



UNIVERSITY OF SARGODHA
OFFICE OF THE REGISTRAR
(ACAD BRANCH)

NOTIFICATION

On the recommendations of Academic Council made in its 24th (1/2025) meeting held on 26.08.2025, the Syndicate in its 72nd (4/2025) meeting held on 12.09.2025 has approved the curriculum of MS Geology for implementation w.e.f. Fall 2025 (Annex-'A').


(WAQAR AHMAD)
Additional Registrar (General)

Dated: 24.10.2025

No. SU/Acad/25/ 1146

Distribution:

- Chairman, Department of Earth Sciences
- Controller of Examinations
- Director Academics

C.C:

- Director, QEC
- Secretary to the Vice-Chancellor
- PA to Registrar
- Notification File

Scheme of Studies
MS Geology
w.e.f Fall, 2025

Retd
Arun
23/10/25

1. Nomenclature of the Program:

MS Geology

2. Department Brief:

The Department of Earth Sciences, Faculty of Sciences, University of Sargodha is a premier institution dedicated to imparting knowledge and fostering research in the field of Earth Sciences. Our well-qualified faculty is committed to create a vibrant learning environment that equips students with a deep understanding of the Earth's evolution and the sustainable management of its invaluable resources. With strong affiliations with national and international institutions, our department offers a comprehensive education that prepares students for diverse careers in private industry, public agencies, and academia. It brings a wealth of knowledge and diverse research expertise to the students, providing the opportunity to learn from leading experts in Earth Sciences. The faculty members actively engage in research, publishing in renowned scientific journals and participating in national and international conferences. They are passionate about mentoring students and guiding them in their academic and research pursuits.

3. Program Learning Objectives:

The MS Geology program aims to provide students with a deeper understanding of advanced geological concepts and techniques by building upon the foundational knowledge they acquired during their undergraduate studies. Through this program, students acquire expertise in specific fields of geology, including sedimentology, geochemistry, geophysics and tectonics. They also enhance their abilities to conduct original research, apply cutting-edge geological tools and methodologies, and interpret complex geological data sets. The curriculum places a strong emphasis on developing critical thinking and problem-solving skills necessary to address challenging geological issues. The MS Geology program addresses the crucial aspect of resource management as it pertains to geological investigations. Students are exposed to a wide range of sustainable techniques and strategies that can be employed to manage natural resources such as minerals, water, land, and energy resources. They also acquire in-depth knowledge on how to thoroughly evaluate the possible environmental impacts of geological activities and create comprehensive plans for the sustainable development and utilization of natural resources.

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4. Program Structure:

Duration	Minimum 1.5-Years (3-Semesters), Maximum 4-Years (8-Semesters)	
Entry Requirements:	MSc/BS in Geology with second division or CGPA 2.00 out of 4.00 + Departmental Test (at least 50% Marks)	
Intra-disciplinary fields allowed for admission	BS/MSc in GIS, Hydrogeology, Geophysics, Hydrology, Mineralogy, Paleontology, Geoinformatics, Geological Engineering, Marine Sciences , Geochemistry , Oceanography, Soil Sciences, Metrology, Engineering Geology and Geotechnical Engineering + GRE/HAT General test (50%)	
Degree Completion Requirements:	Total Credit Hours of Course Work:	26
	Total credit hours of Geological Field	06
	Total Credit Hours of Thesis	06
	Total Credit Hours of Program:	38
Program Mode	Thesis Track	

5. List of Deficiency Courses of Level-6: (for intra-disciplinary admissions only, maximum 03 courses to be offered)

Sr. No.	Course Code	Course Title	Credit Hours	Prerequisite
1.	GEOL-6192	Introduction to Earth Sciences	3(3-0)	Nil
2.	GEOL-6193	Structural Analysis	3(3-0)	Nil
3.	GEOL-6194	Mineralogy and Petrology	3(3-0)	Nil
4.	GEOL-6195	Stratigraphy of Pakistan	3(3-0)	Nil
5.	GEOL-6196	Field and Engineering Geology	3(3-0)	Nil

6. List of General Education Courses

Sr. No.	Course Code	Course Title	Credit Hours	Prerequisite
1.	URCG-5129 URCG-5131 of	Understanding of Holy Quran – I */ Ethics-I*	1(0-1)	Nil
2.	URCG-5130 URCG-5132 of	Understanding of Holy Quran – II */ Ethics-II*	1(0-1)	Nil

7. List of Common Courses

Sr. No.	Course Code	Course Title	Credit Hours	Prerequisite
1.	GEOL-7101	Emerging Trends & Issues in Geology **	3(3-0)	Nil
2.	GEOL-7102	Advanced Research Methods for Geological Sciences **	3(3-0)	Nil

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8. List of Elective Courses:

Sr. No.	Course Code	Course Title	Credit Hours	Prerequisite
1.	GEOL-7103	Applied Mineralogy	3(3-0)	Nil
2.	GEOL-7104	Petroleum Geology of Pakistan	3(3-0)	Nil
3.	GEOL-7105	Engineering Geology	3(3-0)	Nil
4.	GEOL-7106	Applied Geophysics	3(3-0)	Nil
5.	GEOL - 7107	Coal Geology	3(3-0)	Nil
6.	GEOL-7108	Global Tectonics	3(3-0)	Nil
7.	GEOL-7109	Sedimentary Basins of Pakistan	3(3-0)	Nil
8.	GEOL-7110	Basin Analysis	3(3-0)	Nil
9.	GEOL-7111	Clastic Sedimentology	3(3-0)	Nil
10.	GEOL-7112	Geology and Tectonics of Pakistan	3(3-0)	Nil
11.	GEOL-7113	Micropaleontology	3(3-0)	Nil
12.	GEOL-7114	Soil Mechanics	3(3-0)	Nil
13.	GEOL-7115	Geotechnical Engineering	3(3-0)	Nil
14.	GEOL-7116	Mining and Engineering Geology	3(3-0)	Nil
15.	GEOL-7117	Geological Hazards	3(3-0)	Nil
16.	GEOL-7118	Applied Hydrogeology	3(3-0)	Nil
17.	GEOL-7119	Rock Mechanics	3(3-0)	Nil
18.	GEOL-7120	Engineering Seismology	3(3-0)	Nil
19.	GEOL-7121	Earthquake Seismology	3(3-0)	Nil
20.	GEOL-7122	Geoelectrical Methods	3(3-0)	Nil
21.	GEOL-7123	Geophysical Well Logging	3(3-0)	Nil
22.	GEOL-7124	Reflection Seismology	3(3-0)	Nil
23.	GEOL-7125	Gravity and Magnetic Methods	3(3-0)	Nil
24.	GEOL-7126	Engineering Geophysics	3(3-0)	Nil
25.	GEOL-7127	Mining Geophysics	3(3-0)	Nil
26.	GEOL-7128	Isotope Geochemistry	3(3-0)	Nil
27.	GEOL - 7129	Metamorphic Petrology	3(3-0)	Nil
28.	GEOL - 7130	Metallic Mineral Deposits	3(3-0)	Nil
29.	GEOL - 7131	Industrial Mineralogy	3(3-0)	Nil
30.	GEOL - 7132	Applied Geochemistry	3(3-0)	Nil
31.	GEOL - 7133	Igneous Petrology	3(3-0)	Nil

9. Geological Field Work:


01	GEOL-7189	Geological Field Work	6(0-6)	Nil
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10. Thesis:

01	GEOL-7190	Thesis	6(0-6)	Nil
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* These are prescribed for all NQF level 4-8 qualifications as mandated vide HEC letter No. 10-01/2022/Coord(Acad)/HEC/235 dated March 28, 2025.

** These are the mandatory courses for the program, irrespective of the area of specialization.

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Scheme of Studies
Master of Science in Geology

Semester-I

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
Deficiency-1*	GEOL-61XX	To be selected from deficiency course list	3(3-0)	Nil
General Education	URCG-5129 URCG-5131	Understanding of Holy Quran – I/ ^{OR} Ethics-I	1(0-1)	Nil
Compulsory-1	GEOL-7101	Emerging Trends & Issues in Geology	3(3-0)	Nil
Elective-1	GEOL-71XX	To be selected from elective courses list	3(3-0)	Nil
Elective-2	GEOL-71XX	To be selected from elective courses list	3(3-0)	Nil
Elective-3	GEOL-71XX	To be selected from elective courses list	3(3-0)	Nil

Semester-II

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
Deficiency-2*	GEOL-61 XX	To be selected from deficiency course list	3(3-0)	Nil
General Education	URCG-5130 URCG-5132	Understanding of Holy Quran – II/ ^{OR} Ethics-II	1(0-1)	Nil
Compulsory-II	GEOL-7102	Advanced Research Methods for Geological Sciences	3(3-0)	Nil
Elective-4	GEOL-71XX	To be selected from elective courses list	3(3-0)	Nil
Elective-5	GEOL-71XX	To be selected from elective courses list	3(3-0)	Nil
Elective-6	GEOL-71XX	To be selected from elective courses list	3(3-0)	Nil

Semester-III - IV

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
Deficiency-3*	GEOL-61XX	To be selected from deficiency course list	3(3-0)	Nil
	GEOL-7179	Geological Field Work	6(0-6)	Nil
	GEOL-7180	Thesis	6	Course Work Completion

Program Summary:

Category	Minimum No of Courses	Minimum No of Credit Hours
Deficiency Courses	3	9
General Education	2	2
Compulsory Courses	2	6
Elective Courses	6	18
Geological Field Work	1	6
Thesis		6

Note:

- I. The Regulations related to MS/M.Phil./M.Sc.(Hons) or equivalent approved by the Syndicate from time to time shall also be applicable.
- II. Deficiency Courses are to be decided by Graduate Program Committee in start of each session.
- III. Department can change the order of Core/Compulsory and Elective Courses as per availability of resources or demand.
- IV. The department can change the course offering as per available resources but shall be uniform for one session.

* For Intra-disciplinary admitted candidates only
** From Elective Courses List

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GEOL-6192	Introduction to Earth Sciences	3(3-0)
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Course Brief:

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, minerals, fossils present in rocks, and the processes of their formation. Geology is the core discipline of the earth sciences and encompasses many different phenomena, including plate tectonics and mountain building, volcanoes and earthquakes, and the long-term evolution of Earth's atmosphere, surface and life.

Course Learning Objectives:

The goal of the Geology undergraduate program is to equip students with the fundamental knowledge of the diverse fields of Geology (encompassing Geomorphology, Paleontology & Surface Processes, Hydrology & Low-Temperature Geochemistry, Sedimentology & Paleocology, and Tectonics and Solid-Earth Processes). In addition, it is critical that students learn to think like a scientist and to apply the scientific method in their coursework and in their lives. It helps to know the geologic time scale and place important geologic events in a temporal framework.

Course Contents:

1. Introduction and scope of geology; importance and relationship with other sciences;
2. History and philosophy of geology; Earth as a member of the solar system;
3. Earth's origin, age, composition and internal structure;
4. Vertebrate, invertebrate, and microfossils
5. Introduction to plate tectonics, Isostasy; mountain building processes;
6. Earthquakes and volcanoes; weathering and erosion;
7. Introduction, identification and classification of rocks and minerals;
8. Sedimentary, igneous and metamorphic structures;
9. Introduction to fossils in sedimentary rocks;
10. Introduction to folds, faults, joints, cleavage, foliation, lineation and unconformities;
11. Geological Time Scale; Law of Superposition, present is key to the past and Law of Faunal Succession;
12. Concept and techniques of geological dating, relative and absolute dating; evolution of life on earth;
13. Use of Brunton Compass and GPS, etc.

Recommended Texts

1. Plummer, C. C., Carlson, D. H., & Hammersley, L. (2016). *Physical geology*. New York: McGraw-Hill.
2. Plummer, C. C., McGeary, D., & Carlson, D. H. (2000). *Physical Geology: Earth Revealed*. New York: McGraw-Hill.

Suggested Readings

1. McGeary, D., Carlson, D. H., & Plummer, C. C. (2011). *Physical geology*. New York: McGraw-Hill.
2. Smith, G., & Pun, A. (2013). *How Does Earth Work? Physical Geology and the Process of Science: Pearson New International Edition*. London: Pearson Higher Education.
3. Turner, Derek. *Paleontology: a philosophical introduction*. Cambridge University Press, 2011.

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GEOL-6193	Structural Analysis	3(3-0)
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Course Brief:

The subject of structural geology provide knowledge of structures that are formed as a result of deformation in rocks. The course provides a good understanding of structural geology and tectonics. Within structural geology, which is the main focus of the course, will learn in-depth about geological structures that form in different tectonic regimes, the process of their formation, their geometry, and their physical properties. The course also consists of a practical module where will learn to measure and analyze these structures both in the field and in the laboratory. Structural features of complexly folded strata; advanced fold and fault analysis; simple statistical analysis of data; structural analysis; applications to exploration and exploitation; cross-sections and balancing; advanced map interpretation; tectonics; neotectonics. Analyze and integrate structural data within a tectonic framework or general stress field. Comprehend the aspects of structural style, what factors control the style and incorporate the style into an interpretation Describe the general strain path of an observed structure from the incipient state to present day Produce a balanced cross-section, a section that is kinematically viable and admissible Evaluate the quality and limitations of a structural geology interpretation. For example – Practice qualitative evaluations of existing geologic cross-sections and maps Gather structural data from a variety of data sources and evaluate the veracity and limitations of the data.

Course Learning Objectives:

In this course, students will learn how to analyze the complexly folded layers, advanced fold and fault analysis, structural features, statistical techniques for data and their application to exploration and exploitation. Students should be able to evaluate and interpret various structural styles, create balanced cross-sections, and assess the quality and limits of structural interpretations. This involves practical tasks like evaluating existing cross-sections, gathering and evaluating data from multiple sources.

Course Contents:

1. Differentiate between tectonic and structural geology
2. Stress and strain, types of stress/strain, measures of strain
3. know the structural setup of different tectonic regimes
4. know the brittle, ductile and plastic deformation
5. understand deformation mechanisms at micro- and macro-scales
6. Controlling factor of mechanical behavior of rocks
7. Brittle and ductile deformation
8. Mechanism of fold formation
9. Fold geometry
10. Mechanism of faults
11. Types of fault
12. Fractures
13. Tectonics
14. Foliation and lineation

Recommended Texts:

1. Twiss, R. J., & Moores, E. M. (1992). *Structural geology*. Macmillan.
2. Davis, G. H., Reynolds, S. J., & Kluth, C. F. (2011). *Structural geology of rocks and regions*. John Wiley & Sons.

Suggested Readings:

1. Ramsay, J. G., Huber, M. I., & Lisle, R. J. (1983). *The techniques of modern structural geology: Folds and fractures* (Vol. 2). Academic press.
2. Fossen, H. (2016). *Structural geology*. Cambridge university press

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Course Brief:

Mineralogy and petrology are two closely related fields within the realm of geology, but they focus on different aspects of the Earth's materials. Both mineralogy and petrology are fundamental to understanding the Earth's composition, history, and processes, and they play crucial roles in fields such as geology, environmental science, materials science, and even archaeology.

Course Learning Objectives:

As mineralogy is the sub discipline of geology which deals with the study of minerals. So the 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. The composition of igneous rocks and minerals can be determined via a variety of methods of varying ease, cost, and complexity. The study of sedimentary rocks will help the students to understand the classification and depositional system of the sedimentary rock as well as the provenance of sediments and sedimentary structures. By studying of metamorphic petrology students will get familiar with metamorphic processes and the resulting textures and structures in the rocks. Petrogenetic processes such as recrystallization, continuous and discontinuous reactions, mixed volatile reactions and deformation are addressed.

Course Contents:

1. Introduction to mineralogy and crystallography
2. Classification of minerals
3. physical and optical properties of the common silicate and non-silicate mineral group
4. introduction to X-Ray diffractometry and universal stage and their application.
5. Petrogenesis of igneous rocks
6. Tectonism-magmatism relationship
7. Igneous activity related to convergent plate boundary and divergent plate boundary environments
8. Intracontinental hot spots
9. Ophiolites
10. Origin, transportation and deposition of sediments
11. Texture of sedimentary rocks and their statistical parameters
12. Classification and description of sedimentary rocks
13. Types, grades, zones and facies of metamorphism
14. Metamorphic diffusion and differentiation
15. Study of thermal and regional metamorphism of igneous, argillaceous, calcareous and arenaceous rocks
16. Metamorphism in relation to plate tectonics
17. Study of textures and structures of metamorphic rocks.

Lab. Work


1. Mineral identification
2. Microscope analysis
3. X-Ray Diffraction (XRD)
4. Electron Microscopy
5. Petrographic microscopy
6. Chemical analysis

Recommended Texts:

1. Pettijohn, F. J., Potter, P. E., & Siever, R. (2012). Sand and sandstone. Springer Science & Business Media.
2. Blackburn, W. H., & Dennen, W. H. (1994). Principles of mineralogy. WCB/McGraw-Hill.
3. Best, Myron G. Igneous and metamorphic petrology. John Wiley & Sons, 2013.

Suggested Reading

1. Dana, J. D. (1864). Manual of Mineralogy... Wiley.
2. Wilson, B. M. (2007). Igneous petrogenesis a global tectonic approach. Springer Science & Business Media..
3. Blatt, H., Tracy, R., & Owens, B. (2006). Petrology: igneous, sedimentary, and metamorphic. Macmillan.
4. Boggs Jr, S. (2014). Principles of sedimentology and stratigraphy. Pearson Education.

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GEOL- 6195	Stratigraphy of Pakistan	3(3-0)
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Course Brief:

An extensive study of Pakistan's sedimentary strata and formations is provided by the "Stratigraphy of Pakistan" course. Students in this course will get a thorough understanding of Pakistan's stratigraphic framework, including how to identify, correlate, and interpret different rock sequences. The focus of this study will be on the fossil assemblages, depositional conditions, and geological history of Pakistan's stratigraphic units and sedimentary basins.

Course Learning Objectives:

This course will help the students to understand the principles and methods of stratigraphy, including lithostratigraphy, biostratigraphy, and chronostratigraphy of Pakistan. Also to gain knowledge of the geological history of Pakistan and the processes that have shaped its stratigraphy over time. To identify and correlate key stratigraphic units and formations present in Pakistan. To interpret depositional environments, fossils and sedimentary facies within different stratigraphic sequences. Develop skills in fieldwork, stratigraphic mapping, and the interpretation of geological cross-sections and well logs.

Contents


1. Introduction to Stratigraphy of Pakistan
2. Historical geology of Pakistan, Tectonic evolution and plate tectonics
3. Geological time scale and major geological events
4. Overview of the geological provinces and basins in Pakistan
5. Lithostratigraphy of Pakistan
6. Sequence stratigraphy and basin analysis
7. Biostratigraphy and Paleontology
8. Applications of biostratigraphy in correlation and dating of rock sequences
9. Chronostratigraphy and Geochronology
10. Economic Geology and Resource Exploration
11. Petroleum geology and hydrocarbon potential of Pakistan
12. Field Excursions and Practical Applications
13. Interpretation of stratigraphical cross-sections and well logs

Recommended Texts:

1. Shah, S. I. (2000). *Stratigraphy of Pakistan*. Quetta: Geological Survey of Pakistan.
2. Kazmi, A. H., & Abbasi, I. A. (2008). *Stratigraphy & historical geology of Pakistan*. Peshawar: Department & National Centre of Excellence in Geology.

Suggested Readings

1. Boggs Jr, S. (2014). *Principles of sedimentology and stratigraphy*. London: Pearson Education.
2. Shah, S. M. I. (1980). *Stratigraphy and economic geology of Central Salt Range*. Quetta: Geological Survey of Pakistan.


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GEOL-6196	Field and Engineering Geology	3(3-0)
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Course Brief:

The aim of this course is to provide a strong foundation in field and engineering geology to MS students, along with practical skills. The course intends to fill any gaps in students' understanding of geological principles and their application in engineering settings. By combining academic lectures and practical fieldwork, students will learn how to effectively perform geological mapping, site characterization, and interpret geological features relevant to engineering projects.

Course Learning Objectives:

After completing this Engineering and Field Geology Deficiency Course, MS students will have acquired the necessary skills to be proficient in geological mapping, site characterization, and hazard assessment in engineering contexts. They will learn how to accurately gather and analyze geological data, determine the suitability of a location for an engineering project, and effectively communicate geological findings through oral presentations and written reports.

Contents

1. Introduction to Field and Engineering Geology
2. Geological Maps and Mapping Techniques
3. Fieldwork: Geological Mapping and Site Characterization
4. Geological Hazards Assessment for Engineering Projects
5. Site Suitability Evaluation: Geological Considerations
6. Field Instrumentation and Measurement Techniques
7. Interpretation of Geological Data for Engineering Design

Recommended Texts:

1. Bell, F. G. (2016). Fundamentals of engineering geology. Elsevier.
2. Attewell, P. B., & Farmer, I. W. (2012). Principles of engineering geology. Springer Science & Business Media
3. Coe, A. L. (Ed.). (2010). Geological field techniques. John Wiley & Sons.

Suggested Readings

1. Lisle, R. J., Brabham, P., & Barnes, J. W. (2011). Basic geological mapping (Vol. 35). John Wiley & Sons.
2. Dearman, W. R. (2013). Engineering geological mapping. Elsevier.

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URCG-5129	Understanding of Holy Quran – I	1(1-0)
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Annex-‘CXXI’

URCG-5129

Model Course Outline for the Course Understanding of Quran – I

Course Title: Understanding of Quran – I
 Course Book: Muallim ul Quran (Volume 1, 2 & 3) by Dr Ubaid ur Rahman
 Credit Hours: 1 (0-1)
 Contact Hours: 3 per week
 Weeks: 15-16 (45-48 hours)

Course Learning Outcomes:

By the end of this course, students will be able to:

1. Develop the ability to understand basic words of the Quran, phrases and sentences that do not contain verbs (unit 1 to 5 of Muallim ul Quran Book) and then sentences having present tense (first half of unit 6 of Muallim ul Quran Book).
2. Acquire a strong foundation for understanding long verses of the Quran with clarity.
3. Comprehend Quranic vocabulary, particles (operative & non operative particles), compounds (Adjective & Possessive compound), pronouns (singular & plural) and types of plural through hundreds of Quranic sentences.
4. Recognize and understand different styles of Quranic sentences, including nominal sentence, emphatic sentence, double emphatic sentence, negative sentence, interrogative sentence, oath –based sentences.
5. Strengthen understanding of fundamental Quranic linguistic styles, expressions and idioms.
6. Understand at least 30 to 40 % of each page of the holy Quran.

Provision of material, content and books:


- Paper book: All volumes are available in printed book form.
- Tutorial videos: Teaching video of each lesson available on YouTube.
- Confirmation Videos: A complete series of confirmation videos of all lessons is available in which the student can confirm his answers.
- A flipbook: A flipbook edition is also accessible.
- Helping material: Helping material for the teachers like quizzes, question papers and images . . . available on website.

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Course Outline:

Weeks	Lectures (1.5 hrs)	Units	Lessons	Assignments/Home Task	Linguistic Rules
1.	1.	1	1-5	Writing the meaning of Quranic words Lesson 1-8	Proper Noun Masculine & Feminine
	2.	1	9-14	Writing the meaning of Quranic words 9-14	Two kinds of plural Concept of (ر) "And" Common Noun
2.	1.	1	15-17	Writing the meaning of Quranic words, phrases & translation of Sentences 15-17	Demonstrative Noun (This & That for Masculine (هذه) Demonstrative Noun (This & That for Feminine) (ذلك- تلك)
	2.	1	18-19 & Revision (Unit 1)	Writing the meaning of Quranic words, phrases & translation of Sentences 17-19 Quiz	Lam for emphasis (لام التأكيد) Superlative Degree like أكبر Revision of all Quranic Sentences
3.	1.	Unit 2	1-3	Writing the meaning of Quranic words, phrases & translation of Sentences 1-3	Emphatic Particle إن Preposition "For" (اللام) Preposition (في)
		2	4-6	Writing the meaning of Quranic words, phrases & translation of Sentences 4-6	Preposition (على- من- إلى)
4.	1.	2	7-9	Writing the meaning of Quranic words & translation of Sentences 7-9	Preposition (إلى) Absolute Negation Particle Exceptive Particle (لا النافية) (إلا) (ما النافية) (للجنس)
		2	10-13 & Revision (Unit 2)	Writing the meaning of Quranic words, phrases & translation of Sentences 10-13 Quiz	Subordinating Conjunction (أن), Was (كان), Vocative Particle (أحرف التداء)

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5.	1.	Unit 3	1-2	Writing the meaning of Quranic phrases 1-2	Quranic Adjective Compounds (صفة وموصوف)
	2.	3	3-5	Writing the meaning of Quranic phrases & translation of sentences 3-5	Quranic Possessive Construction (مضاف ومضاف إليه)
6.	1	3	6-7	Writing the meaning of Quranic phrase translation of sentences 6-7	Quranic Possessive Construction (مضاف ومضاف إليه)
	2.	3	8-10 & Revision (Unit 3)	Writing the meaning of Quranic phrase & translation of sentences 8-10 Quiz	Active Participle (اسم الفاعل), Passive Participle (اسم المفعول), Dual (متى)
7.	1.	Unit 4	1-2	Writing the meaning of Quranic phrase & translation of sentences 1-2	Personal Pronoun He (هو المتنصل) Possessive Pronoun His (له المتنصل)
	2.	4	3-4	Writing the meaning of Quranic phrase & translation of sentences 3-4	Possessive Pronoun with prepositions like في بيته Pronoun "His" with prepositions like له، منه، فيه
8.		4	5-8	Writing the meaning of Quranic sentences 5-8	Personal Pronoun You (أنت المتنصل) Possessive Pronoun Your (لك المتنصل) Possessive Pronoun with prepositions like في بيتك Pronoun "your" with prepositions like لك، منك، فيك
	2.	Mid Term			

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9.	1.	4	9-12	Writing the meaning of Quranic phrases & sentences 9-12	Personal Pronoun She (هي المنفصل) Possessive Pronoun Her (ها المتصل) Possessive Pronoun with prepositions like في بيئها Pronoun "Her" with prepositions like لها
	2.	4	13-16	Writing the meaning of Quranic phrases & sentences 13-16	Personal Pronoun I (انا المنفصل) Possessive Pronoun Her (ي المتصل) Possessive Pronoun with prepositions like في بيتي Pronoun "My" with prepositions like لي
10.	1	4	17 & Revision Unit 4	Revision of all Quranic sentences of Unit 4 Quiz	Adverb (حال)
	2.	Unit 5	1-2	Writing the meaning of Quranic phrases & sentences 1-2	Masculine Plural جمع المذكر السالم و جمع المذكر السالم المسبوق بحرف الجر
11.	1.	5	3-4	Writing the meaning of Quranic phrases & sentences 3-4	Possessive Construction with Plurals جمع المذكر السالم المسبوق بالإضافة
	2.	5	5-6	Writing the meaning of Quranic phrases, sentences & verses 5-6	Personal Pronoun They (هم المنفصل) Possessive Pronoun Their (هم المتصل)
12.	1.	5	7-8	Writing the meaning of Quranic phrases, sentences & verses 7-8	Possessive Pronoun with prepositions like في بيئهم Pronoun "Their" with prepositions like لهم
	2.	5	9-11	Writing the meaning of Quranic phrases, sentences & verses 9-11	Personal Pronoun You (انتم المنفصل) Possessive Pronoun Your (كم المتصل) Possessive Pronoun with prepositions

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13.	1.	5	12-14	Writing the meaning of Quranic phrases & sentences & verses 12-14	like في بيتكم Pronoun "Your" with prepositions like لكم Personal Pronoun We (نحن المنفصل) Possessive Pronoun Our نا (المتصل)
	2.	5	15-16	Writing the meaning of Quranic sentences & verses 15-16	Possessive Pronoun with prepositions like في بيتنا Pronoun "Our" with prepositions like لنا
14.	1.	5	17-18	Writing the meaning of Quranic sentences & Verses 17-18	Demonstrative Pronoun These, Those (هؤلاء- أولئك)
	2.	5	19-23	Writing the meaning of Quranic sentences & Verses 19-23	ما / إلا، إن / إلا، إنما ليس، ما ، (إلام، أن، بل، كان) (إلا، اليس، اليوم، يومئذ، سبحان، ما بينهما، قل، إذن، ينس، نعم، كلا، ما أدراك، حسب، أعلم ب، مصير، مرجع، ديناً(تمييز)
15.	1.	5	Revision Unit 5	Quiz	
	2.	5	1-3 (till Page 16)	Writing the meaning of Quranic Verbs & Translation of Quranic Sentences & Verses (1-3)	Introduction of Present Tense(فعل مضارع) & Verbal Sentence (جملة فعلية) Present Tense الفعل المضارع صيغة المفرد يعلم
16.	1.	6	3 (From Page 17) & 4-5	Translation of Quranic Sentences & Verses 3-5	Present Tense الفعل المضارع صيغة المفرد يعلم
	2.	6	6	Translation of Quranic Sentences & Verses	Present Tense الفعل المضارع صيغة الجمع يعلمون

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Ethics-I

URCG-5131

1 (0-1)

1-Course Description

The Ethics-I course is designed to provide students with a comprehensive understanding of ethical principles, practices, and theories in various societal contexts. Throughout this degree program, students will explore the complexities of ethical theories of semitic and non-semitic religions along with decision-making and develop critical thinking skills to navigate moral dilemmas. This course will also enable the students to interact with others religious identities with humanistic, inclusive and holistic approach

2- Learning Objectives

This course aims to:

1. Introduce students to the fundamental concepts, scope, and importance of ethics.
2. Explore the relationship between law, morality, and social values.
3. Develop a clear understanding of virtuous and immoral ethics and their impact on individual and collective life.
4. Study the role of major religious figures in the moral development of human society and enable students to apply ethical principles for personal development, conflict resolution, and social harmony.

3- Learning Outcomes

By the end of the course, students will be able to:

1. Students will be able to identify and analyze major ethical theories, values, and their scope in social and individual life.
2. Differentiate between law and ethics, and analyze their interrelationship.
3. Identify types of virtuous and immoral ethics and assess their social impacts.
4. Examine the ethical teachings of major religions and their relevance in contemporary society.
5. Apply ethical principles to address modern challenges in personal and professional life.

4-Course Structure

1. Interactive lectures, Group discussions and debates
2. Reflection papers and presentations
3. Assignments and Quiz

Course Contents**Unit 1: Introduction and Fundamentals of Ethics**

1. Literal and terminological definition of ethics
2. Literal and terminological definition of values
3. Relationship between law and ethics
4. Need, importance, and scope of ethics

Unit 2: Types of Ethics and Their Impact on Society

- Virtuous ethics: concept, types, benefits, and outcomes
- Immoral ethics: concept, types, and harms
- Role of ethics in social refinement and establishment of peace

Unit 3: Virtuous Ethics (Akhlāq-e-Hasanah)

- Concept, need, and importance of virtuous ethics
- Scope of virtuous ethics in the light of religions
- Major virtues in revealed and non-revealed religions
- Impact of virtuous ethics on individual and collective life

Unit 4: Immoral Ethics (Akhlāq-e-Razilah)

- Concept of immoral ethics
- Social problems caused by immoral ethics
- Practical consequences of immoral ethics
- Major vices in revealed and non-revealed religions

Unit 5: Role of World Religious Figures in Moral Development

- Prophet Moses (AS): introduction, miracles, and role in moral refinement
- Prophet Jesus (AS): introduction, miracles, and role in moral refinement
- Prophet Muhammad (ﷺ): introduction, miracles, and role in moral refinement

Textbook

1. Izutsu, T. (2002). *Ethico-Religious Concepts in the Qur'an*. McGill-Queen's University Press.

Suggested Readings

1. Gert, B. (2005). *Morality: Its Nature and Justification*. Oxford University Press.
2. MacIntyre, A. (2007). *After Virtue: A Study in Moral Theory*. University of Notre Dame Press.
3. Al-Ghazali, Abu Hamid (2001). *The Alchemy of Happiness*. Islamic Texts Society.
4. Nasr, S. H. (1994). *The Heart of Islam: Enduring Values for Humanity*. Harper One.
5. Beauchamp, T. L., & Childress, J. P. (2019). *Principles of Biomedical Ethics*. Oxford University Press.
6. Hasan, Z. (2010). *Ethics in Islam: Key Concepts and Contemporary Challenges*. Islamic Research Institute.

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 QATAR

URCG-5129

Understanding of Holy Quran – II

1(1-0)

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Arabic - 'CXXII'

URCG-5130

Model Course Outline
for the Course Understanding of Quran – II

Course Title: Understanding of Quran – II
Course Book: Muallim ul Quran (Volume 3, 4 & 5) by Dr Ubaid ur Rahman
Credit Hours: 1 (0-1)
Contact Hours: 3 per week
Weeks: 15-16 (45-48 hours)

Course Learning Outcomes:

By the end of this course, students will be able to:

1. Directly comprehend hundreds of Quranic sentences & verses.
2. Understand at least 80 to 85 % of each page of the holy Quran.
3. Understand common verses across different Quranic topics.
4. Achieve proficiency in the basic and advance linguistic aspects of the Arabic language.
5. Understand the difference between Quranic verbs in various forms, such as present, past and imperative.
6. Develop the ability to understand long verses of the holy Quran independently and then comprehend their interpretation.

Provision of material, content and books:

- Paper book: All volumes are available in printed book form.
- Tutorial videos: Teaching video of each lesson available on YouTube.
- Confirmation Videos: A complete series of confirmation videos of all lessons is available in which the student can confirm his answers.
- A flipbook: A flipbook edition is also accessible.
- Helping material: Helping material for the teachers like quizzes, question papers and images is available on website.

Course Outline:

Weeks	Lectures	Units	Lessons	Assignments/Home Task	
1.	1.	6	6	Understanding & Translation of Verses	Present Tense صيغة جمع منكر غائب مثل يجدون
	2.	6	7-8	Understanding & Translation of Verses	Present Tense صيغة جمع منكر غائب مثل يجدون
2.	1.	6	9-10	Understanding & Translation of Verses	Present Tense صيغة مفرد منكر مخاطب (تبين) وجمع منكر مخاطب (ليدون)
	2.	6	11-12	Understanding & Translation of Verses	Present Tense صيغة جمع منكر مخاطب (ليدون)

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صيغة المتكلم (أعيد)					
3.	1.	6	13	Understanding & Translation of Verses	Present Tense صيغة جمع المتكلم (تفيد)
	.	6	14-15	Understanding & Translation of Verses	Negative Imperative صيغة المفرد وصيغة الجمع , لا تُعبد , لا تُعبدرا
4.	1.	6	16-17	Understanding & Translation of Verses	Conditional Sentences & masdar moawal (مصدر مؤول)
	2.	6	18-19	Understanding & Translation of Verses	Laam uttaleel (لام للتعليل) & Laam ul jhood (لام الجود)
5.	1.	6	20-21	Understanding & Translation of Verses	Present with object pronouns & Passive Voice
	2.	6	Revision (Unit 6)	Quiz	
6.	1.	Unk 7	1 (sec 1-3)	Understanding & Translation of Verses	Past Tense صيغة المفرد للثانبات
	2.	6	1 (Sec 4-5)	Understanding & Translation of Verses	Past Tense صيغة المفرد للثانبات
7.	1.	6	1 (Sec 5-6)	Understanding & Translation of Verses	Past Tense صيغة المفرد للثانبات
	2.	6	1 (Sec 7-9)	Understanding & Translation of Verses	Past Tense صيغة المفرد للثانبات
8.	1.	7	Revision	Understanding & Translation of Verses QUIZ	Past Tense صيغة المفرد للثانبات
	MID TERM				
9.	1.	7	2 (sec 1-2)	Understanding & Translation of Verses	Past Tense صيغة الجمع للثانبات عيدا
	2.	7	2 (sec 3)	Understanding & Translation of Verses	Past Tense صيغة الجمع للثانبات عيدا
10.	1.	7	2 (sec 4-5)	Understanding & Translation of Verses	Past Tense صيغة الجمع للثانبات عيدا
	2.	7	2 (sec 6-7)	Understanding & Translation of Verses	Past Tense صيغة الجمع للثانبات عيدا
11.	1.	7	3 (sec 1-2)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمتكلم عينا

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	2.	7	3 (sec 2-3)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمتكلم علينا
12.	1.	7	3 (sec 3-4)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمتكلم علينا
	2.	7	3 (sec 4-5)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمتكلم علينا
13.	1.	7	4 (sec 1-2-3)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمخاطب عيبتم
	2.	7	4 (sec 4-5)	Understanding & Translation of Verses	Past Tense صيغة الجمع للمخاطب عيبتم
14.	1.	7	5-6	Understanding & Translation of Verses Quiz	Past Tense صيغة المتكلم والمخاطب عيبت ، عيبت
	2.	7	7	Understanding & Translation of Verses	Past Tense صيغة المؤنث للغائب عيبت
15.	1.	7	8	Understanding & Translation of Verses	Passive Voice (Past Tense) فعل منجهول للمفرد
	2.	7	9	Understanding & Translation of Verses	Passive Voice (Past Tense) فعل منجهول للجمع
16.	1.	8	1-4	Understanding & Translation of Verses	Imperative Verb for singular فعل الأمر للمفرد
	2.	7	5-8	Understanding & Translation of Verses	Imperative Verb for plural فعل الأمر للجمع

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Ethics-II

URCG-5132

1 (0-1)

1-Course Description

The course *Ethics-II* is designed to provide students with a deeper understanding of ethical principles and practices from both Semitic and non-Semitic religions, as well as their application in professional and social contexts. Students will engage with Jewish, Christian, Islamic, Hindu, Buddhist, Sikh, Confucian, and Jain ethical traditions. The course emphasizes moral reasoning, decision-making, tolerance, and peacebuilding. It aims to cultivate an inclusive, humanistic, and holistic approach towards ethical living and interfaith engagement.

2- Learning Objectives

The course objectives are to:

1. Understand the fundamental principles and theories of ethics.
2. Introduce the ethical and moral teachings of Judaism, Christianity, Islam, and Hinduism.
3. Explore the ethical teachings of non-Semitic religions such as Buddhism, Sikhism, Confucianism, and Jainism.
4. Develop critical thinking skills to evaluate ethical arguments and theories.
5. Promote ethical leadership and interfaith harmony.

3- Learning Outcomes

By the end of this course, students will be able to:

1. Identify and analyze major ethical theories and teachings from world religions.
2. Understand the role of religions in improving moral values and social behavior.
3. Demonstrate ethical decision-making in various personal and professional contexts.
4. Recognize the impact of ethical decisions on individuals, communities, and society.
5. Apply skills of ethical leadership, including communication, conflict resolution, and inclusive engagement.

4-Course Structure

1. Interactive lectures, Group discussions and debates
2. Reflection papers and presentations
3. Assignments and Quiz

Course Contents**Unit 1: Ethical Teachings of Semitic Religions**

- Judaism and its ethical teachings
- Christianity and its ethical teachings
- Islam and its ethical teachings

Unit 2: Ethical Teachings of Non-Semitic Religions

- Hinduism and its ethical teachings
- Sikhism and Buddhism: ethical values and practices
- Confucian and Jain ethical traditions

Unit 3: Professional Ethics

- Ethics for students and teachers
- Ethics in doctor-patient relationships
- Ethics in trader-customer interactions

Unit 4: Concept and Significance of Tolerance

- Definition, need, and importance of tolerance
- Teachings of Semitic religions on tolerance and their contemporary relevance
- Teachings of non-Semitic religions on tolerance and their contemporary relevance

Unit 5: Foundational Values and Ethics for Peacebuilding in Society

- Respect for sacred scriptures, personalities, places of worship, and religious symbols
- Promotion of tolerance and broadmindedness
- Encouragement of dialogue and harmony
- Benevolence towards humanity
- Establishment of justice and fairness
- Patience, forbearance, and forgiveness

Textbook

- Kidder, R. M. (2009). *How Good People Make Tough Choices: Resolving the Dilemmas of Ethical Living*. Harper.

Suggested Readings

1. Barash, D. P., & Wehel, C. P. (2014). *Peace and Conflict Studies*. Sage.
2. Smart, N. (1998). *The World's Religions*. Cambridge University Press.
3. Nasr, S. H. (2003). *The Heart of Islam: Enduring Values for Humanity*. HarperOne.
4. Sharma, A. (2006). *Hindu Ethics: Purty, Abortion, and Euthanasia*. SUNY Press.
5. Harvey, P. (2000). *An Introduction to Buddhist Ethics: Foundations, Values and Issues*. Cambridge University Press
6. Coward, H., & Perkinson, J. (2013). *A Cross-Cultural Dialogue on Ethical Leadership*. Wilfrid Laurier University Press.
7. Confucius. (1998). *The Analects*. Oxford University Press.

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GEOL - 7101	Emerging Trends & Issues in Geology	3(3-0)
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Course Brief:

This course explores recent advancements and contemporary issues in the field of geology. It addresses technological innovations, environmental concerns, and the role of geology in sustainable development. Students will learn about climate change impacts, geohazards, and the integration of digital tools in geosciences. Emphasis will be placed on interdisciplinary approaches and global challenges. The course prepares students to critically assess emerging geological topics.

Course Learning Objectives:

Students will identify and explain current trends and innovations in geology, gaining insight into the evolving nature of the field. They will evaluate the impacts of climate change and human activities on geological systems, fostering an understanding of the interconnectedness between geoscience and the environment. Emphasis will be placed on analyzing geological data using modern tools and techniques, enhancing their technical competence. Students will also explore the societal and environmental implications of geoscientific practices, interpreting global geohazards and proposing effective risk mitigation strategies. Finally, they will engage in informed discussions on ethical and policy issues related to geology, preparing them to contribute responsibly to the profession.

Course Contents:


1. Introduction to Emerging Trends in Geology
2. Climate Change and Its Geological Implications
3. Role of Geology in Sustainable Development
4. Advances in Remote Sensing and GIS in Geology
5. Artificial Intelligence and Big Data in Geosciences
6. Geoethics and Environmental Responsibility
7. Renewable Energy Resources and Geological Aspects
8. Groundwater Depletion and Management
9. Urban Geology and Geotechnical Challenges
10. Natural Hazards: Earthquakes, Volcanoes, Landslides
11. Critical Mineral Resources and Global Demand
12. Future Directions in Geoscientific Research

Recommended Texts:

1. Montgomery, C.W. (2019). *Environmental Geology*. McGraw-Hill Education.
2. Keller, E.A., & DeVecchio, D.E. (2021). *Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes*. Pearson.

Suggested Readings:

1. Allison, L. (Ed.). (2020). *Geoethics: Ethical Challenges and Case Studies in Earth Sciences*. Elsevier.
2. Skinner, B.J., Murck, B.W. (2011). *The Blue Planet: An Introduction to Earth System Science*. Wiley.

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 SPRINGFIELD

GEOL - 7102	Advanced Research Methods for Geological Sciences	3(3-0)
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Course Brief:

This course is designed to equip geology students with advanced research methodologies applicable to earth sciences. It covers proposal writing, data acquisition, analytical techniques, and interpretation methods. Emphasis is placed on both qualitative and quantitative approaches, field and lab-based studies, and the use of modern software. The course promotes critical thinking, scientific writing, and ethical research practices. It prepares students for independent research and thesis work.

Course Learning Objectives:

Students will learn to design and formulate geological research questions and hypotheses, laying the foundation for independent scientific inquiry. They will apply advanced data collection and sampling techniques in both field and laboratory settings, ensuring methodological rigor. Emphasis will be placed on analyzing geological data using appropriate statistical and computational tools to derive meaningful insights. Students will interpret their research findings in the context of existing geological theories, enhancing their critical thinking and scientific reasoning. Additionally, they will develop the skills to prepare high-quality research proposals and scientific reports. A thorough understanding of ethical issues, including plagiarism, will be emphasized to promote integrity in geoscience research.

Course Contents:

1. Introduction to Geological Research and Scientific Inquiry
2. Formulating Research Problems, Questions, and Hypotheses
3. Literature Review Techniques and Source Evaluation
4. Research Design: Qualitative, Quantitative & Mixed Methods
5. Sampling Strategies and Field Data Collection Methods
6. Laboratory Techniques in Petrology, Geochemistry & Paleontology
7. Geostatistics and Data Interpretation in Earth Sciences
8. Use of GIS, Remote Sensing, and Modelling Tools
9. Research Ethics and Avoidance of Plagiarism
10. Scientific Writing and Referencing Styles (APA, MLA, etc.)
11. Proposal Development and Thesis Structuring
12. Oral and Poster Presentation Techniques in Geology

Recommended Texts:

1. Creswell, J.W., & Creswell, J.D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE Publications.
2. Davis, J.C. (2002). *Statistics and Data Analysis in Geology*. Wiley.

Suggested Readings:

1. Hancock, G.R., & Turpin, T. (Eds.). (2020). *Research and Fieldwork in Development*. Routledge.
2. Gill, R. (2014). *Modern Analytical Geochemistry: An Introduction to Quantitative Chemical Analysis Techniques for Earth, Environmental and Materials Scientists*. Routledge.

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Course Brief:

This course is masters level course of Mineralogy. Applied Mineralogy, a research field located between Earth Science and Material Science, encompasses such diverse disciplines as the prospection, extraction and refinery of ores, the manufacturing of materials, and the impact of minerals on the environment.

Course Learning Objectives:

The course is designed to acquire the knowledge about the physical and optical properties of various rock forming minerals and to develop a relationship between the structure chemistry and properties of silicates, carbonates, oxides, sulphides, and phosphate. This will help the students to classify minerals in different groups according to their properties and economic importance such as gemstones

Course Contents:

1. Classification of minerals
2. Important properties of feldspars, pyroxenes, amphiboles, micas, garnets, epidote, zeolites, oxides, hydroxides, carbonates and sulfides
3. Structure, classification and identification of clay minerals and mixed layer clay minerals.
4. Gemstones and their mineralogical properties

Lab. Work

1. Megascopic and microscopic identification of common rock forming minerals
2. Construction and interpretation of phase diagrams from given experimental data
3. Lab work related to XRD and Universal stage.

Recommended Texts:

1. Blackburn, W. H., & Dennen, W. H. (1994). Principles of mineralogy. WCB/McGraw-Hill.
2. Dana, J. D. (1864). Manual of Mineralogy. Wiley.
3. Deer, W. A. (2011). Rock-forming minerals. Geological Society of London.

Suggested Readings

1. Nesse, W. D. (2012). Introduction to mineralogy (No. 549 NES).
2. Nesse, W. D. (1991). Introduction to optical mineralogy (No. 549.12 N4 1991).
3. Perkins, D., & Henke, K. R. (2004). Minerals in thin section (No. 549.9 PER)

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UNIVERSITY OF CALIFORNIA
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SAN DIEGO, CALIFORNIA

Course Brief:

Pakistan being a developing country is facing significant challenges of energy crises due to a deficit of hydrocarbons. So, it is essential to explore and develop new oil and gas fields with increasing drilling rate to meet energy requirements. So the course is designed to understand the basic knowledge about tectonics, depositional settings and lithostratigraphic divisions of the rocks of various geological periods in Pakistan as well as to learn about the evaluation of petroleum potentials of different basins. This course covers a wide range of earth science subjects and their application to the full spectrum of hydrocarbon exploration and production. It is designed for students with some industrial experience, as well as for recent graduates seeking careers in the petroleum and allied service industries.

Course Learning Objectives:

In this course, students will learn about Petroleum Exploration in Pakistan, addressing the energy crisis. The course focuses on assessing the potential for finding oil and gas in different regions. It covers various earth science topics and their connection to hydrocarbon exploration. Whether you have experience or are a recent graduate, this course prepares you for careers in the petroleum and related industries.

Course Contents:

1. History of petroleum exploration
2. New trends for petroleum exploration
3. Tectonic framework
4. Sedimentary basins and their evolution and distribution
5. Tectonics, depositional settings and lithostratigraphic divisions of the rocks of various geological periods
6. Facies development and their association in depositional basins such as Indus, Baluchistan and offshore regions
7. Evaluation of petroleum potentials of different basins
8. Structural styles and petroleum play in the basins of Pakistan
9. Geothermal gradients and their maturity
10. Productive and potential oil and gas reservoirs and source rocks and their distribution in the basins
11. Play Fairways and Petroleum System in basins; case studies.

Lab. Work : Case histories of oil and gas fields of Pakistan.

Recommended Texts:

1. Kadri, I. B. (1995). *Petroleum geology of Pakistan*. Karachi: Pakistan Petroleum Limited.
2. Kazmi, A. H., & Abbasi, I. A. (2008). *Stratigraphy & historical geology of Pakistan*. Peshawar: Department & National Centre of Excellence in Geology.

Suggested Readings:

1. Haq, B. U., & Milliman, J. D. (1985). *Marine geology and oceanography of Arabian Sea and coastal Pakistan*. Karachi: Oxford University Press.
2. Bender, F., & Raza, H. A. (1995). *Geology of Pakistan*. Karachi: Oxford Press.

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GEOL-7105	Engineering Geology	3(3-0)
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Course Brief:

The course aims to equip students with the knowledge and skills required to apply geological and geotechnical techniques to various engineering projects such as site investigation, foundation design, slope stability analysis, and construction materials assessment. The course also covers topics such as geological hazards, environmental geology, and geohazards mitigation strategies. The objectives of the course are to develop a deep understanding of the geological and geotechnical factors that affect engineering design, to provide students with hands-on experience in site investigation and laboratory testing, and to develop critical thinking and problem-solving skills necessary to address complex engineering geology challenges.

Course Learning Objectives:

The primary learning outcome of this course is to equip students with advanced knowledge and skills in Engineering Geology. Upon completion of the course, students will be able to proficiently collect process and interpret valuable information from surface and subsurface data, enabling them to make informed decisions in geotechnical and geological projects. Through theoretical discussions, practical exercises, and case studies, students will improve their ability to apply Engineering Geological techniques effectively in real-world scenarios.

Course Contents:

1. Rock and soil mechanics and its application in civil engineering
2. Study of geological factors in relation to the construction of buildings and foundations, roads, highways
3. Excavation and tunneling
4. Mine openings
5. Dams and bridges
6. Construction materials
7. Slope stability analysis
8. Hazard assessment
9. Mass movement, their causes and prevention
10. Application of geophysical methods for site investigation
11. Construction in earth-quake zone
12. Dams and their kinds, geological investigations for selecting a site for a dam
13. Landslides
14. Classification, geometry, causes and preventive methods
15. Groundwater and characteristics of groundwater
16. Case histories of important engineering projects (small and mega) in Pakistan

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

Recommended Texts:

1. Attewell, P. B., & Farmer, I. W. (2012). *Principles of engineering geology*. Springer Science & Business Media.
2. Waltham, T. (2002). *Foundations of engineering geology*. CRC Press.
3. Bell, F. G. (2016). *Fundamentals of engineering geology*. Elsevier.

Suggested Readings:

1. Blyth, F. G. H., & De Freitas, M. (2017). *A geology for engineers*. CRC Press.
2. Záruba, Q. (2012). *Engineering geology* (Vol. 10). Elsevier.

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GEOL-7106

Applied Geophysics

3(3-0)

Course Brief:

This course in applied geophysics is designed to enable graduate students to get understanding for application of geophysical techniques to solving geoscientific problems in resource exploration and development, natural hazards, and pollution control. The course takes a practical, hands-on, field-oriented approach to show the applications of geophysics to these problems. For each topic, the course flow will proceed from basic principles (theory) through methodology and applications, to case histories. This course emphasizes applications, and keeps theory to essentials. The syllabus presents principles and operational procedures of each method initially, along with discussions of where the method is applicable, and is not applicable. Case histories will illustrate applications.

Course Learning Objectives:

The student will be able to demonstrate an advanced understanding of the physical principles underpinning geophysical methods. Critically evaluate geophysical techniques, acquisition procedures, and survey designs for various subsurface targets. Process and analyse collected geophysical data. Employ appropriate modeling methodologies, and evaluate strengths, weaknesses, and limitations. Infer physical properties at depth and formulate geological interpretations from those properties

Course Contents:

1. Study of geophysical features of the Earth
2. Study of gravity, magnetic, and temperature fields.
3. Geophysical methods.
4. Seismology
5. Heat Flow
6. Paleomagnetism
7. Study geophysical and geological processes in the context of plate tectonic theory.
8. Analysis of stress and strain.
9. Measurement and interpretation of strain in geological materials.
10. Elasticity applied to determine stress in the earth's lithosphere.
11. Creep of solids and flow of geological materials.

Recommended Texts:

1. Everett, M. E. (2013). Near-surface applied geophysics. Cambridge: Cambridge University Press..
2. Robert J. Lillie, (2000). *Whole earth geophysics: an introductory textbook for geologists and geophysicists*, Prentice Hall.

Suggested Readings:

1. Dobrin, M.B., (2012), introduction to geophysical prospecting (2nd ed.): McGraw-Hill Book Co., New York..
2. Reynolds, J. M. (2011). An Introduction to Applied and Environmental Geophysics. John Wiley & Sons.

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Course Brief:

Coal geology is the branch of geology that deals specifically with the study of coal, including its formation, composition, distribution, and properties. Coal is formed from the remains of ancient plants that accumulated in swampy environments millions of years ago. The process of coal formation, known as coalification, involves the decomposition of plant material under conditions of heat and pressure over geological time scales. This process results in the formation of different types of coal, including peat, lignite, sub-bituminous, bituminous, and anthracite.

Course Learning Objectives:

Coal primarily consists of carbon, along with varying amounts of other elements such as hydrogen, oxygen, nitrogen, and sulfur. The composition of coal can vary depending on factors such as the type of plant material, the degree of coalification, and geological conditions during its formation. Understanding coal geology is crucial for various stakeholders, including geologists, mining engineers, environmental scientists, policymakers, and energy industry professionals, as it informs decisions related to coal exploration, extraction, utilization, and environmental management.

Course Contents:


1. Introduction to Coal Geology
2. Coal formation and petrography
3. Coal deposits and exploration
4. Coal Mining methods
5. Coal utilization
6. Coal geology and environmental issues
7. Field work and research projects

Recommended Texts:

1. Thomas, L. P. (2023). Global standardization of coal resources and reserves. In *The Coal Handbook* (pp. 53-83). Woodhead Publishing.
2. Gibson, W. (1908). *The geology of coal and coal-mining*. E. Arnold.

Suggested Readings:

1. Thomas, L. (1992). A handbook on practical coal geology.
2. Hemish, L. A. (1989). *Coal geology of Rogers County and western Mayes County, Oklahoma*. University of Oklahoma.


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GEOL – 7108	Global Tectonics	3(3-0)
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Course Brief:

This course is designed to examine the structures and mechanisms, such as plate tectonics, faulting, mountain building, and seismic activity that cause the deformation of the Earth's crust. Students who complete this course will have a basic understanding of the mechanics behind tectonic processes and how they affect natural hazards and the evolution of geology. Analyze tectonic feature evolution and geological past at different temporal and spatial scales.

Course Learning Objectives:

This course will help the students to recognize the fundamentals of plate tectonics and the forces that propel crustal migration. Recognize and explain the many tectonic structural types, such as mountain belts, folds, and faults. Examine how tectonics interacts with other geological processes, including volcanism, metamorphism, and sedimentation.

Course Contents:

1. Historical perspective
2. Concept of geosyncline and sedimentary basins, Continental drift and Sea floor spreading
3. Concept of plate tectonics, Plates and plate boundaries
4. Mechanism of plate tectonics
5. Tectonic structures Extensional, compressional and transpressional tectonics
6. Oceanic ridges and trenches, Continental rifts, Intra-oceanic islands, Hot spot and mantle plumes
7. Relative and absolute plate motions
8. Subduction zones, Transform and transcurrent faults
9. Introduction to neo-tectonics and related hazards
10. Geological mapping and structural analysis
11. Tectonics and natural resources: mineral deposits, hydrocarbons, and groundwater
12. Tectonics and geohazards: earthquakes, tsunamis, and landslides
13. Application of geotectonic in natural resource explorations.

Lab Work

Specified assignments/projects.

Recommended Texts:

1. Cox, A., & Hart, R. B. (2009). *Plate tectonics: how it works*. Hoboken: John Wiley & Sons.
2. Turcotte, D., & Schubert, G. (2014). *Geodynamics*. Oxford: Cambridge university press.

Suggested Readings

1. Keary, P., Vine, F., & Panza, G. F. (2000). *Global Tectonics*. Hoboken: Wiley-Blackwell.
2. Belousov, V. V. (2000). *Fundamentals of geotectonics*. Moscow: Izdatel'stvo Nedra.

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GEOL – 7109	Sedimentary Basins of Pakistan	3(3-0)
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Course Brief:

The course on Sedimentary Basins explores the geological mechanisms and processes that control the creation, development, and sediment fill of sedimentary basins of Pakistan. The different kinds of sedimentary basins, their tectonic settings, depositional environments, and the importance of basin analysis in comprehending Earth's geological past and the exploration of energy resources will all be covered by the students. It is designed for students with some industrial experience, as well as for recent graduates seeking careers in the petroleum and allied service industries. Petroleum potential and economic importance of sedimentary basins, apply the principles of basin analysis. Analyze how sedimentary basins contribute to the preservation of Earth's geologic past and the reconstruction of paleo-environments.

Course Learning Objectives:

In this course, students will learn about how sedimentary basins are formed and categorized in relation to tectonic settings and geological processes. Within sedimentary basins, identify important sedimentary facies and sequences and analyze the depositional settings of these features. Examine how basins have evolved over time, taking into account the effects of tectonics, shifting sea levels, and climatic variations.

Course Contents:

1. History and introduction of sedimentary basins
2. Basin structure and tectonic framework
3. Facies and sedimentary processes
4. Depositional settings and lithostratigraphic divisions of the rocks of various sedimentary basins
5. Facies development and their association in depositional basins
6. Evaluation of petroleum potentials of different basins
7. Structural styles and petroleum play in the basins of Pakistan
8. Geothermal gradients in various basins and their maturity
9. Examples such as Indus, Baluchistan and offshore regions
10. Oil and gas reservoirs and source rocks and their distribution in the basins
11. Sedimentary basin and Petroleum System in basins; case studies.

Lab. Work: Modelling on Petromod, Case histories of oil and gas fields of Pakistan.

Recommended Texts:

1. Allen, P. A., & Allen, J. R. (2013). *Basin analysis: Principles and application to petroleum play assessment*. John Wiley & Sons.
2. Nairn, A. E. M., & Alsharhan, A. S. (1997). *Sedimentary basins and petroleum geology of the Middle East*. Elsevier

Suggested Readings:

1. Einsele, G. (2000). *Sedimentary basins: evolution, facies, and sediment budget*, Springer.
2. Miall, A. D. (2013). *Principles of sedimentary basin analysis*. Springer Science & Business Media.

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GEOL- 7110	Basin Analysis	3(3-0)
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Course Brief:

This comprehensive course covers both conventional and unconventional hydrocarbon resources with modules on petroleum systems and basin evaluation. The creation of different basins near plate edges, as well as the major components and mechanisms of the petroleum system, such as the generation, migration, accumulation, and change of hydrocarbons, are all covered in this course. The mechanics and efficiencies of migration are reconstructed, and methods for evaluating source rock and evaluating organic maturation are discussed. The main areas of attention are basin analysis and thermal history modeling, which serve as the foundation for forecasting the amount and timing of petroleum formation in sedimentary basins.

Course Learning Objectives:

Students will examine both conventional and unconventional energy sources as they investigate petroleum systems and basin evaluation in this course. The formation of basins, components of petroleum systems, and processes like generation and migration will all be covered for students. Methods for examining maturation and source rocks are discussed, as well as migration mechanisms. In order to forecast when and where petroleum will be created in sedimentary basins, the course places a strong emphasis on basin analysis and thermal history modeling.

Course Contents:

1. The Foundation of Sedimentary Basins, Compositional
2. Types of Sedimentary Basins, Physical State of the Lithosphere,
3. Stress and Strain, Heat Flow, Conduction, Convection, Gravity and Isostasy,
4. Mechanism of Sedimentary Basin Formation Basin due to Lithospheric Stretching,
5. Basins due to Flexure, Geometry of Deflection, Flexural Rigidity of Oceanic and Continental lithosphere, Basins associated with Strike slip Deformation,
6. The Structural Pattern of Strike slip Fault system and Basin in Strike slip zones,
7. Long term Eustasy and Epirogeny,
8. Allogenic Controls on Sedimentation,
9. The Basin Stratigraphy, Process Stratigraphy,
10. Driving Mechanism and Numerical Simulation, Subsidence and Thermal History,
11. Geohistory Analysis, Paleo temperatures in Basins, Application to Petroleum Play Assessment,
12. Introduction to Basin Modeling, Geological Processes, Structure of a Model, Modeling Workflow, Structural Restoration, Heat Flow Analysis, ID,
13. Risk Analysis in Basin Modeling.
14. Thermal Conductivity, Specific Heat Capacity, Radiogenic Heat, SWI Temperatures,


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

Recommended Texts

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

Suggested Readings

1. Tucker, M.E., 1991, Sedimentary Petrology Blackwell Publications.
2. Kazmi, A.H and Abbasi, I.A., 2008, Stratigraphy and Historical Geology of Pakistan Graphic Publishers, Karachi, Pakistan.


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Course Brief:

The study of sedimentary rocks made of clastic particles—such as clay, silt, and sand—and their lithification is known as clastic sedimentology. The deposition, transportation, and diagenesis of clastic sediments are thoroughly examined in this course, along with the interpretation of depositional histories and sedimentary environments based on the features, compositions, and textures of the sediments. The effects of diagenetic processes on rocks composed of clastic sediments. Utilize clastic sedimentology concepts to reconstruct sedimentary histories and analyze ancient depositional settings. Stratigraphic principles, sedimentary logs, and field observations analyze the environments of deposition and sedimentary facies.

Course Learning Objectives:

This course will help the students to recognize the weathering, movement, and deposition processes that are essential to clastic sedimentation. Identify and analyze the main textures and sedimentary formations seen in clastic rocks.

Course Contents:

1. Introduction to clastic sedimentology
2. Origin, transportation and deposition of sediments
3. Texture of sedimentary rocks
4. Sedimentary structures, their classification, morphology, significance and paleocurrent analysis
5. Facies and sedimentary environments
6. Provenance of sediments
7. Diagenesis and paragenetic sequence
8. Physical-chemical controls of the sedimentary environments
9. Diagnostic features of glacial, eolian, Fluvial, lagoonal, lacustrine, deltaic, tidal, turbidites and marine clastic environments
10. Tectonic controls of sedimentation.
11. Applications of clastic sedimentology to industry

Lab. Work

1. Rose diagrams and paleocurrent analysis
2. Use of ternary diagrams, discrimination diagrams for tectonic setting
3. Separation and identification of heavy minerals

Recommended Texts:

1. Boggs Jr, S. (2014). Principles of sedimentology and stratigraphy. London: Pearson Education.
2. Selley, R. C. (2000). Applied sedimentology. Amsterdam: Elsevier.

Suggested Readings:

1. Reineck, H. E., & Singh, I. B. (2012). *Depositional sedimentary environments: with reference to terrigenous clastics*. Berlin: Springer Science & Business Media.
2. Pettijohn, F. J., Potter, P. E., & Siever, R. (2012). *Sand and sandstone*. Berlin: Springer Science & Business Media.

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Course Brief:

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. It is the study which describes the Mineral exploration and its exploitation, exploration and development Oil and Gas resources, Metallic and non-metallic mineral resources, suitable aggregate study for construction materials, dams side studies, earthquake studies and mega Infrastructure related. It also describes about the various tectonics elements for collisional, extensional and transform plate boundary setting. From the formation of mighty Himalayas, it includes the detail tectono-sedimentary, metamorphic and deformation mechanism. It will also focuses on the occurrences of Active Seismic Zones of Pakistan and earthquake seismology scenario.

Course Learning Objectives:

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. The core objective of this subject is to provide the detail Geological and Tectonics Setting of Pakistan by introducing the Geo-dynamics setting of Pakistan.

Course Contents:

1. Physiographic and tectonic divisions of Indo Pak Plate and its descriptions.
2. Geology and stratigraphy of the Indian plate, Karakoram plate.
3. Afghan block and Arabian plate.
4. Waziristan, Kohistan, Chagai and Ras Koh magmatic Arcs.
5. Sedimentary basins of Pakistan.
6. Makran subduction complex.
7. Chaman transform zone, arcs, oroclines and suture zones.
8. Tertiary Himalayan and pre-Himalayan orogenic events.
9. Late Precambrian to Early Cambrian Hazaran orogeny.
10. Regional metamorphism (Himalayan and pre-Himalayan).
11. Main episodes of magmatism and their relations to tectonics.
12. Economic mineral and fuel deposits of Pakistan.

Recommended Texts:

1. Bender, F.K. & Raza, H.A. (1997). *Geology of Pakistan*. Berlin: Oxford University Press.
2. Kazmi, A. H., & Jan, M. Q (1997). *Geology and tectonics of Pakistan*. Karachi: Graphic publishers.

Suggested Readings:

1. Farah, A., Abbas, G., De Jong, K. A., & Lawrence, R. D. (1984). Evolution of the lithosphere in Pakistan. *Tectonophysics*, 105(1-4), 207-227.
2. Kazmi, A. H., & Abbasi, I. A. (2008). *Stratigraphy & historical geology of Pakistan*. Peshawar: National Centre of Excellence in Geology.
3. Searle, M. (2013). *Colliding continents: a geological exploration of the Himalaya, Karakoram, and Tibet*. Oxford: Oxford University Press.

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Course Brief:

Micropaleontology deals with fossils organism. This course introduced the broad range of micropaleontological techniques and to the numerous groups of fossils. It is designed to understand the micro-fossils found in geological formations and Tertiary biostratigraphy rock units in Pakistan. Micropaleontology is concerned with microfossils and nanno fossils, the study of which must, of necessity, be carried out using the light or electron microscope. To achieve the objectives, the microfossil must be studied in terms of morphology, structure, chemical and mineralogical composition and taxonomy to discover their origin and systematic affinities. The course is designed to acquire knowledge about the microfossils and micro-organisms and their role in interpretation of depositional environment.

Course Learning Objectives:

To give the students basic knowledge of microfossils and their geological applications. It will provide an extended basis for more advanced studies in paleontology and stratigraphy of basin developments. This course will enable the student to identify various types of microfossils and to understand their role in depositional systems of major sedimentary basins. Application of these microfossils in the field of oil-exploration, biostratigraphy, paleobiology and paleoclimatology is essential. This subject emphasizes on the microfossils that lived in or under sea water. Thus, interaction with the present-day physical, chemical and biological characteristics of the ocean water will be also addressed. The course will introduce the major marine and non-marine invertebrate taxonomic groups found in the fossil record and what we know about them – their stratigraphic range, modes of life, and environmental preferences.

Course Contents:

1. Introduction to Micropaleontology and its applications
2. Detail classification of marine environments,
3. Genus *Miscellanea*, *Assilina*, *Ranikothalia*, *Lockhartia*
4. *Nummulites*, *Discocyliina*, *Orbitolites*, *Globotrucana*
5. Introduction to Foraminifera, Bryozoa, Conodonts,
6. Algae, pollen and spores;
7. Microfossils and nanoplanktons;
8. Principles of Biostratigraphy and Biostratigraphic zones;
9. Biostratigraphic techniques and procedures;
10. Morphological and taxonomic studies of selected micro fossils
11. KT Boundary and its presence in Pakistan
12. Tertiary biostratigraphy with special reference to Pakistan

Recommended Texts:

1. Saraswati, P. K., & Srinivasan, M. S. (2015). *Micropaleontology: principles and applications*. New York: Springer.
2. Brasier, M. D. (1980). *Microfossils*. London: G. Allen & Unwin.

Suggested Readings:

1. McGowran, B. (2000). *Biostratigraphy: microfossils and geological time*. Cambridge: Cambridge University Press.
2. Haq, B. U., & Boersma, A. (Eds.). (2000). *Introduction to marine micropaleontology*. New York: Elsevier.
3. Boggs Jr, S. (2014). *Principles of sedimentology and stratigraphy*. London: Pearson Education.

M.F. _____
CHAIRMAN
Department of Earth Science
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1998

GEOL-7114	Soil Mechanics	3(3-0)
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Course Brief:

This Master's level course provides an in-depth study of soil mechanics, focusing on the behavior of soils under various loading conditions and its applications in geotechnical engineering. Through classroom instruction, lab work, and fieldwork, students will gain advanced knowledge of soil properties, classification, and testing methods. The course will emphasize understanding of consolidation, shear strength, soil-water interaction, and slope stability analysis. Upon completion, students will be equipped with the knowledge and skills to apply soil mechanics principles to geotechnical engineering problems such as foundation design, slope stability evaluation, and earthworks construction.

Course Learning Objectives:

Upon completion of the course, students will have acquired advanced knowledge and skills in soil mechanics. This will enable them to effectively address and resolve complex geotechnical engineering problems. They will gain expertise in laboratory testing, soil classification, and interpretation of soil behaviors under different loading conditions. Furthermore, students will be proficient in calculating shear strength parameters, estimating soil settlement, analyzing slope stability, and evaluating soil-water interactions.

Course Contents:


1. Introduction to Soil Mechanics and Geotechnical Engineering
2. Soil Composition, Classification, and Index Properties
3. Soil-Water Interaction: Capillarity, Permeability, and Seepage Analysis
4. Consolidation Theory and Settlement Analysis
5. Shear Strength of Soils:
6. Mohr-Coulomb Failure Criteria, Direct Shear Tests, and Triaxial Tests
7. Compaction of Soils: Standard and Modified Compaction Tests
8. Earth Pressure and Retaining Structures: Rankine's and Coulomb's Theories
9. Slope Stability Analysis: Deterministic and Probabilistic Approaches
10. Soil Dynamics and Earthquake Engineering: Seismic Response of Soils
11. Ground Improvement Techniques: Soil Stabilization and Reinforcement
12. Soil-Structure Interaction: Foundation Design and Bearing Capacity Analysis
13. Applications of Numerical Modeling in Soil Mechanics
14. Case Studies in Soil Mechanics: Real-World Applications

Recommended Texts:

1. Verruijt, A. (2017). *An introduction to soil mechanics* (Vol. 30). Springer.
2. Craig, R. F. (2013). *Soil mechanics*. Springer..

Suggested Readings:

1. Powrie, W. (2018). *Soil mechanics: concepts and applications*. CRC Press.
2. Ranjan, G., & Rao, A. S. R. (2011). *Basic and applied soil mechanics*. New Age International.


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 DEPARTMENT OF CIVIL ENGINEERING
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GEOL-7115

Geotechnical Engineering

3(3-0)

Course Brief:

The course focuses on strengthening students' knowledge in geotechnical engineering, exposing them to issues related to engineering geology, geotechnical foundation engineering, geological and rock engineering, hydrology, soil structure and pavement design/ analysis/ rehabilitation. Advance level courses have been designed in this group for specialization in geotechnical engineering (geological engineering) with an aim to meet the demands of country in the future. These courses will enable the students to fully understand (1) properties of rocks and soils and their role in construction industry, (2) risk assessment due to earthquake related seismicity and its intensity and (3) earthquake resistant infrastructure development.

Course Learning Objectives:

On completion of this course students will be able to understand present the foundations of many advance Engineering tools and concepts related Geotechnical Engineering. This course will give an experience in the implementation of engineering concepts which are applied in field of Geotechnical Engineering. Especially the application of scientific and technical principles of planning, analysis, design of foundation along with soil improvement techniques at investigation / construction site locations.

Course Contents:

1. Earthquake Engineering
2. Earthquake Risk Assessment
3. Earthquake Resistant Design
4. Rock and Soil Properties
5. Soil and Rock role in Construction Industry
6. Groundwater Systems
7. Excavation and Tunneling
8. Engineering Foundation
9. Dam Engineering
10. Pavement Design, Analysis and Rehabilitation
11. Rock Mechanics
12. Soil Mechanics

Recommended Texts:

1. Price, D. G. (2008). Engineering geology: principles and practice. London: Springer science & business media.
2. Blyth, F. G. H., & De Freitas, M. (2017). A geology for engineers. London: CRC Press.

Suggested Readings:

1. Ashcroft, W. (2011). A petroleum geologist's guide to seismic reflection. John Wiley & Sons.
2. Dvorkin, J., Gutierrez, M. A., & Grana, D. (2014). Seismic reflections of rock properties. Cambridge University Press.
3. Liner, C. L. (2016). Elements of 3D seismology. Society of exploration geophysicists.

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GEOL-7116	Mining and Engineering Geology	3(3-0)
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Course Brief:

This course provides a comprehensive study of mining geology, with a particular focus on engineering geology principles and applications. It aims to equip students with advanced knowledge and essential skills for geological assessment, planning, and management of mining projects. The course integrates theoretical foundations with practical field-oriented methodologies, emphasizing the geological aspects that are relevant to mining engineering. The topics covered in this course include geological mapping, rock mechanics, slope stability analysis, groundwater assessment, and environmental considerations in mining operations. Through case studies, site visits, and practical exercises, students will develop a holistic understanding of geological hazards, risk assessment, and mitigation strategies in mining environments.

Course Learning Objectives:

This course teaches advanced knowledge and skills in mining geology and engineering geology, enabling students to apply geological principles effectively in mining engineering contexts. They will learn to map geological formations, interpret structures, analyze rock mechanics, and evaluate slope stability, groundwater conditions, and environmental considerations. Through practical exercises and case studies, they will develop the ability to conduct geological hazard assessments, formulate risk mitigation strategies, and communicate professionally.

Course Contents:

1. Introduction to Mining Geology and Engineering Geology
2. Geological Mapping Techniques for Mining Projects
3. Structural Geology and Geological Structures in Mining
4. Rock Mechanics Principles and Applications in Mining Engineering
5. Slope Stability Analysis and Geotechnical Hazards
6. Hydrogeology and Groundwater Assessment in Mining Environments
7. Environmental Considerations in Mining Operations
8. Geological Hazard Assessment and Risk Analysis
9. Mitigation Strategies for Geological Hazards in Mining
10. Case Studies in Mining Geology and Engineering Geology
11. Field Excursions and Site Visits to Mining Sites
12. Practical Exercises and Project Work in Mining Geology and Engineering Geology.

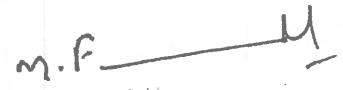
Lab. Work Specified problems on surface and subsurface Mining.

Recommended Texts:

1. Wood, D. M. (2017). Geotechnical Modeling. CRC press.
2. Cui, Z. D., Zhang, Z. L., Yuan, L., Zhan, Z. X., & Zhang, W. K. (2020). Design of underground structures. Springer.
3. Jaeger, J.C., Cook, N.G.W, Zimmerman, R.W.,(2007). Fundamentals of Rock Mechanics, Blackwell Publishing.
4. Hudson, J. A., & Harrison, J. P. (2000). Engineering Rock Mechanics: An Introduction to the Principles. Elsevier.
5. Hoek, E., Kaiser, P. K., & Bawden, W. F. (2000). Support of underground excavations in hard rock. CRC Press.

Suggested Readings:

1. Hartman, H. L., & Mutmansky, J. M. (2002). Introductory Mining Engineering. John Wiley & Sons.
2. Brady, B. H., & Brown, E. T. (2006). Rock mechanics: for underground mining. Springer Science & Business Media.


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GEOL-7117	Geological Hazards	3(3-0)
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Course Brief:

This course is at the Master's level and focuses on studying geological hazards in detail. It provides an overview of various natural phenomena that pose a threat to infrastructure, the environment, and human life. The primary objective of this course is to understand the geological processes that result in natural disasters such as earthquakes, landslides, volcanic eruptions, and tsunamis. Additionally, the course will cover the factors that affect the frequency and intensity of these events.

Course Learning Objectives:

Upon completion of the course, students will possess advanced knowledge and skills related to geological hazards. This will enable them to effectively evaluate, analyze, and mitigate the risks associated with natural disasters. They will have a comprehensive understanding of the geological mechanisms that cause natural disasters such as earthquakes, landslides, volcanic eruptions, and tsunamis, as well as the impact of these events on society.

Course Contents:

1. Introduction to Geological Hazards and Disaster Risk Reduction
2. Seismology and Earthquake Hazards
3. Landslides: Causes, Mechanisms, and Mitigation Strategies
4. Volcanic Hazards: Eruptions, Lahars, and Pyroclastic Flows
5. Tsunamis: Generation, Propagation, and Coastal Impacts
6. Hydrological Hazards: Floods and Debris Flows
7. Climate-Related Hazards: Glacial Lake Outburst Floods, Avalanches
8. Remote Sensing and GIS Applications in Geological Hazard Assessment
9. Hazard Zoning and Vulnerability Mapping
10. Disaster Preparedness and Emergency Response Planning
11. Case Studies of Geological Hazards and Disasters
12. Ethical and Societal Considerations in Geological Hazard Management.

Recommended Texts:

1. Bolt, B. A., Horn, W. L., MacDonald, G. A., & Scott, R. F. (2013). *Geological Hazards: Earthquakes-tsunamis-volcanoes-avalanches-landslides-floods*. Springer Science & Business Media.
2. Keller, E. A., & DeVecchio, D. E. (2019). *Natural hazards: earth's processes as hazards, disasters, and catastrophes*. Routledge.

Suggested Readings:

1. Paul, Bimal Kanti. *Environmental hazards and disasters: contexts, perspectives and management*. John Wiley & Sons, 2011.
2. Montz, B. E., Tobin, G. A., & Hagelman, R. R. (2017). *Natural hazards: explanation and integration*. Guilford Publications.
Alexander, D. (2018). *Natural disasters*. Routledge.

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GEOL-7118	Applied Hydrogeology	3(3-0)
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Course Brief:

This Master's level course is focused on the practical aspects of groundwater exploration, assessment, and management. Students will receive an in-depth examination of applied hydrogeology through a combination of classroom instruction, lab analysis, and fieldwork. They will acquire practical knowledge of a range of methods utilized in hydrogeological research. The course emphasizes the fundamentals of contaminant transport in subsurface environments, aquifer characterization, groundwater modeling, and groundwater flow.

Course Learning Objectives:

Upon completion of the course, students will gain in-depth knowledge and skills in applied hydrogeology to effectively tackle complex groundwater-related issues. They will demonstrate their expertise in conducting hydrogeological studies, analyzing groundwater flow and quality data, and utilizing modeling techniques for assessing and managing groundwater resources.

Course Contents:

1. Introduction to Applied Hydrogeology
2. Principles of Groundwater Flow and Aquifer Properties
3. Groundwater Exploration Techniques: Geophysical and Remote Sensing Methods
4. Hydrogeological Data Collection and Analysis
5. Aquifer Characterization: Pumping Tests and Aquifer Tests
6. Groundwater Modeling: Concepts and Applications
7. Groundwater Contaminant Transport and Remediation Techniques
8. Sustainable Groundwater Management Practices
9. Groundwater Resource Assessment and Decision-Making
10. Hydrogeochemistry: Analysis and Interpretation of Groundwater Quality Data
11. Case Studies in Applied Hydrogeology: Real-World Applications

Recommended Texts:

1. Fetter, C. W. (2018). *Applied hydrogeology*. Waveland Press.
2. Sen, Z. (2017). *Applied hydrogeology for scientists and engineers*. CRC Press.
3. Hiscock, K. M., & Bense, V. F. (2014). *Hydrogeology: principles and practice*. John Wiley & Sons.

Suggested Readings:

1. Sen, Z. (2014). *Practical and applied hydrogeology*. Elsevier..
2. Brassington, R. (2017). *Field hydrogeology*. John Wiley & Sons.

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GEOL-7119	Rock Mechanics	3(3-0)
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Course Brief:

This Master's level course focuses on the behavior of rocks under different stress conditions and its implications for engineering design and construction in geological settings. The course provides an advanced exploration of rock mechanics and students will gain a thorough understanding of the fundamental concepts guiding rock mechanics, such as rock properties, deformation mechanisms, and failure criteria. This will be achieved through theoretical study, lab experiments, and real-world applications. The course emphasizes the use of rock mechanics principles to evaluate slope stability, plan support structures for subterranean excavations, and reduce risks in geotechnical projects.

Course Learning Objectives:

Upon completion of the course, students will possess advanced knowledge and skills in rock mechanics, enabling them to address complex geological and geotechnical engineering challenges. They will demonstrate proficiency in evaluating rock characteristics, predicting rock behavior under various stress conditions, and applying appropriate technical solutions to solve rock-related problems.

Course Contents:

1. Introduction to Rock Mechanics
2. Geological Aspects of Rock Properties
3. Stress and Strain Analysis in Rock Mechanics
4. Mechanical Behavior of Rocks
5. Elasticity, Plasticity, and Failure Criteria
6. Laboratory Testing of Rock Properties
7. Uniaxial Compression,
8. Triaxial Compression
9. Shear Strength Tests
10. Rock Mass Classification Systems
11. Analysis and Design of Rock Support Systems
12. Slope Stability Analysis: Deterministic and Probabilistic Approaches
13. Tunneling and Excavation in Rock:
14. Support Design and Ground Control Measures
15. Applications of Numerical Modeling in Rock Mechanics

Recommended Texts:

1. Attewell, P. B., & Farmer, I. W. (2012). *Principles of engineering geology*. London: Springer science & business media.
2. Jaeger, J. C., Cook, N. G., & Zimmerman, R. (2009). *Fundamentals of rock mechanics*. John Wiley & Sons.
3. Aydan, Ö. (2019). *Rock mechanics and rock engineering: Volume 1: Fundamentals of rock mechanics*. CRC Press.

Suggested Readings:

1. Price, D. G. (2008). *Engineering geology: principles and practice*. London: Springer science & business media..
2. DEBASIS, D., & KUMAR, V. A. (2016). *Fundamentals and applications of rock mechanics*. PHI Learning Pvt. Ltd....

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GEOL-7120	Engineering Seismology	3(3-0)
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Course Brief:

This course is designed for students who want to explore advanced topics in engineering seismology. The course will cover the fundamental principles of earthquakes, geological faults, and the Elastic Rebound theory. Students will learn about the generation, recording, and phases of seismic waves, as well as the concepts of earthquake magnitude, intensity, and their global distribution patterns. Additionally, the course will focus on understanding seismicity data, seismic hazard assessment, and risk analysis methodologies. Students will also explore macroseismic intensity, strong motion records, response spectra, attenuation relationships, and the application of probabilistic and deterministic seismic hazard analysis techniques.

Course Learning Objectives:

This course provides students with an advanced understanding of seismology and seismic hazard assessment. They will learn about earthquakes and geological faults, seismic waves, and data analysis for seismic hazard and risk assessment. Students will acquire the skills to evaluate seismic intensity, response spectra, and attenuation relationships, as well as apply seismic hazard analysis techniques. They will also learn how to interpret seismic design codes and guidelines to ensure structural resilience against seismic events.

Course Contents:

1. Introduction to earthquakes and seismicity
2. Understanding geological faults and their classification
3. Elastic Rebound Theory
4. Generation and Recording of Seismic Waves
5. Seismic Waves Phases
6. Earthquake Magnitude and Intensity
7. Global Seismicity Pattern
8. Factors influencing the distribution of earthquakes worldwide
9. Data for Seismicity Study
10. Seismic Hazard and Seismic Risk
11. Macroseismic Intensity
12. Strong Motion Records
13. Response Spectra
14. Presentation of Seismic Hazard
15. Seismic Design Codes

Recommended Texts:

1. Yilmaz, Ö. (2015). Engineering seismology with applications to geotechnical engineering. Society of Exploration Geophysicists.
2. Chopra, A. K. (2020). Earthquake engineering for concrete dams: analysis, design, and evaluation. John Wiley & Sons.

Suggested Readings:

1. Baker, J., Bradley, B., & Stafford, P. (2021). Seismic hazard and risk analysis. Cambridge University Press
2. Aydan, Ö. (2022). Earthquake science and engineering. CRC Press.
- Filiatrault, A. (2013). Elements of earthquake engineering and structural dynamics. Presses inter Polytechnique.

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GEOL-7121	Earthquake Seismology	3(3-0)
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Course Brief:

This Master's course teaches advanced concepts and methodologies in earthquake seismology. It explores the complex processes that cause seismic events and the techniques seismologists use to analyze seismograms, determine source parameters, and simulate seismic waves in Earth's crust. The course aims to give geoscientists a comprehensive understanding of earthquake seismology, with a focus on developing advanced competencies in seismic event characterization. By exploring and analyzing seismic records, students can extract valuable insights and discern subtle nuances.

Course Learning Objectives:

Upon completion of the Master's course in earthquake seismology, students will have developed the necessary skills to analyze seismograms, measure source parameters, and simulate seismic wave impacts. They will be able to accurately determine the magnitude of seismic events using modern measurement scales and develop critical thinking abilities essential for seismic research and hazard assessment. Graduates will be equipped for prominent positions in academia, industry, and government agencies, focused on seismic hazard mitigation and geophysical exploration.

Course Contents:

1. Mathematical analysis of seismological processes on the basis of elastic wave theory
2. Seismic waves and their analysis in earthquake seismology
3. Frequency, magnitude, energy of an earthquake and their relationship
4. Source parameters and their determination
5. Composite fault plane solutions of earthquakes and their determination
6. Geographical distribution of important earthquakes
7. Earthquakes and their relationship to the tectonics of the area.

Lab. Work

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

Recommended Texts:

1. Kumar, R., Singh, R., Kanhaiya, S., & Maurya, S. P. (2024). Recent Developments in Earthquake Seismology. Springer Cham. <https://doi.org/10.1007/978-3-031-47538-2>.
2. Lee, W. H., Jennings, P., Kisslinger, C., & Kanamori, H. (Eds.). (2012). *International handbook of earthquake & engineering seismology, Part A*. Elsevier.

Suggested Readings:

3. James, D. E. (Ed.). (1989). *Encyclopedia of solid Earth geophysics*. London: Springer Science & Business Media.
4. Shearer, P. M. (2019). *Introduction to seismology*. Cambridge: Cambridge University Press.
5. Baker, J., Bradley, B., & Stafford, P. (2021). *Seismic hazard and risk analysis*. Cambridge University Press.

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Course Brief:

This course at the Master's level offers a detailed examination of electrical exploration techniques as they apply to geological studies. It delves into the theoretical underpinnings, practical applications, and advanced methods of electrical geophysical techniques used in geological investigations. The objective of this course is to provide students with the knowledge and skills required to utilize electrical methods efficiently for the purpose of mapping subsurface geological structures, characterizing lithologies, and identifying hydrocarbon and mineral resources.

Course Learning Objectives:

This course is designed to teach students about electrical exploration methods for geological studies. It covers principles and applications of electrical resistivity, induced polarization, and electromagnetic techniques. Students will learn about advanced concepts such as electrical data inversion and integration with other geophysical and geological datasets. Through hands-on exercises and real-world applications, students will develop critical thinking and problem-solving skills. This course prepares students for careers in academia, industry, and government agencies focused on geological exploration and resource assessment.

Course Contents:

1. Overview of electrical geophysics
2. Principles of electrical resistivity surveys
3. Field instrumentation and data acquisition
4. Data processing and interpretation techniques
5. Electrical data inversion methods
6. Joint inversion with other geophysical data
7. 3D modeling and visualization of electrical properties
8. Case studies and research applications
9. Conducting electrical surveys and data collection in various geological settings
10. Data analysis, interpretation, and reporting of field results
11. Integration with Geological Studies
12. Integration of electrical geophysical data with geological information
13. Multidisciplinary approaches to geological interpretation

Recommended Texts:

1. Florsch, N., & Muhlach, F. (2017). *Everyday applied geophysics 1: Electrical methods*. Elsevier.
2. Parkhomenko, E. I. (2012). *Electrical properties of rocks*. Springer Science & Business Media.

Suggested Readings:

1. Zhdanov, M. S., & Keller, G. V. (1994). The goelectrical methods in geophysical exploration. *Methods in geochemistry and geophysics*, 31, I-IX..
2. Dobrin, M. B., & Savit, C. H. (2000). *Introduction to geophysical prospecting* (Vol. 4). New York: McGraw-hill.
3. Nabighian, M. N. (Ed.). (1991). *Electromagnetic Methods in Applied Geophysics*. Volume 2, Application, Parts A and B. Amsterdam: Society of Exploration Geophysicists.

GEOL-7123	Geophysical Well Logging	3(3-0)
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Course Brief:

This course is designed to provide a detailed exploration of geophysical methods that are specifically used in borehole applications. It aims to equip students with a comprehensive understanding of the theory, techniques, and practical applications of borehole geophysics, with a particular emphasis on petrophysics and formation evaluation. By examining various logging techniques, instrumentation, and field applications, students will gain practical insights into log analysis and interpretation for purposes such as lithological analysis, environmental studies, water resource assessment, geotechnical investigations, mineral exploration, and hydrocarbon studies. Real-world case histories will be used to illustrate the relevance and applications of borehole geophysics in diverse geological and geotechnical projects.

Course Learning Objectives:

The primary learning outcome of this course is to equip students with advanced knowledge and skills in geophysical well Logging.. Upon completion of the course, students will be able to proficiently interpret valuable information from borehole logs, enabling them to make informed decisions in geotechnical and geological projects. Through theoretical discussions, practical exercises, and case studies, students will improve their ability to apply borehole geophysical techniques effectively in real-world scenarios.

Course Contents:

1. Overview to Borehole Geophysics
2. Historical development and technological advancements in well logging
3. Logging Techniques and Instrumentation
4. Advanced Logging Techniques
5. Log Analysis and Interpretation
6. Borehole Geophysics in Resource Exploration
7. Environmental and Engineering Applications
8. Emerging Trends and Future Directions

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

Recommended Texts:

1. Liu, H. (2017). *Principles and applications of well logging* (pp. 237-269). Berlin, Heidelberg: Springer Berlin Heidelberg.
2. Evenick, J. C. (2019). *Introduction to well logs and subsurface maps: Tulsa. Oklahoma, PennWell.*
3. Tittman, J. (2012). *Geophysical well logging: excerpted from methods of experimental physics.* Elsevier.

Suggested Readings:

1. Inson D. E, Pile, K. E. (2006) *Well logging in nontechnical language.* Tulsa. PennWell Books
2. Darling, T. (2005). *Well logging and formation evaluation.* Elsevier.

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 CHAIRMAN
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Course Brief:

This course is designed for Master's level students who are interested in learning about the seismic reflection method. The course covers both land and marine data acquisition and processing, with a focus on the geological interpretation of seismic reflection data. Students will explore the fundamental principles of seismic reflection, including subsurface velocities, reflection coefficients, and seismic wavelet characteristics. The course will also include practical exercises that involve hands-on interpretation of seismic reflection datasets. This will provide students with valuable experience in real-world seismic data analysis.

Course Learning Objectives:

By the end of the course, students will have acquired advanced skills in interpreting and analyzing seismic data. This will enable them to effectively utilize seismic reflection data to explore geology and assess resources. Through practical exercises and real-world case studies, students will be well-prepared to take on roles in the oil and gas industry, environmental consulting, and geological research.

Course Contents:

1. Introduction to Reflection Seismology
2. Understanding 2D and 3D seismic surveys
3. Land and Marine Seismic Data Acquisition
4. Seismic Velocities and Reflection Coefficients
5. Quality control measures for data acquisition and processing.
6. Structural & Stratigraphic Interpretation
7. Seismic-to-Well Tie
8. Seismic mapping and interpretation of both 2D and 3D seismic data.

Recommended Texts:

1. Yang, W. (2014). *Reflection Seismology*. Amsterdam: Elsevier.
2. Avseth, P., Mukerji, T., & Mavko, G. (2010). *Quantitative seismic interpretation: Applying rock physics tools to reduce interpretation risk*. Cambridge university press.

Suggested Readings:

1. Ashcroft, W. (2011). *A petroleum geologist's guide to seismic reflection*. John Wiley & Sons.
2. Dvorkin, J., Gutierrez, M. A., & Grana, D. (2014). *Seismic reflections of rock properties*. Cambridge University Press.
3. Liner, C. L. (2016). *Elements of 3D seismology*. Society of exploration geophysicists.

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GEOL-7125	Gravity and Magnetic Methods	3(3-0)
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Course Brief:

This course at the Master's level offers a comprehensive study of gravity and magnetic methods in geophysics. It focuses on advanced theoretical concepts and practical applications. The course places emphasis on comprehending the physical principles underlying each method, including a conceptual review of the governing laws. The course is designed to be practical and field-oriented, with hands-on experiences aimed at applying gravity and magnetic methods to real-world problems. From foundational principles to methodology, applications, and case studies, students will gain a deep understanding of how these methods are used in various geological contexts.

Course Learning Objectives:

The learning objectives of this course is to teach students about gravity and magnetic methods. It focuses on the physical concepts behind these methods and provides a review of the laws that govern them. The course is practical and field-oriented, aiming to apply gravity and magnetic methods to real-world problems. You'll start with the basics and move on to methodology, applications, and case studies. The goal is to emphasize how these methods are used in various situations, with practical examples illustrating their applications.

Course Contents:

1. Gravity instrumentation and survey planning
2. Rock densities, measurements, and Isostasy
3. Gravity data acquisition, processing and interpretation
4. Identification of gravity anomalies AND anomaly mapping
5. Two and three-dimensional modeling of gravity anomalies
6. Applications of gravity methods in the petroleum industry: case histories
7. Magnetic Instrumentation and survey planning
8. Rock susceptibilities and measurements
9. Magnetic data acquisition and processing and interpretation
10. Identification of magnetic anomalies
11. Two and three-dimensional modeling of magnetic anomalies
12. Applications of magnetic methods in the petroleum industry

Recommended Texts:

1. Telford, W. M., Telford, W. M., Geldart, L. P., Sheriff, R. E., & Sheriff, R. E. (2012). *Applied geophysics*. Cambridge university press.
2. Reynolds, J. M. (2011). *An introduction to applied and environmental geophysics*. John Wiley & Sons.

Suggested Readings:

1. Parasnis, D. S. (2012). *Principles of applied geophysics*. Springer Science & Business Media.
2. Griffiths, D. H., & King, R. F. (2013). *Applied geophysics for geologists and engineers: the elements of geophysical prospecting*. Elsevier.

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Course Brief:

This course provides students with a comprehensive understanding of the principles and practical applications of geophysical techniques in the fields of engineering geophysics. Through a combination of theoretical knowledge, hands-on fieldwork, and data analysis, students will learn how to assess subsurface conditions, investigate environmental challenges, and solve engineering problems using geophysical methods. The course emphasizes the integration of theory and practice, enabling students to develop essential skills in data collection, interpretation, and problem-solving. By exploring real-world case studies and emerging trends, students will gain insights into the limitations and challenges of near-surface geophysics, ultimately preparing them to apply these techniques effectively in environmental and engineering projects.

Course Learning Objectives:

After completion of this course, students will gain a solid grasp of geophysical techniques for engineering purposes. Through theory, hands-on fieldwork, and data analysis, they will learn how to evaluate what's beneath the surface, address environmental issues, and tackle engineering challenges using geophysics. The course combines theory with practical skills, helping you learn data collection, interpretation, and solutions. By studying real cases and new developments, they will understand the limitations and complexities of near-surface geophysics, preparing you to use these methods effectively in environmental and engineering projects.

Course Contents:

1. Introduction to Engineering Geophysics
2. Definition and scope of Engineering Geophysics
3. Geophysical Methods
4. Data Acquisition and Instrumentation
5. Survey planning and design
6. Field instrumentation and data collection techniques
7. Quality control and data validation
8. Data Processing, Inversion, modeling and Interpretation
9. Integration of geophysical data with other subsurface information
10. Applications in Engineering Geophysics
11. Practical considerations in field surveys
12. Limitations, Challenges, Emerging Trends and Future Directions

Recommended Texts:

4. Medhus, A. B., & Klinkby, L. (Eds.). (2022). *Engineering Geophysics*. CRC Press.
5. Reynolds, J. M. (2011). *An Introduction to Applied and Environmental Geophysics*. John Wiley & Sons.
6. Yilmaz, Ö. (2015). *Engineering Seismology with Applications to Geotechnical Engineering*. Society of Exploration Geophysicists.

Suggested Readings:

3. Kearey, P., Brooks, M., & Hill, I. (2002). *An Introduction to Geophysical Exploration*. John Wiley & Sons.
4. Burger, H.R., (2012), *Exploration Geophysics of the Shallow Subsurface*: Prentice-Hall, Englewood Cliffs, NJ..
5. Griffiths, D. H., & King, R. F. (2013). *Applied Geophysics for Geologists and Engineers: the Elements of Geophysical Prospecting*. Elsevier.

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University of Illinois at Urbana-Champaign

GEOL-7127	Mining Geophysics	3(3-0)
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Course Brief:

This course is designed to provide a thorough understanding of mining geophysics, exploring a range of prospecting and exploration methods used in mineral deposits. The course will cover topics such as economic considerations, target selection, deposit modeling, and exploration technology, as well as environmental considerations and program planning. In addition, the course will delve into geochemical prospecting methods, dispersion patterns of trace metals, and principles of primary dispersion of metallic mineral deposits. The course will also cover geophysical methods for exploration and mining, including electromagnetic, resistivity, induced polarization, self-potential, radiometric, gravity, and magnetic techniques, with an emphasis on practical aspects such as site design, data collection, processing, and interpretation. The course will provide students with a theoretical basis and an understanding of the instrumentation used for each technique.

Course Learning Objectives:

After completing the Mining Geophysics course, students will have a comprehensive understanding of various prospecting and exploration methods necessary for identifying mineral deposits. They will develop proficiency in target selection, deposit modeling, and exploration technology, taking into consideration economic viability and environmental sustainability. Additionally, they will master the application of geophysical techniques such as electromagnetic, resistivity, induced polarization, self-potential, radiometric, gravity, and magnetic methods for mineral exploration. By gaining hands-on experience in site design, data collection, processing, and interpretation procedures, they will be equipped to tackle real-world challenges in mining geophysics.

Course Contents:

1. Methods for mineral prospecting and exploration
2. Economic considerations of mineral deposits
3. The behavior of common ore elements
4. Overview of geochemical prospecting methods.
5. Primary dispersion of metallic mineral deposits
6. Geophysical methods for exploration and mining
7. Theoretical basis and instrumentation for each geophysical technique
8. Data collection, processing, and interpretation procedures
9. Review of geophysical research conducted in relevant regions
10. Case Histories

Recommended Texts:

1. Parasnis, D. (2013). *Mining geophysics* (Vol. 3). Elsevier.
2. Zhdanov, M. S. (Ed.). (2021). *Geophysics for Mineral Exploration* (p. 204). MDPI Multidisciplinary Digital Publishing Institute.

Suggested Readings:

1. Sharma, P.V., (2014), *Environmental and Engineering Geophysics*: Cambridge University Press, Cambridge, UK.
2. Dobrin, M.B., (2012), *Introduction to geophysical prospecting* (2nd ed.): McGraw-Hill Book Co., New York.

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GEOL - 7128	ISOTOPE GEOCHEMISTRY	3(3-0)
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Course Brief:

Isotope geochemistry is a branch of geochemistry that focuses on the study of the isotopic compositions of elements and their distribution in geological materials. Isotopes are atoms of the same element that have different numbers of neutrons, leading to variations in atomic mass. Isotope geochemistry utilizes these variations to investigate a wide range of geological processes and phenomena. Stable isotopes do not undergo radioactive decay over geological timescales. Isotope geochemists often study stable isotopes of elements such as oxygen (O), hydrogen (H), carbon (C), nitrogen (N), sulfur (S), and others. Common radiogenic isotopes studied in isotope geochemistry include uranium (U), thorium (Th), rubidium (Rb), and potassium (K), among others.

Course Learning Objectives:

By measuring the abundance of radiogenic isotopes and their decay products in rocks and minerals, geoscientists can determine the ages of geological materials and constrain the timing of geological events such as volcanic eruptions, mountain building, and metamorphism. Overall, isotope geochemistry is a versatile and interdisciplinary field that integrates principles from chemistry, physics, geology, biology, and astronomy to unravel the complex history and dynamics of Earth and other planetary bodies.

Course Contents:

1. Fundamental concepts in Isotope Geochemistry
2. Stable Isotope Geochemistry
3. Radiogenic Isotope Geochemistry
4. Isotope Tracers in Earth System
5. Isotope Geochemistry Laboratory Techniques
Field work and research projects

Recommended Texts:

1. Faure, G. (1977). Principles of isotope geology. Gibson, W. (1908). *The geology of coal and coal-mining*. E. Arnold.
2. Cameron, E. M. Stable Isotope Geochemistry by Jochen Hoefs, fifth.
3. Dickin, A. P. (2018). *Radiogenic isotope geology*. Cambridge university press.

Suggested Readings:

1. Mook, W. G. (2005). *Introduction to isotope hydrology. Stable and radioactive isotopes of hydrogen, oxygen and carbon*. Taylor & Francis Group.
2. De Groot, P. A. (Ed.). (2004). *Handbook of stable isotope analytical techniques* (Vol. 1). Elsevier.

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GEOL - 7129	METAMORPHIC PETROLOGY	3(3-0)
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Course Brief:

Metamorphic petrology is the branch of geology that focuses on the study of metamorphic rocks and the processes that lead to their formation. Metamorphic rocks are rocks that have undergone changes in mineralogy, texture, or chemical composition due to high temperature, high pressure, or both, without melting completely.

Course Learning Objectives:

This course will enable students to understand the mechanism and types of metamorphism as well as the factors that affect the process of metamorphism. Metamorphic rocks provide valuable insights into the geological history of the earth. It linked with plate tectonics and the movement of earth lithospheric plates. Metamorphic petrology applied in various fields, including geotechnical engineering, environmental remediation, exploration and exploitation of natural resources.

Course Contents:

1. Principal of metamorphism
2. Metamorphic processes and reactions
3. Deformation, Fabric, structures and textures of metamorphic rocks.
4. Identification of metamorphic minerals and measurement of metamorphic structures.
5. Metamorphic facies and facies series.
6. Pressure-temperature paths (P-T Paths)
7. Field and hand sample identification of Metamorphic rocks
8. Zones and grades of metamorphism.
9. Metamorphic petrology of specific rock types (e.g. pelitic, mafic and carbonate)
10. Advanced topics such as metamorphic fluid chemistry, thermobarometry and geochronology.

Lab. Work

1. Thin Section Petrography: Thin section analysis provides valuable information about the mineral assemblages, grain sizes, and deformation features within metamorphic rocks.
2. Mineralogical Analysis: Various techniques are used to analyze the mineral composition of metamorphic rocks, including X-ray diffraction (XRD) and electron microscopy (SEM-EDS).
3. Geochemical Analysis: Geochemical analysis involves determining the chemical composition of metamorphic rocks and minerals. Techniques such as X-ray fluorescence (XRF) and inductively coupled plasma mass spectrometry (ICP-MS) are commonly used to measure the concentrations of major and trace elements in rock samples

Recommended Texts:

1. Fettes, D., & Desmons, J. (Eds.). (2011). *Metamorphic rocks: a classification and glossary of terms: recommendations of the International Union of Geological Sciences Subcommission on the Systematics of Metamorphic Rocks*. Cambridge University Press.
2. Best, M. G. (2013). *Igneous and metamorphic petrology*. John Wiley & Sons.

Suggested Readings

1. Bucher, K., & Frey, M. (2002). *Petrogenesis of metamorphic rocks*. Springer Science & Business Media.
2. Blatt, H., Tracy, R., & Owens, B. (2006). *Petrology: igneous, sedimentary, and metamorphic*. Macmillan.
3. Bucher, K. & Frey, M (1994). Definition, Limits and Types of Metamorphism. In *Petrogenesis of Metamorphic Rocks* (pp. 3-11). Springer, Berlin, Heidelberg.
4. Bucher, K., & Frey, M. (1994). Metamorphic Process. In *Petrogenesis of Metamorphic Rocks* (pp. 45-97). Springer, Berlin, Heidelberg.
5. Turner, F. J. (1981). *Metamorphic petrology: Mineralogical, field, and tectonic aspects*. McGraw-Hill Companies.

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GEOL - 7130

METALLIC MINERAL DEPOSITS

3(3-0)

Course Brief:

Metallic mineral deposits refer to areas in the Earth's crust where concentrations of metals accumulate, typically in economically viable quantities. These deposits are crucial for various industries as they serve as primary sources of metals like copper, gold, silver, iron, aluminum, zinc, lead, and nickel, among others.

Course Learning Objectives:

The exploration and exploitation of metallic mineral deposits are essential for meeting the global demand for metals used in various industries, including construction, manufacturing, electronics, and transportation. However, the extraction of these resources can have significant environmental impacts, including habitat destruction, water and air pollution, and soil degradation, necessitating responsible mining practices and environmental regulations.

Course Contents:

1. Fundamentals of Economic Geology
2. Overview of metallic mineral deposits and their significance
3. Geological control on the formation of metallic ore deposits.
4. Classification of metallic mineral deposits.
5. Genesis, occurrence and important features of mineral deposits.
6. Important features of porphyry deposits, Cu-Ni-Fe deposits, volcanic hosted massive sulphide deposits, Mississippi valley type deposits, carbonatites, greisen deposits, skarn deposits and placer deposits.
7. Description of few mineral deposits like chromite, platinum group elements, gold and uranium deposits, in detail.
8. Occurrence, distribution and utilization of metallic mineral deposits in Pakistan.

Recommended Texts:

1. Smirnov, V. I. (1976). *Geology of mineral deposits*. MIR publishers.
2. Mitchell, A. H. G., & Garson, M. S. (1981). *Mineral deposits and global tectonic settings*. Academic Press.
3. Kazmi, A. H., & Abbas, S. G. (2001). *Metallogeny and Mineral Deposits of Pakistan*; Graphic Publ.

Suggested Readings:

1. Ahmad, Z. (1969). Directory of mineral deposits of Pakistan. *Rec. Geol. Surv. Pakistan*, 15, 1-220.
2. Evans, A. M. (1987). Introduction to ore geology.
3. Edwards, R., & Atkinson, K. (1986). Magmatic deposits. In *Ore Deposit Geology and its Influence on Mineral Exploration* (pp. 18-68). Springer, Dordrecht.

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CHAIRMAN
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GEOL - 7131	INDUSTRIAL MINERALOGY	3(3-0)
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Course Brief:

Minerals sector has been one of the significant source of economic development of a number of developed countries. Several developed countries have been exploiting their original mineral resources by using as intermediate goods and finished products. Many of the countries are importing minerals from other countries, refining, value addition and then exporting. Although Pakistan has a number of mineral resources in abundance, yet consolidated and aligned with latest economic system, strategy for exploitation does not exist.

Course Learning Objectives:

As Pakistan has deposits of several minerals including coal, copper, gold, chromite, mineral salt, bauxite and several other minerals. So there is a need to analyse the mineral sector potential, its analysis in domestic and international **perspective, future trends.**

Course Contents:

1. The geology, origin, occurrence and classification of the chief categories of industrial minerals and rocks.
2. The requirements of industry as regard the physical and chemical properties of industrial minerals.
3. Important industrial minerals of Pakistan.
4. Existing industries i.e. Glass, ceramics, limestone and lime, cement, gypsum and anhydrite, bentonite, soapstone, marble, graphite, rock salt, rock phosphate, travertine, china clay, Feldspar and common clays.
5. Dimension stone, Slate, Magnesite, Kaolinite, Bentonite, Dumite and serpentinite, Nepheline syenite, Natural abrasive materials, Fluorite and Barite.
6. Commodity reports on aluminosilicate (Al₂SiO₅) minerals, asbestos, graphite, lithium minerals, perlite, sepolite, talc, wollastonite, anhydrite, diomite, iron oxide pigments, manganese ores, pumice, rutile, trona and zeolites.
7. Interpretation of normal geological maps in terms of industrial rock and mineral potential.

Recommended Texts:

1. Okrusch, M., & Frimmel, H. E. (2020). *Mineralogy: An introduction to minerals, rocks, and mineral deposits*. Springer Nature.
2. Shah, S. M. I. (2009). Stratigraphy of Pakistan (memoirs of the geological survey of Pakistan). *The Geological Survey of Pakistan*, 22.
3. Wenk, H. R., & Bulakh, A. (2016). *Minerals: their constitution and origin*. Cambridge University Press.

Suggested Readings:

1. Gore, D. J. (1961). The New Mineralogy—Principles and Explanations of Mineral Properties. *Journal of Geological Education*, 9(1), 29-31.
2. Malkani, M. S., Alyani, M. I., Khosa, M. H., Somro, N., Arif, S. J., Tariq, S., & Faiz, J. (2016). Mineral Resources of Pakistan-an update. *Lasbela University Journal of Science & Technology*, 5, 90-114.
3. Malkani, M. S., Mahmood, Z., Somro, N., & Arif, S. J. (2017). Gemstone and Jewelry Resources of Pakistan. *Geological Survey of Pakistan, Information Release, 1004*, 1-28.

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GEOL - 7132	APPLIED GEOCHEMISTRY	3(3-0)
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Course Brief:

Applied geochemistry involves the application of principles and techniques from the field of geochemistry to address practical problems in various sectors, including environmental science, natural resource exploration and exploitation, and public health.

Course Learning Objectives:

The 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. One of the goals of geochemistry is to determine the abundance of elements in nature, as this information is essential to hypotheses development about the origin and structure of our planet and the universe. An element is material which has a particular kind of atom with specific electronic structure and nuclear charge, factors that determine their abundance in the rocks. Regarding distribution, it can only have direct evidence on the composition of the Earth's crust and indirect on the mantle and core.

Course Contents:

1. Geochemistry as a recent subdisciplin of geology.
2. Variation diagrams, Eh-pH diagrams.
3. Geothermometry and Geobarometry
4. Thermodynamics
5. Low Temperature geochemistry
6. High Temperature geochemistry
7. Mobility and dispersion of elements under different geochemical environments
8. General chemical properties and abundances of rare earth elements.
9. Isotopes geochemistry.
10. Use of geochemistry in mineral exploration.
11. Geochemical techniques.

Lab. Work: Rock and Mineral Analysis:

1. X-ray diffraction (XRD),
2. electron microprobe analysis (EPMA),
3. laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS)

Recommended Texts:

1. Albarède, F. (2009). *Geochemistry: an introduction*. Cambridge University Press.
2. Gill, R. (2014). *Modern Analytical Geochemistry: an introduction to quantitative chemical analysis techniques for Earth, environmental and materials scientists*. Routledge.
3. Misra, K. C. (2012). *Introduction to geochemistry: principles and applications*. John Wiley & Sons.

Suggested Readings:

1. Killops, V. J., & Killops, S. D. (2013). *Introduction to organic geochemistry*. John Wiley & Sons.
2. Sharp, Z. (2017). *Principles of stable isotope geochemistry*.
3. Allègre, C. J., & Michard, G. (2012). *Introduction to geochemistry* (Vol. 10). Springer Science & Business Media.
4. Shaw, D. M. (2006). *Trace elements in magmas: a theoretical treatment*. Cambridge University Press.

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GEOL - 7133

IGNEOUS PETROLOGY

3(3-0)

Course Brief:

Igneous petrology is the branch of geology that focuses on the study of igneous rocks and the processes that govern their formation, evolution, and occurrence. Igneous rocks are formed through the solidification and crystallization of molten rock material, known as magma, either beneath the Earth's surface (intrusive) or on its surface (extrusive).

Course Learning 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. The generation of primary basalts at mid-ocean ridges and hotspots, and the generation of all other igneous rocks (ranging from acidic to ultrabasic) from primary basalts is discussed. The laboratory is an integral part of the course and students will learn to identify common igneous minerals, rocks and textures in hand specimen and in thin section using a petrographic microscope.

Course Contents:

1. Composition, origin, differentiation and evolution of magma; classification of igneous rocks; mineralogy and petrology and occurrence of the following series: tholeiitic and alkali-olivine basalt; basalt-andesite series; study of granites, granodiorite, syenite, carbonatite, mafic and ultramafic rocks and ophiolites; lamprophyres; facies analysis of volcanic rocks; mode of occurrences and types of extrusive rocks; texture and structure of igneous rocks; economic importance of igneous rocks.
2. Magmatic evolution and fractionational crystallization and congruent melting of magmas.
3. Convection, Contamination and mixing in magma chambers.
4. Hybridization, Assimilation and partial melting.
5. Phase Rule, Binary diagrams and Ternary diagrams (one system).
6. Lever Rule.
7. Systems MgO-SiO₂; albite-anorthite and forsterite-fayalite.
8. Basalt petrogenesis in relation to tectonic environments.
9. Alpine peridotites and Serpentinization.
10. Ophiolites and Ophiolites of Pakistan.
11. Kimberlites, Lamprophyres and layered intrusions.

Recommended Texts:

1. Best, M. G. (2013). *Igneous and metamorphic petrology*. John Wiley & Sons.
2. Blatt, H., Tracy, R., & Owens, B. (2006). *Petrology: igneous, sedimentary, and metamorphic*. Macmillan.

Suggested Readings:

1. Le Maitre, R. W., Streckeisen, A., Zanettin, B., Le Bas, M. J., Bonin, B., & Bateman, P. (Eds.). (2005). *Igneous rocks: a classification and glossary of terms: recommendations of the International Union of Geological Sciences Subcommission on the Systematics of Igneous Rocks*. Cambridge University Press.
2. Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw-Hill Science, Engineering & Mathematics.
3. Hall, A. (1989). M. Wilson. *Igneous Petrogenesis: a Global Tectonic Approach*. London (Unwin Hyman), 1989, xx+466 pp. Price: £ 50.00 (hardback); £ 24.95. *Mineralogical Magazine*, 53(372), 514-515.

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