Appendix 1

मोहनलाल सुखाड़िया विश्वविद्यालय, उदयपुर
MOHANLAL SUKHADIA UNIVERSITY, UDAIPUR

Syllabus of M.Sc. (Geology)

for

Two – Year

Post Graduate M.Sc. Geology Program

As per the Choice Based Credit System (CBCS)

Designed in accordance with Learning Outcomes – Based Curriculum Framework (LOCF) of National Education Policy (NEP-2020)

I to IV Semester M.Sc. (Geology) Courses

for Academic Year 2023-25

(Effective for the Academic Year 2023-24)

Faculty of Earth Sciences

(PG403XX)

Geology in M.Sc. Program: Semester-wise course types, Course codes, Course title, Delivery type, Workload, Credits, Marks of Examination, and Remarks if any.

Level	Sem	Course Type	Course Code	Course Title	Delivery Type			Total Hours	Credit	Total Credit	Internal Assessment	EoS Exam	M.M.	Remarks
					L	T	P							
8	I	DCC 1	GEO8000T	Geodynamics, Geomorphology, and Remote Sensing	L-3	T-1		60	4	4	20	80	100	
	I	DCC 2	GEO8001T	Mineralogy	L-3	T-1		60	4	4	20	80	100	
	I	DCC 3	GEO8002T	Stratigraphy	L-3	T-1		60	4	4	20	80	100	
	I	DCC 4	GEO8003T	Palaeontology	L-3	T-1		60	4	4	20	80	100	
	I	DCC PRACT 1	GEO8000P	Geodynamics, Geomorphology & Remote Sensing and Mineralogy			P-8	60	4	4	20	80	100	
	I	DCC PRACT 2	GEO8001P	Stratigraphy and Palaeontology			P-8	60	4	4	20	80	100	
	II	DCC 5	GEO8004T	Petrology 1	L-3	T-1		60	4	4	20	80	100	
	II	DCC 6	GEO8005T	Structural Geology	L-3	T-1		60	4	4	20	80	100	
	II	DCC PRACT 3	GEO8002P	Structural Geology and Petrology 1			P-8	60	4	4	20	80	100	
	II	DSE 1	GEO8100T	Remote Sensing in Geosciences/	L-3	T-1		60	4	4	20	80	100	
			GEO8101T	Computer Applications in Geosciences/										
			GEO8102T	Marine Geology										
	II	DSE 2	GEO8103T	Geochemistry and Instrumentation/	L-3	T-1		60	4	4	20	80	100	
			GEO8104T	Fuel Geology/										
			GEO8105T	Summer Internship										
	II	DSE PRACT 4	GEO8100P	Remote Sensing in Geosciences/			P-8	60	2	2	20	80	100	
			GEO8101P	Computer Applications in Geosciences/										
			GEO8102P	Marine Geology										
	II	DSE PRACT 5	GEO8103P	Geochemistry and			P-8	60	2	2	20	80	100	
			GEO8104P	Instrumentation/ Fuel Geology/										
			GEO8105S	Summer Internship										
Exit with PG Diploma Certificate														
9	III	DCC 7	GEO9000T	Economic Geology	L-3	T-1		60	4	4	20	80	100	
	III	DCC 8	GEO9001T	Petrology 2	L-3	T-1		60	4	4	20	80	100	
	III	DCC PRACT 6	GEO9000P	Economic Geology and Petrology 2			P-8	60	4	4	20	80	100	
	III	DSE 3	GEO9100T	Crustal Evolution and Mineralization in India/	L-3	T-1		60	4	4	20	80	100	
			GEO9101T	Field Geology and Surveying/										
			GEO9102T	Micropalaeontology										
	III	DSE 4	GEO9103T	Mineral Resource Estimation & Advanced Mining/	L-3	T-1		60	4	4	20	80	100	
			GEO9104T	Gemstones and Decorative stones/										

		GEO9105T	Engineering and Environmental Geology										
III	DSE PRACT 7	GEO9100P	Crustal Evolution and Mineralization in India/			P-8	60	2	2	20	80	100	
		GEO9101P	Field Geology and Surveying/										
		GEO9102P	Micropalaeontology										
III	DSE PRACT 8	GEO9103P	Mineral Resource Estimation & Advanced Mining/			P-8	60	2	2	20	80	100	
		GEO9104P	Gemstones and Decorative stones/										
		GEO9105P	Engineering and Environmental Geology										
IV	DCC 9	GEO9002T	Mineral Exploration and Mining	L-3	T-1		60	4	4	20	80	100	
IV	DCC 10	GEO9003T	Hydrogeology	L-3	T-1		60	4	4	20	80	100	
IV	DCC PRACT 9	GEO9001P	Mineral Exploration and Mining and Hydrology			P-8	60	4	4	20	80	100	
IV	DSE 5	GEO9106T	Applied Hydrogeology/	L-3	T-1		60	4	4	20	80	100	
		GEO9107T	Quaternary Geology/										
		GEO9108T	Gemology										
IV	DSE 6	GEO9109T	Ancient Mining, Metallurgy & Geo-heritage/	L-3	T-1		60	4	4	20	80	100	
		GEO9110T	Advanced Igneous and Metamorphic Petrology/										
		GEO9111T	Dissertation										
IV	DSE PRACT 10	GEO9106P	Applied Hydrogeology/			P-8	60	2	2	20	80	100	
		GEO9107P	Quaternary Geology/										
		GEO9108P	Gemology										
IV	DSE PRACT 11	GEO9109P	Ancient Mining, Metallurgy & Geo-heritage/			P-8	60	2	2	20	80	100	
		GEO9110P	Advanced Igneous and Metamorphic Petrology/										
		GEO9111S	*Dissertation										
Exit with M.Sc. Certificate													

	Semester 1	Semester 2	Semester 3	Semester 4
Core 60Cr (60%)	DCC 1- 4Cr **(Geodynamics, Geomorphology, and Remote Sensing)** DCC 2- 4Cr **(Mineralogy)** DCC 3- 4Cr **(Stratigraphy)** DCC 4- 4Cr **(Palaeontology)** Pract.1- DCC (1 & 2) - 4Cr Pract.2- DCC (3 & 4) - 4Cr	DCC 5- 4Cr **(Petrology 1)** DCC 6- 4Cr **(Structural Geology)** Pract.3- DCC (5 & 6) - 4Cr	DCC-7- 4Cr **(Economic Geology)** DCC-8-4Cr **(Petrology 2)** Petrology Pract.6- DCC (7 & 8) - 4Cr	DCC-9-4Cr **(Mineral Exploration and Mining)** DCC-10 -4Cr **(Hydrogeology)** Pract.9- DCC (9 & 10) - 4Cr
36 Cr		DSE 1- 4Cr **Remote Sensing in Geosciences /** **Computer Applications in Geosciences /** **Marine Geology /** DSE 2- 4Cr **Geochemistry and Instrumentation /** **Fuel Geology /** ***Summer Internship** Pract.4- DSE 1- 2Cr Pract.5- DSE 2- 2Cr*	DSE 3-4Cr **Crustal Evolution and Mineralization in India /** **Field Geology and Surveying /** **Micropalaeontology** DSE 4-4Cr **Mineral Resource Estimation & Advanced Mining /** **Gemstones and Decorative stones /** **Engineering and Environmental Geology** Pract.7- DSE 3 - 2Cr Pract.8- DSE 4 - 2Cr	DSE 5- 4Cr **Applied Hydrogeology /** **Quaternary Geology /** **Gemology** DSE 6- 4Cr **Ancient Mining, Metallurgy & Geo-heritage/** **Advanced Igneous and Metamorphic petrology /** ***Dissertation** Pract.10- DSE 5 -2Cr Pract.11- DSE 6 -2Cr*
96 Cr	6×4= 24 Cr	12+12=24 Cr	12+12= 24	12+12=24

1. For DSE paper to commence in an academic session there should be at least 10 students out of the total the total 36 seats.
2. **The courses provided as an option in DSE will be allotted to students on the availability of infrastructure and faculty members in that particular semester.**
3. Dissertation and Summer Internship reports will be submitted by the candidate for 6 credit calculation under the guidance of a mentor/guide which will be a faculty member, marks of internal on dissertation & summer internship will be given by the mentor/ faculty member. Evolution of dissertation/summer internship reports will be done as per

the guidelines of NEP of MLS University. Dissertation/ Summer Internship under category of special types of delivery of course.

EOES (For Theory):

1. External Exam

a.	Section A	20 Marks
b.	Section B	40 Marks
c.	Section C	20 Marks
	Total	**80 Marks**

2. Internal Exam **20 Marks**

Pass Percentage - 40%

M.Sc. Geology I Semester

Code of the course	**GEO8000T**
Title of the course	**Geodynamics, Geomorphology, and Remote Sensing**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**4**
Type of the course	**Discipline Centric Core Course (DCC)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	• **It is aimed to learn about the role of tectonics in landscape evolution and the coupling of tectonics and climate. Tools and methods used in the investigation of landforms and landscape responses to deformation in different timescales.**
Syllabus	
Semester-1 Geodynamics, Geomorphology, and Remote Sensing	
Unit 1 Interior of Earth	
Heterogeneities and Transitions inside the earth. Rheology of rocks and fluids. Rock Magnetism, Polarity reversals, and Magnetic anomalies. Concept of geoid, spheroid, and isostasy.	
Unit 2 Dynamics of Earth	
Polar wandering and Supercontinent Cycle. Continental Drifts & Mantle Plumes: Mechanisms and evidence. Plate tectonics and seismicity. Heat flow and production in crust. Thermal Modeling of Earth.	
Unit 3 Basic Geomorphology and Landforms	
Concepts &history of geomorphology. Processes of geomorphology: Weathering, Erosion, Pathogenesis, Mass-movement, Transportation & Deposition. Fluvial, Glacial, Aeolian, Eolian, Coastal and Karst. Submarine Relief: Sea-floor, Continental Shelf, Slope, and Rise. Concepts of landscape evolution. Geomorphic Landforms of India: Coastal, Peninsular and Extra-Peninsular.	
Unit 4 Applications of Geomorphology	
Geomorphic mapping, Slope, Drainage, and Basin Analyses. Hydrographs and Flood Frequency Analyses. Topographic analyses & DEM. Applications of geomorphology in mineral prospecting, civil engineering & environmental studies.	
Unit 5 Remote Sensing	
Types of satellites and images. Concept of Photo-geology and Photogrammetry. Types and geometry of aerial photographs. Basics of Remote Sensing, EMR, platforms, and sensors. Elements of image interpretation. Basic drainage patterns and their characteristics.	
Books suggested for reading:	
• Butz, S. and Delmar, Thomas., 2007, Science of Earth Systems., 2nd ed. • Gass, I.G., 1982, Understanding the Earth, Artemis Press (Pvt) Ltd. U.K. • Halis, J.R., 1983, Applied Geomorphology. • Holmes, A., McL, P., Duff, D., Chapman and Hall, 11., 1992, Holmes Principles of Physical Geology. • Holmes A., 1993, Principles of Physical Geology., ed by David Duff, Nelson Thornes Ltd. • Lillesand, T.M. and Kiefer, R.W., 1987, Remote Sensing and Image Interpretation, John Wiley. • Sharma, H.S. 1990, Indian Geomorphology, Concept Publishing Co., New Delhi.	

- Singh, Savindra 2006, Geomorphology, Prayag Pustak Bhavan, Allahabad.
- Skinner, B.J., Porter, S.C. and Botkin, D.B., 1999, The Blue Planet., 2nd ed. J. Wiley & Sons.
- Thornbury, W.D, 1980, Principles of Geomorphology, Wiley Easton Ltd., New York

Suggested E-resources :

- https://epgp.inflibnet.ac.in
- e-PG Pathshala - INFLIBNET Centre
- https://academistan.com › geography Applied Geomorphology: Concept and Applications
- https://lotusarise.com › applied-geo Applied Geomorphology: Meaning, Applications & Techniques
- https://geologyscience.com › geology Earth's Layers, Structure of Earth Interior: Core, Mantle, Crust

Course learning outcomes :

- Outcomes are expected in terms of coupled knowledge of tectonics and geomorphology. It is expected that the students bear the knowledge to understand the processes of geomorphology with the role of tectonics.

Code of the course	**GEO8001T**
Title of the course	**Mineralogy**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**4**
Type of the course	**Discipline Centric Core Course (DCC)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	• **The objective of the course is to understand the distribution of minerals in different Earth's spheres and evaluate different processes of the Physico-chemical environment of their formation. The course also includes minerals, which are of economic significance, and learn the basic principles to identify them.**
Syllabus	

Semester-1 Mineralogy

Unit1 Introduction to Mineralogy

Introduction to mineralogy, bonding in minerals, solid solution, polymorphism, isomorphism, Pseudomorphism; Pauling's rules governing the ionic structures. Structural classification of silicates.

Unit 2 Optical Mineralogy

Nature of light, Behavior of lights in isotropic, uniaxial, and bi-axial crystals, Introduction to the petrological microscope; Double refraction, polarization, Nicol Prism, Indicatrix; Pleochroism, Refractive index, and Birefringence; Extinction, Interference figures, Michael Levy chart of interference colours, interference figures, and use of interference figures for determination of optic sign.

Unit 3 Silicate Minerals

A detailed study of the following silicate mineral groups with reference to their general formulae, classification, atomic Structure, chemistry, experimental work, and paragenesis:
a) Nesosilicates: Olivine Group, Garnet Group
b) Inosilicates; Pyroxene Group; Amphibole Group.
c) Phyllosilicates: Kaolinite Group, Serpentine Group, Pyrophyllite, Talc, Mica Group, Chlorite.
d) Tectosilicate: Feldspar Group, Cordierite, Quartz.

Unit 4 Non-Silicate Minerals

Mineralogical study of non-silicates such as Spinel, Sulfide, Sulfate, Halides, Phosphate, and Carbonate (calcite, aragonite, dolomite) group of minerals.

Unit 5 Instrumentation in mineral science

Introduction to X-ray; Crystallography Bragg's Law and its derivation; X-ray diffractometer. Brief introduction & Application of Electron Micro Probe analyses (EPMA) and Scanning Electron Microscopy (SEM) in mineral characterization.

Books suggested for reading:

- Dana, E.S. and Ford, W.E., 2002, A textbook of Mineralogy (Reprint)
- Deer, W.A., Howie, R.A. & Zussman, J., 2013, An Introduction to the rock-forming minerals, ELBS and Longman
- Gribble C.D., 2005, Rutley's Elements of Mineralogy, Springer.

- Kerr, P.F. and Hill, Grew, M.C., 1977, Optical Mineralogy.
- Nesse, D.W. and Hill, Grew, M.C., 1986, Optical Mineralogy.
- Perkins, D., 2013, Mineralogy, Prentice Hall.
- Phillips, F.C., 1971, Introduction to Crystallography, Longman Group Publication.
- Reed, S.J. B., 1996, Electron Microprobe Analysis and Scanning Electron Microscopy in Geology, Cambridge University press.
- Sharma, R.S. and Sharma, A. 2013, Crystallography and Mineralogy- concepts and methods, Geological Society of India.
- Winchell, E.N. and Eastern, Wiley., 1951, Elements of Optical Mineralogy,

Suggested E-resources :

- https://egyankosh.ac.in/handle/123456789/58908
- http://www.ignouhelp.in/ignou-bgyct-133-study-material/
- https://users.metu.edu.tr/lunel/

Course learning outcomes :

- At the end of the course, the successful students should be able to identify and characterize the common minerals based on their physical, chemical, and optical properties. The students will also get the idea of preliminary knowledge on instrumentation techniques used for mineralogical studies.

Code of the course	**GEO8002T**
Title of the course	**Stratigraphy**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**4**
Type of the course	**Discipline Centric Core Course (DCC)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	• **It is aimed to make understand almost 90% of Earth's geological history through this paper by pertaining knowledge of lithology, crustal evolution, and geochronology.**
Syllabus	
Semester-1 Stratigraphy	
Unit 1 Precambrian Earth	
Early History of the Earth. Evolution of Granite-Greenstone belts. Methods of correlation of Precambrian rocks. Major breaks and events in stratigraphy. Major stratigraphic breaks and events in stratigraphy. Episodic nature of the stratigraphic records. Stratigraphic boundary problems Archean – Proterozoic boundary.	
Unit 2 Precambrian Belts of South India	
Dharwar Protocontinent, Southern Granulite Belt, Eastern Granulite Belt, Charnockites, Central Indian Tectonic Zone, and Bastar Craton.	
Unit 3 Precambrian of North India	
Aravalli Protocontinent, Bundelkhand Protocontinent (including Vindhyans), Singhbhum Protocontinent, Precambrian of Rajmahal, Shillong and Himalaya. Comparative crustal evolutionary history of Precambrian Protocontinents.	
Unit 4 Phanerozoics of India I	
Palaeozoic Formations of Himalayan Belt, Gondwana Supergroup, Triassic of Spiti and adjoining areas, Mesozoics of Kutch, Rajasthan, and Central India. Cretaceous of Trichinopolly	
Unit 5 Phanerozoics of India II	
K-T Magmatism in India, Caenozoic Formations of Assam, Siwalik Group, Palaeogene and Neogene formations of North East and Rajasthan and distribution of oil-basins.	
Books suggested for reading:	
• Vaidyanadhan, R. and Ramakrishnan, M., 2010, Geology of India vol. I & II, Geol. Soc. of India, Bangalore. • Roy, A.B., Purohit, R. and Elsevier., 2018, Indian Shield. • The Making of India, Geodynamic evolution, Macmillan Publishers India Ltd. • Kumar, Ravindra., 1988, Fundamentals of Historical Geology and Stratigraphy of India.	
Suggested E-resources:	
• https://egyankosh.ac.in/bitstream/123456789/69603/1/Block-2.pdf • https://en.wikipedia.org/wiki/Geology_of_India • https://www.researchgate.net/publication/248552540_Stratigraphic_setting_of_the_Phanerozoic_rocks_along_the_northern_boundary_of_the_Indian_Plate	
Course learning outcomes:	
• It is aimed that students should come out after passing this paper with a comprehensive knowledge of the Stratigraphic Units of India. Students should have a	

broad idea about distribution, lithological characters, petrochemistry, structural features, and crustal evolution.

- The paper has definite objectives to build a basic geological knowledge of Indian Precambrian and Phanerozoic terranes with core geological knowledge and applied aspects of stratigraphy besides learning. It is aimed to study a broad idea about Phanerozoic processes that Indian Shield underwent after its Precambrian evolution. The idea about Phanerozoic sequence stratigraphy has been expanded and extended in terms of reconstitution processes that were witnessed in the form of rift margins, volcanism, development of new basins, and collision of the Indian Plate with the Eurasian Plate that subsequently led to the rise of Himalayas in various phases.

Code of the course	**GEO8003T**
Title of the course	**Palaeontology**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**4**
Type of the course	**Discipline Centric Core Course (DCC)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	• **The students will be able to understand the mechanism and evidence of evolution of life through ages.** • **The students will be able to understand the morphology and evolution of various invertebrate and vertebrate fossils.** • **The students will get a brief idea about Gondwana plant fossils** • **The students will get a brief idea about Evolutionary trends.**
Syllabus	
Semester-1 Palaeontology	
Unit 1 Introduction	
Theories on origin of life. Organic evolution – Punctuated Equilibrium and Phyletic Gradualism models. Mass extinctions and their causes. Application of fossils in age determination and correlation.	
Unit 2 Preservation and Classification	
Paleoecology, Life habitats and various ecosystems, Paleobiogeography. Modes of preservation of fossils and taphonomic considerations. Outline of classification of invertebrates and vertebrates.	
Unit 3 Invertebrate Organization	
Anthozoa: Morphology and Geological history. Trilobite: evolutionary trends, geological history and palaeoecology. Graptolite: Evolution, palaeoecology and geological history Echinoid: Change in symmetry, ambulacral areas and compound plates, variation in oculogenital system, classification.	
Unit 4 Invertebrate Organization	
Bivalve: Evolution of hinge and dentition, adaptive modification of foot, mantle and pallial sinus; palaeoecology, geological history and classification. Gastropod: forms, various apertures, classification, palaeoecology, and geological history. Brachipoda: Classification; Variation in brachial skeleton, pedical opening and commissure. Cephalopoda: Ammonite - Morphology, ornamentation and type of sutures, evolutionary theories about ammonite, classification and time-ranges of ammonites (geological history). Nautiloidea: Variation in conchs of Nautiloidea, Morphology of Dibranchia.	
Unit 5 Gondwana Plants and Vertebrates Organization	
Study of important Indian Gondwana plant fossils. Significance of vertebrate paleontology, Sequence of vertebrates through geological ages. Evolutionary history of man and horse.	
Books suggested for reading:	
• Black, R.M., 1988, The Elements of Palaeontology, Cambridge Univ. • Clarkson, E.N.K., 1986, Invertebrate Palaeontology and Evolution, Allen and Unwin Publ. • Jain, P.C. and Anantharaman, M.S., 1983, Palaeontology, Evolution and Animal Distribution, Vishal Publ.	

- Lehmann, U., 1983, Fossils Invertebrate, Cambridge Univ. Press.
- Moore, R.C., Lalicker, C.G. and Fischer, A.G., 1997, Invertebrate Fossils, CBS Publ.
- Nield, E.W. and Tucker, V.C.T., 1985, Palaeontology, An Introduction, Pergamon Press.
- Prothero, D.R. and Hill, Graw, M.C., 2004, Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.).
- Rastogi, 1988, Organic Evolution, Kedarnath and Ramnath Publ.
- Raup, D.M. and Stanley, S.M., 1985, Principles of Palaeontology, CBS Publ.
- Shrock, R.R. and Twenhoffel, W.H., 1952, Principles of Invertebrate Paleontology, CBS Publ.
- Stebbins, 1979, Process of Organic Evolution (3rd Ed.) Prentice Hall.
- Woods, H., 1985, Palaeontology Invertebrate, CBS Publ.

Suggested E-resources :

- https://www.youtube.com/watch?v=-S-bhiEDEcc
- https://www.youtube.com/watch?v=VF5hySdWsKY
- https://www.youtube.com/watch?v=NQl2RPE7Tpw
- https://www.youtube.com/watch?v=5ALNHhocXZY&list=PLtmeb20f7jz-Q5YwTpgUefo4N3X9bkiC8
- https://www.futurelearn.com/courses/extinctions-past-present/19/steps/1312906

Course learning outcomes :

- The students will be able to develop an understanding about the evolution and extinction mechanism.
- The students will be able to identify various invertebrate, vertebrate and plant fossils.

Code of the course	**GEO8000P**
Title of the course	**Geodynamics, Geomorphology, and Mineralogy**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**4**
Type of the course	**Discipline Centric Core Course (DCC)**
Delivery type of the course	**Practical**
Objectives of the Course	• **As per the objectives defined in Geodynamics, Geomorphology theory paper to develop practical skills.** • **And how to identify various minerals and know their properties.**
Syllabus	

Semester-1 Geodynamics, Geomorphology, and Mineralogy

Geodynamics and Geomorphology

- Identification and description of various landforms.
- Morphometric analysis of drainage basins.
- Studies of drainage patterns.
- Exercise on slope analysis.

Mineralogy

- Principles of stereographic projection and determination of axial ratio.
- Identification of minerals in hand specimen.
- Microscopic properties of minerals with emphasis on the pleochroic scheme, identification of interference figures and optical sign, determination, and measurement of 2V.

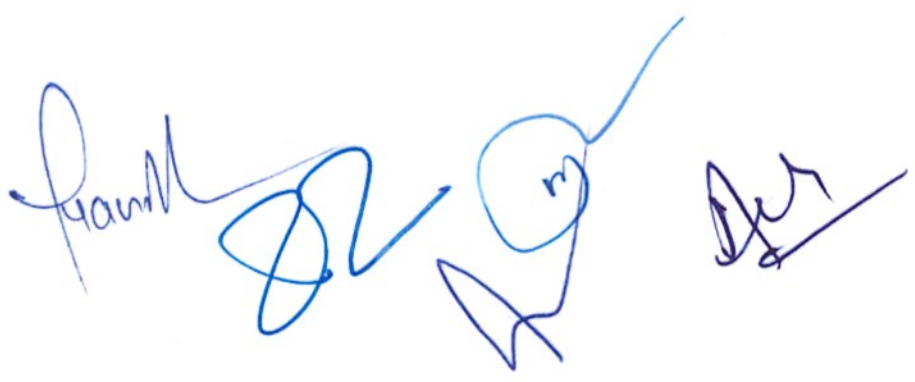
Books suggested for reading:

- Butz, S. and Delmar, Thomas., 2007, Science of Earth Systems., 2nd ed.
- Gass, I.G., 1982, Understanding the Earth, Artemis Press (Pvt) Ltd. U.K.
- Halis, J.R., 1983, Applied Geomorphology.
- Holmes, A., McL, P., Duff, D., Chapman and Hall, 11., 1992, Holmes Principles of Physical Geology.
- Holmes A., 1993, Principles of Physical Geology., ed by David Duff, Nelson Thornes Ltd.
- Sharma, H.S. 1990, Indian Geomorphology, Concept Publishing Co., New Delhi.
- Singh, Savindra 2006, Geomorphology, Prayag Pustak Bhavan, Allahabad.
- Skinner, B.J., Porter, S.C. and Botkin, D.B., 1999, The Blue Planet., 2nd ed. J. Wiley & Sons.
- Thornbury, W.D. 1980, Principles of Geomorphology, Wiley Easton Ltd., New York.

Suggested E-resources :

- https://epgp.inflibnet.ac.in
- e-PG Pathshala - INFLIBNET Centre
- https://academistan.com › geography Applied Geomorphology: Concept and Applications
- https://lotusarise.com › applied-geo Applied Geomorphology: Meaning, Applications & Techniques
- https://geologyscience.com › geology Earth's Layers, Structure of Earth Interior: Core, Mantle, Crust

Course learning outcomes :	
• As per the outcomes defined in the Geodynamics, Geomorphology theory paper with relevance to practical aspects. • And to acquire the knowledge of how to identify various minerals and to know their properties in hand specimens and also under a petrological microscope.	
EOSE (PRACTICAL):	**80 Marks**
Practical - 45 Marks	
Viva – Voce - 15 Marks	
Record - 20 Marks	
Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**



Code of the course	**GEO8001P**
Title of the course	**Stratigraphy and Paleontology**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**4**
Type of the course	**Discipline Centric Core Course (DCC)**
Delivery type of the course	**Practical**
Objectives of the Course	• **As per the objectives defined in Stratigraphy and Paleontology theory paper to develop practical skills.**
Syllabus	

Semester-1 Stratigraphy and Paleontology

Paleontology

- Drawing, description, age, and identification of important fossils of Trilobites, Echinoids, and Graptolites.
- Drawing, description, age, and identification of important fossils of Anthozoa, Bivalvia, Brachiopoda, Gastropoda, Cephalopods, and Gondwana Plant fossils.

Stratigraphy

- Identification, description, and geochronology of Indian Pre-Cambrian stratigraphic rocks.
- Pre-Cambrian Stratigraphic maps of India.
- Pre-Cambrian Palaeogeographic maps of India.
- Identification, description, and geochronology of Indian Phanerozoic Stratigraphic rocks.
- Phanerozoic Stratigraphic maps of India.
- Phanerozoic Palaeogeographic maps of India.

Compulsory Field Training Program: Geological Field Training is mainly based on Stratigraphy and Paleontology aspects.

Note: **Compulsory field training program at the end of every semester will be a value-added part of the practical syllabus which will be of 10 days duration and students opting out of it will lose proportionally marks from the practical credit score. The student will have a chance to improve the score by doing the field training at his/her expense before the commencement of the final practical exam and after producing a valid certificate from the recognized institute/company duly approved by the field training mentor/ faculty member.**

Books suggested for reading:

- Black, R.M., 1988, The Elements of Palaeontology, Cambridge Univ.
- Clarkson, E.N.K. 1986, Invertebrate Palaeontology and Evolution, Allen and Unwin Publ.
- Jain, P.C. and Anantharaman, M.S., 1983, Palaeontology: Evolution and Animal Distribution, Vishal Publ.
- Lehmann, U., 1983, Fossils Invertebrate, Cambridge Univ. Press.
- Moore, R.C., Lalicker, C.G. and Fischer, A.G., 1997, Invertebrate Fossils, CBS Publ.
- Nield, E.W. and Tucker, V.C.T., 1985, Palaeontology: An Introduction, Pergamon Press.
- Prothero, D.R. and Hill, Graw, M.C., 2004, Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.).

- Rastogi, 1988, Organic Evolution, Kedarnath and Ramnath Publ.
- Raup, D.M. and Stanley, S.M., 1985, Principles of Palaeontology, CBS Publ.
- Shrock, R.R. and Twenhoffel, W.H., 1952, Principles of Invertebrate Paleontology, CBS Publ.
- Stebbins, 1979, Process of Organic Evolution (3rd Ed.) Prentice Hall.
- Woods, H., 1985, Palaeontology Invertebrate, CBS Publ.

Suggested E-resources :

- https://www.youtube.com/watch?v=-S-bhiEDEcc
- https://www.youtube.com/watch?v=VF5hySdWsKY
- https://www.youtube.com/watch?v=NQl2RPE7Tpw
- https://www.youtube.com/watch?v=5ALNHhocXZY&list=PLtmeb20f7jz-Q5YwTpgUefo4N3X9bkiC8
- https://www.futurelearn.com/courses/extinctions-past-present/19/steps/1312906
- https://egyankosh.ac.in/bitstream/123456789/69603/1/Block-2.pdf
- https://en.wikipedia.org/wiki/Geology_of_India
- https://www.researchgate.net/publication/248552540_Stratigraphic_setting_of_the_Phanerozoic_rocks_along_the_northern_boundary_of_the_Indian_Plate

Course learning outcomes :

- As per the outcomes defined in the Paleontology theory paper with relevance to practical aspects.
- The student is expected to come out with the knowledge of the extension of lithostratigraphic units in relevance to chronostratigraphy with sum-to knowledge of the Indian subcontinent specifically during Precambrian time.
- With respect to the outcome, it is expected that students should bear the knowledge of Phanerozoic lithostratigraphic units in the Indian subcontinent, palaeogeographic linkages with the surrounding landmasses, and position of India within the various Supercontinents.

EOSE (PRACTICAL):	
Practical - 45 Marks	**80 Marks**
Viva – Voce - 15 Marks	
Record - 20 Marks i. Field Tour Report – 10 Marks ii. Practical Record – 10 Marks	
Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**

M.Sc. Geology II Semester

Code of the course	**GEO8004T**
Title of the course	**Petrology-I**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**4**
Type of the course	**Discipline Core Courses (DCC)**
Delivery type of the course	**Theory & Lecture**
The Objective of the Course	• **To understand the nature of diverse types of magma/magma series evolved in different tectonic settings, processes of magma generation in the lower crustal and upper mantle govern the texture and chemical composition of various igneous rocks by different magmatic processes.**
Syllabus	
Semester-2 Petrology-I	
Unit 1 Introduction to Sedimentology	
Weathering & Erosion; Sediment transport: modes of transport, fluid flow, movement of particles, settling velocity of sediments, transport types, Textures and sedimentary structures and their significance.	
Unit 2 Clastic and Non-Clastic Sedimentary rocks	
Classification, nomenclature, and genesis of sedimentary rocks. Clastic rocks: Conglomerate, Breccia, Sandstone, and Shale. Non clastic rock: Limestone and Dolomite. Evaporite, Phosphorite,Chert, Iron and Manganese rich sediments.	
Unit 3 Sedimentary Environments	
Sedimentary environment and facies models-Marine, Non-Marine and Mixed environments. Tectonics and sedimentation, Classification, definition, and description of sedimentary basins, Paleocurrent analysis and its application in basin analysis. Sedimentary basins of India.	
Unit 4 Introduction to Igneous Petrology	
Magma: Its physics, nature, factors affecting magma, and its evolution. Thermal structure of the earth and melting of the mantle. Plate tectonics and generation of different magmas in various tectonic settings.	
Unit 5 Forms, Textures & Classification of Igneous Rocks	
Concept of primary and secondary magma. Magma series, Dynamics, differentiation. Forms of igneous rocks & Mode of occurrence of igneous rocks. Interpretation of igneous textures in terms of rate of nucleation and crystal growth. Textures and Structures of Igneous Rock. Bases of classification of igneous rocks: mineralogical, textural, and chemical.	
Books suggested for reading:	
• Winter, J.D., 2010, Principles of Igneous and Metamorphic Petrology, Pearson Prentice Hall. • Gill, Robin., 2010, Igneous Rocks and Processes: a practical guide, John Wiley & Sons • Sen, Gautam., 2014, Petrology, Principles and Practice, Springer-Verlag publisher. • Philpotts and J. Ague 2009, Principles of Igneous and Metamorphic Petrology • Best, M.G., 1986, Igneous Petrology, CBS Publ. • Hall Bose, M.K., 1997, Igneous Petrology. World Press	

- McBriney, A.R., 1993, Igneous Petrology. Jones &Bartelt Publ.
- Perchuk, L.L. and Kushiro, I., 1991, Physical Chemistry of Magmas. Springer Verlag.
- Philipotts, A., 1992, Igneous and Metamorphic Petrology. Prentice Hall.

Suggested E-resources :

- http://en.wikipedia.org/wiki/Igneous_petrology
- http://www.tulane.edu/~sanelson/eens212/intro&textures.htm
- http://ericfdiaz.wordpress.com/an-introduction-to-igneous-petrology/

Course learning outcomes :

- The outcome of petrology will have imparting knowledge on the classification, description, origin, and evolution of igneous and sedimentary rocks.

Code of the course	**GEO8005T**
Title of the course	**Structural Geology**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**4**
Type of the course	**Discipline Centric Core Course (DCC)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	• **The objective of the course is to teach the students how the Earth responds to applied forces. This course looks at how rocks deform and change shape, and how we can recognize and use structures within rocks to determine ancient magnitudes and orientations of stress fields. Basic concepts of the rheological properties of rocks and their control of the deformation processes.**
Syllabus	
Semester-2 Structural Geology	
Unit 1 Stress and Strain	
Theory, Relationship of elastic, plastic and viscous materials. Stress and strain effects in relation to folding, faulting, and shear zones.	
Unit 2 Folds	
Geometry, classification, mechanism of development of folds. Interference patterns of superimposed folds. Structural diagram: interpretation and projections.	
Unit 3 Faults	
Geometry, classification, mechanism of Faulting. Joints and Fractures: Nomenclature, Age relationship, Origin and Significance. Relation of joints and fractures to strain field.	
Unit 4 Foliation and Cleavage	
Types, origin, mechanics, and relationship with folding. Lineation: Types, origin, significance, and deformation. Boudinage, Fabric.	
Unit 5 Shear Zones	
Geometry, Types, patterns, displacement, strain, and fabric. Mylonites, Microbreccia, Pseudotachylites. Shear sense indicators.	
Books suggested for reading:	
• Hobbs, B.E., Means, W.D. and Williams, P.F., 1976, An outline of structural geology, John Wiley. • Ramsay, J.G. and Hill Graw M.C., 1967, Folding and fracturing of rocks. • Davis, H., Stephen J., Reynolds, and Kluth, Chuck., Structural geology of rocks and regions /George 3rd edition • Park, R.G., 1997, Foundations of Structural Geology, 3rd edition. • Fossen, Haakon., 2010, Structural Geology. • Ghosh, S.K.,1993, Structural Geology– Fundamentals and modern development. • Passchier, C.W. and Trouw, R.A.J., 2005, Microtectonics . • Billings, M.P., 2008, Structural Geology, Prentice Hall of India Pvt. Ltd., Delhi, - 3rd Edition. • Ramsay, J.G. and Huber, M.L., 1987, Modern Structure Geology- Vol. I & II. Academic Pres.	
Suggested E-resources :	
• egyankosh.ac.in	

- http://egyankosh.ac.in//handle/123456789/53276
- BGYCT-131 Physical and Structural Geology
- https://egyankosh.ac.in › handle
- https://epgp.inflibnet.ac.in › epgp_content
- https://ocw.mit.edu/courses/12-113-structural-geology-fall-2005/pages/lecture-notes

Course learning outcomes :

- After this class, students should be able to quantitatively describe the three-dimensional structure of rocks in the earth's crust, using geologic maps and/or outcrop data, and reconstruct the deformation history of deformed rocks based on fabrics and geometric relationships.

Code of the course	**GEO8002P**
Title of the course	**Structural Geology & Petrology 1**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**4**
Type of the course	**Discipline Centric Core Course (DCC)**
Delivery type of the course	**Practical**
Objectives of the Course	• **To learn the practice of Practical knowledge for applying ground observation in the field and to learn essential observational and practical skills.** • **As per the defined objectives Petrology 1 theory paper to develop practical skills.**
Syllabus	

Semester-2 Structural Geology & Petrology 1

Structural Geology

- Solution of structural problems by stereographic and orthographic projections.
- Identification of structural elements and their chronology in hand specimen.
- Structural analysis with the stereo net: S- pole and beta-pole diagrams; Fold axis and axial plane; Contoured diagrams; Methodology and interpretation of patterns.
- Interpretation of complex geological maps and drawing of cross sections of Platt Series Maps.

Petrology 1

- Identification and description of important sedimentary rocks in hand specimen.
- Petrographic studies of important sedimentary rocks.
- Graphic representation of data, histogram, cumulative curves, frequency curves, rose diagram, and star symbols.
- Identification and description of important igneous rocks in hand specimen.
- Calculation of CIPW norms.

Compulsory Field Training Program: Geological Field Training mainly based on Structural Mapping.- 10 days duration

Note: Compulsory field training program at the end of every semester will be a value-added part of the practical syllabus which will be of 10 days duration and students opting out of it will lose proportionally marks from the practical credit score. The student will have a chance to improve the score by doing the field training at his/her expense before the commencement of the final practical exam and after producing a valid certificate from the recognized institute/company duly approved by the field training mentor/ faculty member.

Books suggested for reading:

- Ramsay, J.G. and Hill Graw M.C., 1967, Folding and fracturing of rocks.
- Park, R.G., 1997, Foundations of Structural Geology, 3rd edition.
- Ghosh, S.K.,1993, Structural Geology– Fundamentals and modern development,
- Passchier, C.W. and Trouw, R.A.J., 2005, Microtectonics.
- Platt. John I., Selected Exercises upon Geological Maps, London WCI.
- Billings, M.P., 2008, Structural Geology, Prentice Hall of India Pvt. Ltd., Delhi, - 3rd Edition.
- Ramsay, J.G. and Huber, M.L., 1987, Modern Structure Geology- Vol. I & II. Academic Pres. A Guide to Field Geology – N.W. Gokhale, 2001.
- Ragan, Donal M., Structure Geology, USA Cambridge Uni. Press, New York.

• Lewis, Douglas W. and David, McConchie., Practical Sedimentology, Springer Book Archive. • Laboratory Methods in Geology	
Suggested E-resources :	
• egyankosh.ac.in • http://egyankosh.ac.in//handle/123456789/53276 • BGYCT-131 Physical and Structural Geology • https://egyankosh.ac.in › handle • https://epgp.inflibnet.ac.in › epgp_content • https://ocw.mit.edu/courses/12-113-structural-geology-fall-2005/pages/lecture-notes	
Course learning outcomes :	
• To train the students for adaptation to the fieldwork environment in certain professional and scientific organizations. Students will know and imparted through field trips. Students are expected to learn different deformational structures. • As per the outcomes defined in the Petrology 1 theory paper with relevance to practical aspects.	
EOSE (PRACTICAL):	**80 Marks**
Practical - 45 Marks	
Viva – Voce - 15 Marks	
Record - 20 Marks i. Field Tour Report – 10 Marks ii. Practical Record – 10 Marks	
Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**

Code of the course	**GEO8100T**
Title of the course	**Remote Sensing in Geosciences**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**4**
Type of the course	**Discipline Specific Elective Course(DSE)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	**The objective of the present syllabus of Remote Sensing in Geosciences is as follows:** • **To understand the concepts of sensors and satellites.** • **To understand the concepts of aerial photography and its applications in geosciences.** • **To develop elementary ideas about remote sensing techniques.** • **To develop concepts of Software like ERDAS /GIS (QGIS).** • **To help students in getting employability in various space and remote sensing organizations.**
Syllabus	
Semester-2 Remote Sensing in Geosciences	
Unit 1 Introduction to Aerial Photography	
Fundamental principles and technology of aerial photography; types of aerial photographs; types of camera, film, and filters; scale of aerial photography and factors affecting scale; mosaics and annotation; relief displacement; vertical exaggeration	
Unit 2 Techniques and Applications of Aerial Photography	
Factors affecting aerial photography, Techniques of visual interpretation of aerial photographs; application of aerial photographs in geoscience and geomorphological studies.	
Unit 3 Fundamentals of Remote Sensing	
Remote sensing systems; space platforms and orbit patterns; remote sensing sensors; thermal, radar, and hyperspectral images; signatures of rocks, minerals, and soils.	
Unit 4 Digital Image Processing	
Digital data formats; fundamental steps in image processing; image rectification and restoration; elements of pattern recognition and image classification.	
Unit 5 Geographic Information System	
Introduction to Geographic Information System (GIS); components of GIS; Georeferencing of maps and images. Open source vs commercial software in GIS and remote sensing. Overview of ArcGIS and ERDAS software. Information extraction from satellite images and thematic mapping. Applications of GIS in geosciences.	
Books suggested for reading:	
• Pandey, S. N., 1987, Principles and Applications of Photogeology, Wiley Eastern Limited. • Gupta, R.P., 2003, Remote Sensing Geology, 2nd Edition- Springer. • Bhatia, S. C., 2008, Fundamentals of Remote Sensing, Atlantic Publications. • Drury, S.A., 1987, Image Interpretation in Geology, Springer. • Gopi, S., Sathikumar, R. and Madhu, N., 2006, Advanced Surveying total station	

GIS and Remote Sensing, Pearson Education.

- Jensen, J R., 2013, Remote Sensing of the Environment, An Earth Resource Perspective, 2nd Edition, Pearson India.
- Lilles, T.M., Kiefer, R.W. and Chipman, J., 2008, Remote Sensing and Image Interpretation, 6thEdition, John Wiley and Sons
- Miller, V.C. & Miller, C.F., 1961, Photogeology, McGraw-Hill Book Co.
- Joseph, George., 2005, Fundamentals of Remote Sensing 2nd edition, Universities Press
- Sabins, F.F., 2012, Remote Sensing Principles and Practice 3rd Edition, Levant Books.
- Rao, D.P., 1999, Remote sensing for earth resources.

Suggested E-resources :

- https://vidyamitra.inflibnet.ac.in/index.php/search?subject%5B%5D=Geology&course%5B%5D=Remote+sensing+and+GIS+%28GEL 11%29&domain%5B%5D=Physical+%26+Basic+Sciences
- https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=8zYwEsyFCoiPyJlPmzHDxg==

Course learning outcomes :

At the end of the syllabus, the outcome of the proposed syllabus will be helpful for students in the following way:

- The students will be able to understand the concepts, methodologies, and applications of Remote Sensing Technology.
- The students will be able to get National and Global Employability.
- They will acquire skills in handling instruments, tools, and techniques while using Remote Sensing Technology.
- They will learn the introduction and use of GIS in geosciences.
- It empowers the students with confidence and leadership qualities.

Code of the course	**GEO8100P**
Title of the course	**Remote Sensing in Geosciences**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**2**
Type of the course	**Discipline Specific Elective Course(DSE)**
Delivery type of the course	**Practical**
Objectives of the Course	• **To impart an understanding of the basics of aerial photography and photogrammetry.** • **To impart an understanding of the fundamentals of remote sensing components.** • **To gain knowledge about ERDAS Software and its application.** • **To gain knowledge of Geographic Information Systems (GIS)**
Syllabus	

Semester-2 Remote Sensing in Geosciences

PRACTICAL

- Scale and Height of Aerial Photographs.
- Visual Interpretation of Satellite Imageries.
- Overview of ERDAS, and GIS Software.
- Various applications of ERDAS and GIS software in Geosciences.

Books suggested for reading:

- Demers, M.N., 1997, Fundamentals of Geographic Information System, John Wiley & Sons. Inc.
- Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001, GPS: Theory & Practice, Springer Wien New York.
- Jensen, J.R., 1996, Introductory Digital Image Processing: A Remote Sensing Perspective, Springer- Verlag.
- Lillesand, T. M. & Kiefer, R.W., 2007, Remote Sensing and Image Interpretation, Wiley.
- Richards, J.A. and Jia, X., 1999, Remote Sensing Digital Image Analysis, Springer-Verlag.
- Gupta, R.P., 1990, Remote Sensing Geology. Springer Verlag.

Suggested E-resources :

- https://vidyamitra.inflibnet.ac.in/index.php/search?subject%5B%5D=Geology&course%5B%5D=Remote+sensing+and+GIS+%28GEL11%29&domain%5B%5D=Physical+%26+Basic+Sciences
- https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=8zYwEsyFCoiPyJlPmzHDxg==

Course learning outcomes :

- Understanding of various types of aerial photographs and their scale
- Understanding the basic components of Remote Sensing
- Students may be able to understand the functioning, data acquisition, and orbit operations of missions.
- Students will able to understand the various components of ERDAS and GIS software and its Applications

EOSE (PRACTICAL):	**80 Marks**
Practical - 45 Marks	

Viva – Voce - 15 Marks Record - 20 Marks	
Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**

Code of the course	**GEO810IT**
Title of the course	**Computer Applications in Geology**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**4**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	**The objectives of this course are to:** • **Introduce the applications of computing devices in geosciences** • **Develop skills to utilize computing facilities of MS Office package including MS Word, MS Excel & MS Powerpoint** • **Introduce the programming in Basic and C language** • **Introduce the basic statistics and their application in geosciences** • **Introduce the utility of various software like AutoCad and Surfer.**
Syllabus	

Semester-2 Computer Applications in Geology

Unit 1 Computer fundamentals

Principles, Historical development, general characteristics, construction and organization of computers; Classification of computers, Computer hardware: input and output devices, storage devices, printers, and plotters; Binary arithmetic and coding; Computer software, flow chart, and algorithm; Computer language: machine language, assembly language, and high-level language; Operating System: MS-DOS and Windows. Introduction to computer applications in geosciences. Geological Data compilation, processing, and presentation.

Unit 2 MS Office with special reference to Geosciences

MS Word: word processing, cursor navigation, functions, main menu, sub-menu, toolbars, document creating, editing, formatting, and printing.
MS Excel: Electronic spreadsheet, navigation, main menu and sub-menu, toolbars, functions, worksheet and chart, database, and data processing.
MS Powerpoint: Operations, main menu, sub-menu, toolbars, slides creating, editing, templates - formatting and presentation.

Unit 3 Basics of Programming Language C

Structure of program, character set, constant, variables and operators, arithmetic expressions, classification of program statements: input and output statements, control statements.

Unit 4 Basics of Programming Language C

x Concepts & Definition, Merits, and limitation: Tabular and diagrammatic illustration: Bar diagram and pie diagram, histogram and frequency polygon, ogives; Measures of central tendency: AM, Median, Mode, Dispersion: standard deviation, skewness, kurtosis

Unit 5 Understanding basic applications, tools, and tabs of software for use in geosciences:

AutoCAD & Surfer.

Books suggested for reading:

- Miller, Rober L., and James, Stevenkahn., 1962, Statistical analysis in the Geological Sciences, John Wiley & Sons, Inc.
- John, C.Davis., 1973, Statistics and Data Analysis in Geology, John Wiley & Sons.

- Krumbein and Graybill., 1965, An introduction to Statistical methods in Geology, Mc Graw Hill.
- Burrough, P.A., 1986, Principles of Geographical information system for land resource assessment.
- Merriam, D.F. and Elsevier, 2000, Computer Methods in the Geosciences.
- Kanetkar, Yashavant., 2022, Let Us C: Authentic guide to C Programming language
- Humphrey, M.L., 2020, Microsoft Office for Beginners.
- Nighat, Yasmin., Introduction to AutoCAD 2024 for Civil Engineering Applications.

Suggested E-resources :

- http://downloads.goldensoftware.com/guides/Surfer12_Users_Guide_Preview.pdf
- https://images.autodesk.com/adsk/files/autocad_aca_user_guide_english.pdf
- https://images-na.ssl-images-amazon.com/images/I/C1BxaOC0-IS.pdf

Course learning outcomes :

On completion of this course, students should have developed skills in the following areas:

- Computer application in various domains of Earth Sciences
- MS Office package which includes MS Word, MS Excel, and MS Powerpoint
- Basics of computer programming in language C.
- Basic use and interpretation of statistics
- AutoCAD & Surfer software.

Code of the course	**GEO810IP**
Title of the course	**Computer Applications in Geology**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**2**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Practical**
Objectives of the Course	• **As per the objectives defined in the theory paper to develop practical skills.**
Syllabus	

Semester-2 Computer Applications in Geology

PRACTICALS

Hands-on training on

- MS Word
- MS Excel
- MS Powerpoint
- Computer Programming
- AutoCAD
- Surfer
- Exercises in simple statistics

Books suggested for reading:

- Miller, Rober L., and James, Stevenkahn., 1962, Statistical analysis in the Geological Sciences, John Wiley & Sons, Inc.
- John, C.Davis., 1973, Statistics and Data Analysis in Geology, John Wiley & Sons.
- Krumbein and Graybill., 1965, An introduction to Statistical methods in Geology, Mc Graw Hill.
- Burrough, P.A., 1986, Principles of Geographical information system for land resource assessment.
- Merriam, D.F. and Elsevier, 2000, Computer Methods in the Geosciences.
- Kanetkar, Yashavant., 2022, Let Us C: Authentic guide to C Programming language
- Humphrey, M.L., 2020, Microsoft Office for Beginners.
- Nighat, Yasmin., Introduction to AutoCAD 2024 for Civil Engineering Applications.

Suggested E-resources :

- http://downloads.goldensoftware.com/guides/Surfer12_Users_Guide_Preview.pdf
- https://images.autodesk.com/adsk/files/autocad_aca_user_guide_english.pdf
- https://images-na.ssl-images-amazon.com/images/I/C1BxaOC0-IS.pdf

Course learning outcomes :

- As per the outcomes defined in the theory paper with relevance to practical aspects.

EOSE (PRACTICAL):	
Practical - 45 Marks	**80 Marks**
Viva – Voce - 15 Marks	
Record - 20 Marks	
Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**

Code of the course	**GEO8102T**
Title of the course	**Marine Geology**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**4**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	• **The objective of this course is to develop an understanding of the field of Marine Geology.** • **The student will develop an understanding of the currents, circulation, and water mass and their impact on global climate.** • **This course will also deliver insight into the proxies used for paleoceanographic and paleoclimatic studies.**
Syllabus	
Semester-2 Marine Geology	
Unit 1 Structure of the Ocean	
Morphologic and tectonic domains of the ocean floor. Hypsography of the continents and ocean floor –continental shelf, slope, rise, and abyssal plains. Physical and chemical properties of seawater and their spatial variations. Residence times of elements in seawater	
Unit 2 Physical Processes	
Ocean Circulation, Coriolis effect and Ekman spiral, convergence, divergence and upwelling, El Nino. Indian Ocean Dipole Thermohaline circulation and oceanic conveyor belt. Formation of Bottom waters; major water masses of the world's oceans.	
Unit 3 Marine Sediments	
Oceanic sediments: Factors controlling the deposition and distribution of oceanic sediments; geochronology of oceanic sediments. Tectonic evolution of the ocean basins.	
Unit 4 Proxies in Paleo-oceanography	
Paleoceanography – Approaches to paleoceanographic reconstructions; various proxy indicators for paleoceanographic interpretation. Reconstruction of monsoon variability by using marine proxy records	
Unit 5 Paleoceanographic Reconstruction	
Opening and closing of ocean gateways and their effect on circulation and climate during the Cenozoic. Sea level processes and Sea level changes. Methods of paleo Sea Surface temperature quantifications.	
Books suggested for reading:	
• Emiliani, C., 1992, Planet Earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press. • Gross, M. G., 1977, Oceanography: A view of the earth. • Pinet, Paul R., Jones & Barlett., 2009, Learning Invitation to Oceanography. • Trujillo, A. and Thurman, H., 2012, Essentials of Oceanography, 12th Edition, Pearson. • Bradley, R.S., Paleoclimatology: Reconstructing Climates of the Quaternary, Academic. Press. • Brasier, M.D., 1980, Microfossils, George Allen and Unwin. • Cronin, T.M., 1999, Principles of Paleoclimatology, Columbia University Press.	

- Kennett, J.P., 1982, Marine Geology, Prentice-Hall Inc.

Suggested E-resources :

- http://ocean.stanford.edu/courses/bomc/chem/lecture_17.pdf
- https://ocw.mit.edu/courses/12-740-paleoceanography-spring-2008/pages/lecture-notes/
- https://www.whoi.edu/sbl/liteSite.do?litesiteid=20812&articleId=53807
- http://condor.wesleyan.edu/ethomas/ees123/index.htm

Course learning outcomes :

- The students will be able to learn the structure and composition of the ocean and realize the behavior of elements in the marine system.
- The students will be aware of ocean circulation and its impact on global climate.
- The student will be able to understand the role of tectonics in changing ocean circulation and regulating global climate on a long time scale.
- Students will learn about the proxies used for paleoceanographic and paleoclimatic studies
- The students will be able to interpret the paleoceanographic and paleoclimatological data
- The student will also learn about the various sampling techniques used in such studies.

Code of the course	**GEO8102P**
Title of the course	**Marine Geology**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**2**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Practical**
Objectives of the Course	• **As per the objectives defined in the theory paper to develop practical skills.**
Syllabus	

Semester-2 Marine Geology

PRACTICALS

- Ocean current maps
- Ocean floor morphology maps
- Ocean circulation maps
- Exercise on establishing the chronology of marine sediments
- Interpretation of various types of paleoceanographic data
- Identification of microfossils used for paleoceanographic and paleoclimatic reconstructions.

Books suggested for reading:

- Emiliani, C., 1992, Planet Earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
- Gross, M. G., 1977, Oceanography: A view of the earth.
- Pinet, Paul R., Jones & Barlett., 2009, Learning Invitation to Oceanography.
- Trujillo, A. and Thurman, H., 2012, Essentials of Oceanography, 12th Edition, Pearson.
- Bradley, R.S., Paleoclimatology: Reconstructing Climates of the Quaternary, Academic. Press.
- Brasier, M.D., 1980, Microfossils, George Allen and Unwin.
- Cronin, T.M., 1999, Principles of Paleoclimatology, Columbia University Press.
- Kennett, J.P., 1982, Marine Geology, Prentice-Hall Inc.

Suggested E-resources :

- http://ocean.stanford.edu/courses/bomc/chem/lecture_17.pdf
- https://ocw.mit.edu/courses/12-740-paleoceanography-spring-2008/pages/lecture-notes/
- https://www.whoi.edu/sbl/liteSite.do?litesiteid=20812&articleId=53807
- http://condor.wesleyan.edu/ethomas/ees123/index.htm

Course learning outcomes :

- As per the outcomes defined in the theory paper with relevance to practical aspects.

EOSE (PRACTICAL):	
Practical - 45 Marks	**80 Marks**
Viva – Voce - 15 Marks	
Record - 20 Marks	
Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**

Code of the course	**GEO8103T**
Title of the course	**Geochemistry & Instrumentation**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**4**
Type of the course	**Discipline Specific Elective course (DSE)**
Delivery type of the course	**Theory & Lecture**
The Objective of the Course	• **The objective of the syllabus helps the students to understand the chemical principles which are used to explain the mechanisms that control large geological systems. The course also helps to understand the distribution of elements in different Earth's spheres and evaluate different processes of element migration.**
Syllabus	

Semester-2 Geochemistry & Instrumentation

Unit 1 Introduction to Geochemistry

Introduction to atomic structures and properties of the elements. Basic principles of crystal chemistry, radius ratio, coordination number, Principles of ionic substitution in minerals; crystal structures, and classification of silicate structures. Origin and cosmic abundance of elements. Structure and composition of the universe, solar system, and earth.

Unit 2 Introduction to Igneous Geochemistry

Geochemical classification of elements. Chemical composition of the Earth and its constituent reservoirs. Concept of distribution coefficient and element partitioning between minerals/rocks and melts. Trace element geochemistry and its application in petrogenesis. Interpretation of REE patterns.

Unit 3 Introduction to Geochemical Reservoirs and Sedimentary Geochemistry

Introduction to the chemical composition and properties of the atmosphere, lithosphere, hydrosphere, and biosphere. Geochemical cycles; Concept of the biogeochemical cycle; A brief introduction to geochemistry of natural waters. Introduction to sedimentary geochemistry. The geochemical process involved weathering, transportation, deposition,s, and soil formation. Study of Mineral stability in Eh-pH diagrams.

Unit 4 Introduction to Radiogenic and Stable Isotope Geochemistry

Radiogenic isotopes. Decay scheme of Rb-Sr, Sm-Nd, U-Pb, and K-Ar. Radiometric dating of single minerals and whole rocks. Application of Rb-Sr, and Sm-Nd isotope geochemistry in geochronology, petrogenesis, and crust-mantle evolution processes. Stable isotope geochemistry of carbon and oxygen and its applications to Geology.

Unit 5 Importance of Instrumentation in Geology

Role and importance of instrumentation techniques in Geology; Brief introduction to the instrumental techniques with emphasis on their applicational aspects.

Books suggested for reading:

- Faure, G., 1986, Principal of Isotope Geology, John Wiley.
- Govett, G.J.S., and Elsevier, 11983, Handbook of Exploration Geochemistry.
- Henderson, P., 1987, Inorganic Geochemistry, Pergamon Press, Oxford.
- Hoefs, J., 1980, Stable Isotope Geochemistry, Springer Verlag.
- Krauskopf, K.B. and Hill, Graw, M.C., 1979, Introduction to Geochemistry.

- Marshal, C.P. and Fairbridge, R.W., 1999, Encyclopedia of Geochemistry, Kluwer Academic.
- Mason, B. and Moore, C.B., 1991, Introduction to Geochemistry, Wiley Eastern.
- Nordstrom, D.K. and Munoz, J.L., 1986, Geochemical Thermodynamics, Blackwell.
- Rollinson, H., 2007, Using geochemical data-evaluation, Presentation, and interpretation, Publisher Longman Scientific & Technical 2nd Edition.
- Albarede, F., 2003, An introduction to geochemistry, Cambridge University Press.
- William, M White and Wiley, Blackwell., 2013, Geochemistry.
- Mason, B., Willey, J. and Sons., 1982, Principles of Isotope Geology,

Suggested E-resources :

- https://ocw.mit.edu/
- https://mitocw.ups.edu.ec/courses/
- https://epgp.inflibnet.ac.in/

Course learning outcomes :

- By attending the courses, the students can understand the evolution of the early earth and its differentiation from the present-day state. The students also have an idea of the chemical composition of the geochemical reservoirs. The knowledge of the radiogenic isotope's signature helps to trace the source of mineral and rock separation from the magma.

Code of the course	**GEO8103P**
Title of the course	**Geochemistry & Instrumentation**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**2**
Type of the course	**Discipline Specific Elective course (DSE)**
Delivery type of the course	**Practical**
The Objective of the Course	• **As per the objectives defined in the theory paper to develop practical skills.**
Syllabus	

Semester-2 Geochemistry & Instrumentation

PRACTICALS

- Presentation of analytical data and graphical representation in various diagrams.
- Calculation of important mineral formulas from chemical analysis.
- REE normalized plots and their interpretation

Books suggested for reading:

- Faure, G., 1986: Principal of Isotope Geology. John Wiley
- Govett, G.J.S.(Ed), 11983: Handbook of Exploration Geochemistry Elsevier.
- Henderson, P., 1987: Inorganic Geochemistry, Pergamon Press, Oxford.
- Hoefs, J., 1980: Stable Isotope Geochemistry. Springer Verlag.
- Krauskopf, K.B., 1979: Introduction to Geochemistry. McGraw hill
- Marshal, C.P. and Fairbridge, R.W., 1999: Encyclopedia of Geochemistry. Kluwer Academic.
- Mason, B. and Moore, C.B., 1991: Introduction to Geochemistry, Wiley Eastern
- Nordstrom, D.K. and Munoz, J.L., 1986: Geochemical Thermodynamics, Blackwell
- Rollinson H. (2007) Using geochemical data-evaluation. Presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
- Albarede, F, 2003. An introduction to geochemistry. Cambridge University Press.
- Geochemistry by William M White, Wiley-Blackwell (2013).
- Mason, B. 1982 Principles of Isotope Geology, J. Willey & Sons.

Suggested E-resources :

- https://ocw.mit.edu/
- https://mitocw.ups.edu.ec/courses/
- https://epgp.inflibnet.ac.in/

Course learning outcomes :

- As per the outcomes defined in the theory paper with relevance to practical aspects.

EOSE (Practical):	**80 Marks**
Practical - 45 Marks	
Viva – Voce - 15 Marks	
Record - 20 Marks	
Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**

Code of the course	**GEO8104T**
Title of the course	**Fuel Geology**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**4**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	• **The course is divided into two sections namely Coal and Petroleum Geology, which is spread over five units. In the first portion of the course, course enables students to learn details about the formation of Coal, the fundamental concept of coal petrography, and its classification and distribution across the globe. In the Petroleum part, the course is designed to enable students to acquire an understanding of the processes involved in the formation of petroleum, its migration, maturation, its distribution, etc.**
Syllabus	

Semester-2 Fuel Geology

Unit 1 Introduction to Coal Geology

Definition and origin of coal. Sedimentology of coal-bearing strata, types of seam discontinuities, and structures associated with coal seams. Chemical characterization: proximate and ultimate analysis. Classification of coal in terms of rank, grade, and type; Indian classification for coking and non-coking coals.

Unit 2 Coal Bed Methane

Coalbed methane – a new energy resource. An elementary idea about the generation of methane in coal beds, coal as a reservoir, and coalbed methane exploration. Underground Coal Gasification: definition, concept and Development, environmental benefits.

Unit 3 Distribution of Coal Resources

Geological and geographical distribution of coal and lignite deposits in India. Coal exploration and estimation of coal reserves. Indian coal reserves and production of coal in India.

Unit 4 Introduction to Petroleum Geology

Petroleum – its composition. Origin (Formation of source rocks-kerogen, organic maturation, and thermal cracking of kerogen) and migration of petroleum. Reservoir rocks-porosity and permeability. Reservoir traps: structural, stratigraphic, and combination traps.

Unit 5 Distribution of Oil Resources

Oilfield fluids – water, oil, and gas. Methods of prospecting for oil and gas. Onshore and offshore petroliferous basins of India. Oil-shale and shale-oil

Books suggested for reading:

- Chandra, D., Singh, R.M. and Singh, M.P., 2000, Textbook of Coal (Indian context), Tara Book Agency, Varanasi.
- Holson, G.D. and Tiratso, E.N., 1985, Introduction to Petroleum Geology, Gulf Publishing, Houston, Texas.
- Isabel Suárez-Ruiz John Crelling, 2008, Applied Coal Petrology: The Role of Petrology in Coal Utilization, Academic Press.
- North, F.K. and Allen Unwin, 1985, Petroleum Geology.

- Selley, R.C., 1998, Elements of Petroleum Geology, Academic Press.
- Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R. and Robert P., 1998, Organic Petrology, Gebruder Borntraeger, Stuttgart.
- Scott, A.C., 1987, Coal and Coal-bearing strata, Recent Advances. The Geological Society of London, Publication no. 32, Blackwell Scientific Publications.
- Singh, M.P., (Ed.) 1998, Coal and Organic Petrology. Hindustan Publishing Corporation, New Delhi.
- Stach, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and Teichmuller R., 1982, Stach Texbook of Coal petrology. Gebruder Borntraeger, Stuttgart.
- Tissot, B.P. and Welte, D.H., 1984, Petroleum Formation and Occurrence, Springer – Verlag.
- Levorsen, A.L., Geology of Petroleum, AAPG Foundation.

Suggested E-resources :

- https://nptel.ac.in/courses/103105110
- https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000448GO/P000594/M022677/ET/1505974141E-TextPetroleum-Itscomposition.pdf
- https://ocw.mit.edu/courses/12-110-sedimentary-geology-spring-2007/650229f0f026cff60d8e567ab0b430ec_ch12.pdf

Course learning outcomes :

On completion of this course, students should have developed skills in the following areas:

- Fundamental concepts of the origin of energy minerals include petroleum and coal.
- The students will know based approach towards exploration and exploitation including the background of their distribution across the globe with a special focus on India

Code of the course	**GEO8104P**
Title of the course	**Fuel Geology**
Level of the course	**NHEQF Level 6.0**
Credit for the course	**2**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Practical**
Objectives of the Course	• **As per the objectives defined in the theory paper to develop practical skills.**
Syllabus	

Semester-2 Fuel Geology

PRACTICALS

- Distribution of petroleum and coal in the World, India, and Rajasthan; Numerical exercises on coal & petroleum; Coal petrography

Books suggested for reading:

- Chandra, D., Singh, R.M. and Singh, M.P., 2000, Textbook of Coal (Indian context), Tara Book Agency, Varanasi.
- Holson, G.D. and Tiratso, E.N., 1985, Introduction to Petroleum Geology, Gulf Publishing, Houston, Texas.
- Isabel Suárez-Ruiz John Crelling, 2008, Applied Coal Petrology: The Role of Petrology in Coal Utilization, Academic Press.
- North, F.K. and Allen Unwin, 1985, Petroleum Geology.
- Selley, R.C., 1998, Elements of Petroleum Geology, Academic Press.
- Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R. and Robert P., 1998, Organic Petrology, Gebruder Borntraeger, Stuttgart.
- Scott, A.C., 1987, Coal and Coal-bearing strata, Recent Advances. The Geological Society of London, Publication no. 32, Blackwell Scientific Publications.
- Singh, M.P., (Ed.) 1998, Coal and Organic Petrology. Hindustan Publishing Corporation, New Delhi.
- Stach, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and Teichmuller R., 1982, Stach Texbook of Coal petrology. Gebruder Borntraeger, Stuttgart.
- Tissot, B.P. and Welte, D.H., 1984, Petroleum Formation and Occurrence, Springer – Verlag.
- Levorsen, A.L., Geology of Petroleum, AAPG Foundation.

Suggested E-resources :

- https://nptel.ac.in/courses/103105110
- https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000448GO/P000594/M022677/ET/1505974141E-TextPetroleum-Itscomposition.pdf
- https://ocw.mit.edu/courses/12-110-sedimentary-geology-spring-2007/650229f0f026cff60d8e567ab0b430ec_ch12.pdf

Course learning outcomes :

- As per the outcomes defined in the theory paper with relevance to practical aspects.

EOSE (Practical):	**80 Marks**
Practical - 45 Marks	
Viva – Voce - 15 Marks	
Record - 20 Marks	
Internal Exam -	**20 Marks**
i. Exam - 10 Marks	
ii. Assignment/ Seminar/Quiz – 10 Marks	

Code of the course	GEO8104T
Title of the course	Summer Internship
Level of the course	NHEQF Level 6.0
Credit for the course	4
Type of the course	Discipline Specific Elective (DSE)
Delivery type of the course	Special type of Course
Objectives and Outcomes of the Course	Students will be able to work independently on a Geological Project.

Code of the course	GEO8104P
Title of the course	Summer Internship
Level of the course	NHEQF Level 6.0
Credit for the course	2
Type of the course	Discipline Specific Elective (DSE)
Delivery type of the course	Special type of Course
Objectives and Outcomes of the Course	Students will be able to work independently on a Geological Project.

M.Sc. Geology III Semester

Code of the course	GEO9000T
Title of the course	Economic Geology
Level of the course	NHEQF Level 6.5
Credit for the course	4
Type of the course	Discipline Core Course (DCC)
Delivery type of the course	Theory & Lecture
Objectives of the Course	The objectives of this course are to: • Familiarize with common ore minerals and their identifying criteria at various scales of study, • Understand the genetic controls exerted by physical and chemical processes on ore formation in various geologic settings, • Create an enhanced understanding of the nature or genesis of mineral deposits formed by ore-forming processes; • Understand the distribution of various ore deposits across time and space, and; • Increase and update the knowledge and skills required by geoscientists for the exploration and exploitation of mineral deposits.
Syllabus	

Semester-3 Economic Geology

Unit 1 Introduction to Economic Geology

Definition of mineral. Classification of minerals, Composition of Mamga, Introduction to mineral deposit and ore body, Magma and its relation to mineral deposits, Ore forming processes. Magmatic Deposits.

Unit 2 Ore Forming Processes

Weathering and its significance (Residual concentration deposit). Sedimentation (Chemical Precipitation). Sedimentation (Mechanical concentration). Oxidation and chemistry in the zone of oxidation. Gossans, interpretation, and significance. Supergene enrichment and Metamorphism of ores.

Unit 3 Mineralization Controls

Metallogenic Province and Epochs. Mineralization related to Plate tectonics. Classification of ore deposits. Structure and texture of Ores. Controls of mineralization. Coal, Petroleum, and Radioactive Minerals.

Unit 4 Metallic Deposits

Metallic Mineral Deposits of India with reference to uses, modes of occurrence & distribution in India of the following: Gold, Silver, Copper, Lead, Zinc, Iron, Manganese, Chromium, and Aluminium

Unit 5 Nonmetallic Deposits

Non Metallic Mineral Deposits of India with reference to uses, modes of occurrence & distribution in India of the following: Industrial Minerals, Abrasives Minerals, Refractory Minerals, and Ceramic Minerals.

Books suggested for reading:

- Branes, H.L. and John, Willey., 1979, Geochemistry of Hydrothermal Ore Deposits.
- Craig, J. R. and Vaughan, D. J., John, Wiley and Sons., 1994, Ore microscopy and ore

petrography.

- Colbert, J.M. and Park, Jr. C.F., 1986, The Geology of Ore Deposits, Freidman.
- Evans, A.M., 1993, Ore Geology and Industrial Minerals, Blackwell.
- Klemm, D.D. and Schnieder, H.J., 1977, Time and Strata Bound Ore Deposits, Springer-Verlag.
- Mishra, K.C., 2000, Understanding Mineral Deposits, Kluwer Academic publishers.
- Mookherjee, A., 2000, Ore Genesis-A Holistic Approach, Allied Publisher.
- Pohl, W.L., 2011, Economic Geology, Wiley Blackwell.
- Ramdhor, P., 1969, The Ore Minerals and their Intergowths, Pergamon Press.
- Stanton, R.L., 1972, Ore Petrology, McGraw Hill.
- Wolf, K.H., 1976-1981, Hand Book of Stratabound and Stratiform Ore Deposits, Elsevier Publ.

Suggested E-resources:

- https://egyankosh.ac.in/handle/123456789/78228
- https://egyankosh.ac.in/handle/123456789/78229
- https://egyankosh.ac.in/handle/123456789/78230

Course learning outcomes :

On completion of this course, the following outcomes will be attained:

- The course provides a better capability to understand the processes and principles involved during the origin and evolution of the ore minerals.
- Knowledge about a wide range of ore deposits, the geometry of ore bodies, alteration patterns, and assemblage of ore and gangue minerals
- Awareness about the distribution of mineral deposits in India
- Develop an understanding of basic concepts of mineral economics
- Recognize common ore minerals in hand samples and under the microscope

Code of the course	**GEO9001T**
Title of the course	**Petrology 2**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**4**
Type of the course	**Discipline Centric Core Course (DCC)**
Delivery type of the course	**Theory & Lecture**
The objective of the Course:	• **To impart knowledge of basic metamorphic petrology** • **To train the students to understand the processes of formations of different rock groups**

Syllabus

Semester-3 Petrology 2

Unit 1 Phase Diagrams & Origin of Important Igneous Rocks

The crystallization process in silicate melts in light of experimental studies, especially for following systems: binary magma; Diopside – Anorthite Eutectic system; Albite – Anorthite solid – solution system; Foresteite – Silica Incongruent melting system; Crystallization of Ternary system: Albite – Anorthite – Diopside; Nepheline-Kaliophylite-Silica; Diopside-Forsterite-Silica.

Unit 2 Introduction to Metamorphism

Agents and kinds of metamorphism; metamorphic zones; grades; iso-grades; metamorphic facies; Fabric of metamorphic rocks formed under regional, dynamic, and thermal metamorphisms; Classification of regional metamorphism based on P/T ratio.

Unit 3 Demographic Projections

Principles of thermodynamics; Mineralogical phase rule; Diagrammatic representation of mineral paragenesis in ACK, AKF, and AFM diagrams; thermodynamics and kinetics of metamorphic reactions.

Unit 4 Tectonics and its Relation to Various Rock Processes

Studies of metamorphic facies: zeolite facies; pumpellyite-prehnite facies; glaucophane schist facies; greenschist facies; amphibolite facies; granulite facies, eclogite facies; albite-epidote hornfels facies; hornblende-hornfels facies; pyroxene-hornfels facies; sanidinite facies.

Unit 5 Introduction to Metamorphic Facies

Tectonics and sedimentation. Petrographic Provinces: Definition and characteristics. Principles of metasomatism and metamorphic differentiation. Metamorphism in relation to plate tectonics.

Books suggested for reading:

- Bucher, K. and Frey, M., 1984, Petrogenesis of Metamorphic Rocks, Springer Verlag.
- Kretz, R., 1994, Metamorphic Crystallization, John Wiley.
- Philipotts, A., 1992, Igneous and Metamorphic Petrology, Prentice Hall.
- Turner, F.J., 1980, Metamorphic Petrology, McGraw Hill, New York
- Wood, B.J., and Fraser, D.G., 1976, Elementary thermodynamics for Geologist, Oxford University Press.
- Yardely, B.W., 1989, An Introduction to Metamorphic Petrology, Longman New York
- Winter, J.D., 2010, Principles of Igneous and Metamorphic Petrology, Pearson Prentice Hall.
- John, Petti., Sedimentary Rocks.

- Gupta, Sen, S., 1997, Introduction to Sedimentology, Oxford – IBH.
- Sharma, R.S., Thermophysical properties of rocks, Allied Publishers Pvt Ltd.
- Condie, Kent C., Plate Tectonics and Crustal Evolution, Butterworth – Heinemann Ltd.

Suggested E-resources:

- https://www.gsi.gov.in/
- https://egyankosh.ac.in/handle/123456789/66681
- https://opengeology.org/petrology/
- https://egyankosh.ac.in/handle/123456789/66699
- https://www2.tulane.edu/~sanelson/eens212/index.html

Course learning outcomes :

- Upon successful completion of the course, the students would be able to:
- Understand the binary and ternary systems of crystallization
- Understand the basic concept of metamorphic petrology
- Understand the metamorphic facies and Pressure temperature variation.
- Understand the role of thermodynamics and kinetics of metamorphic reactions
- Understand the tectonics and formation of the rock group

Code of the course	**GEO9000P**
Title of the course	**Economic Geology and Petrology 2**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**4**
Type of the course	**Discipline Centric Core Course (DCC)**
Delivery type of the course	**Practical**
Objectives of the Course	**The objectives of this practical course are to familiarize and understand:** • **The distribution of metallic and non-metallic ore minerals in Rajasthan, India, and the World** • **The properties of ore minerals in hand specimen and identify them** • **The principles of Ore Microscopy and the study of important polished sections of ore minerals under a reflected light microscope to identify them.** • **To train the students in the identification of various rocks through megascopic and microscopic studies.** • **Students get ideas about chemographic projection and their applications in petrology.**
Syllabus	
Semester-3 Economic Geology and Petrology 2	
Economic Geology • Study properties of common ore minerals in hand specimens and their identification • Distribution of important mineral deposits in Rajasthan • Distribution of important mineral deposits in India • Distribution of important Mineral deposits in the World • Study properties of common ore minerals in hand specimens and their identification • Geological field trip to important deposits/ mines • An introduction to Ore Microscopy. Study properties of important ore minerals in reflected light and their identification	
Petrology Petrology • Identification and description of important metamorphic rocks in hand specimen. • Petrographic studies of important metamorphic rocks. • Graphic construction of ACF, AKF, and AFM diagrams • Differentiation in various types of rocks through megascopic and microscopic properties	
Compulsory Field Training Program: Geological Field Training is mainly based on Petrology 2 and Economic Geology aspects. Note: **Compulsory field training program at the end of every semester will be a value-added part of the practical syllabus which will be of 10 days duration and students opting out of it will lose proportionally marks from the practical credit score. The student will have a chance to improve the score by doing the field training at his/her expense before the commencement of the final practical exam and after producing a valid certificate from the recognized institute/company duly approved by the field training mentor/ faculty member.**	
Books suggested for reading:	

- Craig, J. R. and Vaughan, D. J., John, Wiley and Sons., 1994, Ore microscopy and ore petrography.
- Tiwari, S. K., 2019, Ore Geology, Economic Minerals And Mineral Economics, Atlantic Publisher.
- Mookherjee, A., 2000, Ore Genesis-A Holistic Approach, Allied Publisher.
- Bucher, K. and Frey, M., 1984, Petrogenesis of Metamorphic Rocks, Springer Verlag.
- Kretz, R., 1994, Metamorphic Crystallization, John Wiley.
- Philipotts, A., 1992, Igneous and Metamorphic Petrology, Prentice Hall.
- Turner, F.J., 1980, Metamorphic Petrology, McGraw Hill, New York
- Wood, B.J., and Fraser, D.G., 1976, Elementary thermodynamics for Geologist, Oxford University Press.
- Yardley, B.W., 1989, An Introduction to Metamorphic Petrology, Longman New York
- Winter, J.D., 2010, Principles of Igneous and Metamorphic Petrology, Pearson Prentice Hall.
- John, Petti., Sedimentary Rocks.
- Gupta, Sen, S., 1997, Introduction to Sedimentology, Oxford – IBH.
- Sharma, R.S., Thermophysical properties of rocks, Allied Publishers Pvt Ltd.
- Condie, Kent C., Plate Tectonics and Crustal Evolution, Butterworth – Heinemann Ltd.
- Moorehouse, W.W., 1959, The study of rocks in thin section, Harper & Brothers.

Suggested E-resources :

- https://egyankosh.ac.in/bitstream/123456789/58886/1/EXPERIMENT%209.pdf
- https://opengeology.org/Mineralogy/9-ore-deposits-and-economic-minerals/
- https://nitsri.ac.in/Department/Civil%20Engineering/CIV404(P)_Geology_Lab_EGM_Lab_Manual_2.pdf
- https://www.virtualmicroscope.org/
- http://egyankosh.ac.in//handle/123456789/6632
- www.gsi.gov.in
- https://www.usgs.gov/
- https://www.geosciences.fau.edu/Resources/CourseWebPages/Spring2012/GLY4310_S12/index.4310_S10.htm

Course learning outcomes :

. On completion of this practical course, the following outcomes will be attained:

- The course will acquaint the learners with the distribution of metallic and non-metallic ore minerals in Rajasthan, India, and the World.
- Knowledge about the importance of physical properties of ore minerals and identify them in hand specimens.
- Recognize common ore minerals in polished sections under a reflected light microscope.
- Understand the various texture and structure of metamorphic rocks through petrographic study.
- Understand the chemographic projection and their application in petrological studies.

EOSE (PRACTICAL):	**80 Marks**
1. Practical - 45 Marks	
2. Viva – Voce - 15 Marks	
3. Record - 20 Marks i. Field Tour Report – 10 Marks	

ii. Practical Record – 10 Marks	
4. Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**

Code of the course	**GEO9100T**
Title of the course	**Crustal Evolution and Mineralization in India**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**4**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	• **The objectives of studying crustal evolution and mineralization in India subject are to understand the geological processes that have shaped the Earth's crust over time and to explore the formation and distribution of mineral deposits within the Indian subcontinent.** • **This syllabus helps in gaining insights into the country's geological history, identifying potential mineral resources, and aiding in sustainable resource management and exploration activities.**
Syllabus	

Semester-3 Crustal Evolution and Mineralization in India

Unit 1 Crustal Evolution in Southern India

Crustal Evolution of Granite-Greenstone, Granulites belts, Cratonic nuclei, and Mobile belts. Precambrian crustal evolution of southern India in relation to: Dharwar Orogeny, Eastern Ghat and Southern Granulite Accretionary Belts, Central India Tectonic Zone, Satpura Orogeny.

Unit 2 Crustal Evolution in Northern India

Precambrian Crustal Evolution of Northern India in Relation to: Singhbhum Orogeny, Bundelkhand Cratonization, Aravalli-Delhi and Sirohi Orogeny, Vindhyan Platformal Basin.

Unit 3 Phanerozoic Reconstitution of Indian Shield

Precambrian-Cambrian and Permian-Triassic boundary transitions, K-T Boundary volcanism, Collision of Indian and Eurasian Plates, Himalayan Orogeny: Morphotectonic characterization, India-Eurasia collision, Growth and evolution of subdivisions of Himalayas. Post-collision evolution: Syntaxes, Uplift, Rejuvenation, and inverted metamorphism.

Unit 4 Precambrian Metallogeny in India

Metallic Epochs and Provinces of India. Important Mineralizing Belts of India: Kolar Gold Field, Hutti Gold Field, Sukinda Chromite Belt, Malanjkhand and associated Copper Belts, Iron deposits of south India, Singhbhum Copper deposits, Manganese deposits of Central India, Khetri Copper Belt, Basantgarh and Deri

Unit 5 Other Mineralizations in Indian Shield

Rock Phosphate deposits of Jhamarkotra and associated regions, Bauxite Deposits of Central India, Uranium Deposits of Bihar, Phanerozoic Coal, and Petroleum deposits, Recent REE discoveries in India, etc.

Books suggested for reading:

- Butz, S. and Delmar, Thomas., 2007, Science of Earth Systems., 2nd ed.
- Holmes A., 1993, Principles of Physical Geology., ed by David Duff, Nelson Thornes Ltd
- Vaidyanadhan, R. and Ramakrishnan, M., 2010, Geology of India vol. I & II, Geol. Soc. of India, Bangalore.
- Roy, A.B., Purohit, R. and Elsevier., 2018, Indian Shield.
- The Making of India, Geodynamic evolution, Macmillan Publishers India Ltd.

Suggested E-resources :

- https://www.researchgate.net › 2765 (PDF) Chapter 22 Precambrian metallic mineralization in India
- https://www.researchgate.net › 2404 Proterozoic crustal evolution in the NW Himalaya (India) as recorded
- https://www.researchgate.net › 2455 (PDF) Precambrian Tectonics and Crustal Evolution in South India
- https://www.sciencedirect.com › pii Crustal evolution of the Southern Granulite Terrane, south India

Course learning outcomes :

- It provides a comprehensive understanding of the geological history and processes that have shaped the Indian subcontinent over millions of years.
- Studying this syllabus can identify potential mineral deposits and assess their distribution and abundance, aiding in resource exploration and development.
- The knowledge gained from studying mineralization helps in targeted exploration efforts, leading to the discovery and responsible exploitation of valuable mineral resources.
- Overall, the study of this subject has wide-ranging implications for economic growth, environmental sustainability, and scientific knowledge.

Code of the course	**GEO9100P**
Title of the course	**Crustal Evolution and Mineralization in India**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**2**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Practical**
Objectives of the Course	• **As per the objectives defined in the theory paper to develop practical skills.**
Syllabus	

Semester-3 Crustal Evolution and Mineralization in India

PRACTICAL

- Project work related to this DSE paper will be given to students according to the theory syllabus.

Books suggested for reading:

- Butz, S. and Delmar, Thomas, 2007, Science of Earth Systems., 2nd ed.
- Holmes A., 1993, Principles of Physical Geology., ed by David Duff, Nelson Thornes Ltd
- Vaidyanadhan, R. and Ramakrishnan, M., 2010, Geology of India vol. I & II, Geol. Soc. of India, Bangalore.
- Roy, A.B., Purohit, R. and Elsevier., 2018, Indian Shield.
- The Making of India, Geodynamic evolution, Macmillan Publishers India Ltd.

Suggested E-resources :

- https://www.researchgate.net › 2765 (PDF) Chapter 22 Precambrian metallic mineralization in India
- https://www.researchgate.net › 2404 Proterozoic crustal evolution in the NW Himalaya (India) as recorded
- https://www.researchgate.net › 2455 (PDF) Precambrian Tectonics and Crustal Evolution in South India
- https://www.sciencedirect.com › pii Crustal evolution of the Southern Granulite Terrane, south India

Course learning outcomes :

- As per the outcomes defined in the theory paper with relevance to practical aspects.

EOSE (Practical):	**80 Marks**
Practical - 45 Marks	
Viva – Voce - 15 Marks	
Record - 20 Marks	
Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**

Code of the course	**GEO9101T**
Title of the course	**Field Geology and Surveying**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**4**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Theory & Lecture**

The objective of the Course:	• **Understanding the principles and techniques of field geology** • **Understanding the fundamentals and principles of surveying** • **Understanding the working mechanism and familiarity with geological field instruments and equipment** • **Understanding the concept of sampling and techniques of sampling collection.**

Syllabus

Semester-3 Field Geology and Surveying

UNIT 1 Field Geology

Introduction to toposheets, Scale definition; small scale and large-scale maps; reading various components of a toposheet. Toposheets and Indian numbering system, Reading toposheets, interpretation of contour patterns. Base maps, Geological maps, and various components of a geological map including scale, legend, structures, etc. Studies of outcrop pattern, topographic law, and rules of 'V'.

U NIT-2 Surveying: Fundamental Concepts and Principles

Primary division and classification of surveys; Common methods of surveying: Reconnaissance survey, Offsetting, Radiation, triangulation; Open and closed traversing; Leveling. Accuracy and errors in surveying; Basic elements of map preparation and map reading. Stages of survey operations, Linear Measurement, Distance measurement devices: Chain, tape – Merits and demerits.

UNIT 3 Instruments used in geological field studies and surveying

Techniques and use of geological tools during field work-use of clinometers compass, Brunton compass, GPS, altimeter. Attitude measurements; measurement of true thickness and distance, section measurement techniques and significance. Application and working mechanism of DGPS and Theodolite.

UNIT 4 Geological mapping procedures

Geological mapping of igneous terrains, geological mapping of sedimentary terrains. Geological mapping of metamorphic terrains and recording of structural information, preparation of Geological Cross-section. Uses of Software during fieldwork and geological mapping.

UNIT 5 Techniques for sample collection

Sampling and oriented sampling, its significance; sampling for isotopic, geochronological, and geochemical studies and its significance. Sampling strategies for micro-palaeontological and biostratigraphic studies and recording of paleontological information.

Books suggested for reading:

- Angela, L. C., 2010, Geological field techniques, Blackwell Publishing Ltd.
- Lisle, R. J., Brabham, P. and Barnes, J. W., 2011, Basic Geological Mapping (Geological Field Guide), Wiley-Blackwell 5th edition.
- Mathur, S.M., 2001, Guide to Field Geology, PHI Learning Private Limited-New Delhi.
- Maley, T. S., 1994, Field Geology (Illustrated), Mineral Land Publications.
- Lahee, F. H., 1961, Field Geology, McGraw-Hill 6th edition.

Suggested E-resources:

- https://surveyofindia.gov.in/
- https://www.usgs.gov/core-science-systems/national-cooperative-geologicmapping-program
- https://www.usgs.gov/products/maps/geologic-maps
- http://www.geosci.usyd.edu.au/users/prey/FieldTrips/BrokenHillOlary/M apping.html
- https://www.gsi.ie/en-ie/programmes-and projects/minerals/activities/mineral-exploration/Pages/GeologicalMapping.aspx

Course learning outcomes:

- Upon successful completion of this course, the student will be able to be aware of the different field accessories in geosciences.
- Measure the equipment confidently at the field.
- Evaluate the processes and practices of geological mapping.
- Assess the processes of sampling techniques.

Code of the course	**GEO9101P**
Title of the course	**Field Geology and Surveying**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**2**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Practical**
The objective of the Course:	• **As per the objectives defined in the theory paper to develop practical skills.**

Syllabus

Semester-3 Field Geology and Surveying

PRACTICALS

- Exercise on toposheet reading and interpretation of geological maps
- Exercise on cross-section and profile
- Exercise on Survey instruments GPS, DGPS, Brunton Compass, and Theodolite.
- Preparation of Geological maps and Report writing

Books suggested for reading:

- Angela, L. C., 2010, Geological field techniques, Blackwell Publishing Ltd.
- Lisle, R. J., Brabham, P. and Barnes, J. W., 2011, Basic Geological Mapping (Geological Field Guide), Wiley-Blackwell 5th edition.
- Mathur, S.M., 2001, Guide to Field Geology, PHI Learning Private Limited-New Delhi.
- Maley, T. S., 1994, Field geology (Illustrated), Mineral Land Publications.
- Lahee, F. H., 1961, Field geology McGraw-Hill 6th edition.

Suggested E-resources:

- https://surveyofindia.gov.in/
- https://www.usgs.gov/core-science-systems/national-cooperative-geologicmapping-program
- https://www.usgs.gov/products/maps/geologic-maps
- http://www.geosci.usyd.edu.au/users/prey/FieldTrips/BrokenHillOlary/M apping.html
- https://www.gsi.ie/en-ie/programmes-and projects/minerals/activities/mineral-exploration/Pages/GeologicalMapping.aspx

Course learning outcomes:

- As per the outcomes defined in the theory paper with relevance to practical aspects.

EOSE (Practical):	
Practical - 45 Marks	**80 Marks**
Viva – Voce - 15 Marks	
Record - 20 Marks	
Internal Exam -	**20 Marks**
i. Exam - 10 Marks	
ii. Assignment/ Seminar/Quiz – 10 Marks	

Code of the course	**GEO9102T**
Title of the course	**Micropalaeontology**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**4**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Theory & Lecture**

Objectives of the Course	• **The objective of this course is to develop an understanding of the microfossils.** • **This course will give an idea about the morphology and significance of microfossils in the field of paleosciences.** • **This course will also impart the application of microfossils in hydrocarbon exploration**
Syllabus	

Semester-3 Micropalaeontology

Unit 1 Introduction and Importance of the Subject

Definition, Historical account of the development of the subject and scope of the subject. Classification of microfossils. Techniques of collection and preparation of microfossils. Application of Micropalaeontology in petroleum, Exploration in the determination of the age of the stratum, local and regional correlation of subsurface succession of Oil Wells, palaeofacies and Tectonic history of the basin, Procedure in classification.

Unit 2 Foramininifera

Foraminifera: Planktic foraminifera, their modern biogeography, the outline of morphology, significance in Cenozoic oceanic biostratigraphy and paleoceanographic, paleoclimatic interpretations; Benthic foraminifera - their brief morphology and application in bottom water paleoceanography and paleo bathymetric reconstructions; Larger foraminifera, their outline of morphology and application in Indian stratigraphy.

Unit 3 Ostracode and Conodonts

Ostracode: Morphology; Classification, Systematic of important genera, Ecology and Palaeoecology and geological history. Application in Paleobiogeographic reconstruction and Indian stratigraphy.

Condonts: Morphology; Classification, Zoological affinity, and geological history; Stratigraphic significance of conodonts with special reference to India.

Unit 4 Other Microfauna and Palynology

Acritarchs, Calcareous algae, Calpionellids, Chitinozoans, Coccoliths, Diatoms, Dinoflagellates, and Radiolarians - outline of morphology, modern biogeography, their environmental significance and application in biostratigraphy.

Pollen, Spore, and Seeds: Morphology; Classification, and geological history. Application of Palynology with reference to Petroleum and Coal exploration.

Unit 5 Application of Microfauna

Geochemical study of microfossil tests (stable isotopes) and its application in paleoceanography and paleoclimatology and tracing the history of marine pollution. Determination and correlation of paleofacies by microfossils; Interpretation of seafloor tectonism from micropaleontological evidence.

Books suggested for reading:

- Saraswati, P. K. and Srinivasan, M. S., 2016, Micropaleontology, Principles and Applications, Springer.
- Arnold and Simon, Haslett, K., 2002, Quaternary Environmental Micropaleontology, Oxford.
- Haq, B. U. and Boersma, A., 1998, Introduction to Marine Micropaleontology, Elsvier.
- Pinet, P. R., 1992, Oceanography: An introduction to the Planet Oceanus, West Pub, Co.
- Bignot, G., Grahm and Trottman., 1985, Elements of Micropaleontology, London.

- David. Tolmazin., 1985, Elements of Dynamic Oceanography, Allen and Unwin.

Suggested E-resources :

- https://www.geol.umd.edu/~tholtz/G331/331Syl.html
- http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000010ES/P001694/M020138/ET/1494502494046.N011.ES07-273BiostratigraphyANReddy.pdf
- https://igntu.ac.in/eContent/MSc-Geology-02Sem-DrVikramSingh-MICROPALEONTOLOGY.pdf
- https://www.youtube.com/watch?v=S2XVlSSDoWQ
- https://www.youtube.com/watch?v=nH8aR-nnuJE

Course learning outcomes :

- The students will be able to identify various microfossils used in stratigraphy, hydrocarbon exploration, and paleosciences.
- The students will be able to interpret facies/water mass based on microfossil assemblage.
- The students will develop a broad understanding of the morphology and significance of various microfossils.

Code of the course	**GEO9102P**
Title of the course	**Micropalaeontology**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**2**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Practical**
Objectives of the Course	**As per the objectives defined in the theory paper to develop practical skills.**
Syllabus	

Semester-3 Micropalaeontology

PRACTICALS

- Types of microfossils: Calcareous, Siliceous, Phosphatic, and organic-walled microfossils
- Study of important planktic foraminifera useful in surface water paleoceanography and biostratigraphy
- Study of larger benthic foraminifera useful in Indian stratigraphy with special reference to Cenozoic petroliferous basins of India
- Study of modern surface water mass assemblages of planktic foraminifera from Indian, Atlantic, and Pacific Ocean
- Depth biotopes and estimation of paleodepth of the ocean using benthic foraminiferal assemblages
- Identification of benthic foraminifera characteristic of various deep-sea environments
- Identification of planktic foraminifera characteristic of Warm Mixed Layer, Thermocline, and deep surface waters of the modern oceans
- Identification of modern and ancient surface water mass with the help of planktic foraminifera
- Identification and morphological study of the following microfossil genera under a stereo zoom microscope: Ostracodes, Conodonts, and Charophytes.
- Morphological features of Pollens & spores, Acritarchs, Diatoms, and Radiolaria.

Books suggested for reading:

- Saraswati, P. K. and Srinivasan, M. S., 2016, Micropaleontology, Principles and Applications, Springer.
- Arnold and Simon, Haslett, K., 2002, Quaternary Environmental Micropaleontology, Oxford.
- Haq, B. U. and Boersma, A., 1998, Introduction to Marine Micropaleontology, Elsvier.
- Pinet, P. R., 1992, Oceanography: An introduction to the Planet Oceanus, West Pub, Co.
- Bignot, G., Grahm and Trottman., 1985, Elements of Micropaleontology, London.
- David. Tolmazin., 1985, Elements of Dynamic Oceanography, Allen and Unwin.

Suggested E-resources :

- https://www.geol.umd.edu/~tholtz/G331/331Syl.html
- http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000010ES/P001694/M020138/ET/1494502494046.N011.ES07-273BiostratigraphyANReddy.pdf
- https://igntu.ac.in/eContent/MSc-Geology-02Sem-DrVikramSingh-MICROPALEONTOLOGY.pdf
- https://www.youtube.com/watch?v=S2XVlSSDoWQ

• https://www.youtube.com/watch?v=nH8aR-nnuJE	
Course learning outcomes :	
• As per the outcomes defined in the theory paper with relevance to practical aspects.	
EOSE (Practical):	**80 Marks**
Practical - 45 Marks	
Viva – Voce - 15 Marks	
Record - 20 Marks	
Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**

Code of the course	**GEO9103T**
Title of the course	**Mineral Resource Estimation & Advanced Mining**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**4**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	• **The objective to commence this course M.Sc. is to specifically orient students with a geological background to develop learning skills related to mineral exploration and mine geology. These two fieldworks are the requirement for the future exploration of minerals and so an industry need-based course has been planned.**
Syllabus	
Semester-3 Mineral Resource Estimation & Advanced Mining	
Unit 1 Data Collection, Geological Orebody Modelling	
Data Collection:- Mapping and litho-structural Logging, Sampling, Assaying, QAQC, Density, etc. Geological Orebody Modelling, Geologic Interpretation on section & amp; plan, Interpretation of the geology and the delineation of the resource, generation of 3D resource envelop.	
Unit 2 Exploratory Data Analysis	
Cut-off-Grade, Statistical analysis, Stationarity Analysis, Variography	
Unit 3:- Resource Estimation	
Inference of Characteristics of Samples to Deposit, Assessment of the resource, Choosing an Appropriate Estimation Method, Types of Estimation Methods – Sectional and Polygonal, ISD & amp; Kriging. Application of the Estimation method, Validation of the Estimates. Reconciliation. Resource Classification based on geoscientific evidence (sample spacing, Kriging variance), Resource Reporting in the Public Domain, Types of resource classification - UNFC classification	
Unit 4 Mining Methods	
Alluvial, open-pit, and underground mining methods; drifting; cross-cutting; winzing; stoping; room and pillaring; top–slicing; sub-level caving and block caving; ocean bottom mining, mine organization, and operation; mine hazards.	
Unit 5 Geo-Tech. & Mine Planning	
Mine Subsidence and the support of mine excavation; timber treatment; methods of breaking rocks; drilling blast holes; explosives used in mining; blasting practices; shaft sinking; mine drainage; ventilation; illumination	
Books suggested for reading:	
• Mario, E.R., amp., and Clayton, V.D., 2014, Mineral Resource Estimation. • Mookherjee, A., 2000, Ore genesis a holistic approach. • Haldar, S.K., 2015, Mineral Exploration Principles and Exploration. • Haldar, S.K., 2018, Exploration modeling of Base Metal Deposits. • Young, G.J., Elements of Mining. • Lewis, R.A. and Clark, G.A., Elements of Mining. • Arogyaswami., Mining Geology.	

- Meckinstry, H.E., Mining Geology.
- Sheryanthov, L., Mining of Mineral deposits1

Suggested E-resources :

- https://mrmr.cim.org/media/1129/cim-mrmr-bp-guidelines_2019.pdf
- https://www.researchgate.net/publication/346029212_MINERAL_RESERVES_ESTIMATION_BY_USING_TRIANGULAR_METHOD
- https://www.geokniga.org/bookfiles/geokniga-geological-methods-mineral-exploration-and-mining.pdf
- https://archive.org/details/textbookofmining00parkrich

Course learning outcomes :

- Students will come out with theoretical as well as practical approach that involves industrial training as well as field-based knowledge.

Code of the course	**GEO9103P**
Title of the course	**Mineral Resource Estimation & Advanced Mining**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**2**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Practical**
Objectives of the Course	• **As per the objectives defined in the theory paper to develop practical skills.**
Syllabus	

Semester-3 Mineral Resource Estimation & Advanced Mining

PRACTICALS

- Project work related to this DSE paper will be given to students according to the theory syllabus.

Books suggested for reading:

- Mario, E.R., amp., and Clayton, V.D., 2014, Mineral Resource Estimation.
- Mookherjee, A., 2000, Ore genesis a holistic approach.
- Haldar, S.K., 2015, Mineral Exploration Principles and Exploration.
- Haldar, S.K., 2018, Exploration modeling of Base Metal Deposits.
- Young, G.J., Elements of Mining.
- Lewis, R.A. and Clark, G.A., Elements of Mining.
- Arogyaswami., Mining Geology.
- Meckinstry, H.E., Mining Geology.
- Sheryanthov, L., Mining of Mineral deposits1

Suggested E-resources :

- https://mrmr.cim.org/media/1129/cim-mrmr-bp-guidelines_2019.pdf
- https://www.researchgate.net/publication/346029212_MINERAL_RESERVES_ESTIMATION_BY_USING_TRIANGULAR_METHOD
- https://www.geokniga.org/bookfiles/geokniga-geological-methods-mineral-exploration-and-mining.pdf
- https://archive.org/details/textbookofmining00parkrich

Course learning outcomes :

- As per the outcomes defined in the theory paper with relevance to practical aspects.

EOSE (Practical):	**80 Marks**
Practical - 45 Marks	
Viva – Voce - 15 Marks	
Record - 20 Marks	
Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**

Code of the course	**GEO9104T**
Title of the course	**Gemstone and Decorative stone**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**4**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	• **The course for the gemstone is developed to promote skills in the identification and testing of gemstones.** • **Building and decorative stones are taught to give knowledge of different types of stones used for the construction of buildings, monuments, temples, etc.** • **Students will learn the uses and manufacturing of Gemstones.** • **Decorative stones are to be used for architectural works.**
Syllabus	

Semester-3 Gemstone and Decorative stone

Unit 1 Introduction of Gem Stone

Gemstones – Basic qualities of gemstones, the 4 'C's – Colour, Clarity, Carat and Cut, Differences and similarities between Minerals and Gemstones. Gemstone classification – Precious gemstones and Semi-precious gemstones, Gemstone Varieties – Natural, Cultured and Imitation, Synthetic and Stimulant Gemstones.

Unit 2 Examples with their properties

Weights and measures, Treatments and Enhancements, Valuation of gemstones. Chemical composition, physical and optical properties and identification of Gemstones: Diamond, Chrysoberyl, Amethyst & other Quartz gems, Ammolite, Chalcedony, Emerald, Aquamarine & amp; other Beryls, Garnet, Ijolite, Jade (Jadeite + Nephrite), Kunzite (Spodumene), Lapis Lazuli, Malachite, Moonstone +Some other feldspars, Opal, Peridot, Ruby + Sapphire(corundum), Spinal, Tanzanite (zoisite), Topaz, Tourmaline (A group of mineral species), Turquoise, Zircon. Description and identification of the following Organic gems: Amber, Coral, Pearl, Jet, and Ivory.

Unit 3 Instruments and Market Status

The instrument used for cutting, grinding, polishing, and identification of gemstones: Jewelers Lens, Microscope, Dichroscope, Polariscope, Refractometer, Spectroscope, Diamond Tester, Moissanite Tester, Chelsea colour filter, Hardness pencil, etc. Sawing, Grinding, Polishing, and Faceting machines.

Selecting styles of cut and orientation. Cutting and polishing of cabochons and facetted stones. Carving and Engraving. Techniques of decoration.

Marketing and Appraising of Gems and Jewelry in India and its position in the world market. Hall Marking, Export/ Import law. Gemstones in human destiny and Occult power of gemstones. Astrological and Zodiac.

Unit 4 Introduction of Decorative Stone with examples

Introduction to Machinery used in cutting and polishing of Building stones. Mineral Concession Rules and Procedures for acquiring mines for building stones. Granite, definition and mineral composition, its origin, classification, texture, and structure. Physical and engineering properties of granites. Mining, processing, and uses. Occurrences, and distribution of granites in India.

Unit 5 Examples with their properties and Mining status

Marble, definition and mineral composition, its origin, Types of marbles, mineral composition, texture, and structure. Physical and engineering properties of Marble. Mining, processing, and uses.Occurrences, and distribution of Marble in Rajasthan. Sandstone and limestone, definition sand mineral composition, their origin, texture, and structure. Physical and engineering properties of sandstones and limestones. Their mining, processing, and uses. Occurrences, and distribution of sandstone and Limestone in Rajasthan.

Books suggested for reading:

- Gribble, C.D., 2005, Rutley's Elements of Mineralogy Reprint CBS Pub. & amp, Dist., New Delhi
- Alexander, P.O., 2008, Handbook of Minerals, Crystals, Rocks, and Ores, New Age India.
- Karanth, R.V., 2008, Gemstones Enchanting Gifts of Nature. Geological Society of India, Bangalore.
- Karanth, R.V., Gems and Gem Industry in Industry.
- Webster, Robert., Gems, Their sources, Descriptions, and Identification.
- Singh, Parbin., Engineering & amp; General Geology. B. D. Kataria & amp; Sons, Opposite Clock Tower, Ludhiana
- Tyrrel, G.W., The Principles of Petrology. B.I. Publications Pvt. Ltd., 13, Daryaganj, New Delhi – 2

Suggested E-resources :

- https://www.gia.edu/gem-education/online-division
- https://iigindia.com/gemology-courses-online-iig-india
- https://deepwear.info/blog/gemstone-sourcing/
- https://www.gemstones.com/gemopedia/all

Course learning outcomes :

- This course has been formulated in such a manner that students from all the streams get the basic idea about gemstones, their formation, identification, valuation, etc. are dealt with for their future applicability. Since gemstones have high commercial value. Presently, minerals, rocks, and gemstones are also used for crystal therapy as a branch of medicinal gemmology, hence, this course would offer significant input in this important field also.
- Decorative stones are very much used in present times so students learn their importance and uses.
- By completing projects on Gemstones and Decorative stones students will able to make their future in the particular field, which plays an important role in the present scenario.

Code of the course	**GEO9104P**
Title of the course	**Gemstone and Decorative stone**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**2**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Practical**
Objectives of the Course	• **As per the objectives defined in the theory paper to develop practical skills.**
Syllabus	

Semester-3 Gemstone and Decorative stone

PRACTICAL

- Project work related to this DSE paper will be given to students according to the theory syllabus.

Books suggested for reading:

- Gribble, C.D., 2005, Rutley's Elements of Mineralogy Reprint CBS Pub. & amp, Dist., New Delhi
- Alexander, P.O., 2008, Handbook of Minerals, Crystals, Rocks, and Ores, New Age India.
- Karanth, R.V., 2008, Gemstones Enchanting Gifts of Nature. Geological Society of India, Bangalore.
- Karanth, R.V., Gems and Gem Industry in Industry.
- Webster, Robert., Gems, Their sources, Descriptions, and Identification.
- Singh, Parbin., Engineering & amp; General Geology. B. D. Kataria & amp; Sons, Opposite Clock Tower, Ludhiana
- Tyrrel, G.W., The Principles of Petrology. B.I. Publications Pvt. Ltd., 13, Daryaganj, New Delhi – 2

Suggested E-resources :

- https://www.gia.edu/gem-education/online-division
- https://iigindia.com/gemology-courses-online-iig-india
- https://deepwear.info/blog/gemstone-sourcing/
- https://www.gemstones.com/gemopedia/all

Course learning outcomes :

- As per the outcomes defined in the theory paper with relevance to practical aspects.

EOSE (Practical):	**80 Marks**
Practical - 45 Marks	
Viva – Voce - 15 Marks	
Record - 20 Marks	
Internal Exam -	**20 Marks**
i. Exam - 10 Marks	
ii. Assignment/ Seminar/Quiz – 10 Marks	

Code of the course	**GEO9105T**
Title of the course	**Engineering and Environmental Geology**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**4**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	• **To familiarize with the scope of Engineering Geology, properties of rocks, selection of reservoir sites, Tunnels and Foundation of geological investigations, and groundwater problems.** • **To know about the basic concepts of environmental Geology, Causes, effects, strategies for their mitigation, Natural Hazards, and Coastal processes** • **To understand Natural disasters, monitoring and disaster management measures for Earthquake, Landslide, Volcanoes, and Tsunamis**

Syllabus

Semester-3 Engineering and Environmental Geology

Unit 1 Fundamentals of Engineering Geology

Role of Engineering Geologist in planning, design, and construction of major manmade structures. Engineering properties of rocks: crushing strength, porosity, density, abrasive resistance. Concept mechanism and significance of rock quality designation (RQD), Rock structure rating (RSR), Rock mass rating (RMR), and Tunnelling Quality Index (Q),

Unit 2 Applications of Engineering Geology

Geological investigation for construction of dams, and tunnels with remedial measures. Building materials - sand, building and dimension stones, aggregates, lime and cement, clays, and clay products. Use of Dolerite, Granite, Gneiss, Marble, Slate, and Sandstone as decorative stones.

Unit 3 Environmental Geology

Definition of ecology and environmental geology, man and environment, scope and importance. Role of Geology in environmental studies. The physical environment - Atmosphere, hydrosphere, lithosphere, and biosphere. Anthropogenic environments

Unit 4 Pollution

Pollution- air, water, and soil pollution - causes and effects. Heavy metal pollution in groundwater. Greenhouse effect, Global Warming and their effect on the environment. Ozone depletion

Unit 5 Geohazards and Disasters

Geological hazards: Earthquakes, volcanism, landslides, floods, droughts; Hazard mitigation.

Books suggested for reading:

- Krynin, D.P. and Judd, W.R., 1957, Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
- Johnson, R.B. and De, Graf, J.V., 1988., Principles of Engineering Geology, John Wiley.
- Goodman, R.E., 1993, Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y.
- Waltham, T., 2009, Foundations of Engineering Geology Taylor & Francis, (3rd Ed.).

- Bell, F.G., 2006, Basic Environmental and Engineering Geology.
- Valdiya, K. S., 1987, Environmental Geology - Indian Context. Tata McGraw Hill New Delhi.
- Keller, E. A., 2000, Environmental Geology. Shales E. Merril Publishing Co., Columbus, Ohio.
- Montgomery, C., 1984, Environmental Geology. John Wiley and Sons, London.
- Bird, Eric., 2000, Coastal Geomorphology: An Introduction. John Wiley & Sons, Ltd. Singapore.
- Liu, B.C., 1981, Earthquake Risk and Damage, Westview.

Suggested E-resources

- https://www.aegweb.org/e-eg-journal-nm
- https://www.researchgate.net/publication/355201938_Engineering_Geology_I_-_Lecture_Notes
- https://www.pinterest.com/pin/779545016763184623/
- https://openlibrary.org/books/OL3949697M/Environmental_geology

Course learning outcomes

- An understanding of the scientific method and how it is used by geologists
- Knowledge of the structure and composition of Earth's interior, oceans, and atmosphere.
- Knowledge of the major types of earth material and explain how each type forms
- An understanding of the hydrologic, rock, and tectonic cycles
- An understanding of natural hazards and earth resources
- An understanding of how earth processes create hazards to life and property
- Knowledge of where earth resources occur, how they form, and the major environmental effects of extraction, processing, and use
- Knowledge of the major sources of water, soil, and sediment pollution
- Knowledge of the major type of natural hazards, and water, soil, and sediment pollution
- An understanding of the causes and effects of global climate change.

Code of the course	**GEO9105P**
Title of the course	**Engineering and Environmental Geology**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**2**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Practical**
Objectives of the Course	• **As per the objectives defined in the theory paper to develop practical skills.**

Syllabus

Semester-3 Engineering and Environmental Geology

PRACTICAL

- Problems related to aggregate impact values of rock samples, moisture content, and dry density in rock.
- Exercise based on physico- mechanical properties of rock samples.

Books suggested for reading:

- Krynin, D.P. and Judd, W.R., 1957, Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
- Johnson, R.B. and De, Graf, J.V., 1988., Principles of Engineering Geology, John Wiley.
- Goodman, R.E., 1993, Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y.
- Waltham, T., 2009, Foundations of Engineering Geology Taylor & Francis, (3rd Ed..).
- Bell, F.G., 2006, Basic Environmental and Engineering Geology.
- Valdiya, K. S., 1987, Environmental Geology - Indian Context. Tata McGraw Hill New Delhi.
- Keller, E. A., 2000, Environmental Geology. Shales E. Merril Publishing Co., Columbus, Ohio.
- Montgomery, C., 1984, Environmental Geology. John Wiley and Sons, London.
- Bird, Eric., 2000, Coastal Geomorphology: An Introduction. John Wiley & Sons, Ltd. Singapore.
- Liu, B.C., 1981, Earthquake Risk and Damage, Westview.

Suggested E-resources

- https://www.aegweb.org/e-eg-journal-nm
- https://www.researchgate.net/publication/355201938_Engineering_Geology_I_-_Lecture_Notes
- https://www.pinterest.com/pin/779545016763184623/
- https://openlibrary.org/books/OL3949697M/Environmental_geology

Course learning outcomes

- As per the outcomes defined in the theory paper with relevance to practical aspects.

EOSE (Practical):	
Practical - 45 Marks	**80 Marks**
Viva – Voce - 15 Marks	
Record - 20 Marks	
Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**

M.Sc. Geology IV Semester

Code of the course	**GEO90002T**
Title of the course	**Mineral Exploration & Mining**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**4**
Type of the course	**Discipline Core Courses(DCC)**
Delivery type of the course	**Theory & Lecture**
The objective of the Course:	• **To impart knowledge of mineral exploration and mining.** • **To train the students on methods of exploration and techniques of mining.**

Syllabus

Semester-4 Mineral Exploration & Mining

Unit 1 Guides for locating Ore Deposits

Structural, lithological, stratigraphic, and physiographic guides. Surface prospecting methods: pitting and trenching; Sub-surface exploration: drilling, different types of drilling, use of diamond drilling in exploration; core-logging and assaying; sampling: various methods of sampling.

Unit- 2 Ore Reserves and Resources

Definition and outline of United Nations International framework classification of mineral reserves and resources; grades and recovery of ores; methods of ore reserve estimations; surface area and cross-sectional area methods; recoverable reserves and anticipated life of the deposits.

Unit 3 Geophysical and Geochemical Exploration

Principles of geophysical and geochemical prospecting. Applications of various geophysical methods in mineral exploration (e.g., gravity, magnetic, electrical, and seismic surveys). Methods and applications of exploration geochemistry. Field and laboratory analytical methods. Treatment of geochemical data. Role of remote sensing in mineral exploration.

Unit 4 Elements of Mining: Mining Methods

various types of surface and underground mining methods; factors involved in the selection of open cast and underground mining methods; salient features of bench-mining, shrinkage stopping, sub-level stopping, and sub-level top slicing; coal mining methods: room and pillar method, longwall method.

Unit 5 Mineral Policies and Legislation

Outlines of the rules governing conservation, development, and utilization of mineral resources; National mineral policy; prospecting license and mining lease; procedures of granting prospecting license and mining lease. Environmental aspects of Mining activities.

Books suggested for reading:

- Dobrin, M. B., 1976, Introduction to Geophysical Prospecting, McGraw Hill.
- Arogyaswami, R.P.N., 1996, Courses in Mining Geology. IV Ed. Oxford IBH.
- Boyle, R.W. and Elsevier., 1982, Geochemical Prospecting for Thorium and Uranium Deposits.
- Clark, G.B., 1967, Elements of Mining. III Ed. John Wiley
- Kearey, P., Brooks, M. and Hill, I., 2002, An Introduction to Geophysical Exploration, Wiley-Blackwell.
- Hawkes, H. E., Webb J. S., 2012, Geochemistry in mineral exploration, Literary Licensing, LLC.
- Haldar, S. K., 2013, Mineral Exploration: Principles and Application, Elsevier.
- Moon C. J., Whateley, M. K. G. and Evans, A. M., 2005, Introduction to Mineral Exploration, Blackwell Science.

Suggested E-resources :

- https://www.gsi.gov.in/
- https://mines.gov.in/admin/storage/app/uploads/64352887bcfa41681205383.pdf
- http://egyankosh.ac.in//handle/123456789/78247
- https://pubs.usgs.gov/of/1995/ofr-95-0831/CHAP3.pdf
- https://www.osti.gov/servlets/purl/895050
- http://faculty.washington.edu/dersh/Files/Geophysics2006.pdf
- https://eclass.uoa.gr/modules/document/file.php/GEOL312/Geophysical%20

Course learning outcomes:

Upon successful completion of the course, the students would be able to:

- Understand the basic concept of mineral exploration and mining
- Understand the methods of sampling, drilling, and core logging.
- Understand the fundamentals of the geophysical and geochemical methods of mineral exploration.
- Understand the mineral policies and Environmental aspects of mining activities.

Code of the course	**GEO90003T**
Title of the course	**Hydrogeology**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**4**
Type of the course	**Discipline Centric Core Course(DCC)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	• **To impart knowledge of basic hydrogeology including groundwater origin, occurrence, and distribution.** • **To train students on methods of Groundwater Exploration, quality, and management.** • **To train students about the understanding of Groundwater problems and Groundwater resources in India.**
Syllabus	
Semester-4 Hydrogeology	
Unit 1 Introduction to Groundwater	
Ground Water Geology: Introduction, history of groundwater development, the importance of groundwater. Elements of groundwater hydrology. Sources of groundwater and origin, hydrological cycle, occurrence and distribution of groundwater, hydrological properties of rocks.	
Unit 2 Groundwater Quality and Management	
Groundwater quality: factors affecting the quality of groundwater, analysis of groundwater, identification in terms of suitability of groundwater for domestic, irrigation, and industrial purposes. Hydrogeology of India. wetlands with special reference to Rajasthan.	
Unit 3 Water level fluctuations, Groundwater Movement and Water Wells	
Water table fluctuations: Causative factors, Water Table Contour Maps, Theory of groundwater flow, Darcy's law and its application, determination of permeability in the laboratory and field, Types of wells, Drilling methods, and Construction Design.	
Unit 4 Exploration Of Groundwater	
Exploration and Evaluation of groundwater, hydrologic investigation; surface geophysical methods, seismic methods, and electric resistivity methods. Introduction to sub- surface Geophysical methods.	
Unit 5 Groundwater problems	
Groundwater problems related to foundation work, mining, canals and tunnels, problems of overexploitation and groundwater mining, groundwater development in urban areas, rainwater harvesting, and groundwater potentials of Rajasthan.	
Books suggested for reading:	
• Todd, D.K., 1988, Ground Water Hydrology, John Wiley & Sons, New York. • Davies, S.N., Dc-West., and R.J.N., 1966, Hydrogeology, John Willey & Sons, New York. • Hiscock, K.M. and Bense, V.F., 2014, Hydrogeology: Principles and Practice Wiley-Blackwell, 2nd Edition. • Raghunath, H.M., 1983, Ground Water, Wiley Eastern Ltd., Calcutta. • Driscoll, F.G., 1988, Ground Water and Wells, UOP, Johnson Div. St. Paul. Min. USA • Freeze, R.A. and Cherry, J.A., 1971, Groundwater.	

- Fetter, C.W., 1990, Applied Hydrology.
- Karanth, K.R., 1987, Groundwater assessment, Development and Management.
- Alley, W.M., 1983, Regional groundwater quality.
- Subramaniam, V., 2000, Water.

Suggested E-resources :

- https://vidyamitra.inflibnet.ac.in/index.php/search?subject%5B%5D=Geology&course%5B%5D=&domain%5B%5D=Physical+%26+Basic+Sciences
- https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=8zYwEsyFCoiPyJlPmzHDxg==

Course learning outcomes :

Upon successful completion of the course, the students would be able to

- Understand the hydrologic cycle and its components, hydrologic properties of rock, Darcy's law, and its applications.
- Understand water level fluctuations and their causes.
- Understand Groundwater Explorations and its various methods

Code of the course	**GEO90001P**
Title of the course	**Mineral Exploration Mining and Hydrogeology**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**2**
Type of the course	**Discipline Centric Core Course(DCC)**
Delivery type of the course	**Practical**
Objectives of the Course	• **The practical exercises aim to develop an understanding of various practical aspects of Hydrogeology.** • **As per the objectives defined in the Mineral Exploration theory paper to develop practical skills.**
Syllabus	

Semester-4 Mineral Exploration Mining and Hydrogeology

Mineral Exploration

Survey by prismatic compass and theodolite.

- Leveling
- Use of GPS
- Borehole plotting, core logging, and correlation.
- Ore reserves estimation.

Hydrogeology

- Calculation Exercises on Groundwater Quality parameters and their suitability for domestic, irrigation, and industrial purposes
- Calculation Exercises on aquifer properties like porosity and permeability
- Calculation Exercises on Saline Water Intrusion

Compulsory Field Training Program: Geological Field Training is mainly based on Mineral Exploration and Hydrogeology.

Note: **Compulsory field training program at the end of every semester will be a value-added part of the practical syllabus which will be of 10 days duration and students opting out of it will lose proportionally marks from the practical credit score. The student will have a chance to improve the score by doing the field training at his/her own expense before the commencement of the final practical exam and after producing a valid certificate from the recognized institute/company duly approved by the field training mentor/ faculty member.**

- Todd, D.K., 1988, Ground Water Hydrology, John Wiley & Sons, New York.
- Davies, S.N., Dc-West., and R.J.N., 1966, Hydrogeology, John Willey & Sons, New York.
- Hiscock, K.M. and Bense, V.F., 2014, Hydrogeology: Principles and Practice Wiley-Blackwell, 2nd Edition.
- Raghunath, H.M., 1983, Ground Water, Wiley Eastern Ltd., Calcutta.
- Driscoll, F.G., 1988, Ground Water and Wells, UOP, Johnson Div. St. Paul. Min. USA
- Freeze, R.A. and Cherry, J.A., 1971, Groundwater.
- Fetter, C.W., 1990, Applied Hydrology.
- Karanth, K.R., 1987, Groundwater assessment, Development and Management.
- Alley, W.M., 1983, Regional groundwater quality.
- Subramaniam, V., 2000, Water.

Suggested E-resources:

• https://vidyamitra.inflibnet.ac.in/index.php/search?subject%5B%5D=Geology&course%5B%5D=&domain%5B%5D=Physical+%26+Basic+Sciences • https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=8zYwEsyFCoiPyJlPmzHDxg==	
Course learning outcomes:	
Upon successful completion of the course the students would be able to:- • Estimate Calculation Exercises on Groundwater Quality parameters and their suitability for domestic, irrigation, and industrial purposes. • Estimate various hydrogeological properties of rocks. • Analysis of hydrographs for various components. • Chemical and Physical analysis of water and presentation of data for uses in irrigation, drinking, and industry. • As per the outcomes defined in the Mineral Exploration theory paper with relevance to practical aspects.	
EOSE (Practical):	**80 Marks**
Practical - 45 Marks	
Viva – Voce - 15 Marks	
Record - 20 Marks i. Field Tour Report – 10 Marks ii. Practical Record – 10 Marks	
Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**

Code of the course	**GEO9106T**
Title of the course	**Applied Hydrogeology**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**4**
Type of the course	**Discipline Specific Electives (DSE)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	• **To impart knowledge of various applied aspects of Hydrogeology.** • **To provide students with various job aspects in Government and private organizations related to Hydrogeology.**
Syllabus	

Semester-4 Applied Hydrogeology

Unit 1 Occurrence and Distribution of Groundwater

Origin of water, surface and subsurface distribution of water, and residence time concept. Global water cycle. Vertical distribution of subsurface water and concept of groundwater. Groundwater basins and springs.

Unit 2 Groundwater Quality

Physical characteristics viz: Turbidity, colour, tastes, odor, temperature, specific conductivity, Chemical characters: T.D.S., PH value, Hardness, Heavy metals, and dissolved gases. Estimation and methods of treatment for various uses. Ground Water quality map of Rajasthan. Water contaminants and Pollutants: Problems of Fluoride, Nitrate, T.D.S., Sulphate, Chloride and Salinity in Rajasthan.

Unit 3 Groundwater Exploration and Development

Hydro geomorphic mapping and application of remote sensing in groundwater exploration. Groundwater basins of India. Application of stable isotopes in hydrogeology. Groundwater development and over-exploitation. Water resource evaluation and National Groundwater Resource Estimation Methodology.

Unit 4 Hydrogeological Scenario of Rajasthan

Hydrogeological provinces of Rajasthan and potential groundwater zones. Status of groundwater development in Rajasthan and categorization into safe, semi-critical, critical, and over-exploited zones. Water quality deterioration due to industrialization and urbanization in different parts of Rajasthan. The problem of fluorosis in Rajasthan and remedial measures. Conventional practices of water conservation and rainwater harvesting in Rajasthan and their relevance in sustainable development.

Unit 5 Groundwater Sampling

Groundwater sampling: types and techniques, Groundwater Analysis, Introductory knowledge about common analytical Instruments: Flame Photometer, UV Double Beam Spectrophotometer. Preparation of Hydrogeological Report

Books suggested for reading:

- Todd, D.K., 1988, Ground Water Hydrology, John Wiley & Sons, New York.
- Davies, S.N., Dc-West., and R.J.N., 1966, Hydrogeology, John Willey & Sons, New York.
- Hiscock, K.M. and Bense, V.F., 2014, Hydrogeology: Principles and Practice Wiley-Blackwell, 2nd Edition.
- Raghunath, H.M., 1983, Ground Water, Wiley Eastern Ltd., Calcutta.
- Driscoll, F.G., 1988, Ground Water and Wells, UOP, Johnson Div. St. Paul. Min. USA

- Freeze, R.A. and Cherry, J.A., 1971, Groundwater.
- Fetter, C.W., 1990, Applied Hydrology.
- Karanth, K.R., 1987, Groundwater assessment, Development and Management.
- Alley, W.M., 1983, Regional groundwater quality.
- Subramaniam, V., 2000, Water.
- CGWB, Groundwater Report of India.
- Groundwater Atlas of Rajasthan.

Suggested E-resources:

- https://vidyamitra.inflibnet.ac.in/index.php/search?subject%5B%5D=Geology&course%5B%5D=&domain%5B%5D=Physical+%26+Basic+Sciences
- https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=8zYwEsyFCoiPyJlPmzHDxg==

Course learning outcomes :

Upon successful completion of the course, the students would be able to understand

- Various applied aspects of Hydrogeology.
- To get a job in various Government and private organizations related to Hydrogeology.
- Upon successful completion of the course, the students would be able to understand the various practical aspects of Applied Hydrogeology and will be able to work independently in the field of Hydrogeology

Code of the course	**GEO9106P**
Title of the course	**Applied Hydrogeology**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**2**
Type of the course	**Discipline Specific Electives (DSE)**
Delivery type of the course	**Practical**
Objectives of the Course	• **As per the objectives defined in the theory paper to develop practical skills.**
Syllabus (Practical)	

Semester-4 Applied Hydrogeology

PRACTICALS

- Analysis of various water quality parameters.
- Interpretation of Groundwater Quality Parameters
- Introductory knowledge about common analytical Instruments: Flame Photometer, UV Double Beam Spectrophotometer.
- Preparation of Hydrogeological Report

Books suggested for reading:

- Todd, D.K., 1988, Ground Water Hydrology, John Wiley & Sons, New York.
- Davies, S.N., Dc-West., and R.J.N., 1966, Hydrogeology, John Willey & Sons, New York.
- Hiscock, K.M. and Bense, V.F., 2014, Hydrogeology: Principles and Practice Wiley-Blackwell, 2nd Edition.
- Raghunath, H.M., 1983, Ground Water, Wiley Eastern Ltd., Calcutta.
- Driscoll, F.G., 1988, Ground Water and Wells, UOP, Johnson Div. St. Paul. Min. USA
- Freeze, R.A. and Cherry, J.A., 1971, Groundwater.
- Fetter, C.W., 1990, Applied Hydrology.
- Karanth, K.R., 1987, Groundwater assessment, Development and Management.
- Alley, W.M., 1983, Regional groundwater quality.
- Subramaniam, V., 2000, Water.
- CGWB, Groundwater Report of India.
- Groundwater Atlas of Rajasthan.
- CGWB, Groundwater Report of India
- Groundwater Atlas of Rajasthan

Suggested E-resources:

- https://vidyamitra.inflibnet.ac.in/index.php/search?subject%5B%5D=Geology&course%5B%5D=&domain%5B%5D=Physical+%26+Basic+Sciences
- https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=8zYwEsyFCoiPyJlPmzHDxg==

Course learning outcomes :

- As per the outcomes defined in the theory paper with relevance to practical aspects.

EOSE (Practical):	
Practical - 45 Marks	**80 Marks**
Viva – Voce - 15 Marks	
Record - 20 Marks	
Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**

Code of the course	**GEO9107T**
Title of the course	**Quaternary Geology**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**4**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	• **The objective of this course is to develop an understanding of the field of Quaternary Geology.** • **The student will develop an understanding of short and long-term climate change that occurred during the Quaternary Period.** • **This course will also deliver insight into the proxies used for inferring the climatic events that occurred during the Quaternary.**
Syllabus	
Semester-4 Quaternary Geology	
Unit 1 Introduction	
Definition of Quaternary. Quaternary Stratigraphy – Oxygen Isotope stratigraphy, biostratigraphy, and magnetostratigraphy.	
Unit 2 Quaternary Climate	
Quaternary climates – glacial-interglacial cycles, eustatic changes, proxy indicators of paleoenvironmental/ paleoclimatic changes, - land, ocean, and cryosphere (ice core studies).	
Unit 3 Climate Response	
Responses of geomorphic systems to climate, sea level, and tectonics on variable time scales in the Quaternary.	
Unit 4 Dating Methods	
Quaternary dating methods, –radiocarbon, Uranium series, Luminescence, Aminoacid. Quaternary stratigraphy of India– continental records (fluvial, glacial, aeolian, palaeosols); marine records; continental-marine correlation of Quaternary record.	
Unit 5 Life during Quaternary	
Evolution of man and Stone Age cultures. Plant and animal life in relation to glacial and interglacial cycles during Quaternary	
Books suggested for reading:	
• Emiliani, C., 1992, Planet Earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press. • Bradley, R.S., Paleoclimatology: Reconstructing Climates of the Quaternary, Academic. Press. • Kumar, Ravindra., 1988, Fundamentals of Historical Geology and Stratigraphy of India. New Age International Publishers. • Pomerol, C., 1982, The Cenozoic Era: Tertiary and Quaternary. Ellis Harwood Ltd. • Calvin, M.C., Seismology	
Suggested E-resources :	
• https://serc.carleton.edu/NAGTWorkshops/coursedesign/goalsdb/24327.html • https://www.geologieportal.ch/en/themes/fundamentals-of-geology/quaternary-geology.html	

- https://www.youtube.com/watch?v=lQY5Oz_4JX0
- https://www.geosocindia.org/index.php/bgsi/article/view/56085
- https://www.geol.umd.edu/~tholtz/G102/lectures/102quaternary.html

Course learning outcomes :

- The students will be able to understand the classification of the Quaternary period based on climatic events
- The students will be able to interpret quaternary records.
- The students will be able to understand various dating methods used for Quaternary.
- The student will understand the evolution of humans and plants during this period.

Code of the course	**GEO9107P**
Title of the course	**Quaternary Geology**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**2**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Practical**
Objectives of the Course	• **As per the objectives defined in the theory paper to develop practical skills.**
Syllabus	

Semester-4 Quaternary Geology

PRACTICALS

- Exercises in oxygen isotope stratigraphy
- Exercises on magnetostratigraphy
- Exercises in quaternary dating methods and age calculation
- Exercises in interpreting paleoclimatic events from the proxy records
- Interpretation of various types of paleoceanographic data
- Quaternary deposits in India.

Books suggested for reading:

- Emiliani, C., 1992, Planet Earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
- Bradley, R.S., Paleoclimatology: Reconstructing Climates of the Quaternary, Academic. Press.
- Kumar, Ravindra., 1988, Fundamentals of Historical Geology and Stratigraphy of India. New Age International Publishers.
- Pomerol, C., 1982, The Cenozoic Era: Tertiary and Quaternary. Ellis Harwood Ltd.
- Calvin, M.C., Seismology

Suggested E-resources :

- https://serc.carleton.edu/NAGTWorkshops/coursedesign/goalsdb/24327.html
- https://www.geologieportal.ch/en/themes/fundamentals-of-geology/quaternary-geology.html
- https://www.youtube.com/watch?v=lQY5Oz_4JX0
- https://www.geosocindia.org/index.php/bgsi/article/view/56085
- https://www.geol.umd.edu/~tholtz/G102/lectures/102quaternary.html

Course learning outcomes :

- As per the outcomes defined in the theory paper with relevance to practical aspects.

EOSE (Practical):	**80 Marks**
Practical - 45 Marks	
Viva – Voce - 15 Marks	
Record - 20 Marks	
Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**

Code of the course	**GEO9108T**
Title of the course	**Gemology**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**4**
Type of the course	**Discipline Specific Elective (DSE)**

Delivery type of the course	**Theory & Lecture**
Objectives of the Course	**The objectives of this course are to:** • **Introduce the characteristics of gemstones, their properties, and identification** • **Understand the application of gem identification tools and techniques.** • **Introduce the synthetic gemstone genesis and identification**
Syllabus	
Semester-4 Gemology	
Unit 1 Introduction to Gemology	
Gem and Gemstones. General characteristics and chemical composition of gemstones: Physical characteristics: Form, cleavage, fracture, hardness, and specific gravity.	
Unit 2 Optical Properties	
Optical characteristics: colour, luster, the play of colour, refractive index, reflectivity, pleochroism, dispersion.	
Unit 3 Identification	
Application of ultraviolet rays, X-rays, and Infrared rays in gem identification. Electrical thermal and magnetic characteristics of the gem. Classification of gemstones.	
Unit 4 Distribution	
Systematic description, genesis, mode of occurrence, distribution in India, and also important world occurrences of important precious and semi-precious stones.	
Unit 5 Synthetic Gemstones	
Synthetic gemstones: methods of synthesis, and its characteristics and identification. Gem enhancement methods and their identification: colourless/coloured impregnation, heat treatment, coating, irradiation, diffusion, treatment, etc.	
Books suggested for reading:	
• Bauer, Max., 1968, Precious stones, Vol. I and II. • Bruton, Eric, F.G.A., 1970, Diamonds. • Orlov, Yu, L., 1973, The Mineralogy of the Diamond. • Wilson, M. and Gems, Brocardo, G., 1981, Minerals and Gemstones – An Identification Guide.	
Suggested E-resources:	
• https://www.gia.edu/doc/spring-2022-gems-gemology.pdf • https://www.giceylon.com/wp-content/uploads/2021/06/Gemology.pdf • https://gemology.se/gill-library/gemjewelry/A_Book_of_Precious_Stones_Julius_Wodiska_1909.pdf	
Course learning outcomes :	
On completion of this course, students should have developed skills in the following areas: • Understand the important properties of gemstones for their identification • Understand the principles and science behind techniques identification of gemstones • Distribution of gem and gemstone-bearing horizons in the country	

Code of the course	**GEO9108P**
Title of the course	**Gemology**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**2**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Practical**
Objectives of the Course	• **As per the objectives defined in the theory paper to develop practical skills.**
Syllabus	

Semester-4 Gemology

PRACTICALS

- Study important properties and identification of gems
- Distribution of gem and gemstone-bearing horizons in India

Books suggested for reading:

- Bauer, Max., 1968, Precious stones, Vol. I and II.
- Bruton, Eric, F.G.A., 1970, Diamonds.
- Orlov, Yu, L., 1973, The Mineralogy of the Diamond.
- Wilson, M. and Gems, Brocardo, G., 1981, Minerals and Gemstones – An Identification Guide.

Suggested E-resources:

- https://www.gia.edu/doc/spring-2022-gems-gemology.pdf
- https://www.giceylon.com/wp-content/uploads/2021/06/Gemology.pdf
- https://gemology.se/gill-library/gemjewelry/A_Book_of_Precious_Stones_Julius_Wodiska_1909.pdf

Course learning outcomes :

- As per the outcomes defined in the theory paper with relevance to practical aspects.

EOSE (Practical):	**80 Marks**
Practical - 45 Marks	
Viva – Voce - 15 Marks	
Record - 20 Marks	
Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**

Code of the course	**GEO9109T**
Title of the course	**Ancient Mining and Metallurgy**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**4**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Theory & Lecture**
Objectives of the Course	**The objectives of studying ancient mining, metallurgy, and geoheritage are:** • **To gain insights into the techniques and practices of ancient societies in mining and metallurgy, which can provide valuable information about their technological advancements, economic activities, and cultural development.** • **To promote the conservation and protection of mining sites, ancient metallurgical remains, and geological features that have significant cultural, historical, and scientific value, ensuring their legacy for future generations.** • **To enhance cultural tourism by highlighting the significance of ancient mining sites and metallurgical heritage, attracting visitors interested in history, archaeology, and geology.** • **Overall, studying ancient mining, metallurgy, and geoheritage provides a comprehensive understanding of the past, helps preserve cultural heritage, and contributes to scientific knowledge and sustainable practices.**
Syllabus	

Semester-4 Ancient Mining and Metallurgy

Unit 1 Ancient Mining
Ancient references on mining and metallurgy (Vedic, Poranic, Shastra, etc.) on metal oxides and instruments. Noted works of pioneers on ancient metallurgy: Alchemist, Nagarjun, Rasratnasamuchchya, etc. Correlation of major geological terranes with ancient mining sites. Earliest Evidence of mining globally (Africa, Greece, France, China, Sri Lanka, Afghanistan, etc) with special reference to India.
Unit 2 Metallurgical processes adopted by ancient people
Evidence of mining along with metallurgy in Literary, Archaeological, and Foreign Accounts Furnaces and Crucibles, Force-draught furnace; Bowl, Domed, Blast, and Shaft Furnaces, Tuyeres; and Retorts.
Unit 3 Uses of Metal by Ancient People
Defence Tools-Arrowhead, Spearhead, Swords Shields, Agrarian Tools -Ploughshares, Axe, Chisel, and Spade, etc.; Utensils; Pots for Rituals; Ornaments; Net Shinkers; Surgical Instruments; and Oxides of Several Metals like Iron, Silver, Gold, and Mica.
Unit 4 Sites of Ancient Mining in Rajasthan
Khetri, Zawar, Dariba, Agucha (a Potential Site of Silver For Coins), Alwar, Jhunjunu, Bhilwara, Nathadwara, Mining of Copper, Silver, Iron, Delwara-Karoli area, Rikhabdeva, Ghughra, Mando, Wardolia for Copper, Iron, Silver, Zinc, Lead, and Tin.

Unit 5 Significance of Ancient Metallurgical Knowledge

Use of Zinc Metallurgy, Ayurvedic Medicines, Oxides of Silver, Iron, Mica, Gold, and Mercury. Induction of Wootz Steel Technology, Revival of Rural Technology at Orissa, Pedagogical Utility of Traditional Furnaces, etc.

Books suggested for reading:

- Eliade, Mircea., translated from French in English Stephen Corrin; The Forge and The Crucibles, University of Chicago Press,
- Craddock, P.T., 2017, Early Indian Metallurgy, Archetype Publications; London
- Jane, Humphris and Rohren., 2013, The World of IRON; Archetype Publications, London;
- Bhardwaj, H.C., 2000, Metallurgy in Indian Archaeology; Tata Book Agency, Delhi
- Agrawal, D P., 1971, Copper-Bronze Age in India, MunshiramManoharlal, Delhi,
- Tripathi, Vibha., 1998, Archaeometallurgy in India, Sharda Publishing House, Delhi.

Suggested E-resources :

- https://www.egyankosh.ac.in › ...PDF PRECAMBRIAN OF INDIA
- https://www.rajras.in › geology › Geo-Heritage Sites in Rajasthan | National Geological Monuments
- https://pib.gov.in › printrelease Geo-Heritage Sites
- https://www.academia.edu ›Ancient Mines and Metal Processing Activities in Shekhawati Region of ...
- http://www.heritageuniversityofkerala.com › ...PDF Ancient Mines and Metal Processing Activities in Shekhawati Region of ...
- https://pages.ucsd.edu › arch › meta... Ancient Metallurgy. An Overview for College Students
- http://ancientindianwisdom.com › Ancient Indias Development in Metallurgy
- https://www.encyclopedia.com › Metallurgy through the Ages
- kosmossociety.chs.harvard.edu
- https://www.earthsystems.com › A Brief History of Mining

Course learning outcomes :

- The study of ancient mining, metallurgy, and geoheritage can lead to various outcomes:
- Historical and Archaeological Discoveries: Researchers may uncover new insights into ancient mining techniques, metallurgical processes, and the organization of ancient societies, enriching our understanding of the past.
- Conservation and Preservation: The subject promotes the preservation and protection of valuable mining sites, ancient metallurgical remains, and geological features, ensuring they are conserved for future generations.
- The subject raises awareness of the cultural and historical significance of ancient mining and metallurgy, fostering a deeper appreciation for the achievements of past civilizations.
- Knowledge gained from studying ancient mining and metallurgy can influence policies and regulations concerning cultural heritage preservation, sustainable mining, and resource management.
- Overall, the study of ancient mining, metallurgy, and geoheritage contributes to historical knowledge, cultural appreciation, sustainable practices, and scientific advancements, benefiting society and the environment.

Code of the course	**GEO9109P**
Title of the course	**Ancient Mining and Metallurgy**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**2**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Practical**
Objectives of the Course	• **As per the objectives defined in the theory paper to develop practical skills.**
Syllabus	

Semester-4 Ancient Mining and Metallurgy

PRACTICAL

- Project work related to this DSE paper will be given to students according to the theory syllabus.

Books suggested for reading:

- Eliade, Mircea., translated from French in English Stephen Corrin; The Forge and The Crucibles, University of Chicago Press,
- Craddock, P.T., 2017, Early Indian Metallurgy, Archetype Publications; London
- Jane, Humphris and Rohren., 2013, The World of IRON; Archetype Publications, London;
- Bhardwaj, H.C., 2000, Metallurgy in Indian Archaeology; Tata Book Agency, Delhi
- Agrawal, D P., 1971, Copper-Bronze Age in India, MunshiramManoharlal, Delhi,
- Tripathi, Vibha., 1998, Archaeometallurgy in India, Sharda Publishing House, Delhi.

Suggested E-resources :

- https://www.egyankosh.ac.in › ...PDF PRECAMBRIAN OF INDIA
- https://www.rajras.in › geology › Geo-Heritage Sites in Rajasthan | National Geological Monuments
- https://pib.gov.in › printrelease Geo-Heritage Sites
- https://www.academia.edu ›Ancient Mines and Metal Processing Activities in Shekhawati Region of ...
- http://www.heritageuniversityofkerala.com › ...PDF Ancient Mines and Metal Processing Activities in Shekhawati Region of ...
- https://pages.ucsd.edu › arch › meta... Ancient Metallurgy. An Overview for College Students
- http://ancientindianwisdom.com › Ancient Indias Development in Metallurgy
- https://www.encyclopedia.com › Metallurgy through the Ages
- kosmossociety.chs.harvard.edu
- https://www.earthsystems.com › A Brief History of Mining

Course learning outcomes :

- As per the outcomes defined in the theory paper with relevance to practical aspects.

EOSE (Practical):	**80 Marks**
Practical - 45 Marks	
Viva – Voce - 15 Marks	
Record - 20 Marks	
Internal Exam -	**20 Marks**
i. Exam - 10 Marks	
ii. Assignment/ Seminar/Quiz – 10 Marks	

Code of the course	**GEO9110T**
Title of the course	**Advanced Igneous and Metamorphic Petrology**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**4**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Theory & Lecture**
The objective of the Course:	• **This is an advanced course to provide an understanding of the different groups of igneous rocks and the processes involved in their formation. This course starts with the chemistry and physics of melts and their behavior under varying temperature and pressure conditions and goes on to discuss the different kinds of igneous rocks and rock suites that form under different tectonic conditions. The application of thermodynamics to metamorphic petrology imparts the pressure and temperature of the formation of various metamorphic rocks.**

Syllabus

Semester-4 Advance Igneous and Metamorphic Petrology

Unit 1 Some Fundamental Concepts

Introduction; The Earth's interior; Origin of the Solar System and differentiation of Earth; Meteorites; P-T variations with depth; Review of mineralogy. Revision of classification of Igneous rocks.

Unit 2 Chemical Petrology

Major and minor elements in the crust; Analytical methods and results; Normative minerals; Variation diagrams using major and minor elements; Using variation diagram to model magmatic evolution; Trace element distribution; Batch melting and Rayleigh fractionation; Rare Earth Elements; Spider diagrams; Applications of trace elements to igneous systems; Geochemical criterion for distinguishing between tectonic environments; Isotopes and their applications to igneous processes.

Unit 3 Petrogenesis of Igneous Rocks in Relation to Plate Tectonics

Petrology. petrogenesis & tectonic settings of the following igneous rocks with suitable Indian examples;
(I) Felsic Igneous rocks: Granitoids, Adakites, and Sanukitoids.
(II) Mafic Igneous rocks: Basalt, Gabbro, Anorthosite.
(III) Ultramafic Igneous rocks: Peridotites, komatiites,
(IV) Alkaline rocks: carbonatites, kimberlites, lamprophyres, and Lamproites.
(V) Large igneous Provinces, layered complexes & Ophiolites.

Unit 4 Metamorphism and Plate tectonics

Principles of metasomatism and metamorphic differentiation. Anatexis and origin of migmatites. Petrogenesis of chanockites. Metamorphism in relation to plate tectonics. Paired metamorphic belt in relation to plate tectonics. Metamorphic provinces of India and their evolution with respect to orogenic cycles.

Unit 5 Thermodynamics & Metamorphic Reactions

Laws of Thermodynamics, Enthalpy, Entropy, Gibb's Free Energy, Δ G of Metamorphic Reactions (solid-solid and dehydration Reactions). Clausius-Clapeyron Equation. Application of equilibrium concept to rocks in thermodynamics. Mineral formula calculation.

Geothermobarometry. Petrogenetic grids and their application to petrological problems.
Books suggested for reading:
• Bucher, K. and Frey, M., 1984, Petrogenesis of Metamorphic Rocks, Springer Verlag. • Kretz, R., 1994, Metamorphic Crystallization, John Wiley. • Winter, J.D., 2009, Principles of Igneous and Metamorphic Petrology, 2nd ed. • Philpotts, A.R. and Ague, J.J., 2009, Principles of Igneous and Metamorphic Petrology, Cambridge University. • Bucher, K. and Grapes, R., 2010, Petrogenesis of Metamorphic Rocks, Springer. • Fry, N., 1985, Field Description of Metamorphic Rocks, New York, Geological Society of London. • Spear, F.S., 1995, Metamorphic Phase Equilibria and Pressure-Temperature-Time paths. • Turner, F.J., 1980, Metamorphic Petrology, McGraw Hill, New York. • Wood, B.J., and Fraser, D.G., 1976, Elementary thermodynamics for Geologist. Oxford University Press. • Yardley, B.W., 1989, An Introduction to Metamorphic Petrology, Longman New York. • Sharma R.S., 2016, Metamorphic Petrology: Concepts and Methods, Geological Society of India. • Thomas, H., 2005, Metamorphism and Crustal Evolution, Atlantic Publishers & Dist.
Suggested E-resources :
• http://en.wikipedia.org/wiki/Igneous_petrology • http://www.tulane.edu/~sanelson/eens212/intro&textures.htm • http://ericfdiaz.wordpress.com/an-introduction-to-igneous-petrology/ • http://en.wikipedia.org/wiki/Metamorpic_petrology
Course learning outcomes :
• At the end of the course, the successful students have developed their understanding to know the important varieties of igneous rocks and their formation and are aware of the importance of trace elements and rare earth elements in igneous petrogenesis. They have devolved ideas to distinguish between regional and other types of metamorphism and indicate the likely tectonic setting, and provide constraints on tectonic models for the formation of the crust.

Code of the course	**GEO9110P**
Title of the course	**Advanced Igneous and Metamorphic Petrology**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**2**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Practical**
The objective of the Course:	• **As per the objectives defined in the theory paper to develop practical skills.**
Syllabus	
Semester-4 Advance Igneous and Metamorphic Petrology	

PRACTICALS:

- Preparation of binary phase diagrams preparation of variation diagrams: Harkar, Larsen, Nockold and Allen, Niggli.
- Calculation of Fractionation Indices: Larsen Index, Nockolds Index, Mafic Index
- (MI), Mg- Number, Solidification Index, Felsic Index, Differentiation Index. Spider Diagram.
- Geochemical modeling to interpret various magmatic processes.
- Mathematical problem solving to estimate the Geothermometers and Geobarometers by different metamorphic reactions.

Books suggested for reading:

- Bucher, K. and Frey, M., 1984, Petrogenesis of Metamorphic Rocks, Springer Verlag.
- Kretz, R., 1994, Metamorphic Crystallization, John Wiley.
- Winter, J.D., 2009, Principles of Igneous and Metamorphic Petrology, 2nd ed.
- Philpotts, A.R. and Ague, J.J., 2009, Principles of Igneous and Metamorphic Petrology, Cambridge University.
- Bucher, K. and Grapes, R., 2010, Petrogenesis of Metamorphic Rocks, Springer.
- Fry, N., 1985, Field Description of Metamorphic Rocks, New York, Geological Society of London.
- Spear, F.S., 1995, Metamorphic Phase Equilibria and Pressure-Temperature-Time paths.
- Turner, F.J., 1980, Metamorphic Petrology, McGraw Hill, New York.
- Wood, B.J., and Fraser, D.G., 1976, Elementary thermodynamics for Geologist. Oxford University Press.
- Yardley, B.W., 1989, An Introduction to Metamorphic Petrology, Longman New York.
- Sharma R.S., 2016, Metamorphic Petrology: Concepts and Methods, Geological Society of India.
- Thomas, H., 2005, Metamorphism and Crustal Evolution, Atlantic Publishers & Dist.

Suggested E-resources :

- http://en.wikipedia.org/wiki/Igneous_petrology
- http://www.tulane.edu/~sanelson/eens212/intro&textures.htm
- http://ericfdiaz.wordpress.com/an-introduction-to-igneous-petrology/
- http://en.wikipedia.org/wiki/Metamorpic_petrology

Course learning outcomes :

- As per the outcomes defined in the theory paper with relevance to practical aspects.

EOSE (Practical):	
Practical - 45 Marks	**80 Marks**
Viva – Voce - 15 Marks	
Record - 20 Marks	
Internal Exam - i. Exam - 10 Marks ii. Assignment/ Seminar/Quiz – 10 Marks	**20 Marks**

Code of the course	**GEO9111T**
Title of the course	**Dissertation**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**4**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Special type of Course**
Objectives and Outcomes of the Course	• **Independent Students will be able to work independently on a Geological Project.**
• Dissertation can be under any subject teacher on a topic related to M.Sc. Geology and the proposed topic and plan will have to get the pre-approval of the Mentor and HoD.	

Code of the course	**GEO9111P**
Title of the course	**Dissertation**
Level of the course	**NHEQF Level 6.5**
Credit for the course	**2**
Type of the course	**Discipline Specific Elective (DSE)**
Delivery type of the course	**Special type of Course**
Objectives and Outcomes of the Course	• **Independent Students will be able to work independently on a Geological Project.**
• Dissertation can be under any subject teacher on a topic related to M.Sc. Geology and the proposed topic and plan will have to get the pre-approval of the Mentor and HoD.	