

Course Outline:
Week-1: Preliminaries: Real-number line, functions and their graphs,
Week-2: -Do-
Week-3:solution of equationsinvolving absolute values, inequalities.
Week-4: Do-
Week-5: Limits and Continuity: Limit of a function, continuity, continuous functions.
Week-6: Derivatives and their Applications: Differentiable functions,
Week-7: differentiation of polynomial, rational and transcendental functions, derivatives.
Week-8: *Presentations, Quizzes and Assignments*

Week-9: Integration and Definite Integrals: Techniques of evaluating indefinite integrals,
Week-10:-Do-
Week-11: Do-
Week-12:integration by substitution, integration by parts,
Week-13: -Do-
Week-14:change of variables in indefinite integrals.
Week-15: -Do-
Week-16: *Presentations, Quizzes and Assignments*

Books Recommended:

1. Anton H, Bevens I, Davis S, *Calculus: A New Horizon* (8th edition), 2005, John Wiley, New York.
2. Stewart J, *Calculus* (3rd edition), 1995, Brooks/Cole (suggested text).
3. Swokowski EW, *Calculus and Analytic Geometry*, 1983, PWS-Kent Company, Boston.
4. Thomas GB, Finney AR, *Calculus* (11th edition), 2005, Addison-Wesley, Reading, Ma, USA.

CHE-101: Chemistry-1 **(3 Credit hours)**

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

Learning Outcomes:
Upon completion of this course students willlearn basic tools of chemistry to apply the concepts and techniques in their respective discipline.

Course Content:
Week-1: Phase rule for one and two component system
Week-2:and Distribution laws;
Week-3:first and second laws of thermodynamics with applications;
Week-4:brief introduction to nuclear chemistry:
Week-5: nuclear fission and fusion,
Week-6:nuclear reactors,
Week-7:uses of isotopes and radioisotopes;
Week-8: Metallurgy: major steps involved in metallurgy of iron,
Presentations, Quizzes and Assignments

Week-9:copper, nickel,
Week-10:chromium, gold and platinum.
Week-11:metallurgy raw materials;
Week-12:cement preparation;
Week-13:solutions: types, Eubulioscopic constant,
Week-14:distribution law and various properties of solutions;
Week-15: Complexometric Methods: titration and its various types,
Week-16:concept of mono, di and plydentateligoinds.
Presentations, Quizzes and Assignments

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

Recommended Books:

1. Physical Chemistry for BSc students by Ghulam Nabi and P.A Khokar (Latest edition).
2. Chromatography by Dr. Nasar-ud-din (Latest edition).
3. See also relevant updated books.

CHE-151: Chemistry-II **(3 credit hours)**

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

Learning Outcomes:
Upon completion of this course students will have learnt about the basic of the chemistry and will help them in understanding various chemical methods and its use in geology.

Course Content:
Week-1: Gravimetric and volumetric method of analysis;
Week-2: chromatography,
Week-3: TLC, PC, CC ion exchange procedure and application of all these techniques;
Week-4: solvent extraction, classification,
Week-5: important terms involved,
Week-6: types of extraction and
Week-7: factor influencing the extraction system;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: electro analytical method;
Week-10: basic principles and elementary techniques;
Week-11: conductometer ;
Week-12: potentiometery;
Week-13: PH and EH measurement;
Week-14: atomic absorption techniques,
Week-15: neutron activation technique and
Week-16: mass spectrometry.
Presentations, Quizzes and Assignments

Labs: volumetric analysis; calorimetric analysis of Ni. Fe and Mn; PH and EHmeasurements; atomic absorption, neutron activation and mass spectrometry analyses.

Recommended Books:
1. Physical Chemistry for BSc student by Gulam Nabi and P.A. Khokar (Latest edition).
2. Chromatography by Nasar-ud-din (Latest edition).
3. See also relevant updated books.

PHY-105: Physics I **(3 credit hours)**

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

Learning Outcomes:
At the end of this course, the students will be able to understand the basic principles of physics and its application in geophysics.

Course Content:
Week-1:Vector: Vector notation, vector addition, vectors in the Cartesian coordinatesystem,
Week-2: scalar product (of two vectors) vector product (of two vectors), scalar of triple product,
Week-3: vector triple product, gradiset of a scalar, divergence of a vector, divergence theorem and Stock's theorem;
Week-4:conservation of energy: concept of conservation laws, conservation of energy, worked and kinetic energy,
Week-5: power, conservation forces, rotational energy,
Week-6: potential energy in an electric and gravitational field; dynamics of rigid bodies, center of mass,
Week-7: conservation of angular momentum, equation of motion of rotating body, moment of inertia, perpendicular axes and parallel axis theorems;
Week-8: *Presentations, Quizzes and Assignments*

Week-9:calculation of moment of inertia for a disc and solid sphere; Euler's theorem, Gyroscope cortolis forces;
Week-10:InverseSquare Law of forces: Newton laws, ficlitioris forces, Newton law of Universal Gravitation b/w point mass and solid spheres,
Week-11: Kepler's laws, satellite in circular orbit escape velocity;
Week-12:Electrostatics: electro charges as source of electric flux,
Week-13: Gauss's theorem,Electrostatic potential, Poisson's equation,
Week-14: Laplace Equation Potential due to: (a) Point Charge
Week-15: (b) dipole capacity of spherical condenser, dielectrics.
Week-16: *Presentations, Quizzes and Assignments*

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:
1. Physics by Holiday, Resnik and Krane (Latest edition).Mechanics by A. B. Pal (Latest edition).
2. B.Sc. Physics by A.B. Paul (Latest edition).
3. See also updated relevant books.

PHY-155: Physics-II **(3 credit hours)**

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

Learning Outcomes:
After studying this course, the students will learn to understand the non-classical aspects of Physics and will provide them an initial plat form for core courses present in the field of Geophysics and nuclear Physics.

Course Content:

Week-1: Magnetism: Explanation of dia, pura and ferromagnetism on atomic structure of an atom, **Week-2:**magnetic circuit, relation b/w susceptibility and permeability,

Week-3: Hysteresis determination of B-H curve using a Ballistic galvanometer, Magnetic Shell and

Week-4: Ampere's law and method of measuring magnetic field;
Week-5:Current Electricity: Magnetic flux density B. Ampher' s law and calculation of B due to current in
Week-6: (a) Long Straight, (b) Solenoid, (c) Toriod, Biot and Sarvat's lawand calculation of B, unit of current carrying conductor in a magnetic field,
Week-7:theory and construction of moving coil and magnetic galvanometer;
Week-8: *Presentations, Quizzes and Assignments*

Week-9: definition of different system of units C.G.S Electrostatic and C.G.S Electro-magnetic system of units,
Week-10: practical units, Gavssion System of units;
Week-11: Optics: Reflection and refraction, Sertent wave theory, Interference,
Week-12: Biprism and Michelin interferometer determination of wave length and thickness by using Michelin's interfero - meter,
Week-13: diffraction, diffraction by single and double and "N" slits;
Week-14: Radio Activity: Natural radio activity, mature and charge of alpha, Beta and Gama rays, **Week-15:** radioactive series, laws of radioactive decay, Half life and artificial radio activity and transuranic elements.
Week-16: *Presentations, Quizzes and Assignments*

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:
1. Physics by Holiday, Resnik and Krane (latest edition).
2. B.Sc. Physics by A.B. Paul (Latest edition).
3. See also updated books.

Annexure – E

Award list for Field Work

University of Swat

CENTRE FOR EARTH & SPACE SCIENCE

Program Name: B.S Geology

Award List for Field Work

Fresh ☐ **Repeat** ☐ **SCE** ☐ **Makeup** ☐ **IOG** ☐

Examination
Fall ☐
Spring ☐
Year ☐
Session ☐

Semester: I ☐ II ☐ III ☐ IV ☐ V ☐ VI ☐ VII ☐ VIII ☐ IX ☐ X ☐

Course Title: _____

Teacher Name: _____ Credit Hours: (e.g) ☐

Roll No.	Name of Student	Marks Obtained		Total Marks (100)
		Viva Voce (50)	Field Report (50)	

_____
Signature of Examiner with date

_____
Countersigned by
Head of the Department

Annexure – F

Marks Breakdown for BS Non Lab Courses

Item	Maximum Marks
Mid Term Examination	30
Internal Marks (Assignments, Quizzes, Presentations)	20
Final Term Examination	50
Total	100

Marks Breakdown for BS Lab Courses

Item	Maximum Marks
Mid Term Examination	30
Internal Marks (Assignments, Quizzes, Presentations) (Laboratory Work)	 10 10
Final Term Examination	50
Total	100

Marks Breakdown for BS Field Works

Item	Maximum Marks
Field Report	50
Field Viva	50
Total	100