GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

M I N U T E S

of the 6th Meeting of the Standing Committee of

X ACADEMIC COUNCIL

Day & Date

Thursday, 11th May, 2023
Monday, 15th May, 2023
&
Monday, 22nd May, 2023

Time

10.00 a.m.

Conference Hall
Administrative Block
Goa University

	1. Only one major to be retained, Course Code HIS – 101 Contemporary Goa to be shifted/dropped. 2. Number of hours of the SE Course to be increased to 75 (1T+2P). 3. Minor Course and Major Course for Semester I and II should be common. 4. Uniform format to be followed for Reference/Readings indicating the year of publication, name of the publisher etc. The House authorised the Vice-Chancellor to approve the minutes with the above suggestions on behalf of the Academic Council. **(Action: Assistant Registrar Academic – PG)**
D 3.19	**Minutes of the Board of Studies in Physical Education meeting held on 10.04.2023.** The Standing Committee of the Academic Council did not approve the minutes of the Board of Studies in Physical Education meeting held on 10.04.2023. The item was deferred with the suggestion to have meeting with the concerned Dean and the Academic Division. The Chairperson was requested to incorporate the various suggestions/modifications made by the members together with the following: 1. The spelling of 'Bachelor' to be corrected in Revised practical component of B. P. Ed. Programme (Annexure II). 2. The Chairperson was requested to submit the Value-Added Courses to the Chairperson of Interdisciplinary and Transdisciplinary Studies. **(Action: Assistant Registrar Academic – PG)**
D 3.20	**Minutes of the Board of Studies in Microbiology meeting held on 12.04.2023.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Microbiology meeting held on 12.04.2023. The Chairperson was requested to incorporate the various suggestions/modifications made by the members together with the following: 1. Course Codes of the Programmes to be verified. 2. Prerequisite of the Programme to be indicated as Nil. 3. Ability Enhancement Course for Semester I and II only English subject to be retained. Similarly for Semester III and IV MIL to be retained. 4. Under Course Code MIC – 101, Unit 4, word demonstration to be deleted. 5. Course Code MIC – 102, Unit 3, C Minor Project Assignment on (any 1) Point (c) Emerging infectious disease to be deleted. 6. Semester VIII, *MIC-406 Research Methodology (4) to be shifted under Semester VII. **(Action: Assistant Registrar Academic – PG)**
D 3.21	**Minutes of the Board of Studies in Earth Science meeting held on 28.04.2023.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Earth Science meeting held on 28.04.2023. The Chairperson was requested to incorporate the various suggestions/modifications made by the members together with the following: 1. SE Courses shall be of 1 Credit of Theory and 2 Credits of Practical components.

	2. Course Codes of the Programme to be mentioned in the Structure. 3. Practical component for the course to be properly specified. 4. Minor Course should include only theory in Semester I and II. The House authorised the Vice-Chancellor to approve the minutes with the above suggestions on behalf of the Academic Council. **(Action: Assistant Registrar Academic – PG)**
D 3.22	**Minutes of the Board of Studies in Geography Meeting held on 03.04.2023.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Geography Meeting held on 03.04.2023. The Chairperson was requested to incorporate the various suggestions/modifications made by the members together with the following: 1. Credits for Course GOG-222 and GOG-223 to be specified. 2. Only One Major Course to be retained for Semester I and Semester II. 3. Dissertation to be specified as 12 Credits. 4. SE Courses shall be of 1 Credit of Theory and 2 Credits of Practical components. 5. Titles of the Courses in Semester III and IV to be verified. 6. Repetition in the Pedagogy to be deleted. 7. Word Satellite to be removed from content of the Course GOG-100. 8. Exit Course to be added at the end of the First Year and Second Year. 9. Paper to be included in Cyclone/tsunami/land slide. **(Action: Assistant Registrar Academic – PG)**
D 3.23	**Minutes of the Board of Studies in Architecture and Interior Design meeting held on 11.04.2023 and 17.04.2023.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Architecture and Interior Design meeting held on 11.04.2023 and 17.04.2023. The Chairperson was requested to incorporate the various suggestions/modifications made by the members together with the following: 1. Exit Course to be added at the end of the First Year and Second Year. 2. At least Course outcomes should be included for every Course. 3. Course IDE - 307 should be Project. 4. AE Course under Semester I and Semester II should be English. 5. Number of hours of the Courses to be verified. **(Action: Assistant Registrar Academic – PG)**
D 3.24	**Minutes of the Board of Studies in Electronics meeting held on 06.04.2023.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Electronics meeting held on 06.04.2023. The Chairperson was requested to incorporate the various suggestions/modifications made by the members together with the following: 1. Major Course ELE-101: Basic Circuit Theory and Network Analysis (3L+ 1T) and one minor course to be dropped. 2. Value Added Course to be dropped, these may be referred to Board of

Std. Com. X AC- 6
11.05.2023

GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

P R E L I M I N A R Y A G E N D A

For the 6th Meeting of the Standing Committee of

X ACADEMIC COUNCIL

Day & Date

Thursday, 11th May 2023

Time

10.00 a.m.

Venue
Council Hall
Administrative Block
Goa University

	(c).Text books and reading material as listed along with the course content of UG in Microbiology for Semester I and Semester II ii. The declaration by the Chairman, that the minutes were read out by the Chairman at the meeting itself. Date: 12.04.2023 Sd/- Place:Science Block E, SBSB. Signature of the Chairperson Part G The remarks of the Dean of the faculty i. The minutes are in order. ii. The minutes may be placed before the Academic Council with remarks if any. iii. May be recommended for approval of Academic Council. iv. Special remarks if any. Date : 12.04.2023 Sd/- Place: Office of Dean, Signature of the Dean School of Biological Sciences and Biotechnology (Back to Index)
D 3.21	**Minutes of the Board of Studies in Earth Science meeting held on 28.04.2023.** **Part A.** i. Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level: **(a) The Board approved the titles of the courses of the Undergraduate (UG) program as per the framework provided by the University under NEP 2020 (Annexure I). Refer page No. 656** **(b) The Board approved the syllabus of the courses of Semester I and II of the Undergraduate (UG) program as per the framework provided by the University (Annexure II Refer page No.660).** ii. Recommendations regarding courses of study in the subject or group of subjects postgraduate level: **The Board approved the interchange of Course Codes of the courses of PG (Applied Geology) program (Annexure III Refer page No.671).** **Part B** i. Scheme of Examinations at undergraduate level: **NIL** ii. Panel of examiners for different examinations at the undergraduate level: **NIL** iii. Scheme of Examinations at postgraduate level: **NIL** iv. Panel of examiners for different examinations at post-graduate level: NIL **Part C** i. Recommendations regarding preparation and publication of selection of reading material in the subject or group of subjects and the names of the persons recommended for appointment to make the selection: **NIL** **Part D** i. Recommendations regarding general academic requirements in the Departments of

	University or affiliated colleges: **NIL** ii. Recommendations of the Academic Audit Committee and status there of: **NIL** **Part E** i. Recommendations of the text books for the course of study at undergraduatelevel: **(Annexure II)** ii. Recommendations of the text books for the course of study at post graduate level: (**Annexure III)** **Part F.** <u>Important points for consideration/approval of Academic Council</u> i. The important points/recommendations of BoS that require consideration/approval of Academic Council (points to be highlighted) as mentioned below **(a) Approval of the titles of the courses of the Undergraduate (UG) program as per the framework provided by the University under NEP 2020.** **(b) Approval of the syllabus of the courses of Semester I and II of the Undergraduate (UG) program as per the framework provided by the University.** **(c) Approval of the interchange of Course Codes of the courses of PG (Applied Geology) program.** ii. The declaration by the chairman that the minutes were read out by the Chairman at the meeting itself. **The minutes were read and confirmed.** Date: 8/04/2023 Place:Taleigao Plateau Sd/- Signature of the Chairman **Part G**. The Remarks of the Dean of the Faculty i. The minutes are in order. ii. The minutes may be placed before the Academic Council with remarks if any. iii. May be recommended for approval of Academic Council. iv. Special remarks if any Date: 28/04/2023 Place: Taleigao Plateau Sd/- Signature of the Dean **(Back to Index)**
D 3.22	**Minutes of the Board of Studies in Geography Meeting held on 03.04.2023.** **Part A**. i. Recommendations regarding courses of study in the subject or group of subjects at the Under Graduate level: Decisions: **The BoS in Geography has unanimously approved the following in its meeting held on 3rd April 2023:** **1. Attached syllabus (hard and soft copy) for Semester I to II B. A. and BSc Geography related papers to be implemented w.e.f. 2023-24 as per the Ordinance.** **2. The nomenclature, codes (Broad Framework for III to VIII Semesters) of B. A. and**

D 3.21 Minutes of the Board of Studies in Earth Science meeting held on 28.04.2023.

Annexure I

GEOLOGY SYLLABUS
For UG Degree (Honors/Honors with Research) Programmes with Single Major/Double Major/Interdisciplinary subjects/Multidisciplinary subjects

Single Major:

SEM	Major Core	Minor	MC	SEC
I	Major 1 – Introduction to Mineralogy and Petrology (4) 3 + 1	Minor 1 – Introduction to Geology (4) 3 + 1	MC 1 – The Dynamic Earth (3)	SEC 1 – Introduction to Remote sensing and Drone Photography (3) 2+1
II	Major 2 – Introduction to Mineralogy and Petrology (4) 3 + 1	Minor 2 – Introduction to Geology (4) 3 + 1	MC 2 – Physical Geology (3)	SEC 2 – Water Quality Assessment (3) 2+1
III	Major 3 - Structural Geology and Physical Geology (4) Major 4 – Principles of Stratigraphy and Palaeontology (4)	Minor 3 – Principles of Stratigraphy, Structural and Physical Geology (4)	MC 3 – Natural Hazards (3) MC 4 – Environment of Goa (3)	SEC 3 – Quality, Health, Safety and Environment (3) 2+1
IV	Major 5 – Descriptive Mineralogy (4) Major 6 – Mining Geology (4) Major 7 – Geotectonics and associated Rocks (4) Major 8 – Geology of Goa (2) Fieldwork	Minor 4 – Engineering Geology (4) (V) Or Minor 5 – Geophysical Exploration (4) (V)		
V	Major 9 – Ore Genesis / Formation (4) Major 10 – Structural Geology (4) Major 11 – Igneous Petrology (4) Major 12 – Optical Mineralogy (2)	Minor 6 – Hydrogeology (4) (V) Or Minor 7 – Gemmology (4) (V)		
VI	Major 13 – Sedimentary Petrology (4) Major 14 – Metamorphic Petrology (4)	Minor 8 – Environment Geology (4) (V) Or		

	Major 15 – Indian Stratigraphy (4) (FW)	Minor 9 – Geoheritage (4) (V) Or Minor 10 – Introduction to GIS (4) (V)		
	Major 16 – Project (4)			
VII	Major 17 – Principles of Mineralogy and Geochemistry (4)	Minor 7 - Groundwater Geology (Skilled Based Course) (4)		
	Major 18 – Structural Geology and Geotectonics			
	Major 19 – Igneous Petrology			
	Major 20 – Geological Field Mapping (Skilled Based Course) (1+3)			
VIII	Major 21 – Sedimentology	Minor 8 - Marine Geology		
	Major 22 – Metamorphic Petrology			
	Major 23 – Principles of Stratigraphy and Indian Geology			
	Major 24 – Economic Geology			

Double Major (Major Geology)

SEM	Major Core	Minor	MC	SEC
I	Major A1 – Introduction to Mineralogy and Petrology (4) 3 + 1	Minor 1 – Introduction to Geology (4) 3 + 1	MC 1 – The Dynamic Earth (3)	SEC 1 – Introduction to Remote sensing and Drone Photography (3) 2+1
II		Minor 2 – Introduction to Geology (4) 3 + 1	MC 2 – Physical Geology (3)	SEC 2 – Water Quality Assessment (3) 2+1
III	Major A2 - Structural Geology and Physical Geology (4)	Minor 3 – Principles of Stratigraphy, Structural and Physical Geology (4)	MC 3 – Natural Hazards (3) MC 4 – Environment of Goa (3)	SEC 3 – Quality, Health, Safety and Environment (3) 2+1
IV	Major A3 – Principles of Stratigraphy and Palaeontology (4)	Minor 4 – Engineering Geology (4) (V)		
	Major A4 - Descriptive			

	Mineralogy (4) Major A5 - Geology of Goa (2) Fieldwork	Or Minor 5 – Geophysical Exploration (4) (V)		
V	Major A6 – Structural Geology (4) Major A7 – Igneous Petrology (4) Major A8 – Optical Mineralogy (2)	Minor 6 – Hydrogeology (4) (V) Or Minor 7 – Gemmology (4) (V)		
VI	Major A9 – Sedimentary and Metamorphic Petrology Major A10 - Project	Minor 8 – Environment Geology (4) (V) Or Minor 9 – Geoheritage (4) (V) Or Minor 10 – Introduction to GIS (4) (V)		
VII	Major A11 – Geological Field Mapping (Skilled Based Course) (1+3) Major A12 – Research Methodology	Minor 7 - Groundwater Geology (Skilled Based Course) (4)		
VIII	Major A13 – Principles of Stratigraphy and Indian Geology *Dissertation (12)*	Minor 8 - Marine Geology		

Double Major (Minor Geology)

SEM	Major Core	Minor	MC	SEC
I		Minor 1 – Introduction to Geology (4) 3 + 1	MC 1 – The Dynamic Earth (3)	SEC 1 – Introduction to Remote sensing and Drone Photography (3) 2+1
II	Major B1 – Introduction to Mineralogy and Petrology (4) 3 + 1	Minor 2 – Introduction to Geology (4) 3 + 1	MC 2 – Physical Geology (3)	SEC 2 – Water Quality Assessment (3) 2+1

III	Major B2 - Structural Geology and Physical Geology (4)	Minor 3 – Principles of Stratigraphy, Structural and Physical Geology (4)	MC 3 – Natural Hazards (3) MC 4 – Environment of Goa (3)	SEC 3 – Quality, Health, Safety and Environment (3) 2+1
IV	Major B3 - Descriptive Mineralogy (4)	Minor 4 – Engineering Geology (4) (V) Or Minor 5 – Geophysical Exploration (4) (V)		
V	Major B4 – Igneous Petrology (4)	Minor 6 – Hydrogeology (4) (V) Or Minor 7 – Gemmology (4) (V)		
VI	Major B5 – Sedimentary and Metamorphic Petrology Major B6 – Principles of Stratigraphy and Palaeontology (4)	Minor 8 – Environment Geology (4) (V) Or Minor 9 – Geoheritage (4) (V) Or Minor 10 – Introduction to GIS (4) (V)		
VII	Major B7 - Structural Geology (4) Major B8 – Geological Field Mapping (Skilled Based Course) (1+3)	Minor 7 - Groundwater Geology (Skilled Based Course) (4)		
VIII		Minor 8 - Marine Geology		

(Back to Index) (Back to Agenda)

Annexure II

GEOLOGY SYLLABUS
For UG Degree (Honors/Honors with Research) Programmes
with Single Major/Double Major

Major 1 (SEM I and SEM II)
Name of the Programme: UG Degree Geology (Honors) Programme with Single/Double Major
Course Code: GEO 100
Title of the Course: Introduction to Mineralogy and Petrology
Number of Credits: 4 (3 Theory + 1 Practical)
Effective from AY: 2023-24

Pre-requisites for the course:	Passed HSSC (Std. XII) Examination	
Course Objectives:	1. To discuss the origin, shape, and size of the Earth. 2. To explain the concepts of continental drift and plate tectonics. 3. To demonstrate the symmetry in crystals 4. To describe minerals and rocks using physical properties.	
Content:	Introduction to Geology; Applications and Career opportunities in Geosciences. Introduction to Planetary Geology, Origin of the earth: Nebular Hypothesis; Shape, Size, Structure of the earth, Introduction to Plate Tectonics	**(5 Hours)**
	Elementary Crystallography and Mineralogy: Scope and importance, states of matter, crystalline state, atomic arrangement in crystals. External characteristics of crystals, face, form, interfacial angles, law of constancy of interfacial angles.—Goniometers, crystal symmetry, classification of crystals, crystallographic axes and systems, parameters and indices, study of the normal symmetry classes. Applications of crystal properties. Physical properties of minerals, colour, streak, lustre, diaphaneity, cleavage, fracture, form, habit, hardness, specific gravity, electrical and magnetic properties. Introduction of common rock - forming minerals: quartz, feldspar, micas, pyroxenes, amphiboles and olivine.	**(15 hours)**

	Petrology: Scope and importance of Petrology, Rocks: their classification into three broad classes, igneous, sedimentary and metamorphic, Rock Cycle. Igneous Rocks: plutonic hypabyssal and volcanic types. Forms, structures and textures. Bowen's Reaction series. Classification based on grain size and mineral composition. Mineralization. Sedimentary Rocks: Structures, Textures and Classification of Sedimentary Rocks. Depositional Environments. Metamorphic Rocks: agents of metamorphism, types of metamorphism, fabric and Classification of Metamorphic Rocks.	**(25 Hours)**
	PRACTICAL **Crystallography, Mineralogy and Petrology** 1. Study of 15 crystal models. 2. Identification and description of the physical properties, compositions, occurrence and uses of 20 common minerals. 3. Systematic description and Identification of 20 common rocks. 4. Field Work: All the students shall undertake geological field work to study the local geology under the guidance of a teacher. Each student shall maintain a field diary and write a geological report. The minimum time spent in the field should be 15 hours.	**(30 hours)**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	● Videos ● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments
References/Readings:	1. Singh, P. (1978). A textbook of engineering and general geology (3rd ed.). S. Chand & Company Ltd. 2. Grotzinger, J. P., & Jordan, T. H. (2020). Understanding Earth. Macmillan Learning. 3. Monroe, J. S., & Wicander, R. (2015). The changing earth: Exploring Geology and Evolution. Cengage Learning. 4. Mukherjee, P. K., (2013). A Textbook of Geology. World Press. 5. Holmes, A. (2013). Principles of Physical Geology. Routledge.	

	6. Rutley, F. (2019). Rutley's Mineralogy. Routledge. 7. Klein, C., & Hurlbut, C. S. Jr. (2021). Dana manual of mineralogy. Wiley. 8. Lutgens, F. K., Tarbuck, E. J., & Tasa, D. G. (2021). Essentials of geology (13th ed.). Pearson. 9. Marshak, S. (2015). Earth science (14th ed.). John Wiley & Sons. 10. Blyth, F. G. H., & de Freitas, M. H. (2018). Geology for engineers (3rd ed.). CRC Press.
Course Outcome:	At the end of the course the student will be able to: 1. Differentiate the layers of the Earth based on their structure and composition. (CL2) 2. Identify minerals based on their physical properties. (CL3) 3. Deduce the symmetry of crystals. (CL4) 4. Categorize rocks based on their properties. (CL4)

(Back to Index) (Back to Agenda)

Minor 1 (SEM I and SEM II)

Name of the Programme: UG Degree Geology (Honors) Programme with Single /Double Major
Course Code: GEO 111
Title of the Course: Introduction to Geology
Number of Credits: 4 (3 Theory + 1 Practical)
Effective from AY: 2023-24

Pre-requisites for the course:	Passed HSSC (Std. XII) Examination	
Course Objectives:	1. To discuss the origin and various components of earth system. 2. To describe minerals and rocks using physical properties.	
Content:	Introduction to Geology; Applications and Career opportunities in Geosciences. Origin, Shape, Size and internal structure of the earth. Introduction to Plate Tectonics	**(5 Hours)**
	The Earth System: Atmosphere: Structure and Composition, Hydrosphere: Occurrence and distribution of water, Hydrological Cycle, Biosphere: Evolution of life through geologic time, Cryosphere, Geosphere: Minerals and Rocks	**(10 hours)**
	Introduction to Minerals and Rocks: Physical and crystallographic properties of minerals, colour, streak, lustre, diaphaneity, cleavage, fracture, form, habit, hardness, specific gravity and crystal system. Uses of Minerals. Introduction of common rock – forming minerals: quartz, feldspar, micas, pyroxenes, amphiboles and olivine	**(10 hours)**

	Scope and importance of Petrology, Rocks: their classification into three broad classes, igneous, sedimentary and metamorphic, Rock Cycle. Igneous Rocks: Mode of occurrence, Forms, structures and textures. Bowen's Reaction series. Classification based on grain size and mineral composition. Sedimentary Rocks: Structures, textures and classification Metamorphic Rocks: Agents of metamorphism, types of metamorphism, fabric and classification	**(20 hours)**
	PRACTICAL 1. Identification and description of the physical properties, compositions, occurrence and uses of 20 common minerals. 2. Description, Identification, Classification and uses of 20 common rocks. 3. Field Work: All the students shall undertake geological field work to study the local geology under the guidance of a teacher. Each student shall maintain a field diary and write a geological report. The minimum time spent in the field should be 15 hours.	**(30 Hours)**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz ● Videos ● Group Discussion ● Field Visits ● Assignments	
References/ Readings:	1. Singh, P. (1978). A textbook of engineering and general geology (3rd ed.). S. Chand & Company Ltd. 2. Grotzinger, J. P., & Jordan, T. H. (2020). Understanding Earth. Macmillan Learning. 3. Monroe, J. S., & Wicander, R. (2015). The Changing Earth: exploring geology and evolution. Cengage Learning. 4. Mukherjee. P. K. (2013). A Textbook of Geology. 5. Holmes, A. (2013). Principles of Physical Geology. Routledge. 6. Rutley, F. (2019). Rutley's Mineralogy. Routledge. 7. Klein, C., & Hurlbut, C. S. Jr. (2021). Dana manual of mineralogy. Wiley. 8. Lutgens, F. K., Tarbuck, E. J., & Tasa, D. G. (2021). Essentials of Geology (13th ed.). Pearson.	

	9. Marshak, S. (2015). Earth science (14th ed.). John Wiley & Sons. 10. Blyth, F. G. H., & de Freitas, M. H. (2018). Geology for engineers (3rd ed.). CRC Press.
Course Outcome:	At the end of the course the student will be able to: 1. Distinguish between the layers of the earth based on the structure and composition (CL2) 2. Explain the Earth System (CL2) 3. Identify the minerals based on their physical properties (CL3) 4. Categorize different rock types (CL4)

(Back to Index) (Back to Agenda)

MC 1 (SEM I)
Name of the Programme: UG Degree Geology (Honors) Programme with Single/Double Major
Course Code: GEO 131
Title of the Course: The Dynamic Earth
Number of Credits: 3
Effective from AY: 2023-24

Pre-requisites for the course:	Passed HSSC (Std. XII) Examination	
Course Objectives:	1. To discuss the origin and various components of earth system. 2. To explain geologic time. 3. To describe minerals and rocks using physical properties.	
Content	Introduction to Geology; Applications and Career opportunities in Geosciences. Introduction to the Dynamic Earth System. Overview of Earth's systems: Atmosphere, Biosphere, Hydrosphere, Geosphere. Origin, shape, size, Internal Structure and composition of the Earth. Earth's Magnetism.	**15 hours**
	Plate Tectonics and Continental Drift, Evolution of Himalayas. Volcanoes and Earthquakes. Geologic Time and Evolution of Life. Relative and absolute dating.	**15 hours**
	Introduction to minerals and their uses. Introduction to Igneous, Sedimentary and Metamorphic Rocks and their uses. Minerals and Rocks of Goa.	**15 hours**
Pedagogy:	• Chalk and Board • PPT and Practical demonstration of Mineral and Rock	• Class Quiz • Videos • Group Discussion

	Specimens	• Assignments
References/Readings:	1. Singh, P. (1978). A textbook of engineering and general geology (3rd ed.). S. Chand & Company Ltd. 2. Lutgens, F. K., Tarbuck, E. J., & Tasa, D. (2021). Essentials of geology. Pearson. 3. Marshak, S. (2015). Earth: Portrait of a planet (5th ed.). W. W. Norton & Company. 4. Marshak, S., & Rauber, R. (2017). Earth Science. W.W. Norton & Company. 5. Plummer, C. C., Carlson, D. H., & Hammersley, L. (2015). Physical geology. New York: McGraw-Hill Education. 6. Carlson, D. H., Plummer, C. C., & McGeary, D. (2016). Earth revealed. McGraw-Hill Education. 7. Thompson, J. R., & Turk, J. (2017). Introduction to Physical Geology. Pearson. 8. Dessai, A. G. (2018). Geology and Mineral Resources of Goa. New Delhi Publishers.	
Course Outcome:	1. At the end of the course the students will be able to: 2. Differentiate between the layers of the earth based on the structure and composition (CL2) 3. Relate the occurrence of earthquakes and volcanoes with plate tectonics. (CL3) 4. Identify various minerals and rocks (CL3)	

(Back to Index) (Back to Agenda)

MC 2 (SEM II)
Name of the Programme: UG Degree Geology (Honors) Programme with Single/Double Major
Course Code: GEO 132
Title of the Course: Physical Geology
Number of Credits: 3
Effective from AY: 2023-24

Pre-requisites for the course:	Passed HSSC (Std. XII) Examination
Course Objectives:	1. To describe the major relief features of the Earth. 2. To discuss the various geological processes that operate on and near the surface of the Earth. 3. To explain the formation of different landforms.

<table>
<tr><td rowspan="3">Content</td><td>Scope and importance, Major relief features of the Earth, Characteristic features of mountain, plateaus and plains, general relief features of the ocean floor. Hypsographic curve, Isostasy.
Present is key to the past – Principle of Uniformitarianism</td><td>15 hours</td></tr>
<tr><td>Weathering and Erosion - physical, chemical and biological. Rivers: development of a typical river system, source and surface flow, erosion, transport, deposition and associated landforms.
Geological work of groundwater and Karst topography</td><td>15 hours</td></tr>
<tr><td>Glaciers: types and movements, formation and morphology, erosion, transport, deposition and resulting landforms.
Wind: erosion, transport and deposition and resulting landforms, types of deserts and dunes, loess.
Oceans and seas: Waves and currents, erosion, transport, deposition and resulting landforms.</td><td>15 hours</td></tr>
<tr><td>Pedagogy:</td><td colspan="2">● Chalk and Board
● PPT and Practical demonstration
● Class Quiz
● Videos
● Group Discussion</td></tr>
<tr><td>References/Readings :</td><td colspan="2">1. Singh, P. (2010). Engineering and general geology. S. K. Kataria & Sons.
2. Holmes, A. (2017). Physical Geology. Wiley.
3. Condie, K.C. (2015). Plate tectonics and crustal evolution. Oxford: Butterworth-Heinemann.
4. Plummer, C. C., & McGeary, D. (2015). Physical Geology (15th ed.). McGraw-Hill.
5. Tarbuck, E. J., & Lutgens, F. K. (2017). The Earth: An Introduction to Physical Geology (12th ed.). Pearson.
6. Grotzinger, J. P., & Jordan, T. H. (2014). Understanding the Earth (7th ed.). W. H. Freeman.
7. Monroe, J. S., & Wicander, R. (2017). The Changing Earth: Exploring Geology and Evolution (7th ed.). Cengage Learning.
8. Carlson, D. H., Plummer, C. C., & Hammersley, L. (2019). Physical Geology (16th ed.). McGraw-Hill.
9. Livard, D. A. (2016). Satellite Geology and Geomorphology (2nd ed.). Springer.
10. Thompson, G. W., & Turk, J. T. (2017). Introduction to Physical</td></tr>
</table>

	Geology (2nd ed.). Pearson. 11. Tucker, M. E. (2016). Field Geology (6th ed.). Wiley-Blackwell. 12. Compton, R. R. (1985). Field Geology (2nd ed.). Wiley.
Course Outcome:	At the end of the course the student will be able to: 1. Recognize the major relief features of the earth based on their characteristics. (CL2) 2. Identify the landforms. (CL3)

(Back to Index) (Back to Agenda)

SEC 1 (SEM I)
Name of the Programme: UG Degree Geology (Honors) Programme with Single/Double Major
Course Code: GEO 141
Title of the Course: Remote Sensing and Drone Photography
Number of Credits: 3 (2 Theory + 1 Practical)
Effective from AY: 2023-24

Pre-requisites for the course:	Passed HSSC (Std. XII) Examination	
Course Objectives:	1. To describe the remote sensing process. 2. To explain the applications of remote sensing in various fields.	
Content	Remote Sensing: Definition, scope and limitations. Elements of Remote Sensing, active and passive sensing. Electromagnetic radiation (EMR), Interaction of EMR with atmosphere and earth surface. Remote Sensing Platforms, Satellites: geostationary, geosynchronous and sun-synchronous satellites, types of sensors. Resolutions: spatial, spectral, radiometric, temporal resolutions. Global and Indian space missions.	**15 hours**
	Introduction to drone photography: History of drone photography, Applications of drone photography: Environmental monitoring, Geological studies, Agriculture; Types of drones and their features. Drone technology and equipment: Drone components and operation, Camera and gimbal systems, Remote control and mobile app. Legal and ethical considerations: Drone regulations and licensing, Privacy and property rights, Safety and ethical considerations.	**15 hours**
	PRACTICAL: Interpretation of Aerial Photos and Satellite Images Hands-on training on Drone Photography	**30 hours**

Pedagogy:	• Chalk and Board • PPT and Practical demonstration	• Class Quiz • Videos • Group Discussion
References/ Readings:	1. Reed, B. (2019). Physical principles of remote sensing. Cambridge University Press 2. Lillesand, T. M., & Kiefer, R. W. (2018). Remote sensing and image interpretation. John Wiley & Sons. 3. Gupta, R. P. (2013). Remote sensing geology. Springer. 4. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2020). Remote sensing and image interpretation. John Wiley & Sons. 5. Pande, P. C. (1987). Principles and applications of photogeology. IBH. 6. Miller, M. M., & Miller, J. D. (2014). Photogeology. Springer Science & Business Media. 7. Moffitt, F. H., & Mikhail, E. M. (2010). Photogrammetry. Wiley. 8. Carroll, M. (2019). Drone photography basics: Your guide to the sky. Skyhorse Publishing. 9. Hall, C. (2018). The drone photography handbook: Capture stunning aerial photos and videos with your drone. Ilex Press. 10. Hall, M. (2018). Aerial photography and videography using drones. CRC Press. 11. LaRue, M. A. (2018). Introduction to drone photography: Learn how to take stunning aerial photos and videos. Skyhorse Publishing.	
Course Outcome:	At the end of the course the student will be able to: 1. Demonstrate EMR interactions. (CL2) 2. Analyse the applications of satellites and sensors. (CL4) 3. Identify ground features using aerial photos and satellite images. (CL3) 4. Operate a drone according to proper procedures and safety measures. (CL3)	

(Back to Index) (Back to Agenda)

SEC 2 (SEM II)
Name of the Programme: UG Degree Geology (Honors) Programme with Single/Double Major
Course Code: GEO 142
Title of the Course: Water Quality Assessment

Number of Credits: 3 (2 Theory + 1 Practical)
Effective from AY: 2023-24

Pre-requisites for the course:	Passed HSSC (Std. XII) Examination	
Course Objectives:	1. To explain the occurrence and distribution of water on Earth. 2. To discuss the water quality parameters and standards. 3. To recognize the sources of water pollution, types of pollutants and their effects on human health and ecosystems.	
Content	Introduction, hydrologic cycle. Precipitation, runoff, evapotranspiration, infiltration, groundwater recharge: measuring instruments and methods. Occurrence of water, surface and groundwater. Water quality parameters and WHO and BIS standards.	**15 hours**
	Water Quality Assessment: Methods of estimation of important quality parameters: Temperature, pH, Electrical Conductivity, Hardness, Turbidity. Water pollution: sources of pollution, Point and non-point sources, major water pollutants and toxic pollutants, Microbiological pollution. Sea water intrusion, eutrophication and biomagnification. Remediation. Water Quality Issues in India: Problems - Arsenic and Fluoride pollution in India, Causes and Mitigation including case studies.	**15 hours**
	PRACTICAL: Water sampling and sampling techniques. Creation of geotagged inventory of water bodies. Estimation of Water Quality Parameters: pH, Electrical Conductivity, TDS, Rapid Test for E. coli Graphical Representation of water quality parameters: Collin's Bar Graph, Stiff's Polygon, Piper's Trilinear Diagram. Calculation of Water quality parameters: Total Hardness, TDS. Visit to a water purification plant or laboratory facility where water is tested.	**30 hours**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration ● Class Quiz ● Videos ● Group Discussion	
References/ Readings:	1. Hiscock, K. M., & Bense, V. F. (2014). Hydrogeology: Principles and Practice. John Wiley & Sons. 2. David, T. (2008). Fundamentals of Hydrology. In Routledge eBooks. Informa. https://doi.org/10.4324/9780203933664	

	3. WHO (1993b). Guidelines for Drinking-water Quality. World Health Organization. 4. BIS (2001). Bureau of Indian Standards Catalogue, 2001. 5. Raghunath, H. M. (2007). Ground Water. New Age International. 6. Fetter, CW., Bowing, T & Kreamer, D (2018): Contaminant Hydrogeology, Waveland. 7. Dessai, A. G. (2023). Environment, Resources and Sustainable Tourism: Goa as a Case Study (Advances in Geographical and Environmental Sciences). (1st Ed). Springer Verlag.
Course Outcome:	At the end of the course the student will be able to: 1. Describe the hydrologic cycle and its components. (CL2) 2. Identify point and non-point sources of pollution (CL 3) 3. Test important water quality parameters in field and in laboratory (CL4) 4. Illustrate water quality data graphically (CL3)

(Back to Index) (Back to Agenda)

Annexure III

M.Sc. in Applied Geology Program Structure and Syllabus
(With effect from academic year 2022-2023)

Semester I

Discipline Specific Core

Course Code	Course Title	L-P (Hours/week)	Credits (s)	Page Number
GEO-500	Principles of Mineralogy and Geochemistry	3-0	3	2
GEO-501	Practical of Principles of Mineralogy and Geochemistry	0-2	1	4
GEO-502	Structural Geology and Geotectonics	3-0	3	5
GEO-503	Practical of Structural Geology	0-2	1	7
GEO-504	Igneous Petrology	3-0	3	8
GEO-505	Practical of Igneous Petrology	0-2	1	10
GEO-506	Geological Field Mapping (Skilled Based Course)	1-0	1	11
GEO-507	Geological Field Mapping (practical)(Skilled Based Course)	0-3	3	12
Discipline Specific Elective (DSE)				
GEO-521	Marine Geology	3-0	3	16
GEO-522	Practical of Marine Geology	0-2	1	18
GEO-523	Groundwater Geology(Skilled Based Course)	3-0	3	20
GEO-524	Practical of Groundwater Geology (Skilled Based Course)	0-2	1	22

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-500
Title of the Course: Principles of Mineralogy and Geochemistry
No of Credits: 03
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	This course addresses the concepts of crystal chemistry, mineralogy, geochemistry and isotope geology. Further it also provides an insight on the origin of the earth, distribution of elements, evolution of minerals and also to understand geological processes that are necessarily inaccessible to observe directly.	
Content:	**Module 1: Crystal chemistry:** Ionic radii, co-ordination of ions, Pauling's Rules, different types of chemical bonding, crystal growth, crystal defects, external and internal symmetry, XRD: powder and single crystal diffraction. Twinning, Polymorphism and pseudomorphism. Mineral stability and phase diagram, two component eutectic systems, incongruent melting, solid solution system, exsolution. **Module 2: Mineralogy:** Mineral evolution, Biological-mineralogical interactions, Medical mineralogy. Composition, structure, Chemistry and paragenesis of the mineral groups: Olivine, Pyroxene, Amphibole, Mica, Feldspar, Garnet, Sulphide, Sulphate, Carbonate and Oxides. Optical mineralogy: Study of isotropic and anisotropic minerals under convergent light. Working principles of XRD, ICPMS, Spectroscopy, SEM, X-ray tomography. **Module 3: Geochemistry:** Introduction and scope of geochemistry, geochemical classification of elements, distribution and behavior of major, trace elements and REE in igneous, sedimentary and metamorphic processes and products. Introduction to isotope geochemistry: Elements of nuclear systematics, introduction to isotopes and their properties. Introduction to Meteorites, origin, composition, classification and mineral constituents of meteorites.	15 hours 15 hours 15 hours
Pedagogy:	Lectures/ tutorials/assignments/field study/discussion	
References/Readings	1. Deer, W. A., Howie, R. A., and Zussman, J. (1992). *An introduction to the rock-forming minerals.* 2nd ed. Harlow, Essex, England. New York, NY. Longman Scientific and Technical. 2. Klein, C., Hurlbut, C. S., and Dana, J. D. (1999). *Manual*	

	of mineralogy: (after James D. Dana). New York: J. Wiley. 3. Winchell, A. N. (1991). *Elements of optical mineralogy: An introduction to microscopic petrography*. New York. Wiley. 4. Nesse W. (2012*). Introduction to Optical Mineralogy.4th ed.* Oxford University Press 5. Kerr, P. F. (1977). *Optical mineralogy*. New York. McGraw-Hill Book Co. 6. Mason B., and Moore C.B. (1982). *Principles of geochemistry*. 4th ed. Chichester John Wiley 7. Krauskopf, K. B., and Bird, D. K. (1995). *Introduction to geochemistry*. New York. McGraw-Hill 8. Klein, C., and Dutrow, B. (2007). *Manual of mineral science*. New York. John Wiley and sons ltd 9. Mason, B., and Moore, C. B. (1982). *Principles of geochemistry*. New York. Wiley. 10. Walther, J. V. (2009). *Essentials of geochemistry*. Sudbury, Mass. Jones and Bartlett Publishers. 11. White, W. M. (2014). *Isotope Geochemistry*. Hoboken. Wiley. 12. Faure, G. (1986). *Principles of isotope geology. Second edition*. John Wiley and Sons Inc., New York, NY 13. Dyar, M. D., and Gunter, M. E. (2008). *Mineralogy and optical mineralogy*. Chantilly. Mineralogical Society of America.	
Course outcomes	1. Students will able to understand about earth as a whole with detail emphasis on elemental distribution. 2. students will able to do thorough study on crystal chemistry 3. students will acquire indepth knowledge about mantle processes	

	4. Students will able to learn about mineral evolution in detail.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-501
Title of the Course: Practical of Principles of Mineralogy and Geochemistry
No of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	This course deals with the megascopic and petrographic identification of minerals. And thereafter also deals with the use of instruments (Spectrophotometer, flame photometer) for analyses of different chemical constituents in water/soil/rocks.	
Content:	**Module 1:** Observing and recording properties of representative minerals in hand specimens. **Module 2:** Observation and recording of optical properties of rock forming minerals. **Module 3:** Determination of different chemical constituents in water/soil/rock using flame photometer and spectrophotometer. Reading of plots/graphs. **Module 4:** Numerical problems on partition coefficient, calculation of isotope ratios.	30 hours
Pedagogy:	Megascopic and microscopic identification of minerals/Demonstrations/Laboratory experiments/Plotting and Interpretations.	
References/Readings	1. Mackenzie, W. S. (2015). *Atlas of the rock-forming minerals in thin section*. Routledge. 2. Barker, A. J. (2017). *A key for identification of rock-forming minerals in thin section* 3. Deer, W. A., Howie, R. A., and Zussman, J. (1992). *An introduction to the rock-forming minerals.* 2nd ed. Harlow, Essex, England. New York, NY. Longman Scientific and Technical. 4. Khandpur, R. S. (2006). *Handbook of analytical instruments*. New York, N.Y. McGraw-Hill Education LL	
Course outcomes	1. Technique to identify minerals using physical and optical properties 2. students will develop analytical skills to determine the concentrations of various chemical parameters in	

	water/soil/rock.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-502
Title of the Course: Structural Geology and Geotectonics
No of Credits: 03
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	To provide a conceptual understanding of deformation processes and mechanisms at different levels in the Earth's lithosphere and their effects at different scales from regional to microscopic. Students will also be introduced to plate tectonics and tectonic processes in the context of major tectonic features present in different tectonic environments.	
Content:	**Module 1: Introduction to Deformation and Rock Mechanics** Components of deformation, Strain in 1D, 2D and 3D, strain ellipsoid, Pure shear and simple shear, progressive deformation, strain analysis. Introduction to stress, deviatoric and mean stress, Mohr Circle diagram. Rheology: elastic, viscous and plastic deformation, rheologic stratification of the lithosphere. Deformation microstructures and mechanisms, recovery and recrystallization. Fractures: brittle deformation mechanisms, failure and fracture criteria, types of fractures and joints. **Module 2: Fault and Fold Mechanics** Faults: Characteristics of faults and fault planes, movement mechanisms, role of fluids, brittle versus ductile faults, mylonites, shear sense indicators, shear zone kinematics. Folds: Mechanisms of folding, kinematic models of folding, Ramsay's classification of folds, superposed folding, occurrence and recognition. Cleavage and foliations. Linear structures and their interpretation. An overview of structures in contractional and extensional regimes with field examples. **Module 3: Geotectonics** Fundamental concepts of Geotectonics, Isostasy and geoid. Continental drift, Sea floor spreading, paleomagnetism and Plate tectonics. Supercontinent cycles. Volcanic and seismic belts of the Earth. Major tectonic features in intraplate settings and at convergent, divergent and transform plate margins.	15 hours 15 hours 15 hours
Pedagogy	Lectures/ tutorials/ assignments/ self-study	

References/ Readings	1. Condie, K. C. (2013). *Plate tectonics and crustal evolution*. Elsevier. 2. Davis, G.H. and Reynolds, S.J. (1996). *Structural Geology of rocks and regions*, John Wiley and Sons. 3. Fossen, H. (2010). *Structural Geology*, Cambridge University Press. 4. Ghosh, S.K. (1993). *Structural Geology: Fundamentals, and modern developments*, Pergamon Press. 5. Means, W. D., and Williams, P. F. (1976). *An outline of structural geology*. John Wiley. 6. Passhier, C. and Trouw, R.A.J. (2005). *Microtectonics*. Springer, Berlin. 7. Pollard, D.D. and Fletcher, R.C. (2005). *Fundamentals of structural geology*, Cambridge University Press. 8. Ramsay, J.G and Huber, M.I. (1983). *Techniques of Modern Structural Geology: Vol. I and II*, Academic Press. 9. Ramsay, J.G. (1967). *Folding and Fracturing of Rocks*, McGraw-Hill Book Company, New York. 10. Turcotte, D.L., and Schubert, G. (2002). *Geodynamics*. Cambridge University Press. 11. Twiss, R.J. and Moores, E.M. (2007). *Structural Geology*. Freeman. 12. Van der Pluijm, B.A. and Marshak, S. (2004). *Earth structure: an introduction to structural geology and tectonics*, W.W. Norton and Company Ltd. 13. Windley, B.F. (1996). *The evolving continents*. Oceanographic Literature Review, 8(43), 785.
Course outcomes	1. Students will acquire a comprehensive understanding of how rocks deform at different scales 2. Students will be able to relate stress to strain in rocks and quantitatively measure strain. 3. Students will acquire in depth understanding of brittle and ductile deformation 4. Students will be able to relate deformation with the tectonic processes responsible for the formation of the different tectonic features present within the Earth's lithosphere.

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-503
Title of the Course: Practical of Structural Geology and Geotectonics
No of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	This course deals with solving geologic maps, structural problems and description of structural data in rocks.	
Content:	**Module 1:** Completion of outcrops. **Module 2:** Preparation and interpretation of geological maps and sections, Structural problems concerning economic deposits . **Module 3:** Recording and plotting of the field data, stereographic projections. Petro-fabric analysis and study of deformed structures in hand specimens. **Module 4:** Strain estimation from the data already collected from the field. . **Module 5:** Study and interpretation of structures from photographs and satellite imagery.	30 Hours
Pedagogy:	Demonstrations /Laboratory observations / Plotting and Interpretations	
References/Readings	1. Davis, G.H. and Reynolds, S.J. (1996). *Structural Geology of rocks and regions*, John Wiley and Sons. Marshak, S., and Mitra, G. (1988). *Basic methods of Structural geology*. Prentice Hall. Rowland, S.M., Duebendorfer, E. and Schiefelbein, I.M. (2007). *Structural analysis and synthesis: a laboratory course in structural geology*, Blackwell Pub.	
Course outcomes	1. The students will be familiar with the common ways to measure and represent data from structurally deformed rocks 2. Students will be able to solve structural maps and problems related to economic geology.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-504
Title of the Course: Igneous Petrology
No of Credits: 03
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	The main objective of this course is to get students acquainted with a wide range of igneous rocks and their corresponding geological settings.	
Content:	**Module 1:** Introduction to Magmas and Magmatic Processes; Process of formation and description of Textures and Structures of volcanic and plutonic rocks; Classification of igneous rocks: modal, chemical, quasi-chemical-schemes: their merits and demerits. Working principles of XRF, EPMA. **Module 2:** Composition of the mantle; Enriched- and Depleted-mantle and their characteristics; Magma generation: Heat source and the factors responsible to bring about melting, Fractional melting, Batch melting and Zone melting; Magmatic Evolution; Magmatic differentiation: crystal fractionation, gravitational differentiation, flowage differentiation, filter pressing, liquid immiscibility; Magmatic assimilation, Magma Mixing and contamination. **Module 3:** Magma Associations in relation to Plate Tectonics: continental flood basalts such as the Deccan Traps, Paranas, Karoo; Mid Ocean Ridge Basalts, Ocean Island basalts, Continental as well as ocean Arc magmatism; Alpine type intrusions and Ophiolites; Alkaline rocks- Nephelinites and Ijolites, Lamprophyres and Lamproites, Carbonatites and Kimberlites; Granites and Granitic rocks, I-type, S-type, A-type and M-type granites, anatexis and Granitization; Anorthosites. Continental Layered Intrusions: Mineralogical and Petrological characteristics with special reference to the Bushveld, Skaergaard, Stillwater Complexes.	15 hours 15 hours 15 hours
Pedagogy:	Lectures/ tutorials/ assignments/ self-study	
References/ Readings	1. Barker, F. (Ed.). (2013). *Trondhjemites, dacites, and related rocks*. Elsevier 2. Best and Christainsen (2002). *Igneous Petrology Daly: Petrology of Igneous Rocks*. 3. Dawson, J. B. (2012). *Kimberlites and their xenoliths* (Vol. 15). Springer Science and Business Media. 4. Middlemost, E. A. (1986). *Magmas and magmatic rocks: an introduction to igneous petrology*. 5. Moorhouse, W. W. (1959). *The study of rocks in thin sections: by WW Moorhouse*. Harper. 6. Philpotts, A. R., and Ague, J. J. (2022). *Principles of igneous and metamorphic petrology*. Cambridge University Press.	

	7. Rock, N. M. (2013). *Lamprophyres*. Springer Science and Business Media. 8. Wager, L. R., and Brown, G. M. (1967). *Layered igneous rocks*. WH Freeman. 9. Williams, T., and Turner, F. J. Gilbert (1954): *Petrography*. 10. Wilson, M. (Ed.). (1989). *Igneous petrogenesis*. Dordrecht: Springer Netherlands. 11. Winter, J. D. (2013). *Principles of igneous and metamorphic petrology*. Pearson education. 12. Woolley, A. R. (2019, September). *Alkaline Rocks and Carbonatites of the World, Part 4: Antarctica, Asia and Europe (excluding the former USSR), Australasia and Oceanic Islands*. Geological Society of London.	
Course outcomes	1. The students will develop skills, to identifying a wide range of igneous rocks 2. The students will understand the processes of formation of the rocks. 3. The students will learn to identify the corresponding geological settings. 4. The student can apply the knowledge to understand the magmatic evolution	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-505
Title of the Course: Practical of Igneous Petrology
No of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	The main objective of this course is to get students acquainted with identification of rocks in hand specimens and petrographic thin section.	
Content:	**Module 1:** Study of the textures and structures and identification of rocks in hand specimens. **Module 2:** Characterization of the following suites of rocks from micro-sections: ultramafic rocks, mafic igneous rocks, intermediate rocks, granitic rocks and alkaline igneous rocks. **Module 3:** CIPW normative calculations of minerals based on available compositional data using excel sheet. **Module 4:** Applications of trace elements in igneous petrology,	30 hours

	such as spider diagrams, REE distribution patterns and implications in deducing origin, source and evolution of magma, and tectonic diagrams-trace element ratio plots.	
Pedagogy:	It is a practical component and the entire course is taught in the laboratory.	
References/ Readings	1. Howie, R. A., Zussman, J., and Deer, W. (1992). *An introduction to the rock-forming minerals* (p. 696). London, UK. Longman. 2. Hutchinson, C.S. (1974). *Laboratory handbook of petrographic techniques*. New York. 3. Nesse, W. D. (2012). *Introduction to mineralogy* (No. 549 NES). 4. Phillips, W. R., and Griffen, D. T. (1981). *Optical mineralogy: The nonopaque minerals*. 5. Turner, F. J., and Howel. and Gilbert William (Charles M.). (1965). *Petrography; an Introduction to the Study of Rocks in Thin Section*. Vakils, Feffer and Simons.	
Course outcomes	1. The students will develop skills, to identifying minerals and other phases and thus identify the rock 2. The students will understand the geologic occurrence of the rocks 3. They will be able to infer the processes of formation and environmental conditions from the mineral assemblage, texture, and tectonic setting.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-506
Title of the Course: Geological Field Mapping (Theory)
No of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	The main objective of this course is to give students the hands on experience in the field to understand the lithology structure and their plates in Stratigraphy besides getting a thorough knowledge of field mapping.	
Content:	Theoretical knowledge and use of clinometer compass and brunton compass. Detailed Stratigraphy and representative locations of the field study area will be discussed, The students will be taught the techniques of geological mapping, field data	15 hours

	collection: recording the attitude of beds, foliation, lineation, joints and their analysis. Use of GPS, DGPS, GNSS for spatial data collection.	
Pedagogy:	Lectures and familiarity with clinometer and brunton compass as well topographic maps.	
References/ Readings	1. Mehr S.S., (1991) *Geology of Gujarat* Geological Society of India, 1. Radharishnan B.P. and Vaidhyanadhan R., (1977). *Geology of Karnataka*, Geological Society of India. 2. Radharishnan B.P. and Vaidhyanadhan R., (1977). *Geology of Karnataka*, Geological Society of India. 3. Raman, P.K. and Murty, V. N. (2012). Geological Society of India.. 4. Roy, A.B and Jakhar, S.R. (2012). *Geology of Rajasthan (North-West India-Precambriam to Recent)* Scientific Publishers, 5. Sinha Roy. (1991). *Geology of Rajasthan*, Geological Society of India.	
Course outcomes	1. The students will be familiar with common field techniques. 2. Learn to use the clinometer and brunton compass. 3. To use geological maps	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-507
Title of the Course: Geological Field Mapping (Practical)(Skill Based Course)
No of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	The main objective of this course is to give students the hands on experience in the field to understand the lithology structure and their plates in Stratigraphy besides getting a thorough knowledge of field mapping.	
Content:	The students will be taught the techniques of geological mapping, field data collection: recording the attitude of beds, foliation, lineation, joints and their analysis. Use of GPS, DGPS, GNSS for spatial data collection. Sampling of rocks, preparation of geological field report. The record of data will be maintained	90 hours

	in a field-diary. This work will be carried out under the supervision of teachers who will accompany the students during the course of the field-traverse. There will be a viva-voce examination based on the field report.	
Pedagogy:	Lectures and on-field Training.	
References/ Readings	1. *Geology of Gujarat*, Mehr S.S., Geological Society of India, 1991. 2. *Geology of Karnataka*, Radharishnan B.P. and Vaidhyanadhan R., Geological Society of India. 1977. 3. *Geology of Rajasthan*, S. Sinha Roy. Geological Society of India.1991. 4. Geology of Rajasthan (North-West India-Precambriam to Recent) A.B Roy and S.R. Jakhar. Scientific Publishers, 2012. 5. *Geology of Andhra Pradesh*. P.K. Raman and V. N. Murty, Geological Society of India. 2012. 6. *Field Guide Book of Geology of Kutch (Kachchh) Basin, Gujarat, India*. 7. *Geology and Mineral Resources of Goa*. A.G. Dessai 8. *Geology of Maharashtra* Second Edition. G.G. Deshpande and Pitale U. L. Geological Society of India. 2012.	
Course outcomes	1. The students will be able to identify the various rocks. 2. The study of their structures will help in deciphering the processes of formation and tectonics. 3. They will be able to prepare geological map based on their observations in the field 4. They will get an idea to write a detailed technical report of the study area.	

(Back to Index) (Back to Agenda)

Discipline Specific Elective (DSE)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-521
Title of the Course: Marine Geology
No of Credits: 03
Effective from AY: 2022-23

Prerequisites for the	Degree of Bachelor of Science in Geology from any UGC recognized

course:	University or an equivalent examination.	
Objective:	To provide a conceptual understanding of marine processes, landforms, marine minerals, methods of geo-physical surveys for sea-bed mapping and coastal zone management.	
Content:	**Module I** Introduction and scope of marine geology, coastal zone and coastline classifications, beach and beach landforms, oceanic profile and landform features, morphologic and tectonic domain of the ocean floor, origin of oceanic crust, marine sediment and classification, ocean tectonics. Coastal surveys including beach profiling, Exclusive Economic Zone, concept and causes of sea level changes and measurements, Holocene sea level curves and future projections, Introduction to paleo-beaches and paleo-oceanography, coastal geomorphology and coastal tectonic framework of India. **Module II** Classification of marine mineral deposits, origin and depositional system of marine resources, beach placers, shelf deposits, phosphorites, gas hydrates, hydrocarbon deposits, sulphate deposits, hydro-thermal deposits, polymetallic nodules, reserves and economics of marine resources with special reference to India. Introduction to marine geophysics, methods of geophysical surveys for seabed mapping and mineral exploration; Introduction to marine geochemistry, laboratory methods for sample analyses; Introduction to isotope geology and geochronology. **Module III** Coastal zone management, coastal erosion and protection measures, coastal natural disasters and management, salt water intrusion and submarine ground water discharge, marine spatial planning, coastal zone regulation and acts, the law of the seas.	15 hours 15 hours 15 hours
Pedagogy:	Lectures/ tutorials/assignments/field study/discussion	
References/Readings	1. Shepard, *Submarine Geology*, Third Edition. 2. Kuenen, P. *Marine Geology*, 2008, John Wiley. 3. Cuchlaine A.M.King, *Introduction to Marine Geology and Geomorphology* 4. M.J.Keen*, Introduction to Marine Geology*, Elsevier.	

	5. James Kennet, *Marine Geology*, 1982, Prentice Hall 6. Chester and Jickells, 2012, *Marine Geochemistry*, Wiley 7. Roy-Barman and Jeandel, 2016, *Marine Geochemistry*, Oxford University Press. 8. Jones, *Marine Geophysics*, 1999, John Wiley and Sons Inc	
Course outcomes	1. students will able to explain the coastal processes and landforms 2. detail understanding on processes of mineral formation 3. students will acquire indepth knowledge about ocean tectonics 4. students will learn in detail about coastal zone management and remedial measures.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-522
Title of the Course: Practical of Marine Geology
No of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	To provide a conceptual understanding of identification of marine minerals and preparing profiles of beaches, coastal landforms and ocean features.	
Content:	Study of marine minerals in hand specimen and under microscopy, identification of micro fossils, granolometric analysis, beach profile mapping and beach survey, preparation of coastal geomorphology map from satellite images, understanding the maps relating to of ocean morphometry, resources and tectonics.	30 hours
Pedagogy:	Lectures/ tutorials/assignments/field study/discussion	
References/Readings	1. Michael J. Kennish *Practical Handbook of Marine Science, Fourth Edition,* CRC Press. 2. Mackenzie, W. S. (2015). *Atlas of the rock-forming minerals in thin section*. Routledge.	

Course outcomes	1. Students will learn to prepare profile of the beaches 2. students will able to identify marine minerals 3. field visits will help the students to observe different coastal landforms and ocean features.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-223
Title of the Course: Groundwater Geology (Skill Based Course)
No of Credits: 03
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	To understand occurrence and circulation of groundwater To study the functioning, methods and problems related to Groundwater.	
Content:	**Module 1: Introduction:** Genetic classification of water, GLEbal distribution of water. Hydrologic cycle: Precipitation, runoff, infiltration and evapotranspiration. Historical developments in science of hydrogeology. Vertical distribution of sub surface water, classification of aquifers and confining layers, hydraulic properties of aquifers, water table fluctuations. Concepts of drainage and groundwater basins. Water table and piezometric surface. **Module 2: Well Hydraulics and well designs**: Theory of groundwater flow, Darcy's law, its validity and applications, determination of permeability in laboratory and in field. Types of wells, drilling methods, construction, design, development and maintenance of wells. Specific capacity and its determination steady and unsteady and radial flow conditions. Pumping tests-methods, data analysis and interpretations. Rainwater Harvesting and conservation. **Module 3: Groundwater Chemistry, Contamination and occurrence:** Groundwater Chemistry: Groundwater quality- physical, chemical, biological properties of water quality criteria for different uses, graphical presentation of water quality data. Groundwater contamination. Problems of arsenic and fluoride in India. Saline water intrusion and Sub-marine Groundwater Discharge (SGD) in coastal aquifers and its modelling. Classification of rocks with respect to their water bearing characteristics, aquifer modelling and groundwater provinces of India. Groundwater exploration techniques.	15 hours 15 hours 15 hours
Pedagogy:	Lectures / Assignments / Seminars/ Self-study	
References/ Readings	1. Mays, L. W., and Todd, D. K. (2005). *Groundwater Hydrology.* John Wily	

	and Sons, Inc., Arizona State University, Third addition. 2. Fetter, C. W. (2018). *Applied hydrogeology*. Waveland Press. 3. Hiscock, K. M., and Bense, V. F. (2021). *Hydrogeology: principles and practice*. John Wiley and Sons. 4. Raghunath, H. M., and Raghunath, H. M. (2007). *Ground water*. New Age International (P) Limited Publishers. 5. Davis, S. N., and De Wiest, R. J. (1966). *Hydrogeology* New York: Wiley.	
Course outcomes	1. Students will understand the natural occurrence and circulation of surface and groundwater. 2. Learn about different types of aquifers and their relation to the groundwater flow and quality. 3. Identify problems related to water pollution and precautionary measures. 4. Understand use of various techniques in exploration of water.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-224
Title of the Course: Practical of Groundwater Geology (Skill Based Course)
No of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	To make use principles of groundwater movement and well hydraulics to solve problems related to groundwater flow and hydraulic parameters	
Content:	**Module 1:** Exercises on Groundwater flownet construction and interpretations of equipotential line and groundwater flow direction, interaction between various surface water, movement of contaminants related to groundwater flow. **Module 2:** Problem related to aquifer parameters such as hydraulic conductivity, transmissivity and specific yield. Analysis of aquifer test data; Theis method, Jacob-cooper method and chows method. Problem solving on groundwater recharge and groundwater volume. **Module 3:** Problems related to wells under various aquifer conditions. Graphical plotting and interpretation of chemical quality data of waters: Hill piper diagram, Schoeller diagram,	30 hours
Pedagogy:	Lectures / Self-study	

References/ Readings	1. Mays, L. W., and Todd, D. K. (2005). *Groundwater Hydrology.* John Wily and Sons, Inc., Arizona State University, Third addition. 2. Raghunath, H. M., and Raghunath, H. M. (2007). *Ground water*. New Age International (P) Limited Publishers. Fetter, C. W. (2018). *Applied hydrogeology*. Waveland Press.	
Course outcomes	1. Students will understand about the natural occurrence and circulation of groundwater. 2. Learn about different types of aquifers and its relation to the groundwater flow. 3. Solve problems related to groundwater flow. 4. Understand groundwater quality and its relation with different lithologies associated.	

(Back to Index) (Back to Agenda)

M.Sc. in Applied Geology Program structure and syllabus
(with effect from Academic year 2022-2023)

Semester II

Discipline Specific Course (DSC)

Course Code	Course Title	L-P (Hours/week)	Credits (s)	Page Number
GEO-510	Sedimentology	3-0	3	20
GEO-511	Practical of Sedimentology	0-2	1	22
GEO-512	Metamorphic Petrology	3-0	3	24
GEO-513	Practical of Metamorphic Petrology	0-2	1	26
GEO-514	Principles and Stratigraphy and Indian Geology	3-0	3	27
GEO-515	Practical of Principles and Stratigraphy and Indian Geology	0-2	1	29
GEO-516	Economic Geology	3-0	3	30
GEO-517	Practical of Economic Geology	0-2	1	32
	Discipline Specific Elective (DSE)			
GEO-525	Exploration Geophysics	3-0	3	33
GEO-526	Practical of Exploration Geophysics	0-2	1	35
GEO-527	Petroleum Geology(Skill Based Course)	3-0	3	36
GEO-528	Practical of Petroleum Geology (Skill Based Course)	0-2	1	37

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-510
Title of the Course: Sedimentology
No of Credits: 03
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	To understand the different processes operating in sediment formation, transportation and deposition. To impart a detailed knowledge of different types of sedimentary rocks, their origin and applications. To understand different types of depositional environments.	
Content:	**Module 1: Sedimentary processes** Introduction to sedimentology, distribution of sedimentary rocks in time and space and their applications. Weathering: Types and their products, soils and paleosols. Transportation and Deposition: Fundamentals of fluid flow, particle transport by fluid and by sediment gravity flows. Textures and structures of sedimentary rocks, their origin. **Module 2: Sedimentary rocks** Petrography, classification and provenance of: Terrigenous/clastic sedimentary rocks: ConGLEmerates, sandstones and mud rocks. Carbonate rocks: Limestones and dolomites. Evaporites, silicious, phosphatic, iron and manganese-rich sedimentary rocks. **Module 3: Depositional environments** Introduction and classification of: Terrestrial environment: fluvial system, eolian desert system, lacustrine system and glacial system. Marine environment: Deltaic system, beach and barriers island system, estuarine system, lagoonal system, tidal flat system; shelf and deep water environment.	15 hours 15 hours 15 hours
Pedagogy:	Lectures, Case studies, Discussions and Assignments.	
References/ Readings	1. Pettijohn, F. J. (1975). *Sedimentary rocks* (Vol. 3, p. 628). New York: Harper and Row. 2. Collinson, J. (2006). *Sedimentary structures*. Dunedin Academic Press Ltd. 3. Nichols, G. (2009). *Sedimentology and stratigraphy*. John Wiley and Sons. 4. Prothero, D.R. and Schwab, F. (2013). *Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy.* W.H. Freeman, 3rd Edition. 5. Selley, R. C. (2000). *Applied sedimentology*. Elsevier.2nd Edition.	

	6. Tucker, M. E. (2001). *Sedimentary petrology: an introduction to the origin of sedimentary rocks*. John Wiley and Sons. 3rd Edition. 7. Boggs, S. (2006). *Principles of sedimentology and stratigraphy*. Pearson Prentice Hall. 4th Edition. 8. Boggs Jr, S., and Boggs, S. (2009). *Petrology of sedimentary rocks*. Cambridge university press. 2nd Edition. 9. Greensmith, J. T. (1978). *Petrology of the sedimentary rocks*. Textbook of petrology Vol. 2.	
Course outcomes	1. The concepts of sediment formation and various processes involved in transportation and deposition. 2. Thorough knowledge on textures and structures exhibited by sedimentary rocks. 3. Detail understanding of the sedimentary rocks. 4. Infer various depositional environments and origin of diverse rock types.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-511
Title of the Course: Practical of Sedimentology
No of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	To assess the grain size and grain size parameters by different methods. To identify and characterize sedimentary rocks at mega and microscopic scales. To study sedimentary textures, structures, and paleocurrent methods for environmental reconstructions.	
Content:	**Module 1:** Granulometric analysis: Textural analyses of sediments, plotting of grain size data and statistical analyses and interpretation. **Module 2:** Palaeocurrent analysis: Exercises using sets of directional data to understand spatial variation in vectorial data. **Module 3:** Study of hand specimens: Megascopic identification of sedimentary rocks, observation of texture, structure and diagenetic changes; inferences on depositional environment. **Module 4:** Study of thin sections: Microscopic identification of sedimentary rocks, observation of texture, mineralogy and	30 hours

	diagenetic changes. **Module 5:** Heavy mineral analysis.	
Pedagogy:	Lectures, problem solving, hands on experience in megascopic and microscopic identification of rocks and discussions.	
References/ Readings	1. Lindholm, R. (1987). *A practical approach to sedimentology*. Springer Science and Business Media. 2. Prothero, D.R. and Schwab, F. (2013). *Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy.* W.H. Freeman, 3rd Edition. 3. Selley, R. C. (2000). *Applied sedimentology*. Elsevier. 2nd Edition. 4. Tucker, M. E. (2001). *Sedimentary petrology: an introduction to the origin of sedimentary rocks*. John Wiley and Sons. 3rd Edition. 5. Boggs, S. (2006). *Principles of sedimentology and stratigraphy.* Pearson Prentice Hall. 4th Edition. 6. Boggs Jr, S., and Boggs, S. (2009). *Petrology of sedimentary rocks*. Cambridge University Press. 2nd Edition. 7. Tucker, M. E. (2011). *Sedimentary rocks in the field: a practical guide (Vol. 38).* John Wiley and Sons. 8. Adams, A. E., MacKenzie, W. S., and Guilford, C. (2017). *Atlas of sedimentary rocks under the microscope*. Routledge.	
Course outcomes	1. Thorough knowledge on textures and structures exhibited by sedimentary rocks. 2. Detail understanding of the sedimentary rocks. 3. Interpretation of sedimentary processes based on the composition of the rock and sedimentary structures.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-512
Title of the Course: Metamorphic Petrology
No of Credits: 03
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.

Objective:	To provide a conceptual understanding of metamorphism, and metamorphic rocks encompassing the chemical and physical transformations that take place in response to changing pressure, temperature, and chemical environments, including different petrogenetic processes involving mineral reactions and equilibrium thermodynamics.	
Content:	**Module 1:** Introduction, Types, Facies and Textures of metamorphic rocks: Definitions, factors and conditions of metamorphism; pressure and temperature limits of metamorphism; Types of metamorphism - orogenic metamorphism, ocean-floor metamorphism, regional metamorphism, contact metamorphism, cataclastic metamorphism, hydrothermal metamorphism, other types of small-scale metamorphism. Facies and facies series; Zones of Metamorphism; Concept and origin of isograds; General characteristics of contact and regional metamorphic rocks; Classification and types of textures; Interpretation of porphyroblast–inclusion relations.	15 hours
	Module 2: Introduction to Elementary Thermodynamics Related to Mineral Science: Concept of equilibrium in metamorphic systems; Gibbs phase rule and Mineralogical Phase Rule and their application in simple and complex systems. First law of thermodynamics, second law of thermodynamics- definition of entropy, third law of thermodynamics, thermodynamic equations, free energy of formation of minerals at any temperature and pressure, free energy surface in G–T–P–X space, free energy of ideal and non-ideal solutions, the regular solution model, equilibrium constant of a reaction and its relation with Gibbs free energy; Introduction to geothermobarometry.	15 hours
	Module 3: Metamorphic Reactions, Chemographic Projections and Progressive metamorphism in pelitic, carbonate and mafic rocks: Different types of metamorphic reactions, reactions among solid-phase components, reactions involving volatiles as reacting species, controls of pressure, temperature and chemical compositions on the metamorphic reactions, time scale of metamorphism; ACF, AKF and AFM diagrams; Progressive metamorphism in pelitic, carbonate and mafic rocks; Metamorphism in the context of plate tectonics	15 hours
Pedagogy	Lectures/ tutorials/ assignments/ self-study	
References/ Readings	1. Winter, J. D. (2010). *An Introduction to Igneous and Metamorphic Petrology* (2nd Edition), Pearson Education, Inc. 2. Philpotts, A., and Ague, J. (2009). *Principles of Igneous and Metamorphic Petrology* (2nd ed.). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511813429.	

	3. Bucher, K., and Grapes, R. (2011). *Petrogenesis of Metamorphic Rocks* (8th Edition), Springer. 4. Best, M. (2002). *Igneous and metamorphic petrology* (2nd Edition). Blackwell Science Ltd. 5. Frost, R., and Frost, C., (2014). *Essentials of Igneous and Metamorphic Petrology.* Cambridge University Press, New York. 6. Vernon, R., (2018). *A Practical guide to Rock Microstructure* (2nd Ed.), Cambridge University Press, https://doi.org/10.1017/9781108654609. 7. Winkler, H.G.F., (1979). *Metamorphic petrogenesis* (5th Ed.). Springer-Verlag, New York. 8. Spear, F., (1993). *Metamorphic Phase Equilibria and Pressure-Temperature-Time paths*. Mineralogical Society of America, Washington, D.C.
Course outcomes	1. Students will acquire a comprehensive understanding of metamorphism and types of metamorphic rocks 2. Students will learn thermodynamic principles related to metamorphic petrology, applicable to a number of orogenic events in time and space 3. Students will be able to estimate Pressure-Temperature conditions of metamorphic rocks especially those formed during orogenesis.

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-513
Title of the Course: Practical of Metamorphic Petrology
No of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.
Objective:	The main objective of this course is to get students acquainted with identification of metamorphic rocks in hand specimens and petrographic thin section and to identify fabric forming processes.

Content:	Identification of typical metamorphic minerals in hand specimen and thin section. Description, identification and classification of commonly occurring metamorphic rocks in hand specimen and thin section. Description of fabrics and textures of common metamorphic rocks in hand specimen and thin section.	30 hours
Pedagogy:	It is a practical component and entire course is taught in the laboratory.	
References/ Readings	1. Yardley, B. W., MacKenzie, W. S., and Guilford, C. (1997). *Atlas of metamorphic rocks and their textures*. Longman. 2. Vernon, R. H. (2018). *A practical guide to rock microstructure*. Cambridge University Press. 3. Dana, E. S., and Ford, W. E. (1952). *Dana's textbook of mineralogy*. Wiley Easstern Limited 4. Winter, J. D. (2010). *An Introduction to Igneous and Metamorphic Petrology* (2nd Edition), Pearson Education, Inc. 5. Phillips W. R. and Griffen, D.T. (1981). *Optical Mineralogy: The Non-opaque Minerals*. W. H. Freeman and Co., Ltd. New York.	
Course outcomes	1. The students will develop skills to identify metamorphic minerals and rocks 2. Students will be able to understand their geologic occurrence and infer the processes of formation and environmental conditions from the mineral assemblage, texture, and tectonic setting.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-514
Title of the Course: Principles and Stratigraphy and Indian Geology
No of Credits: 03
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.
Objective:	To understand the stratigraphic principles by which standards in stratigraphy are developed. To understand deposition and emplacement of different stratigraphic units in India and its evolution through time.

Content:	**Module 1:** Introduction: Stratigraphic principles and their applications. Evolution of Stratigraphic column. Stratigraphic (Lithostratigrapic, Chronostratigraphic and Biostratigraphic) nomenclature and their inter-relationships. Palaeomagnetism and time correlation. Concepts of Magnetostratigraphy, Seismic stratigraphy, Chemostratigraphy and Event stratigraphy. **Module 2:** Stratigraphy of India: Cratons and mobile belts, Archaean-Proterozoic boundary. Important Proterozoic basins of India. Precambrian/Cambrian boundary, Palaeozoic rocks in Himalayas. Mesozoic of Peninsular and extra peninsular India. K-T boundary. Paleocene Eocene Thermal Maxima (PETM), Cenozoic successions, Quaternary and Holocene stratigraphy. **Module 3:** Important Stratigraphic Units of India: Stratigraphy of Gondwana Supergroup with special emphasis on fossils, climate and economic important minerals. Deccan Volcanic Province, its distribution and lithological characteristics. Siwalik: Classification, significant vertebrate fauna and its basin evolution. Geology of Goa.	15 hours 15 hours 15 hours
Pedagogy:	Lectures / Assignments / Seminars/ Self-study	
References/ Readings	1. Ramakrishnan, M., and Vaidyanadhan, R. (2010). Geology of India (vol. 1 and 2). *GSI Publications*, *2*(1). 2. Naqvi, S. M., and Rogers, J. J. W. (1987). *Precambrian geology of India*. Oxford University Press, USA. 3. Krumbein, W. C. (2013). *Stratigraphy and sedimentation*. aearpeman company. 4. Prothero, D. R., and Schwab, F. (2004). Sedimentary geology. Macmillan. 5. Boggs, S. (2012). Principles of sedimentology and stratigraphy. 6. Fetter, C. W. (2018). *Applied hydrogeology*. Waveland Press. 7. Salvador, A. (Ed.). (1994). International stratigraphic guide: a guide to stratigraphic classification, terminology, and procedure (No. 30). Geological Society of America	
Course outcomes	1. Students will understand the principles of stratigraphy and techniques in correlation. 2. Learn about different types of cratons, mobile belts and proterozoic basins in India. 3. Understand the Phanerozoic eon, its rock distribution in India and evolution of life.	

	4. Learn about major geological events and its relation to basin evolution, climatic condition and mass extinction.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-515
Title of the Course: Practical of Principles and Stratigraphy and Indian Geology
No of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	To make use of stratigraphic principles in correlation with different stratigraphic units and to understand the location and distribution of different stratigraphic units in India.	
Content:	**Module 1:** Study of rocks in hand specimens from Indian stratigraphic horizons and type localities. **Module 2:** Exercises on stratigraphic classification and correlation. Preparation of stratigraphic range charts. **Module 3:** Study of geological map of India and identification of major stratigraphic units. Locating/drawing of stratigraphic units in outline map of Goa and India.	30 hours
Pedagogy:	Lectures / Seminars/ Self-study	
References/Readings	1. Krishnan, M. S. (1982) *Geology of India and Burma*, CBS Publishers, Delhi 2. Doyle, P. and Bennett, M. R. (1996) *Unlocking the Stratigraphic Record*. John Wiley 3. Ramakrishnan, M. and Vaidyanadhan, R. (2008) *Geology of India* Volumes 1 and 2, Geological Society of India, Bangalore.	
Course outcomes	1. Students will understand the principles of stratigraphy and its use. 2. Learn about different techniques which are used in correlation . 3. The students will get acquainted with distribution of important Groups and Supergroups in India. 4. Learn about important lithological characteristic association with different formations in India.	

(Back to Index) (Back to Agenda)

Discipline Specific Elective (DSE)
Name of Programme: M. Sc. Applied Geology
Course Code: GEO-516
Title of the Course: Economic Geology
No of Credits: 03
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	To provide a conceptual understanding of economic minerals, processes involving formation of economic mineral, economic importance of economic minerals	
Content:	**Module 1:** Introduction: scope of economic geology Mineral economics. Ore, tenor, gangue, resource, reserves Texture and structures of ore deposits. Classification of ore deposits. **Module 2:** Ore bearing fluids: type, nature, chemistry Physico-chemical controls of ore deposition Wall-rock alteration. Controls of ore localization. Distribution of ore deposits in relation to plate tectonic settings. Magmatic and hydrothermal deposits. **Module 3:** Ore Deposits of India (Banded Iron Formations; Iron ore deposits; Manganese ore deposits; Polymetallic ore deposits: copper, lead, zinc; Chromite deposits; Laterite and Bauxite deposits: distribution in India and genesis; Asbestos deposits of India; Barite deposits; Gold in India; Diamond deposits. Offshore and deep sea deposits. Mineral deposits of Goa.	15 hours 15 hours 15 hours
Pedagogy:	Lectures/ tutorials/assignments/field study/discussion	
References/Readings	1. Guilbert, J. M., & Park Jr, C. F. (2007). *The geology of ore deposits*. Waveland Press. 2. Jensen, M. L., & Bateman, A. M. (1991). *Economic Mineral Deposits* 3rd edition-Revised Printing. 3. Brown, J. C., & Dey, A. K. (1976). *Mineral and nuclear fuels of the Indian subcontinent and Burma*. 4. Roy, B. C. (1973). *Indian Mineral Resources, Industries, and Economics*. Calcutta: Editions Indian. 5. Arndt, N., Kesler, S., & Ganino, C. (2015). *Metals and society: An introduction to economic geology*. Springer. 6. Taylor, R. (2010). *Ore textures: recognition and interpretation*. Springer Science & Business Media.	
Course outcomes	1. The students will get comprehensive knowledge of	

	economic deposits. 2. They will understand the processes involved in the initiation, movement and concentration of deposits 3. The students will be able to identify potential deposits using the knowledge of this and other geological subjects.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-517
Title of the Course: Practical of Economic Geology
No of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in geology of any UGC recognized University or an examination of any other University recognized as equivalent.	
Objective:	To provide a conceptual understanding of economic minerals, processes involving formation of economic mineral, economic importance of economic minerals	
Content:	Study of representative ores, and industrial minerals in hand specimens. Preparation of charts showing the distribution of ore minerals in India. Mineralogical and textural studies of common ore minerals in incident light.	30 hours
Pedagogy:	Lectures/field study/mine visits/discussion	
References/Readings	1. Guilbert, J. M., & Park Jr, C. F. (2007). *The geology of ore deposits*. Waveland Press. 2. Ridley, J. (2013). *Ore deposit geology*. Cambridge University Press. 3. Dixon, C. J. (Ed.). (2012). *Atlas of economic mineral deposits*. Springer Science & Business Media. 4. Brown, J. C., & Dey, A. K. (1976). *Mineral and nuclear fuels of the Indian subcontinent and Burma*. 5. Roy, B. C. (1973). *Indian Mineral Resources, Industries, and Economics*. Calcutta: Editions Indian. 6. Arndt, N., Kesler, S., & Ganino, C. (2015). *Metals and society: An introduction to economic geology*. Springer. 7. Taylor, R. (2010). *Ore textures: recognition and interpretation*. Springer Science & Business Media.	

Course outcomes	1. The students will be able to identify ore bearing minerals. 2. They will get comprehensive knowledge of distribution of ore minerals in India.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-525
Title of the Course: Exploration Geophysics
No of Credits: 03
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	The main objective of this course is to get students acquainted with applications of geophysics in geology.	
Content:	**Module 1:** Introduction to exploration geophysics: Introduction to electro-magnetic spectrum, usefulness of various methods, Electrical methods: instrumentation, field procedure and interpretation using electrical methods. Electrical profiling and sounding using Wenner and Schlumberger configurations. Principles and fundamental procedures of data collection and interpretation. **Module 2:** Seismic Methods: Principles, instrumentation, survey procedures and interpretation using seismic methods. Correction applied to seismic data. Geophysical well logging: Introduction well logging methods, porosity logs, well log interpretation. Latest methods from air-borne sources including drones and helicopters. **Module 3:** Gravity and magnetic methods: Principles-field methods-gravimeters-corrections, interpretation of gravity data. Principles, instrumentation, field procedures, data analysis and interpretation of magnetic data. Principles and field application of Ground Penetrating Radar (GPR) for sub-surface studies. Data analysis and interpretation.	15 hours 15 hours 15 hours
Pedagogy:	It is a theory component and entire course is taught in the class and various case studies for the application of different geophysical methods are discussed.	

References/Readings	1. Kearey, P., Brooks, M., and Hill, I. (2002). *An introduction to geophysical exploration* (Vol. 4). John Wiley and Sons. 2. Telford, W. M., Geldart, L. P., and Sheriff, R. E. (1990). *Applied geophysics*. Cambridge university press. 3. William, L. (1997). Fundamentals of geophysics. 4. Sharma, P. V. (1985). Geophysical methods in geology. 5. Dobrin, M. B., and Savit, C. H. (1960). *Introduction to geophysical prospecting* (Vol. 4). New York: McGraw-Hill.	
Course outcomes	1. Students will get knowledge about the physical properties of the Earth. 2. The students will learn various geophysical techniques. 3. They will learn to identify and choose the technique used for locating and exploiting resources like hydrocarbons, minerals and groundwater. 4. Upon completion of this course the student will learn to analyze and interpret geophysical data.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-526
Title of the Course: Practical of Exploration Geophysics
No of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	The main objective of this course is to get students acquainted with various method of Geophysical-exploration and interpretation of the results.	
Content:	Exploration Geophysics Field survey using resistivity methods. Interpretation of resistivity data using master curves matching and digital techniques; Interpretation of seismic refraction and reflection data; Field survey using magnetometers and data interpretation; Interpretation of well logs. GPR applications and interpretations.	30 hours
Pedagogy:	It is a practical component. Case studies are discussed.	
References /Readings	1. Kearey, P., Brooks, M., and Hill, I. (2002). *An introduction to*	

	geophysical exploration (Vol. 4). John Wiley and Sons. 2. Telford, W. M., Geldart, L. P., and Sheriff, R. E. (1990). *Applied geophysics*. Cambridge university press. 3. William, L. (1997). Fundamentals of geophysics. 4. Sharma, P. V. (1985). Geophysical methods in geology. Dobrin, M. B., and Savit, C. H. (1960). *Introduction to geophysical prospecting* (Vol. 4). New York: McGraw-hill.	
Course outcomes	1. Upon completion of this course the student will learn to interpret the geophysical data. 2. The students will be able to understand the subsurface geology by using geophysical techniques.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-527
Title of the Course: Petroleum Geology (Skill Based Course)
No of Credits: 03
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized, University or an equivalent examination.	
Objective:	To provide a conceptual understanding of petroleum deposits, processes involved in the formation of these deposits and their distributions.	
Content:	Module I: Introduction to petroleum. Physical properties and chemical composition of petroleum. Module II: Origin of Petroleum. Petroleum Traps and Reservoir rocks. Primary and secondary migration and Accumulation. Module III : Petroleum exploration. Petroliferous basins of India. Oil belts of the world.	15 hours 15 hours 15 hours
Pedagogy:	Lectures/ tutorials/assignments/field study/discussion	
References/Readings	1. Selley, R.C., 1998, Elements of Petroleum Geology: W.H. Freeman & Company, New York. 2. Tissot, B.P., and Welte, D.H., 1978, Petroleum Formation and Occurrence - A New Approach to Oil and Gas Exploration: Springer -Verlag, Berlin. 3. Levorsen , A.I., 1967, Geology of Petroleum: W.H. Freeman and Company. 4. North, F.K., 1986, Petroleum Geology: Allen & UnWin, 607p.	

Course outcomes	1. Students will acquire indepth knowledge about origin of petroleum 2. Students will get comprehensive knowledge on petroleum system. 3. Students will acquire theoretical knowledge about techniques used in petroleum industry. 4. Students will get a comprehensive knowledge about the petroliferous basins of the world.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-528
Title of the Course: Practical of Petroleum Geology (Skill Based Course)
No of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	To provide a conceptual understanding of petroleum deposits, processes involved in the formation of these deposits.	
Content:	Determination of moisture content and the porosity of rocks. Determination of direction, amount of dip and of reservoirs from the given bore hole data. Interpretative contouring method for the determination of depth of oil bearing horizons. Well-log interpretation	
Pedagogy:	Megascopic and microscopic identification of minerals/Demonstrations/Laboratory experiments/Plotting and Interpretations.	
References/Readings	1. Mackenzie, W. S. (2015). *Atlas of the rock-forming minerals in thin section*. Routledge. 2. Barker, A. J. (2017). *A key for identification of rock-forming minerals in thin section* 3. Deer, W. A., Howie, R. A., and Zussman, J. (1992). *An introduction to the rock-forming minerals.* 2nd ed. Harlow, Essex, England. New York, NY. Longman Scientific and Technical. 4. Khandpur, R. S. (2006). *Handbook of analytical instruments*. New York, N.Y. McGraw-Hill Education LL	

Course outcomes	1. Students will learn the subsurface contour mapping. 2. Techniques to calculate porosity and permeability of reservoir rock. 3. Students will learn to interpret the well log data.	

(Back to Index) (Back to Agenda)

M.Sc. in Applied Geology Program Structure and Syllabus
(With effect from academic year 2023-2024)

Semester III

Course Code	Course Title	L-P (Hours/week)	Credits (s)	Page Number
Research Specific Elective (RSE)				
GEO-600	Microtectonics	3-0	3	8
GEO-601	Practical of Microtectonics	0-2	1	10
GEO-602	Basics of RS, GIS and GNSS (IIRS-ISRO online Edusat course)	3-0	3	11
GEO-603	Practical of Basics of RS, GIS and GNSS (IIRS-ISRO online Edusat course)	0-2	1	12
GEO-604	Micropaleontology	3-0	3	14
GEO-605	Practical of Micropaleontology	0-2	1	11
GEO-606	Trace Elements Geochemistry	3-0	3	15
GEO-607	Practical of Trace Elements Geochemistry	0-2	1	17
GEO -608	Industrial Training	0-2	3	18
Generic Elective Course (GE)				
GEO-621	Mining Geology	3-0	3	19
GEO-622	Practical of Mining Geology	0-2	1	21
GEO-623	Engineering Geology	3-0	3	22
GEO-624	Practical of Engineering Geology	0-2	1	24
GEO-625	Environmental Geology	3-0	3	25
GEO-626	Practical of Environmental Geology	0-2	1	27
GEO-627	Soil Science	3-0	3	28
GEO-628	Practical of Soil Science	0-2	1	29
GEO-629	Glaciology	3-0	3	30
GEO-630	Geomorphology	3-0	3	31
GEO-631	Natural Hazards and Disaster Management	3-0	3	35
GEO-632	Planetary Geology	3-0	3	37
GEO-633	Petroliferous Basins of India	3-0	3	39
GEO-634	Practical of Petroliferous Basins of India	0-2	1	41

MSC-621	Remote Sensing and its Applications	3-0	3	42
MSC-622	Remote Sensing and its Applications Practical	0-2	1	

Research Specific Elective (RSE)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-600
Title of the Course: Microtectonics
No of Credits: 03
Effective from AY: 2023-24

Prerequisites for the course:	Students should have undergone course in structural geology at MSc part I.	
Objective:	To impart knowledge of deformed rock fabrics and textures on microscales to reconstruct tectonic events.	
Content:	**Module 1** Introduction to microtectonics: Introduction to flow and deformation; progressive and finite deformation, rheology; deformation mechanisms: intracrystalline deformation, recovery, recrystallisation, grain-boundary-area reduction (GBAR), and static recrystallisation; deformation of rock-forming minerals-quartz, calcite and dolomite, feldspars, micas, olivine, pyroxenes, garnet, amphiboles. Foliation, lineation and lattice preferred orientation (LPO). **Module 2** Shear zones, microscopic shear sense indicators in mylonites, shear sense indicators in brittle regime, dilatational sites- veins, strain shadows, fringes and boundins. Primary structures in rocks. **Module 3** Nucleation and growth of porphyroblasts, porphyroblast-matrix relations, problematic porphyroblast microstructures, reaction rims, natural microgauges, special techniques and instruments used in microstructural studies. Qualitative and quantitative interpretation of microstructures and fabric elements – to deduce the tectono metamorphic history of a rock.	15 hours 15 hours 15 hours
Pedagogy	Lectures/ tutorials/ assignments/ self-study	
References/ Readings	1. Philpotts, A. R., and Ague, J. J. (2022). *Principles of igneous and metamorphic petrology*. Cambridge University Press. 2. Kornprobst, J. (2006). *Metamorphic rocks and their geodynamic significance: a petrological handbook (Vol. 12).* Springer Science & Business Media. 3. Passchier, C. W., and Trouw, R. A. (2005). *Microtectonics*. Springer Science & Business Media. 4. Trouw, R. A., Passchier, C. W., and Wiersma, D. J. (2009). *Atlas of Mylonites-and related microstructures.* Springer Science & Business Media. 5. Vernon, R. H., Vernon, R. H., and Clarke, G. L. (2008). *Principles of metamorphic petrology*. Cambridge University Press.	

	6. Vernon, R. H. (2018). *A practical guide to rock microstructure*. Cambridge university press.
Course outcomes	1. The student will be able to recognize microstructures and understand the process of formation of each. 2. The student will be able to interpret the kinematic and tectonometamorphic significance of each microstructure. 3. The student will be aware of quantitative measurements of temperature/pressure/stress undergone by rocks based on microstructures. 4. The student can apply the knowledge to understand the tectonic evolution of their own samples.

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-601
Title of the Course: Practical of Microtectonics
No of Credits: 01
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone course in structural geology at MSc part I.
Objective	To describe and interpret deformed rock fabrics and textures on microscales to reconstruct tectonic events.
Content	● Observation and recognition of diagnostic microstructures and fabric elements in rocks and minerals in thin sections ● Observation and recognition of diagnostic microstructures and fabric elements in rocks and minerals in hand specimens ● Field studies on structural aspects of faults and shear zones
Pedagogy	Practical exercises
References/ Readings	1. Trouw, R. A., Passchier, C. W., and Wiersma, D. J. (2009). *Atlas of Mylonites-and related microstructures*. Springer Science & Business Media. 2. Vernon, R. H. (2018). *A practical guide to rock microstructure*. Cambridge university press. 3. Passchier, C. W., and Trouw, R. A. (2005). *Microtectonics*. Springer Science & Business Media.
Course outcomes	1. The student will be able to recognize and interpret microstructures in thin section 2. The student will be able to recognize and interpret microstructures in hand specimen 3. The student will be able to recognize and interpret structural features of faults and shear zones in field. 4. The student can apply the knowledge to understand the tectonic evolution of their own samples.

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-602
Title of the Course: Basics of RS, GIS and GNSS (IIRS-ISRO online Edusat course)
No of Credits: 03
Effective from AY: 2023-24

Prerequisites for the course	Bachelor of Science
Objective	To provide exposure to students in gaining knowledge on concepts and applications of RS, GIS and GNSS.
Content	Content as per the IIRS-ISRO offered Course in Distance/Internet Mode using EDUSAT facility
Course Outcomes	1. The course will give an understanding of basics of GIS, remote sensing and GNSS. 2. Applications of remote sensing. 3. Students will get comprehensive understanding on the application of remote sensing and GIS in solving the research problems.

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-603
Title of the Course: Practical of Basics of RS, GIS and GNSS (IIRS-ISRO online Edusat
No of Credits: 01
Effective from AY: 2023-24

Prerequisites for the course:	Students should have undergone M.Sc. Semester I and II.
Objective:	To provide exposure to students in gaining knowledge on concepts and applications of RS, GIS and GNSS.
Content:	Content as per the IIRS-ISRO offered Course in Distance/Internet Mode using EDUSAT facility
Course Outcomes	1. Students will learn to evaluate effective sensors and advance technique required for map preparation. 2. Students will get an understanding of the application of remote sensing and GIS

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-604
Title of the Course: Micropaleontolog**y**
No of Credits: 03
Effective from AY: 2023-24

Prerequisites for the course:	Students should have undergone M.Sc. Semester I and II.
Objective:	To impart knowledge of microfossils. To provide skills on the application of microfossils in biostratigraphy, hydrocarbon exploration, understanding causes and types of bioevents, paleoclimate and

	paleoceanography.	
Content:	**Module 1** Scope of micropaleontology, methods of exploring deep Ocean, Ocean drilling programs, introduction to important deep sea drilling vessels, sample processing techniques and idea about equipment like mass spectrometer, scanning electron microscope and stereo zoom binocular microscope which are used for micropaleontological studies.	15 hours
	Module 2 Calcareous microfossils: Planktic and benthic foraminifera, their biogeography, morphology, calcareous nanofossils. Application of foraminifera in stratigraphy with special reference to Jurassic, Cretaceous and Tertiary periods in India. Siliceous microfossils: Radiolaria, diatoms and silicoflagellates, their morphology and biogeography. Phosphatic microfossils: Conodonts, outline of morphology and paleoecology.	15 hours
	Module 3 Application of microfossils: Application of microfossils in biostratigraphy - First Appearance Datum (FAD) and Last Appearance Datum (LAD), units of biostratigraphy and biostratigraphic correlation. Application of microfossils in understanding patterns, causes and types of global events. Micropaleontology in hydrocarbon exploration. Application of microfossils in interpretation of paleoenvironment and paleoclimate: paleo-temperature estimation and sea-level change. Application of micropaleontology in oceanography, paleogeography and engineering geology.	15 hours
Pedagogy:	Lectures, Case studies, Discussions and Assignments.	
References/ Readings	1. Armstrong, H. A., & Brasier, M. D. (2005). *Microfossils*. 296 Malden. 2. Bignot, G. (Ed.). (1985). *Elements of micropalaeontology*. Springer Science & Business Media. 3. Brasier, M. D. (1980). *Microfossils*. George Allen and Unwin. 4. Gross, M. G. (1977). *Oceanography: A view of the Earth*. Prentice Hall. 5. Haq, B. U., & Boersma, A. (Eds.). (1998). *Introduction to marine micropaleontology*. Elsevier. 6. Haslett, S. K. (Ed.). (2002). *Quaternary environmental micropalaeontology*. Oxford University Press.	

	7. Jones, R. W. (1996). *Micropalaeontology in petroleum exploration* (p. 432). Oxford: Clarendon Press. 8. Kennett, J. P., & Srinivasan, M. S. (1983). *Neogene planktonic foraminifera. A phylogenetic atlas*, *265*, 546-548. 9. Martin, R. E. (Ed.). (2000). *Environmental micropaleontology: the application of microfossils to environmental geology* (Vol. 15). Springer Science & Business Media. 10. Sinha, D. K. (2007). *Micropaleontology: application in stratigraphy and paleoceanography*. Narosa Publishing House.
Course Outcome	1. Students will get acquainted with various ocean drilling programmes and sampling strategies. 2. They will be able to identify different types of microfossils. 3. Use microfossils to decipher paleo-oceanographic changes. 4. Understanding applications of microfossils in paleoclimate.

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-605
Title of the Course: Practical of Micropaleontology
No of Credits: 01
Effective from AY: 2023-24

Prerequisites for the course:	Students should have undergone M.Sc. Semester I and II.	
Objective:	Skill development of students in sample preparation techniques, systematic study of microfossils and exercises related biostratigraphy and environmental applications.	
Content:	Extraction of microfossils from geologic formations and sediments using standard procedures for: a. Foraminifera b. Diatoms c. Silicoflagellates d. Radiolarians Study of important planktic foraminifera useful in surface water paleoceanography and oceanic biostratigraphy. Sorting, identification, morphological description and classification of microfossils.	30 hours

	Quantification of microfossils of different species.	
Pedagogy:	Practicals and exercises.	
References/Readings	1. Armstrong, H. A., & Brasier, M. D. (2005). *Microfossils*. 296 Malden. 2. Bignot, G. (Ed.). (1985). *Elements of micropalaeontology*. Springer Science & Business Media. 3. Gross, M. G. (1977). *Oceanography: A view of the Earth*. Prentice Hall. 4. Haq, B. U., & Boersma, A. (Eds.). (1998). *Introduction to marine micropaleontology*. Elsevier. 5. Sinha, D. K. (2007). *Micropaleontology: application in stratigraphy and paleoceanography*. Narosa Publishing House.	
Course outcome	1. Students will learn the technique of sample collection. 2. They will be able to process and extract the samples. 3. Analyze microfossils in qualitative and quantitative way.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-606
Title of the Course: Trace Element Geochemistry
No of Credits: 03
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester I and II.	
Objective	To provide knowledge of the concepts of trace element geochemistry, isotope geochemistry, hydro geochemistry, geological and geodynamic processes.	
Content	**Module I** Geochemistry: Historical perspective of geochemistry; Atomic properties of elements, the periodic table and geochemical classification of elements with examples; abundance of elements in the universe, bulk earth, crust, hydrosphere, atmosphere and biosphere; introduction to mineral structures and compositions; distribution and behaviour of major, minor, trace elements and REE in geological systems. Thermodynamic consideration of TE solid solutions. Nomenclature for trace element classification. Determination of partition coefficients. Fractional crystallization and melting, complex melting models.	15 hours

	Module II Isotope geochemistry: Elements of nuclear systematics, introduction to isotopes and their properties. Fundamentals of radiogenic isotope geochronometers, isotope geology of Sr, Nd and Pb and their applications. Thermochronology. Introduction to stable isotopes, studies of O, H, S, and C isotopes and their applications, cosmogenic nuclides and their applications, extinct radionuclides, analytical techniques for TE measurements. **Module III** Hydro geochemistry: Chemical properties and principles. Chemical equilibria, association and dissociation of dissolved species, mineral dissolution and solubility. Evolution of natural groundwater hydrochemical sequences and facies, graphical methods of representation of chemical data, groundwater in crystalline and sedimentary rocks, Groundwater contamination and hydrogeochemical behaviour of contaminants, measurements of parameters, sources of contamination. Rock-water interaction studies chemical interaction of rock and water at low temperatures, thermal springs chemistry, origin, interpretation of chemical data, hydrochemical exploration of mineral deposits.	15 hours 15 hours
Pedagogy	Lectures/ tutorials/assignments/field study/discussion	
References/ Readings	1. Albarede, F. (1995) *Introduction to Geochemical Modeling.* New York, NY: Cambridge University Press 2. Faure, G. and Mensing, T. M., (2005) *Isotopes: Principles and Applications*, 3rd Edn. John Wiley & Sons 3. Freeze, R.A. and Cherry, J.A. (1979) *Groundwater*. Prentice Hall 4. Gasper, E. and Onescu, M. (1972) *Radioactive tracers in hydrology.* Elsevier 5. Hiscock, K. M., & Bense, V. F. (2021). *Hydrogeology: principles and practice*. John Wiley & Sons. 6. McSween, H. Y., Jr., S. M. Richardson, and M. E. Uhle (2003). *Geochemistry: Pathways and Processes*. New York, NY: Columbia University Press. 7. Wood, B. J., and D. G. Fraser (1977). *Elementary Thermodynamics for Geologists*. New York, NY: Oxford University Press. 8. Rollinson, H. R. (1993). *Using Geochemical Data: Evaluation, Presentation, Interpretation*. Harlow, Essex, England: Longman Group 9. Sharp Zachary (2006). *Principle of Stable Isotope Geochemistry*. Prentice	

	Hall 10. Shaw, D. M. (2006) *Trace Elements in Magmas*. New York, Cambridge University Press. 11. Stumm, W. and Morgan, J.J. (1981) *Aquatic chemistry*. John Wiley & Sons 12. White, M. W. (2014). *Isotope Geochemistry*. Wiley – Blackwell
Course outcomes	1. Students will able to learn about the geochemical distribution of elements in space and time. 2. The students will be able to discuss the geochemical attributes and fingerprint different magmatic and tectonic processes involved in the origin and evolution of trace elements. 3. Techniques to use isotopic study as a tool for tracking source composition and in rock water interaction systems. 4. students will acquire indepth knowledge about hydrogeochemistry

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-607
Title of the Course: Practical of Trace Element Geochemistry
No of Credits: 01
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester I and II.	
Objective	To familiarize the students with the calculation and interpretation of trace element geochemical parameters.	
Content	Measurement of trace elements in rocks/water using AAS/spectroscopy methods. Measuring of partition coefficients, plotting of chemical data on variation diagrams, their correlation and interpretation. Geochemical interpretation of isotope data.	30 hours
Pedagogy	Practical exercises	
References/Readings	1. Ewing, G. W. and McGraw-Hill (1981) *Instrumental Methods of Chemical Analysis*, New York. 2. Freeze, R.A. and Cherry, J.A. (1979) *Groundwater.* Prentice Hall 3. Rollinson, H. R. (1993) *Using Geochemical Data: Evaluation,*	

	Presentation, Interpretation. Harlow, Essex, England: Longman Group
Course outcomes	1. student will learn the techniques to generate geochemical data 2. The students will be able to plot and interpret trace element geochemical data.

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-608
Title of the Course: Industrial Training
No of Credits: 03
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester I and II.	
Course objectives	To provide an exposure to the students to skill based training.	
Content	Hands-on training at Industry/Professional organization/National Research Labs/Well site/Mine site wherein the student/group of students is/are expected work under the guidance of a Scientist/Professional Geologist to gain experience in analytical/field methodologies, data analysis, presentation and interpretation. A report based on work will be submitted which will be evaluated by the Discipline Specific Committee.	45 hours
Pedagogy:	Skill based training	
Course Outcomes:	1. The students will be able to undertake field mapping 2. The students will be able to record the structural data and process the samples. 3. The students will be able perform data analysis. 4. Based on their observations they will be able to interpret the data.	

(Back to Index) (Back to Agenda)

Generic Elective Course (GEC)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-621
Title of the Course: Mining Geology
No of Credits: 03
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester I and II.
Objective	To introduce the students to the concepts of mining, types of mining and processes involved in winning the ore, as well as consideration of the safety, environment and laws governing mining activities.

Content	**Module 1** Introduction to mining geology and exploration methods. Role of geologists in mining. Mining methods for metal and coal mining. Outlines of surface methods of mining. Underground mining: Shaft sinking and development of mine, stoping methods, mine ventilation. Recent development in shaft sinking. **Module 2** Principles of sampling and sampling methods. Core drilling (wet and dry). Type of core bits. Casing and their applications. UNFC classification and estimation of ore reserves, using geostatistical methods, dewatering techniques in open cast and underground mines. Mineral beneficiation techniques. **Module 3** Impact of mining on environment. Pollution aspects, slope stability in open cast mines, mine gases and associated health hazards, Environment management EIA, mine reclamation. Mine evaluation, mineral economics, legislation associated with mining, National Mineral Policy, Mineral Taxation and Mine Leasing. Conservation and substitution.	15 hours 15 hours 15 hours
Pedagogy	Lectures, Case studies, Discussions and Assignments.	
References/ Readings	1. Armstrong, M. (1998). *Basic linear geostatistics*. Springer Science & Business Media. 2. Arogyaswamy, R. N. P. (1980). *Courses in mining geology*. Oxford and IBH. 3. Dhar, B. B. (2000). *Mining Environment Scenario Beyond 2001*. *Mining, Challenges of the 21st Century*, 73. 4. Evans, A. M., Barrett, W. L., Bell, T., Milsom, J., Moon, C. J., & Scott, B. C. (1993). Introduction to mineral exploration. 5. John Wiley Sons, (1964). *Elements of Mining* by Lewis, Robert Publication: New York 6. McKinstry, H. E. (1980). *Mining Geology*. Asia Publishing House. 7. Peters, W. C. (1987). *Exploration and mining geology*. 8. Saxena, N. C., Singh, G., Pathak, P., Sarkar, B. C., & Pal, A. K. (2004). *Mining Environment Management Manual*. Scientific Publishers.. 9. Sinha, Sharma (1970). *Mineral Economics*. Oxford & IBH Publishers. 10. Warhurst, Alyson .(2000). Environmental policy in mining : corporate strategy and planning for closure / by . Publication : Boca Raton : Lewis Publishers.	

	11. Youn, G. J. (1984). *Elements of Mining Geology*. McGraw Hill.
Course outcomes	1. The students will be able to understand the different types of mining. 2. They will be able to understand different sampling procedures in exploration. 3. They will get a comprehensive idea of drilling techniques. 4. They will get an overview of various mining related laws and compliances. 5. The student will understand the various health issues related to mining and environment related issues.

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-622
Title of the Course: Practical of Mining Geology
No of Credits: 01
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester I and II.	
Objective	To train students to prepare mining plans of both opencast and underground mines, to prepare bore logs as well as estimate ore reserves.	
Content	Exercises on reading of open cast and underground mine plans. Preparation of mine plans. Preparation of borehole logs, geological sections, calculation of ore reserves, ore to overburden ratio from sections. Preparation of mine pit sections. Mine visits to get acquainted with mining activities.	30 hours
Pedagogy	Laboratory exercises and mine visits.	
References/ Readings	1. Arogyaswamy, R. N. P. (1980). *Courses in mining geology*. Oxford and IBH. 2. McKinstry, H. E. (1980). *Mining Geology*. Asia Publishing House. 3. Peters, W. C. (1987). *Exploration and Mining Geology* by William Publication: New-York John Wiley & Sons 4. Sinha, Sharma. (1970). *Mineral Economics*. Oxford & IBH Publishers 5. Taggart, (1945). : *Mineral Ore Dressing*	

	6. Youn, G. J. (1984). *Elements of Mining Geology*. McGraw Hill.
Course outcomes	1. Students will be able to prepare borehole logs. 2. They will be able to prepare geological sections. 3. They will be able to estimate ore reserves as well as the ore to overburden ratio.

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-623
Title of the Course: Engineering Geology
No of Credits: 03
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester I and II.	
Objective	To understand rock and soil mechanics. To study civil structures and their implications on the environment.	
Content	**Module 1** Engineering properties of the soil, soil profile, size of the soil particles. Structure: Porosity, voids ratio and degree of saturation. Plasticity and Atterberg limits, clay swelling and tests to determine soil properties and geological characteristics of the sediment. Engineering properties of the rock: physical and mechanical properties, RQD, RMR. **Module 2** Site investigations: planning and design, aerial photography, engineering geophysics, borehole logging and in situ tests. Mass movement with emphasis on landslide, causes of hill slope instability and preventive measure. Coastal processes: coastal hazards and engineering structures. **Module 3** Dams and reservoirs: Types of dams, spillways, forces acting, criteria for site selection, causes of failure, reservoir siltation, reservoir induced seismicity and case studies. Tunnels and Bridges: Design and construction, identifying and managing geologic hazards - groundwater, problematic ground conditions, impacts to existing utilities and adjacent structures. Nuclear plants: Construction, nuclear reactor accidents and safety. Case studies.	15 hours 15 hours 15 hours
Pedagogy	Lectures, Case studies, Discussions and Assignments.	
References/	1. De Vallejo, L. G., & Ferrer, M. (2011). *Geological engineering*. CRC	

Readings	press. 2. Bodansky, D. (2007). *Nuclear energy: principles, practices, and prospects*. Springer Science & Business Media. 3. Krynine, D. P., Judd, W. R., & Krynine, D. P. (1957). *Principles of engineering geology and geotechnics*. New York: McGraw-Hill. 4. Meiswinkel, R., Meyer, J., & Schnell, J. (2013). *Design and construction of nuclear power plants*. John Wiley & Sons. 5. Bromhead, E. N. (1992). *The stability of slopes*. CRC Press. 6. Chandler, R. J. (Ed.). (1991). *Slope stability engineering: developments and applications: proceedings of the International Conference on Slope Stability*. Thomas Telford.
Course outcomes	1. Students will be able to understand engineering properties of rocks and soils. 2. Students will learn engineering tests performed for rock and soil analysis. 3. They will be able to undertake site investigations and prepare technical reports as well as identify and manage geological hazards. 4. Learn about various engineering megastructures and their site selections.

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-624
Title of the Course: Practical of Engineering Geology
No of Credits: 01
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester I and II.	
Objective	To study the engineering properties of earth materials. To study geotechnical parameters for stability of civil structures and their implications on the environment. To impart knowledge about different slope failures	
Content	Forces acting on dams and their distribution with respect to safety of dam. Dam site selection and failure assessment. Tunnel site selection and failure assessment. Problems on rock mechanics – Rock Quality Designation. Problems on rock mechanics - Rock Mass Rating. Reading	30 hours

	and interpreting bore hole data. Calculation of pore water pressure in a slope using groundwater flow net.	
Pedagogy	Practical exercises and discussions.	
References/ Readings	1. Bromhead, E. N. (1992). *The stability of slopes*. CRC Press. 2. Chandler, R. J. (Ed.). (1991). *Slope stability engineering: developments and applications: proceedings of the International Conference on Slope Stability*. Thomas Telford. 3. De Vallejo, L. G., & Ferrer, M. (2011). *Geological engineering*. CRC press. 4. Krynine, D.P., Judd, W.R., &Krynine, D. P. (1957). *Principles of engineering geology and geotechnics* (pp. 1-3). New York: McGraw-Hill.	
Course outcomes	1. Students will be able to identify potential sites for various civil structures. 2. Delineate and interpret borehole data. 3. Calculate pore water pressure using groundwater flow-net.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-625
Title of the Course: Environmental Geology
No of Credits: 03
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester I and II.	
Objective	To impart knowledge about the basics of environmental geology. To understand the interaction of humans with the environment. To create awareness about different natural and manmade hazards.	
Content	**Module 1** Scope and concepts of environmental geology, human population growth and sustainability. Ecosystem, lithosphere, hydrosphere, cryosphere and atmosphere. Assessing natural and manmade hazards, risks and their mitigation measures: Mass movements, deforestation, volcanic eruption, seismic hazard, flood, drought and related case studies. **Module 2** Global warming - industrialization, urbanization, urban environments and their impact. Exploitation of fossil fuels. Sea level changes and causative factors. Coastal processes: Natural and anthropogenic hazards and mitigation. Medical Geology:	15 hours 15 hours

	Trace elements and their implications on health, controls on elemental intake. **Module 3** Hydrology and pollution: Impact assessment of degradation and contamination of surface and groundwater quality due to industrialization and urbanization; organic and inorganic contamination of groundwater and its remedial measures. Geological and hydrogeological aspects of waste disposal, site selection for solid waste disposal-sanitary landfills. Surface and subsurface disposal of toxic, metallic and radioactive wastes. Planning and management of hazardous waste. EIA legislative measures in India**.**	15 hours
Pedagogy	Lectures, case studies, discussions and assignments.	
References/ Readings	1. Keller, E. A. (2012). *Introduction to Environmental Geology* (5th edition). 2. Merrits, D. Wet, A. de and Menking, K. (1997). *Environmental Geology: an Earth System Science Approach.* W. H. Freeman, New York. 3. Montgomery, C. W. (2010). *Environmental geology.* (9th Edition) Professor Emerita, Northern Illinois University 4. Montgomery, C. W. (2020). *Environmental geology.* (11th Edition) Professor Emerita, Northern Illinois University 5. Pipkin, B. W., Trent, D. D., Hazlett, R., & Bierman, P. (2013). *Geology and the Environment.* Cengage Learning. 6. Valdiya, K. S. (2013). *Environmental Geology: Ecology, Resource and Hazard Management.* McGraw-Hill Education.	
Course outcomes	1. Students will learn about the concepts of environmental geology. 2. Recognize natural and manmade hazards and reasons associated. 3. Suggest mitigation measures related to different environmental problems related to geology. 4. Students will be able to prepare maps delineating various types of natural and manmade hazards.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-626
Title of the Course: Practical of Environmental Geology

No of Credits: 01
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester I and II.	
Objective	To impart knowledge about distribution of natural hazards in India as well as hazards caused by anthropogenic activity. To study and interpret movement of pollutants.	
Content	Preparation of global and Indian natural hazard maps; Preparation of maps indicating major mountain ranges, rivers, regions affected by contamination of water, mining activity in India. Interpretation of transport of pollutants in the subsurface based on given data. Preparation of local level maps of pollution case studies; Preparation of groundwater flow nets and assessment of probable contaminant movement in the subsurface. Using simple computer assisted models problem solving on movement of pollutants in the subsurface.	30 hours
Pedagogy	Plotting and interpretation, problem solving, case studies, discussions and assignments.	
References/ Readings	1. Keller, E. A. (2012). *Introduction to Environmental Geology* (5^{th} edition). 2. Montgomery, C. W. (2010). *Environmental geology.* (9^{th} Edition) Professor Emerita, Northern Illinois University 3. Montgomery, C. W. (2020). *Environmental geology.* (11^{th} Edition) Professor Emerita, Northern Illinois University 4. Pipkin, B. W., Trent, D. D., Hazlett, R., & Bierman, P. (2013). *Geology and the Environment.* Cengage Learning. 5. Valdiya, K. S. (2013). *Environmental Geology: Ecology, Resource and Hazard Management.* McGraw-Hill Education.	
Course outcomes	1. Students will learn about the concepts of environmental geology. 2. Recognize natural and manmade hazards. 3. Suggest mitigation measures related to different environmental problems related to geology. 4. Students will be able to prepare maps of natural and manmade hazards and trace the movement of pollutants.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-627
Title of the Course: Soil Science

No of Credits: 03
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester I and II.	
Objective	To make students understand soil properties, their applications as well as conservation and management.	
Content	**Module 1** Introduction: Nature and importance of soil, soil formation, soil survey, physical, chemical and biological characters of soil. Relationship between soil, plants and animals. Soil types: Soil types and classification, soil genesis, mineralogy and geochemistry of soil types: laterites, bauxites, ardisols, vertisols, camborthids. Application of soil micromorphology and landscape evolution. Radiometric age determination of soils. **Module 2** Soil and crop production: Elements essential for plants and animals, soil nutrients, nitrogen, phosphrous, potassium, calcium, magnesium, and sulphur in soil and their significance in plant growth, micronutrients; Soil quality and landscape: Soil and water relation, organic matter in soil, functions of organic matter, organic matter and soil structure, organic matter and essential elements, tillage, cropping systems and fertility and case studies. **Module 3** Soil contamination and desertification. Soil management and conservation: Introduction, irrigation, drainage, soil management for field crops, gardens, lawns, pastures, rangelands and forests. Conservation factors and implementation methods.	15 hours 15 hours 15 hours
Pedagogy	Lectures, Case studies, Discussions and Assignments.	
References/ Readings	1. Brady, N. C., & Weil, R. R. (2002). The nature and properties of soils 13th ed Prentice Hall. *New Jersey, USA*, *249*. 2. Sparks, D. L. (2019). Fundamentals of soil chemistry. *Encyclopedia of Water: Science, Technology, and Society*, 1-11. 3. Raymond, B. D., & Richard, D. (2000). *Soil geomorphology*, John Wiley & Sons, 2000. 4. Summer, M. E. (1995). Hand Book of Soil Science. University of Georgia. 5. Sparks, D. L. (2003). *Environmental soil chemistry*. Elsevier.	
Course outcomes	1. Students will able to get an understanding of the relationship between soil, animals and plants. 2. They will get an understanding of soils and their classification and	

	manage the utility of soils. 3. Students will also learn about soil management and conservation.

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-628
Title of the Course: Practical of Soil Science
No of Credits: 01
Effective from AY: 2023-24

Prerequisites for the course:	Students should have undergone M.Sc. Semester I and II.	
Objective:	To get a hands-on experience of soil, its characteristics and recognition.	
Content:	Preparation of soil distribution maps of Goa using NBSS data source, study of soil profile and nomenclature of horizons, soil colour description in the field. Collection of soil sample and grain size distribution analysis and classification of soils using US SCS method.	30 hours
Pedagogy:	Laboratory exercises and field visits.	
Reference	1. Brady, N. C., & Weil, R. R. (2002). The nature and properties of soils 13th ed Prentice Hall. *New Jersey, USA*, *249*. 2. Sparks, D. L. (2019). Fundamentals of soil chemistry. *Encyclopedia of Water: Science, Technology, and Society*, 1-11. 3. Raymond, B. D., & Richard, D. (2000). *Soil geomorphology*, John Wiley & Sons, 2000. 4. Summer, M. E. (1995). Hand Book of Soil Science. University of Georgia. 5. Sparks, D. L. (2003). *Environmental soil chemistry*. Elsevier.	
Course outcomes	1. Students will be able to prepare soil distribution maps, 2. They will be able to identify soil horizons. 3. They will also be able to undertake grain size distribution analysis and classify soils.	

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-629
Title of the Course: Glaciology
No of Credits: 03
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester I and II.

Course objectives	To introduce the students to the processes involved in glaciation	
Content	**Module 1** Introduction to Global Glaciations; distribution of glaciers and snow cover: Importance of glaciers; general principle of the meteorology of precipitation, formation of snow, physical characteristics of snow crystals, areal distribution of glaciers, snow cover and factors controlling their distribution. **Module 2** Morphology of glaciers: Classification of glaciers, mass balance and mechanism of ice flow; types of deformation, mineralogy /metamorphism of ice, effect of metamorphism on albedo of snow and ice, grain growth. Zones in a glacier, crevasses and icefall; flow and sliding of glaciers: Driving and resisting stresses; steady and non-steady flow of glacier. **Module 3** Glacial erosion and weathering: Processes of glacial transport, sedimentation. Glacial erosional and depositional landforms. Paleoglaciation: Milankovitch cycles and greenhouse effect; Little Ice Age (LIA); glacial and interglacial cycles. Glaciers and climate. Summer and winter mass balance. Dating of glacial samples.	15 hours 15 hours 15 hours
Pedagogy	Lectures/ tutorials/assignments /discussion	
References/ Readings	1. Aber, J. S., Croot, D. G., & Fenton, M. M. (2012). *Glaciotectonic landforms and structures* (Vol. 5). Springer Science & Business Media. 2. Benn, D. I., & Evans, D. J. (2014). *Glaciers & glaciation*. Routledge. 3. Bennett, M. M., & Glasser, N. F. (Eds.). (2011). *Glacial geology: ice sheets and landforms*. John Wiley & Sons. 4. Hambrey & Alean (2004): *Glaciers,* 2nd edition. Cambridge University Press. 5. Knight, P. J. (1999): *Glacier Science and Environmental Change.* Wiley. 6. Marshall, S. J. (2011). *The Cryosphere*. Princeton University Press. 7. Van der Veen, C. J. (2013). *Fundamentals of glacier dynamics*. CRC press.	
Course Outcomes	1. Student will be able to discuss the processes involved in formation of glaciers 2. They will learn to identify erosional and weathering glacial landforms. 3. They will learn to identify depositional glacial landforms. 4. Students will learn to correlate the processes with climate change.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-630
Title of the Course: Geomorphology
No of Credits: 03
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester I and II.	
Course objectives	This course provides an overview of landforms, geological processes, and landscape evolution and geomorphology thus generated.	
Content	**Module 1** Introduction to Geomorphology ; Types of weathering, Weathering Processes and Landforms; Erosional processes, Mass Wasting Processes and Landforms. Role of geology in geomorphology. **Module 2** Fluvial processes and landforms; Aeolian processes and landscapes; evidences of aeolian processes on Mars. Geomorphology of karstic landscapes; tectonic Geomorphology; volcanoes, impact craters, folds, and fault. Coastal Processes and Landforms. Glaciers and glacial processes; and landforms. Periglacial processes and landforms. **Module 3** Dating methods, and establishing timeline in the landscape: Radiometric dating methods Applied Geomorphology: Geomorphological controls on Dam site selection and coastal management.	15 hours 15 hours 15 hours
Pedagogy	Lectures/ tutorials/assignments/field study/discussion	
References/ Readings	1. Ahmad, E. (1972). Coastal geomorphology of India. *Coastal geomorphology of India.* 2. Anderson, R. S., & Anderson, S. P. (2010). *Geomorphology: the mechanics and chemistry of landscapes*. Cambridge University Press. 3. Coates, D. R. (2020). Geomorphic engineering. In *Geomorphology and Engineering* (pp. 3-21). Routledge. 4. Thornbury, W. D. (2018). *Principles of geomorphology*. New Age International. 5. Trudgill, S. (1985). *Limestone geomorphology*. Prentice Hall Press.	
Course Outcomes:	1. Students will be able to identify various geological processes. 2. They will understand the process of landscape evolution and geomorphology generated.. 3. They will be able to identify various landforms. 4. Use of natural geomorphology site selection for engineering projects.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-631
Title of the Course: Natural Hazards and Disaster Management
No of Credits: 03
Effective from AY: 2023-24

Prerequisites	Students should have undergone M.Sc. Semester I and II.

for the course		
Objective	To provide an overview of the common natural hazards and their dynamics and to inculcate the basic concepts of disaster management	
Content	**Module 1** Understanding the Concepts and definitions of Disaster, Hazard, Vulnerability, Risk, Capacity, Natural and Man-made disasters, Types of disasters. Introduction to natural hazards, causes and consequences of geological hazards, flood, drought and climate change issues, forest hazard, tsunami and coastal hazards, cyclone hazards, snow avalanche, Glacial Lake Outburst Flood and glacier related hazards, extreme weather events, urban and industrial hazards. Impact and mitigation in Global and Indian context.	15 hours
	Module 2 Disaster Management Cycle, Pre-Disaster – Risk Assessment and Analysis, Risk Mapping, zonation and Microzonation, Prevention and Mitigation of Disasters, Early Warning System; Preparedness, Capacity Development; Awareness During Disaster – Evacuation, Disaster Communication, Search and Rescue, Emergency Operation Centre, Incident Command System, Relief and Rehabilitation. Post-disaster – Damage and Needs Assessment, Restoration of Critical Infrastructure, Early Recovery, Reconstruction and Redevelopment. Geo-informatics in Disaster Management (RS, GIS, GPS); Disaster Communication System (Early Warning and Its Dissemination); Land Use Planning and Development Regulations; Disaster Safe Designs and Constructions	15 hours
	Module 3 International organisations: Red Cross, Sphere, Oxfam, World Relief, CBM International, UNDRO, UNDDR. Yokohama Strategy, Hyogo Framework of Action, UNISDR. Community Based Disaster Risk Reduction (CBDRR) Disaster Profile of India – Mega Disasters of India and Lessons Learnt Disaster Management Act 2005. NDMA, NIDM.	15 hours
Pedagogy	Lectures/ tutorials/ assignments/ self-study	

References/ Readings	1. Alexander, D., (1999), *Natural Disasters*, Kluwer Academic London, 632 pages 2. Coppola D P, (2007). *Introduction to International Disaster Management*, Elsevier Science (B/H), London. 3. Disaster Management Act 2005, Published by Govt. of India 4. Disaster Management Guidelines, GOI-UN Disaster Risk Program (2009–2020) 5. Hyndman, D., and Hyndman, D. (2016). *Natural hazards and disasters*. Cengage Learning. 6. Keller, E. A., and DeVecchio, D. E. (2016). *Natural hazards: earth's processes as hazards, disasters, and catastrophes*. Routledge. 7. Lopez-Carresi, A., Fordham, M., Wisner, B., Kelman, I., and Gaillard, J. (2014). *Disaster Management: International Lessons in Risk Reduction, Response and Recovery.* Routledge, 352 Pages. 8. Modh S. (2010) *Managing Natural Disasters*, Mac Millan publishers India LTD 9. Publications of National Disaster Management Authority (NDMA) on Various Templates and Guidelines for Disaster Management 10. Srivastava, H.N., and Gupta, G.D., (2006). *Management of Natural Disasters in developing countries*, Daya Publishers, Delhi, 201 p. 11. UNISDR. (2002). *Natural Disasters and Sustainable Development: Understanding the links between Development, Environment and Natural Disasters*, Background Paper No. 5.
Course outcomes	1. Students will acquire a comprehensive understanding of natural disasters. 2. Students will understand the Disaster Management Cycle and evaluate technologies for disaster mitigation. 3. Students will understand the role of international treaties and disaster relief organisations in disaster management. 4. Students will be able to analyze and evaluate the relationship of disasters with development.

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-632
Title of the Course: Planetary Geology
No of Credits: 03
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester I and II.	
Objective	To impart basic knowledge of the Solar system from a geologic perspective.	
Content	**Module 1** Universe, Big Bang theory, Milky Way, Solar system, sun. Terrestrial and Jovian planets, planetoids, moons. Origin of planets - condensation hypothesis, Urey's hypothesis; Evidence of early history from meteorites, asteroids, and comets. Effects of large early collisions (earth-moon system). Earth's moon, general features, geology of surface cover, volcanic flows, lunar craters. Structure of moon - crust and interior. Origin and retention of planetary atmospheres and volatiles. **Module 2**	15 hours

	Physical attributes, atmosphere, atmospheric temperature, planetary surfaces and morphology of terrestrial planets- Mercury, Venus, Earth and Mars. Observation and exploration of the Jovian planets – Jupiter, Saturn, Uranus and Neptune. Basic planetary data of Jovian planets – physical attributes, atmospheres, surfaces and interiors; magnetic fields and structure of the planet. Geological processes affecting the solid surfaces of planets – Meteorite impacts, magmatism, tectonics **Module 3** Small bodies of the inner solar system- Asteroids and meteorites. Asteroid and meteorite types, geological processes on asteroids, zonation of asteroid belt. Classification of meteorites. Basic astronomical data of the Kuiper Belt and dwarf planets- Pluto, Eris and Ceres. Structure, composition, orbits and exploration of comets. Tools and techniques of planetary geology – Telescopes, spectroscopy, computer modelling. Indian initiatives of planetary exploration. Space crafts- Gemini series, Apollo missions, lunar rovers, first lunar landing. International Space station. Seismic method of exploration, remote sensing of physical and chemical attributes of planets.	15 hours 15 hours
Pedagogy	Lectures/ tutorials/ assignments/ self-study	
References/ Readings	1. Beatty, J., Petersen C., and Chaikin, A., (1999). *The New Solar System*. Cambridge University Press, Cambridge, England. 2. Kaula, W.M., (1996). *Theory of satellite geodesy*. Blaisedell 3. Lodders K. and Fegley, B., (1998). *The Planetary Scientist's Companion*. Oxford University Press, New York 4. Morrison, D., (1993). *Exploring Planetary Worlds.* Scientific American Library, New York. 5. Bhardwaj A. (Ed). (2006). *Advances in Geosciences: Planetary Science (Volume 3).* World Scientific Publishing C. Pte. Ltd. Singapore. ISBN: 981-256-983-8. 6. Christiansen E. H., and Hamblin, W. K., (1995) *Exploring the Planets (2nd edition).* Prentice-Hall 7. Cook, A.H., (1973). *Physics of Earth and planets*. London: Macmillian 8. Cook, A.H., (1980). *Interiors of Planets.* Cambridge University Press, London. ISBN: 978-0-521- 23214-2 9. Gunter, F., and Teresa, M., (2007). *Introduction to planetary science: The geological perspective.* M. Springer, the Netherlands. ISBN: 13 978-1-4020-5544-7. 10. McSween Jr, H. Y., Moersch, J.E.; Burr, D.M., Dunne, W. M., Emery, J. P., Kah, L. C., and McCanta, M. C., (2019). *Planetary Geoscience*. Cambridge University Press. ISBN: 1107145384 11. Watters, T.R. and Schultz, R.A, (2010). *Planetary Tectonics*. Cambridge University Press. ISBN 978-0-521-76573-2. 12. Wilhelms, D., (1993). *To a Rocky Moon - A Geologist's History of Lunar Exploration.* University of Arizona Press, Tucson. 13. Wood, J. A. (2000). The Solar System (2nd edition) Prentice-Hall	
Course outcomes	1. Students will be able to discuss the origin of the Solar System and its celestial constituents. 2. Students will understand the properties and compositions of planetary bodies.	

	3. Students will know the instruments and techniques used in space exploration. 4. Students will gain insights into previous and ongoing space missions.

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-633
Title of the Course: Petroliferous basins of India
No of Credits: 03
Effective from AY: 2023-24

Prerequisites for the course:	Students should have undergone M.Sc. Semester I and II.	
Objective:	To impart the knowledge about Petroliferous basins in India. To understand its occurrence, structure and depositional environment	
Content:	**Module 1** Types of petroliferous basins, relations between basin type and hydrocarbon richness; classification of petroliferous basins of India in the framework of Plate tectonics. Cambay basin: Cambay rift and post rift deltaic sedimentation, Lithofacies, depositional environment, organic matter, palynological investigation and reservoir characteristics. Bombay offshore basin: Exploration, seismic study, transgressive-regressive cycle, carbonate facies, reservoir petrography, source rock geochemistry and future prospects along western slope of India. **Module 2** Assam shelf: Depositional environment, structure, tectonics, bio-zonation, hydrocarbon prospects, source rock and associated lithology. Krishna-Godavari basin: Lithology, depositional pattern, petroleum systems and fossils. Bengal basin: Marine depositional environments, clay mineralogy, trace elements and fossil assemblages. Cauvery basin: General geology, tectonic history, sea level changes, modelling and basin analysis. Andaman basin: Structural analysis, its interpretation and evolution of forearc basin. **Module 3** Rajasthan Basin: Hydrogeochemical studies in Jaisalmer basin, Hydrocarbon entrapment conditions and related lithology. Kerala-Konkan basin: Tectonic framework, geology and petroleum prospects. Geoscientific studies and hydrocarbon exploration techniques in Himalayan foothills, Vindhyan and Gondwana basin: Hydrocarbon exploration techniques. Palar basin: Tectonic history, structure and hydrocarbon habitat. Mahanadi basin: Geology and hydrocarbon prospects.	15 hours 15 hours 15 hours
Pedagogy:	Lectures, case studies, discussions and assignments.	

References/Readings	1. Bhandari, L.L., Venkatachala, B.S., Kumar, R., Swamy, S.N., Garga, P. and Srivastava, D.C. (Eds.) (1983). *Petroliferous Basins of India*, Petroleum Asia Journal, Himachal Times Group. 2. Biswas, S.K., Dave, A., Garg, P., Pandey, J., Maithani, A. and Thomas, N.J. (Eds.) (1993) *Proceedings of 2nd Seminar on Petroliferous Basins of India, Dehra Dun, Dec.18-20, 1991, Vol. 1 & 2*, Indian Petroleum Publishers, Dehra Dun. 3. Biswas, S.K., Dave, A., Garg, P., Pandey, J., Maithani, A. and Thomas, N.J. (Eds.) (1994) *Proceedings of 2nd Seminar on Petroleum basins of India, Dehra Dun, Dec. 18-20, 1991, Vol.3*, Indian Petroleum Publishers, Dehra Dun. 4. Chandra, K., Raju, D. S. N., & Mishra, P. K. (1993). Sea Level Changes, Anoxic Conditions, Organic Matter Enrichment, and Petroleum Source Rock Potential of the Cretaceous Sequences of the Cauvery Basin, India. AAPG special volume 5. Gupta, S. K. (2006). Basin architecture and petroleum system of Krishna Godavari Basin, east coast of India. *The Leading Edge*, *25*(7), 830-837. 6. Hasan, S. Z., Farooqui, M. Y., Rao, P. H., Ramachandran, K., Tripathy, P., & Harinarayana, T. (2013). *Petroliferous basins and shale gas-an unconventional hydrocarbon asset of India*. *Geosciences*, *3*(4), 108-118. 7. Singh, L. (2000) *Oil and Gas Field of India*, Indian Petroleum Publishers, Dehra Dun.
Course outcomes	1. Students will be able to understand Petroliferous basins in India. 2. Know about the geological environment and tectonic setting. 3. Learn about various Geoscientific studies and hydrocarbon exploration techniques. 4. Understand its potential with respect to hydrocarbon occurrence.

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-634
Title of the Course: Practical of Petroliferous basins of India
No of Credits: 01
Effective from AY: 2023-24

Prerequisites	Students should have undergone M.Sc. Semester I and II.

for the course:		
Objective:	To impart the knowledge about Petroliferous basins in India. To understand its occurrence, structure and depositional environment	
Content:	Plotting and categorisation of sedimentary basins on outline maps of India based on hydrocarbon potential. Stratigraphic correlation of various petroliferous basins of India. Preparation of basin boundary maps with tectonic features. Oil and gas distribution maps of basin. General stratigraphic succession of basins. Evaluation of basin potential using published data.	30 hours
Pedagogy:	Case studies, map preparation and discussions	
References/Readings	1. Bhandari, L.L., Venkatachala, B.S., Kumar, R., Swamy, S.N., Garga, P. and Srivastava, D.C. (Eds.) (1983) *Petroliferous Basins of India*, Petroleum Asia Journal, Himachal Times Group. 2. Biswas, S.K., Dave, A., Garg, P., Pandey, J., Maithani, A. and Thomas, N.J. (Eds.) (1993) *Proceedings of 2nd Seminar on Petroliferous Basins of India, Dehra Dun, Dec.18-20, 1991, Vol. 1 & 2*, Indian Petroleum Publishers, Dehra Dun. 3. Biswas, S.K., Dave, A., Garg, P., Pandey, J., Maithani, A. and Thomas, N.J. (Eds.) (1994) *Proceedings of 2nd Seminar on Petroleum basins of India, Dehra Dun, Dec. 18-20, 1991, Vol.3*, Indian Petroleum Publishers, Dehra Dun.	
Course outcomes	1. Students will be able to understand Petroliferous basins in India. 2. Know about the geological environment and tectonic setting. 3. Learn about various Geoscientific studies and hydrocarbon exploration techniques. 4. Understand its potential with respect to hydrocarbon occurrence.	

(Back to Index) (Back to Agenda)

Name of Programme: M. Sc.Marine Sciences
Course Code: MSC 621
Title of the Course: Remote Sensing and its Applications
No of Credits: 03
Effective from AY: 2023-24

Prerequisites for the course:	Students who have undergone M.Sc. Part I.
Objective:	To provide a basic understanding of remote sensing, and some applications in physical oceanography and auxiliary disciplines.

Content:	**Module I** Principles of Electromagnetic radiation, energy and matter interactions – Rayleigh scattering – Mie scattering, Non selective scattering – radiative transfer in the atmosphere – Stefan's law and Wien's displacement law – Zenith and azimuth angles. **Module II** Optical remote sensing – bio-optical properties of sea water – inherent and apparent optical properties – scattering – absorption-attenuation - diffuse attenuation – remote sensing reflectance – Case I and Case II waters – radiative transfer in the water column.Sun photometry – BeerLambert's law – spectral variation of aerosol optical thickness – atmospheric correction – interpretation of ocean colour. **Module III** Thermal infrared remote sensing – Thermal infrared properties – Atmospheric windows – Thermal radiation laws – Emissivity – sea surface temperature retrieval through IR sensors – Active and passive microwave remote sensing – Satellite altimetry of sea surface topography.Sensor characteristics of AVHRR, CZCS, SeaWiFS, MODIS, MSI, OCM-2 and FLEX – fundamentals of digital image processing – image rectification – image enhancement – linear stretching – supervised and unsupervised classification.	15 hours
Pedagogy:	Lectures/ Tutorials/ Assignments	
References/Readings	1. Rees, W. G. (1990). *Physical Principles of Remote Sensing*, (1990). U.K.: Cambridge University Press. 2. Sabins Jr., F. F. (1987). *Remote Sensing: Principles and Interpretations (Second Edition).* New York, U.S.A.: W. H. Freeman. 3. Robinson, I. S. (1985). *Satellite Oceanography.* Somerset, N.J., U.S.A.: John Wiley & Sons. 4. Narayan, L. R. A. (1999). *Remote Sensing and its Applications.* Hyderabad: Universities Press. 5. Mukherjee, S. (2004). *Textbook of Environmental Remote Sensing*. Delhi – Chennai – Jaipur – Mumbai – Patna – Bangalore – Bhopal – Chandigarh – Coimbatore – Cuttack – Guwahati – Hubli – Hyderabad – Lucknow – Madurai – Nagpur – Pune – Raipur – Siliguri – Thiruvananthapuram – Visakhapatnam : Macmillan India Limited. ISBN: 1403 92235 7. 6. Emery, W., & Camps, A. (2017). *Introduction to Satellite Remote Sensing: Atmosphere, Ocean, land and Cryosphere Applications*. Amsterdam – Oxford – Cambridge, Massachusetts, U.S.A.: Elsevier. ISBN: 978-0-12-809254-5. 7. Janssen, L. L. F., & Bakker, W. H. (2000). *Principles of Remote Sensing:* An Introductory Textbook. International Institute for Aerospace Survey and Earth Sciences. 8. Joseph, G. (2005). *Fundamentals of Remote Sensing* (Second Edition). Hyderabad: Universities Press.	
Course	1. An understanding of basics of remote sensing.	

outcomes	2. Applications of remote sensing to ocean science. 3. To understand basics of sensors used in remote sensing.

Name of the Programme: M. Sc. Marine Sciences
Course Code: MSC 622
Title of the Course: Remote Sensing and its Applications Practical
Number of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Students who have undergone M.Sc. Part I.	
Objective:	Understanding of remote sensing and its applications in oceanography.	
Content:	1. Analysis of aerosol optical depth (A.O.D.) depth and estimation of atmospheric turbidity parameter and Angstrom exponent. (10 hrs, All references). 2. Chlorophyll-a concentration variability using satellite images (10 hrs, All references). 3. Application of satellite images to environmental issues. (10 hrs, All references).	30 hours
Pedagogy:	Practical/ tutorials/ assignments.	
References/Readings	1. Rees, W. G. (1990). Physical Principles of Remote Sensing, (1990). U.K.: Cambridge University Press. 2. Sabins Jr., F. F. (1987). Remote Sensing: Principles and Interpretations (Second Edition). New York, U.S.A.: W. H. Freeman. 3. Robinson, I. S. (1985). Satellite Oceanography. Somerset, N.J., U.S.A.: John Wiley & Sons. 4. Narayan, L. R. A. (1999). Remote Sensing and its Applications. Hyderabad: Universities Press. 5. Mukherjee, S. (2004). Textbook of Environmental Remote Sensing. Delhi – Chennai – Jaipur – Mumbai – Patna – Bangalore – Bhopal – Chandigarh – Coimbatore – Cuttack – Guwahati – Hubli – Hyderabad – Lucknow – Madurai – Nagpur – Pune – Raipur – Siliguri – Thiruvananthapuram – Visakhapatnam : Macmillan India Limited. ISBN: 1403 92235 6. Emery, W., & Camps, A. (2017). Introduction to Satellite Remote Sensing: Atmosphere, Ocean, land and Cryosphere Applications. Amsterdam – Oxford – Cambridge, Massachusetts, U.S.A.: Elsevier. ISBN: 978-0-12-809254-5. 7. Janssen, L. L. F., & Bakker, W. H. (2000). Principles of Remote Sensing: An Introductory Textbook. International Institute for Aerospace Survey and Earth Sciences. 8. Joseph, G. (2005). Fundamentals of Remote Sensing (Second Edition). Hyderabad: Universities Press.	
Course outcomes	Understanding of basic applications of remote sensing in oceanography.	

(Back to Index) (Back to Agenda)

M.Sc. in Applied Geology Program Structure and Syllabus
(With effect from academic year 2023-2024)

Semester IV

Course Code	Course Title	L-P (Hours/week)	Credits (s)	Page Number
Research Specific Elective (RSE)				
GEO-609	Geological Field Training	0-2	4	45
GEO-610	Climate Geology	2-0	2	47
GEO-611	Microplastic Pollution Studies	2-0	2	49
GEO-612	Precambrian Crustal Evolution	2-0	2	51
GEO-613	Radiogenic Isotope Dating	2-0	2	53
GEO-614	Coal Geology	2-0	2	54
Discipline Specific Dissertation (DSD)				
GEO-651	Dissertation	0-4	16	56

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-609
Title of the Course: Geological Field Training (Practical)
No of Credits: 04
Effective from AY: 2023-24

Prerequisites for the course:	Degree of Bachelor of Science in Geology from any UGC recognized University or an equivalent examination.	
Objective:	The main objective of this course is to give students the hands on experience in the field to understand the lithology structure and their plates in Stratigraphy besides getting a thorough knowledge of field mapping.	
Content:	Visit to important mines/mineral deposits; Visit to Industry/Professional Organizations/National Institutes which may include short term in-house training at respective labs. The training program will be carried out under the supervision of teachers. Students are expected to learn the techniques and methodologies applied on site in the professional organizations and also to gain knowledge related to instrumentation. Students are expected to write a detailed report on their visit. There will be a viva-voce examination based on the field report.	90 hours
Pedagogy:	Field Training.	
References/ Readings	1. Deshpande, GG. and Pitale U. L. (2012). *Geology of Maharashtra* Second Edition. Geological Society of India.	

	2. Dessai, A.G. (2018).*Geology and Mineral Resources of Goa*. 3. Mehr S.S., (1991). *Geology of Gujarat*, Geological Society of India, 1991. 4. Radharishnan B.P. and Vaidhyanadhan R., (1977). *Geology of Karnataka*, Geological Society of India. 5. Raman, P.K. and Murty, V. N. (2012). Geological Society of India.. 6. Roy, A.B and Jakhar, S.R. (2012). *Geology of Rajasthan (North-West India-Precambriam to Recent)* Scientific Publishers, 7. Sinha Roy. (1991). *Geology of Rajasthan*, Geological Society of India.	
Course outcomes	1. The students will be able to identify the various rocks and their structures in the field. 2. They will mine/oil site installations to understand their working. 3. They will be able to prepare geological maps. 4. The students will get to learn the recent techniques, instrumentation and methodologies applied in various institutes. 5. They will learn to write a detailed technical report of the field area, mine, well site installations and lab visited.	

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-610
Title of the Course: Climate Geology
No of Credits: 02
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester III.	
Objective	To understand the climatic variation at various scales. To understand the relationship between ocean and atmosphere and its effect on climate.	
Content	**Module 1** Introduction, scales in climate geology, subfields of climatology. Atmosphere: structure and circulation. Orbital cyclicity and climate: Milankovitch cycles and solar activity, Marine Isotopic Stages - glacial and interglacial stages, Last	15 hours

	Glacial Maximum. Ocean dynamics: The ocean conveyor belt and its role in controlling world's climate, Coriolis force and Ekman Spiral, upwelling, El Niño, La Niña and major currents of the world's oceans. **Module 2** Monsoon: Mechanism of monsoon, monsoonal variation through time and factors associated with monsoonal intensity. Brief introduction to paleoclimate and paleoclimate reconstruction from ice cores, pollens and spores, biogeochemical proxies, corals, speleothems. Role of Antarctica and Arctic in present and past climate.	15 hours
Pedagogy	Lectures, case studies, discussions and assignments.	
References/ Readings	1. Ahrens, C. D. (2003). *An introduction to weather, climate, and the environment.* Meteorology Today (7th ed.) Thomson/Brooks/Cole, 624pp. 2. Kump, L.R., Kasting, J.F. and Crane, R.G. (2004). *The Earth System*, 2nd ed, Prentice Hall. 3. Oerlemans, J. (2001). *Glaciers and climate change, Balkema.* Rotterdam, Netherlands. 4. Oliver, J. E. (2002). *Climatology: An Atmospheric Science, 2/e*. Pearson Education India.	
Course outcomes	1. Students will be able to discuss climate and climatic variations on various time scales. 2. Understand ocean dynamics and its role in controlling climate. 3. Understand aspects of monsoon. 4. Learn different proxies related to paleoclimate.	

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-611
Title of the Course: Microplastics Pollution
No of Credits: 02
Effective from AY: 2023-24

Prerequisites for the course:	Students should have undergone M.Sc. Semester III.	
Course objectives	This course introduces the students to the concept of microplastics as a pollutant and its impact on the environment.	
Content:	**Module 1** Introduction to Microplastics and its distribution	

	Introduction to Plastics and microplastics: Types of plastics: PET, HDPE, PVC, LDPE, PP and PS. Microplastics types: fibres, microbeads, fragments, nurdles, foam. Primary and Secondary, microplastics and its formation. Biotic degradation, Abiotic degradation: Photo-oxidative degradation, atmospheric oxidation and hydrolytic degradation Global occurrence and sources of microplastics. Distribution and fate of plastic in the environment: microplastics pollution in terrestrial environment, freshwater and marine waters, snow and atmosphere. Sampling and characterization: Methods used for sampling, quantification of microplastics. Instrument for identification of microplastics- FTIR and Raman Spectroscopy. **Module 2** Impacts of Microplastics Potential impacts on the environment and human health. Microplastics as vectors for chemical pollutants in the soil and water. Metal and metalloid contaminated microplastics. Assessment and Mitigation: Risk assessment studies and mitigation methods for microplastics pollution. Case studies: Microplastics pollution studies in India- Case studies.	15 hours 15 hours
Pedagogy:	Lectures, case studies, discussions and assignments.	
References/ Readings:	1. Crawford, B.C & Quinn, B. (2016). *Microplastic Pollutants* (1st ed.). Elsevier Science. 2. Rocha-Santos, T., Costa, M. & Mouneyrac, C., (Eds.). (2022). *Handbook of Microplastics in the Environme*nt (1st ed.). Springer. 3. Rocha-Santos, T.A.P. & Duarte, A.C. (Eds.). (2017). *Characterization and Analysis of Microplastics* (1st ed.). Elsevier Science.	
Course Outcomes:	1. Students will be able to identify and classify microplastics. 2. Students will be able to understand the effects of microplastics on humans and environment. 3. Students can come up with need based mitigation methods. 4. Students will be able to propagate the adverse effects of microplastic.	

(Back to Index) **(Back to Agenda)**

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-612
Title of the Course: Precambrian Crustal Evolution
No of Credits: 02
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester III.	
Objective	To provide knowledge to the students about the processes of formation of the Precambrian crust and the variations in Precambrian crustal properties	
Content	**Module 1** Processes responsible for formation of the early crust. Archean cratons-	15 hours

	origin of granite-greenstone belts. Archean-Proterozoic boundary, early atmosphere-hydrosphere. Distribution and tectonic setting of Precambrian crust: Global distribution, Paleomagnetism and continental reconstructions; Orogenies and tectonic cycles; Geologic setting of some cratons: Indian shield, Greenland shield, African shield, Antarctic craton; Nature of Archean crust: Dharwar craton, Southern granulite terrain, Eastern Ghat Belt, Singbhum craton, Bundelkhand craton, Bastar craton. **Module 2** Mineralization associated with Precambrian shields; Early Proterozoic crust; Mid-Proterozoic crust; Evolution of the continental crust; Archean heat flow and geotherms; granitoid associations; composition of continental crust; high- grade metamorphic terrains; Banded Iron Formations; Uraniferous conglomerates.	15 hours
Pedagogy	Lectures/ tutorials/ assignments/ self-study	
References/ Readings	1. Condie, K. C. (2013). *Plate tectonics & crustal evolution*. Elsevier 2. Goodwin, A. M. (1996). *Principles of Precambrian geology*. Elsevier. 3. Kearey, P., Klepeis, K. A., and Vine, F. J. (2009). *Global tectonics*. John Wiley & Sons. 4. Holdsworth, R. E., Handa, M., Miller, J. A., and Buick, I. S. (2001). *Continental reactivation and reworking: an introduction*. Geological Society, London, Special Publications, 184(1), 1-12. 5. Coward, M. P., and Ries, A.C. (1986) *Collision Tectonics*. Geological Society of London Special Publication No. 19, 415 p. 6. Condie, K. C. (Ed.). (1994). *Archean crustal evolution*. Elsevier. 528 p. 7. Moores, E.M., and Twiss, R.J., (1995). *Tectonics*. Freeman and Company. 8. Windley, B., (1977). *The evolving continents.* John Wiley & Sons Ltd 9. Valdiya, K.S., (1984). *Aspects of Tectonics – Focus on south central Asia*. Tata McGraw-Hill	
Course outcomes	1. Students will understand the characteristics of Precambrian crusts worldwide. 2. The student will be able to identify different processes that led to formation of the Precambrian crust. 3. They will be able to delineate economic deposits associated with the Precambrian rocks.	

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-613
Title of the Course: Radiogenic Isotope Dating
No of Credits: 02
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester III.
Objective	The student will acquire the basic knowledge of radiometric dating and the tools to choose between the different dating techniques as a function of the study case.

Content	**Module 1** An introduction to nucleosynthesis and the distribution of elements in the Solar System; Decay mechanisms of radionuclides; Radioactive Decay and radiogenic growth; Geochronometry; Mass spectrometry: Techniques and Applications; Sampling strategy and processing; Dating and applications of the following methods: Rb-Sr, Sm-Nd, K-Ar, Ar-Ar, Re-Os and Lu-Hf; U-Th-Pb geochronology. **Module 2** Isotope Geology of Pb. Fission Track method of dating. U-disequilibrium methods of dating. Processing and presentation of raw isotope geochemical data; Application of Sr, Nd, Pb and Hf isotopes in petrogenetic studies.	15 hours 15 hours
Pedagogy	Lectures/ tutorials/ assignments/ self-study	
References/ Readings	1. Dickin, A.P. (2005). *Radiogenic Isotope Geology*. Cambridge University Press, 492 pp. 2. Faure, G. (1977). *Principles of Isotope Geology*. Wiley, 464 pp. 3. Faure, G. and Mensing, T.M. (2009). *Isotopes Principles and Applications*. Wiley, 896 pp.	
Course outcomes	1. The student will acquire the knowledge of radiometric dating and applications 2. Students will be able to interpret and evaluate radiometric ages.	

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-614
Title of the Course: Coal Geology
No of Credits: 02
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester III.
Objective:	To impart the knowledge about types of coal, its occurrence, structure and depositional environment.

Content:	**Module 1** Coal as rock, types of coal, mode of occurrence, structure in coal seams, coals through ages-physical and chemical characteristics of coal, macropetrographics and microlithotypes; Genetics and exploration: Origin-classification of coal-Indian coal grading and exploration of coal, Modern techniques-drilling and logging, assessment of coal reserves and calculation of coal reserves. Preparation and utilization: Coal preparation, cleaning, sizing washing supporting operations. **Module 2** Beneficiation of coal, coal utilization, combustion, carbonization, gasification and hydrogenation. Resources and Environments: Resources: Production and consumption pattern. Energy policy: conservation, environment pollution and environmental hazards. World coal resources, principal Indian Coal Fields: Occurrences, geology and geographical distribution. Coal mining hazards.	15 hours 15 hours
Pedagogy:	Lectures, case studies, discussions and assignments.	
References/ Readings	1. Chandra, D., Singh, R. M., & Singh, M. P. (2000). *Text book of coal (Indian Context)*. Tara Book Agency, Varanasi. 2. Francis, W. (1961). *Coal: its formation and composition*. E. Arnold. 3. Larry, T. (2002). Coal geology. *A John Wiley & Sons, West Sussex*, *273*. 4. Mackowsky, M. T., Teichmuller, M., Taylor, G. H., Chandra, D., Teichmuller, R., Bwnfraeger, G., ... & Darfmoufh, N. S. (1997). *Stach's textbook of coal petrology*. Gebruder borntraeger.	
Course outcomes	1. Students will be able to identify different types of coal and their occurrences. 2. Learn the formation, geological environment and tectonic setting of coal.	

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-651
Title of the Course: Dissertation (DSD)/Internship
No of Credits: 12
Effective from AY: 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Semester III.
Course objectives	This course introduces to the concept of research.

Content	Dissertation based on the geology of any chosen area, involving independent mapping, collection of samples, data analysis of data and preparation of geological and other maps, charts & report based on the field and laboratory analyses. Student can choose to work for dissertation in the School or in any National Research laboratory / Industry/ Professional organization/ Well site/ Mine site under the supervision of a Faculty/ Scientist/ Professional Geologist on laboratory analytical problems related to geology of any area. To gain the professional experience in analytical/ field methodologies, data analysis, presentation and interpretation. A report based of the work will be submitted which will be evaluated by the Discipline Specific Committee.	15 weeks
Pedagogy:	Project conceptualization, Fieldwork, Skill based training, Laboratory analyses, Data processing, Scientific report writing and presentation.	
Course Outcomes:	1. The student will be able to formulate a research proposal. 2. The students will learn to carry out field work independently. 3. The data generated will be compared with available literature and interpreted. 4. Students will be able to write a detailed report of the study carried out.	

(Back to Index) (Back to Agenda)

ADVANCE THEORY

Name of Programme: M. Sc. Applied Geology
Course Code: GEO-701
Title of the Course: Research Methodology in Earth Science
No of Credits: 04
Effective from AY: 2023-24

Prerequisites for the course	Post graduate in science enrolled for Ph.D. with NET/GATE/GU-PET.
Objective	To develop the logical thinking ability of the Ph.D. candidate and to help determine the reliability and validity of the research work to be carried out.

Content	**Module 1** Scientific Research: Identification of the problem, assessing the status of the problem, formulating the objectives, preparing design. Literature survey: References, Abstraction of a research paper, Possible ways of getting well informed of current literature. Data Analysis and interpretation: Data Preparation - frequency tables, bar charts, pie charts, percentages, graphs. Use of word processing, spreadsheet and database software. Documentation and scientific writing: Results and Conclusions, Preparation of manuscript for Publication of Research paper, Presenting a paper in scientific conferences, thesis writing. Types of Reports: Research project, Review of paper, Impact factor of Journals, Ethical issues related to publishing, Plagiarism and Self-Plagiarism, citation styles, bibliography. Softwares**:** Reference Management Software and Software for detection of Plagiarism.	15 hours
	References 1. Alley, M. (1996). *The craft of scientific writing* (No. 808.0666/A435). New York: Springer. 2. Clough, P., & Nutbrown, C. (2012). *A Student' s Guide to Methodology*. SAGE Publications Ltd Oliver's Yard 55 City Road London EC1Y 1SP. 3. Kumar, R. (2018). *Research methodology: A step-by-step guide for beginners*. SAGE Publications Ltd Oliver's Yard 55 City Road London EC1Y 1SP. 4. Thomas, C. G. (2021). *Research methodology and scientific writing*. Thrissur: Springer.	15 hours
	Module 2 Sampling and Mapping techniques. Concepts of stress and strain ellipsoids. Identification and characterisation of joints, foliations and lineations in deformed rocks in regional and mesoscale and deformation mechanisms in microscale. Shear zones and shear sense indicators. Nature of metamorphic reactions with reference to application in metamorphic assemblages. Tectonic context of metamorphic facies and metamorphic facies series concept. Concepts and application of geothermobarometric techniques. Radiometric dating and	

applications of the following methods: Rb-Sr, Sm-Nd, K-Ar, Ar-Ar, Re-Os and Lu-Hf; U-Th-Pb geochronology.

Sample preparation for XRF: Press pellet and fused bead method. Sample preparation for ICPMS: acid digestion of samples. Study of major, minor, trace and REE and their importance in deciphering the magmatic history. Petrological-geochemical characters of magmas in diverse tectonic settings. Plotting of tectonic discrimination diagram.

References

1. Dickin, A.P. (2005). *Radiogenic Isotope Geology*. Cambridge University Press, 492 pp.
2. Faure, G. and Mensing, T.M. (2009). *Isotopes Principles and Applications*. Wiley, 896 pp.
3. Ghosh, S.K. (1993). *Structural Geology: Fundamentals, and modern developments*, Pergamon Press.
4. Passhier, C. & Trouw, R.A.J. (2005). *Microtectonics*. Springer, Berlin.
5. Philpotts, A., & Ague, J. (2009). *Principles of Igneous and Metamorphic Petrology* (2nd ed.). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511813429
6. Ramsay, J.G & Huber, M.I. (1983). *Techniques of Modern Structural Geology: Vol. I & II*, Academic Press
7. Rollinson, H. R. (1993). *Using Geochemical Data: Evaluation, Presentation, Interpretation*. Harlow, Essex, England: Longman Group
8. Spear, F., (1993). *Metamorphic Phase Equilibria and Pressure-Temperature-Time paths*. Mineralogical Society of America, Washington, D.C.
9. Van der Pluijm, B.A. & Marshak, S. (2004). *Earth structure: an introduction to structural geology and tectonics*, W.W. Norton & Company Ltd.
10. Vernon, R., (2018). *A Practical guide to Rock Microstructure* (2nd Ed.), Cambridge University

	Press, https://doi.org/10.1017/9781108654609. 11. Wilson, M, 1989. Igneous Petrogenesis. Wiley	
	Module 3 Sampling survey, research vessels and expeditions, sediment coring, micro fossils as tools for palaeo-environmental, palaeo-ecological and palaeo-oceanographic studies, micro fossils as pollution indicators, case studies. Introduction to laboratory techniques – working principle and concepts of X-ray diffraction (XRD), Scanning Electron Microscope (SEM), UV-Visible spectroscopy, ICP-MS, X-ray fluorescence (XRF), Electron Microprobe Analysis (EPMA), FTIR and Raman Spectroscopy. Understanding of petrological and stereo zoom microscopes. Concept of Radiometric Isotope dating for sediments. Sampling techniques of microplastic in water and in soil. Equipments used in sampling. Instrument used to quantify and characterize microplastic: Pollution Index, Potential Ecological Risk Index (PERI) and Pollution Hazard Index (PHI). References: 1. Brasier, M. D. (1980). *Microfossils.* George Allen and Unwin. 2. Crawford, B.C & Quinn, B. (2016). *Microplastic Pollutants* (1st ed.). Elsevier Science. 3. Faure, G. (1986). *Principles of isotope geology*. John Wiley & Sons. 4. Hoefs, J. (2013). *Stable isotope geochemistry*. Springer Science & Business Media. 5. Hren, J. (2013). *Introduction to analytical electron microscopy*. Springer. 6. Jenkins, R., & Snyder, R. (1996). *Introduction to X-ray powder Diffractometry*. Wiley-Interscience. 7. Jones, R.W., (2004). *Micropalaeontology in petroleum exploration*. Oxford University press Inc.	15 hours

8. Kathal, P. (2012). *Applied geological micropalaeontology*. Scientific Publishers.

9. Reed, S. J. (2010). *Electron microprobe analysis and scanning electron microscopy in geology*. Cambridge University Press.

10. Rocha-Santos, T., Costa, M. & Mouneyrac, C., (Eds.). (2022). *Handbook of Microplastics in the Environme*nt (1st ed.). Springer

11. Rocha-Santos, T.A.P. & Duarte, A.C. (Eds.). (2017). *Characterization and Analysis of Microplastics* (1st ed.). Elsevier Science.

12. Sinha, D. K. (2007). *Micropaleontology: Application in stratigraphy and Paleoceanography*. Narosa Publishing House.

15 hours

Module 4

Hydrological cycle. Concept of Groundwater flow lines and flow net and generation of groundwater flownet. Classification of aquifers and confining layers, hydraulic properties of aquifers, water table and piezometric surface. Procedure of Aquifer test. Quality criteria for different uses. Pollution of surface and groundwater: Municipal sources, industrial sources, agricultural sources. Procedure for Sampling of groundwater and chemical analysis.

Tectonic domain of the ocean floor. Causes of sea level changes and measurements. Holocene sea level curves and future projections. Gas hydrates, hydrocarbon deposits, sulphate deposits, hydro-thermal deposits, polymetallic nodules, reserves and economics of marine resources. Marine geochemistry, laboratory methods for sample analyses. Isotope geology and geochronology.

References:

1. Appelo, C. A. J., & Postma, D. (2004). *Geochemistry, groundwater and pollution*. CRC press.

2. Edmunds, W. M., & Smedley, P. L. (1996). Groundwater geochemistry and health: an overview. *Geological Society, London, Special Publications*, *113*(1), 91-105.

3. Kuenen, P. *Marine Geology*, 2008, John Wiley

4. Fetter, C. W. (2018). *Applied hydrogeology*. Waveland

	Press. 5. Goldberg, S. (2006). Geochemistry, groundwater and pollution. 6. Roy-Barman and Jeandel, 2016, *Marine Geochemistry*,Oxford University Press. 7. Todd, D. K., & Mays, L. W. (2004). *Groundwater hydrology*. John Wiley & Sons. 8. James Kennet, *Marine Geology*, 1982, Prentice Hall	
Pedagogy	Lectures/ tutorials/ assignments/ self-study	
Course outcomes	Ph.D. candidate will be able to carry out independent research work.	

(Back to Index) (Back to Agenda)

Programme: Ph.D. Earth Science
Code: GEO-702
Title of the Course: Microplastics studies in environment
No. of Credits: 4
Effective from AY: 2023-24

Prerequisites for the course:	Post graduate in science enrolled for Ph.D. with NET/GATE/GU-PET	
Course objectives	To impart in-depth knowledge of microplastics as a pollutant and its impact on the environment and humans.	
Content:	**Module 1: Introduction to Microplastics** Types of plastics: PET, HDPE, PVC, LDPE, PP, PS; Chemical additives. Microplastics types based on size and appearance: fibres, microbeads, fragments, nurdles, foam. Microplastic density. Biotic degradation and biodegradable plastics: degradation of microplastic using micro-organism. Primary and Secondary, microplastics and its formation. Abiotic degradation: Photo-oxidative degradation, Atmospheric oxidation and hydrolytic degradation. **Module 2: Sources and spatial distribution of microplastics** Global occurrence, sources of microplastics. Distribution and fate of plastic in the environment. Microplastics in the terrestrial environment and the atmosphere, microplastics in lakes, rivers, estuaries, marine sediments, shorelines and snow.	15 hours 15 hours

	Module 3: Impacts of Microplastics on environment and climate: Potential impacts on the environment and human health and the interactions of microplastics and chemical pollutants. Microplastics as vectors for chemical pollutants in the soil and water. Metal and metalloid contaminated microplastics. The effect of salinity. Microplastic in plants, animals and humans. Fundamental links between climate change and marine plastic pollution. **Module 4: Sampling, characterization, assessment, mitigation of Microplastics:** Sampling and characterization: Methods used for sampling and processing, quantification of microplastics, visual identification by stereo microscope. Instrument for identification of microplastics- FTIR and Raman Spectroscopy. Assessment, Mitigation and legislation: Mitigation methods for microplastics. Risk assessment studies computation of Pollution Load Index (PLI), Potential Ecological Risk Index (PERI) and Pollution Hazard Index (PHI). Microplastic litter legislation	15 hours 15 hours
Pedagogy:	Lectures/ tutorials/ self-study	
References/ Readings:	1. Crawford, B.C & Quinn, B. (2016). *Microplastic Pollutants* (1st ed.). Elsevier Science. 2. Rocha-Santos, T., Costa, M. & Mouneyrac, C., (Eds.). (2022). *Handbook of Microplastics in the Environmen*t (1st ed.). Springer. 3. Rocha-Santos, T.A.P. & Duarte, A.C. (Eds.). (2017). *Characterization and Analysis of Microplastics* (1st ed.). Elsevier Science.	
Course Outcomes:	The student will be able to decipher the impact of microplastics on environment and humans.	

(Back to Index) (Back to Agenda)