GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

REVISED MINUTES

of the 5th Meeting of the Standing Committee of

X ACADEMIC COUNCIL

Day & Date

Tuesday, 14th February, 2023 & Thursday, 23rd February, 2023

Time

10.00 a.m.

Venue
Council Hall,
Administrative Block
Goa University

	the University as Dean, Shenoi Goembab School of languages & Literature during his tenure. **(Action: Assistant Registrar Academic-PG)**
D 3.17	**Minutes of the Board of Studies in Sanskrit meeting held on 28.10.2022.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Sanskrit meeting held on 28.10.2022 with the following suggestions: 1. Number of hours for Course Code SATE -401, Discipline Specific Elective Course to be verified. 2. Titles of the Courses to be written in Devanagari and English language. **(Action: Assistant Registrar Academic-PG)**
D 3.18	**Minutes of the Board of Studies in Marine Microbiology meeting held on 21.10.2022.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Marine Microbiology meeting held on 21.10.2022 with the following suggestions: 1. Tutorials/Lectures (L-T-P) mentioned under Structure to be deleted. 2. Prerequisite for the courses to be specified. 3. Prerequisite to be changed of the Course MMTE 501 Phytoplankton Ecology and Genomics. 4. Terminology Textbook/References to be changed to References/Readings. **(Action: Assistant Registrar Academic-PG)**
D 3.19	**Minutes of the Board of Studies in Marine Science meeting held on 27.10.2022.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Marine Science meeting held on 27.10.2022 with the following suggestions: 1. Tutorials/Lectures (L-T-P) mentioned under Structure to be deleted. 2. Wherever only one module exists under content, heading 'Module I' to be deleted. 3. Titles and the syllabus of the Courses to be verified. 4. Python to be explored under Course Code MSTE 501. 5. The content of the Course Code MSTE – 530 to be revised. 6. MSTE – 525 Advanced Research Analysis Course, from Pedagogy Terminology 'faculty' to be deleted. **(Action: Assistant Registrar Academic-PG)**
D 3.20	**Minutes of the Board of Studies in Earth Science meeting held on 29.10.2022.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Earth Science meeting held on 29.10.2022 with the following suggestions: 1. Tutorials/Lectures (L-T-P) mentioned under Structure to be deleted. 2. AGPE -508 Practical of Petroliferous Basins of India Programme to be conducted

	under Generic Elective Course (GEC). 3. Number of hours to AGTE-522 Natural Hazards and Disaster Management Programme, Module 3 to be assigned. 4. Number of Credits for AGPE-530 Geological Field Training (Practical) (Skill based Course) to be changed to '4 Credits' and effective from A.Y. to be made as '2023-2024'. 5. Field Oriented Programmes to be included under Semester III/IV**.** **(Action: Assistant Registrar Academic-PG)**
D 3.21	**Minutes of the Board of Studies in Environmental Science meeting held on 11.11.2022.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Environmental Science meeting held on 11.11.2022 with the suggestion to delete Research Specific Elective Course ESTE-533 Community Engagement for Sustainable Rural Development from the syllabus and Tutorials/Lectures (L-T-P) mentioned under Structure to be deleted. **(Action: Assistant Registrar Academic-PG)**
D 3.22	**Minutes of the Board of Studies in Sociology meeting held on 02.11.2022.** The Standing Committee of the Academic Council did not approve the minutes of the Board of Studies in Sociology meeting held on 02.11.2022. The Chairperson was requested to refer the matter back to the Board of Studies to rework on the following and thereafter to be placed before the Academic Council for consideration: 1. Detailed syllabus to be recommended for Course SOTG – 501 State, Refugees, and Displaced People, Generic Elective. 2. Number of hours of SOTR – 504 Ethnographic Research, Research Specific Elective Course to be revised to 60 hours. 3. PhD Course Work Course title to be titled as 'Research Methodology'. 4. PhD Course Work Programme, under content, point No.7 title to be named 'Issues in Social Research'. **(Action: Assistant Registrar Academic-PG)**
D 3.23	**Minutes of the Board of Studies in Hindi meeting held on 19.10.2022.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Hindi meeting held on 19.10.2022 with the following suggestions: 1. Title of the Courses to be indicated in both Hindi and English languages. 2. Translation of titles/font in languages to be thoroughly verified before uploading on the website. 3. Terminology 'Optional Generic Course' under structure to be changed to 'Generic Elective Courses'. **(Action: Assistant Registrar Academic-PG)**

Std. Com. X AC-5
14.02.2023

GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

F I N A L A G E N D A

For the 5th Meeting of the Standing Committee of

X ACADEMIC COUNCIL

Day & Date

Tuesday, 14th February, 2023

Time

10.00 a.m.

Venue
Conference Hall
Administrative Block
Goa University

	i. Recommendations of the text books for the course of study at undergraduate level: Nil ii. Recommendations of the text books for the course of study at post graduate level:Nil **Part F** Important points for consideration/approval of Academic Council i. The important points/recommendations of BoS that require consideration/approval of Academic Council (points to be highlighted) as mentioned below (a) The program structure and syllabus in M.Sc. Marine Sciences (Semester III and IV) was deliberated and new syllabus content was added. The suggestions made by the Experts were incorporated and the same was approved. This syllabus of M.Sc. Marine Sciences (Semester III and IV) was prepared with introduction of thirteen new courses (22%) in view of the implementation of NEP guidelines by the University. (b) The syllabus of Research Methodology paper (04 credits) for Ph. D. in Marine Sciences was placed and the suggestions made by the Experts were incorporated and approved. ii. The declaration by the Chairperson that the minutes were readout by the Chairperson at the meeting itself. Date: 27.10.2022 Sd/- Place: Goa University Campus 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. Sd/- Signature of the Dean Date: 27.10.2022 Place: Goa University Campus **(Back to Index)**
D 3.20	**Minutes of the Board of Studies in Earth Science meeting held on 29.10.2022.** **Part A** i. Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level: NIL ii. Recommendations regarding courses of study in the subject or group ofsubjects postgraduate level: **The Board approved the syllabus of Semester III and IV of the M.Sc. (Applied Geology) program. Annexure I (Refer page No.749)** **Part B** i. Scheme of Examinations at undergraduate level: NIL ii. Panel of examiners for different examinations at the undergraduate level:

The Board approved the examiners for T.Y.B.Sc. Semester End Examinations (Semester V and VI). – (Submitted in a sealed envelope).

iii. Scheme of Examinations at postgraduate level: NIL

iv. Panel of examiners for different examinations at post-graduate level: NIL

Part C

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: NIL

ii. Recommendations of the text books for the course of study at post graduate level:

Part F

Important points for consideration/approval of Academic Council

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 syllabus of SemesterIII and IV of the M.Sc. (Applied Geology) program.
   (b) Approval of the examiners for T.Y.B.Sc. Semester End Examinations (Semester V and VI).

ii. The declaration by the chairman that the minutes were read out by the Chairman at the meeting itself.

Date: 29.10.2022 Sd/-
Place: Taleigao Plateau 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: 29.10.2022 Sd/-
Place: Taleigao Plateau Signature of the Dean

(Back to Index)

D 3.20 Minutes of the Board of Studies in Earth Science meeting held on 29.10.2022.

Annexure I

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

Course Code	Course Title	L-T-P (Hours/week)	Credits (s)	Page Number
Research Specific Elective Course (RSEC)				
AGTE-501	Microtectonics	3-0-0	3	6-7
AGPE-502	Practical of Microtectonics	0-0-2	1	7
AGTE-503	Basics of RS, GIS and GNSS (IIRS-ISRO online Edusat course)	3-0-0	3	8
AGPE-504	Practical of Basics of RS, GIS and GNSS (IIRS-ISRO online Edusat course)	0-0-2	1	8
AGTE-505	Micropaleontology	3-0-0	3	9-10
AGPE-506	Practical of Micropaleontology	0-0-2	1	11
AGTE-507	Petroliferous Basins of India	3-0-0	3	12-13
AGPE-508	Practical of Petroliferous Basins of India	0-0-2	1	14
AGTE-509	Trace Elements Geochemistry	3-0-0	3	15-16
AGPE-510	Practical of Trace Elements Geochemistry	0-0-2	1	17
AGPE-511	Industrial Training	0-0-2	3	18
Generic Elective Course (GEC)				
AGTE-512	Mining Geology	3-0-0	3	19-20
AGPE-513	Practical of Mining Geology	0-0-2	1	20
AGTE-514	Engineering Geology	3-0-0	3	21-22
AGPE-515	Practical of Engineering Geology	0-0-2	1	23
AGTE-516	Environmental Geology	3-0-0	3	24-25
AGPE-517	Practical of Environmental Geology	0-0-2	1	25-26
AGTE-518	Soil Science	3-0-0	3	26-27
AGPE-519	Practical of Soil Science	0-0-2	1	28
AGTE-520	Glaciology	3-0-0	3	29-30
AGTE-521	Geomorphology	3-0-0	3	30-31
AGTE-522	Natural Hazards and Disaster Management	3-0-0	3	31-32
AGTE-523	Planetary Geology	3-0-0	3	33-34

(Back to Index) (Back to Agenda)

Research Specific Elective (RSE)

Title of the Course: Microtectonics
Course Code: AGTE-501 **Number of Credits:** 03
Total Contact Hours: 45 **Effective from AY:** 2023–24

Prerequisites for the course:	Students should have undergone course in structural geology at M.Sc. 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 tectonometamorphic 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.	
Learning outcomes	The student will be able to recognize microstructures and interpret the kinematic and tectonometamorphic significance of each microstructure.	

(Back to Index) (Back to Agenda)

Title of the Course: Practical of Microtectonics
Course Code: AGPE-502 **Number of Credits:** 01
Total Contact Hours: 30 **Effective from:** 2023–24

Prerequisites for the course	Students should have undergone course in structural geology at M.Sc. 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.
Learning outcomes	The student will be able to recognize and interpret microstructures in thin section, hand specimen and field.

Title of the Course: Basics of RS, GIS and GNSS (IIRS-ISRO online Edusat course)
Course Code: AGTE-503 **Number of Credits:** 03
Total Contact Hours: 45 hours **Effective from:** 2023–24

Prerequisites for the course	Undergraduate
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
Learning Outcomes	The student will develop research, analytical and problem solving skills.

Title of the Course: Practical of Basics of RS, GIS and GNSS (IIRS-ISRO online Edusat course)
Course Code: AGPE-504 **Number of Credits:**01
Total Contact Hours: **Effective from:** 2023–24

Prerequisites for the course:	Undergraduate
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.
Learning Outcomes	The student will develop research, analytical and problem-solving skills.

Title of the Course: Micropaleontology
Course Code: AGTE-505 **Number of Credits:** 03
Total Contact Hours: 45 **Effective from AY:**2023–24

Prerequisites for the course:	Students should have undergone M.Sc. Part I.	
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. **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. **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 15 hours 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.
Learning Outcome	Students will be able to identify various types of microfossils and use microfossils to decipherpaleo-oceanographic and paleoclimatic changes in the geological past.

(Back to Index) (Back to Agenda)

Title of the Course: Practical of Micropaleontology
Course Code: AGPE-506 **Number of Credits:** 01
Total Contact Hours: 30 **Effective from AY:**2023–24

Prerequisites for the course:	Students should have undergone M.Sc. Part I.	
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 palaeoceanography and oceanic biostratigraphy. • Sorting, identification, morphological description and classification of microfossils. • Quantification of microfossils of different species.	30 hours
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 palaeoceanography*. Narosa Publishing House.	
Learning outcome	Students will be able to process the samples, extract and identify microfossils.	

(Back to Index) (Back to Agenda)

Title of the Course: Petroliferous basins of India
Course Code: AGTE-507 **Number of Credits:** 03
Total Contact Hours: 45 **Effective from AY:**2023–24

Prerequisites for the course:	Students should have undergone M.Sc. Part I	
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, relation 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.
Learning outcomes	Students will be able to discuss Petroliferous basins in India, their geological environment, tectonic setting and potential of hydrocarbon exploration in India.

(Back to Index) (Back to Agenda)

Title of the Course: Practical of Petroliferous Basins of India

Course Code: AGTE-508 **Number of Credits:** 01

Total Contact Hours: 30 **Effective from AY:**2023–24

Prerequisites for the course:	Students should have undergone M.Sc. Part I	
Objective:	To impart the knowledge about Petroliferous basins in India. To understand its occurrence, structure and depositional environment.	
Content:	Plotting and categorization 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.	
Learning outcomes	Student will be able to plot and categorize various sedimentary basins, correlate different petroliferous basins, prepare basin boundary maps with tectonic features and evaluate basin potential for petroliferous deposits.	

Title of the Course: Trace Element Geochemistry

Course Code: AGTE-509 **Number of Credits:** 03
Total Contact Hours: 45 **Effective from AY:** 2023–24

Prerequisites for the course	Students should have undergone M.Sc. Part I	
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.	15 hours
	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
Pedagogy	Lectures/ tutorials/assignments/field study/discussion	
References/ Readings	1. Wood, B. J., and D. G. Fraser (1977). *Elementary Thermodynamics for Geologists*. New York, NY: Oxford University Press. 2. McSween, H. Y., Jr., S. M. Richardson, and M. E. Uhle (2003). *Geochemistry: Pathways and Processes*. New York, NY: Columbia University Press.	

	3. Rollinson, H. R. (1993). *Using Geochemical Data: Evaluation, Presentation, Interpretation*. Harlow, Essex, England: Longman Group 4. Albarede, F. (1995) *Introduction to Geochemical Modeling.* New York, NY: Cambridge University Press 5. Shaw, D. M. (2006) *Trace Elements in Magmas*. New York, Cambridge University Press. 6. Faure, G. and Mensing, T. M., (2005) *Isotopes: Principles and Applications*, 3rd Edn. John Wiley & Sons 7. White, M. W. (2014). *Isotope Geochemistry*. Wiley – Blackwell 8. Sharp Zachary (2006). *Principle of Stable Isotope Geochemistry*. Prentice Hall 9. Freeze, R.A. and Cherry, J.A. (1979) *Groundwater*. Prentice Hall 10. Stumm, W. and Morgan, J.J. (1981) *Aquatic chemistry*. John Wiley & Sons 11. Gasper, E. and Onescu, M. (1972) *Radioactive tracers in hydrology.* Elsevier 12. Hiscock, K. M., &Bense, V. F. (2021). *Hydrogeology: principles and practice*. John Wiley & Sons.
Learning outcomes	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. Use isotopic study as a tool for tracking source composition and in rock water interaction systems.

(Back to Index) (Back to Agenda)

Title of the Course: Practical of Trace element Geochemistry
Course Code: AGPE-510 **Number of Credits:** 01
Total Contact Hours: 30 **Effective from AY:** 2023–24

Prerequisites for the course	Students should have undergone M.Sc. Part I.	
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	
Learning outcomes	The students will be able to generate, plot and interpret trace element geochemical data.	

Title of the Course: Industrial Training
Course Code: AGPE-511 **Number of Credits:** 03
Total Contact Hours: 45 hours **Effective from AY:** 2023–24

Prerequisites for the course	Students should have undergone M.Sc. Part I.

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	
Learning Outcomes:	The students will be able to undertake field mapping/ sample processing/ measurement, perform data analysis and interpret and present results.	

(Back to Index) (Back to Agenda)

Generic Elective Course (GEC)

Title of the Course: Mining Geology
Course Code: AGTE-512 **Number of Credits:** 03
Total Contact Hours: 45 **Effective from AY:** 2023–24

Prerequisites for the course	Students should have undergone M.Sc. Part I.	
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.	15 hours
	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.	15 hours
	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
Pedagogy	Lectures, Case studies, Discussions and Assignments.	
References/ Readings	1. Arogyaswamy, R. N. P. (1992). *Courses in Mining Geology*. Oxford & IBH Publishers.	

	2. McKinstry, H. E. (1980). *Mining Geology*. Asia Publishing House. 3. Youn, G. J. (1984). *Elements of Mining Geology*. McGraw Hill. 4. Sinha and Sharma (1970), *Mineral Economics*. Oxford & IBH Publishers. 5. Taggart (1945). *Mineral Ore Dressing*. 6. Peters (1987), *Exploration and Mining Geology*. William Publication: New-York John Wiley & Sons 7. Dhar (2000), *Mining and environment.* Bharat Publication: New Delhi A.P.H. Publishing. 8. Lewis Inc. (1964), *Elements of Mining*. Robert Publication: New York John Wiley and Sons, 9. Saxena (2005), *Mining Environment Management Manual*. Naresh C. Publication: Jodhpur: Scientific Publishers; 2005. xix, 711 p, Includes bibliography. 10. Warhurst, Alyson (2000), *Environmental policy in mining: corporate strategy and planning for closure*. Publication: Boca Raton: Lewis Publishers. 11. Evans, A.M. (1995), *Introduction to Mineral Exploration*, Blackwell Science, Oxford. 12. A. G and Huijbregts, Ch (1978), *Mining Geostatistics*. Academic Press. 13. Armstrong, M (1998), *Basic linear Geostatistics*. Springer Verlag, Berlin.
Learning outcomes	The students will be able to discuss the mining techniques, functioning, processes and environmental management.

(Back to Index) (Back to Agenda)

Title of the Course: Practical of Mining Geology
Course Code: AGPE-513 **Number of Credits:** 01
Total Contact Hours: 30 **Effective from:** 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Part I.	
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. (1992). *Courses in Mining Geology*. Oxford & IBH Publishers. 2. McKinstry, H. E. (1980). *Mining Geology*. Asia Publishing House. 3. Youn, G. J. (1984). *Elements of Mining Geology*. McGraw Hill. 4. Sinha and Sharma (1970), *Mineral Economics*. Oxford & IBH Publishers 5. Taggart (1945). *Mineral Ore Dressing*. 6. Peters (1987), *Exploration and Mining Geology*. William Publication: New-York John Wiley & Sons	
Learning	The students will be able to prepare borehole logs, geological sections and	

outcomes	estimate ore reserves.

Title of the Course: Engineering Geology
Course Code: AGTE-514 **Number of Credits:** 03
Total Contact Hours: 45 **Effective from AY:** 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Part I.	
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/ Readings	1. De Vallejo, L. G., & Ferrer, M. (2011). *Geological engineering*. CRC 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.	

Learning outcomes	Students will be able to discuss engineering properties of rocks and soils, undertake site investigations and prepare reports and identify and manage geological hazards.

(Back to Index) (Back to Agenda)

Title of the Course: Practical of Engineering Geology
Course Code: AGPE-515 **Number of Credits:** 01
Total Contact Hours: 30 **Effective from AY:** 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Part I.	
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 and interpreting bore hole data. Calculation of pore water pressure in a slope using groundwater flow net.	30 hours
Pedagogy	Practical exercises and discussions.	
References/ Readings	1. Krynine, D.P., Judd, W.R., & Krynine, D. P. (1957). *Principles of engineering geology and geotechnics* (pp. 1-3). New York: McGraw-Hill. 2. De Vallejo, L. G., & Ferrer, M. (2011). *Geological engineering*. CRC press. 3. Bromhead, E. N. (1992). *The stability of slopes*. CRC Press. 4. Chandler, R. J. (Ed.). (1991). *Slope stability engineering: developments and applications: proceedings of the International Conference on Slope Stability*. Thomas Telford.	
Learning outcomes	Students will be able to select sites for various civil structures like dams, tunnels, bridges, roads and buildings. Interpret borehole data and calculate pore water pressure using groundwater flow-net.	

(Back to Index) (Back to Agenda)

Title of the Course: Environmental Geology
Course Code: AGTE-516 **Number of Credits:** 03
Total Contact Hours: 45 **Effective from AY:** 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Part I.	
Objective	To impart the knowledge about basics of environmental geology. To understand 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,	15 hours

	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: 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 15 hours
Pedagogy	Lectures, case studies, discussions and assignments.	
References/ Readings	1. D. Merrits, A. de Wet and K. Menking (1997). *Environmental Geology: An Earth System Science Approach.* W. H. Freeman, New York. 2. Keller, E. A. (2012). *Introduction to Environmental Geology* (5th edition). 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.	
Learning outcomes	Student will be able to explain the concepts of environmental geology, recognize natural and manmade hazards and suggest mitigation measures.	

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

Title of the Course: Practical of Environmental Geology
Course Code: AGPE-517 **Number of Credits:** 01
Total Contact Hours: 30 **Effective from AY:** 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Part I.
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* (5th edition). 2. Montgomery, C. W. (2010). *Environmental geology.* (9th Edition) Professor Emerita, Northern Illinois University 3. Montgomery, C. W. (2020). *Environmental geology.* (11th 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.	
Learning outcomes	Students will be able to prepare maps of natural and manmade hazards and trace the movement of pollutants.	

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

Title of the Course: Soil Science
Course Code: AGTE-518 **Number of Credits:** 03
Total Contact Hours: 45 **Effective from AY:** 2023-24

Prerequisites for the course	Students should have undergone M.Sc. Part I.	
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,	15 hours 15 hours

	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
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.	
Learning outcomes	Students will able to classify soils and manage their utility.	

(Back to Index) (Back to Agenda)

Title of the Course: Practical of Soil Science
Course Code: AGPE-519 **Number of Credits:** 01
Total Contact Hours: 30 **Effective from:** 2023-24

Prerequisites for the course:	Students should have undergone M.Sc. Part I.	
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 samples 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.	
Learning outcomes	Students will be able to prepare soil distribution maps, identify soil horizons, undertake grain size distribution analysis and classify soils.	

Title of the Course: Glaciology
Course Code: AGTE-520 **Number of Credits:** 03
Total Contact Hours: 30 **Effective from AY:** 2023–24

Prerequisites for the course	Students should have undergone M.Sc. Part I.	
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.	15 hours
	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; dead ice; flow and sliding of glaciers: Driving and resisting stresses; steady and non-steady flow of glacier.	15 hours
	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
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. Van der Veen, C. J. (2013). *Fundamentals of glacier dynamics*. CRC press. 5. Knight, P. J. (1999): *Glacier Science and Environmental Change.* Wiley. 6. Hambrey & Alean (2004): *Glaciers,* 2nd edition. Cambridge University Press. 7. Marshall, S. J. (2011). *The Cryosphere*. Princeton University Press.	
Learning Outcomes	Student will be able to discuss the processes involved in glaciation and climate change and identify erosional and depositional landforms.	

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

Title of the Course: Geomorphology
Course Code: AGTE-521 **Number of Credits:** 03
Total Contact Hours: 45 **Effective from AY:** 2022-23

Prerequisites for the course	Students should have undergone M.Sc. Part I.

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.	
Learning Outcomes:	Students will be able to identify various geomorphological processes and landforms.	

Title of the Course: Natural Hazards and Disaster Management
Course Code: AGTE-522 **Number of Credits:** 03
Total Contact Hours: 45 **Effective from AY:** 2023–24

Prerequisites for the course	Students should have undergone M.Sc. Part I.
Objective	To provide an overview of the common hazards and their dynamics •To inculcate the basic concepts of disaster managemen To provide an overview of the common hazards and their dynamics •To inculcate the basic concepts of disaster managemen To provide an overview of the common hazards and their dynamics •To inculcate the basic concepts of disaster management To provide an overview of the common hazards and their dynamics

	•To inculcate the basic concepts of disaster management To provide an overview of the common hazards and their dynamics •To inculcate the basic concepts of disaster management 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. **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 **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 15 hours
Pedagogy	Lectures/ tutorials/ assignments/ self-study	
References/ Readings	1. Keller, E. A., and DeVecchio, D. E. (2016). *Natural hazards: earth's processes as hazards, disasters, and catastrophes*. Routledge. 2. Hyndman, D., and Hyndman, D. (2016). *Natural hazards and disasters*. Cengage Learning. 3. Coppola D P, (2007). *Introduction to International Disaster Management*, Elsevier Science (B/H), London. 4. 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. 5. Srivastava, H.N., and Gupta, G.D., (2006). *Management of Natural Disasters in developing countries*, Daya Publishers, Delhi, 201 p.	

	6. Alexander, D., (1999), *Natural Disasters*, Kluwer Academic London, 632 pages 7. Disaster Management Act 2005, Published by Govt. of India 8. Publications of National Disaster Management Authority (NDMA) on Various Templates and Guidelines for Disaster Management 9. UNISDR. (2002). *Natural Disasters and Sustainable Development: Understanding the links between Development, Environment and Natural Disasters*, Background Paper No. 5. 10. Disaster Management Guidelines, GOI-UN Disaster Risk Program (2009–2020) 11. Modh S. (2010) *Managing Natural Disasters*, Mac Millan publishers India LTD
Learning outcomes	Students will be able to identify different natural hazards, acquire a comprehensive understanding of disasters and disaster management.

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

Title of the Course: Planetary Geology
Course Code: AGTE-523 **Number of Credits:** 03
Total Contact Hours: 45 **Effective from AY:** 2023–24

Prerequisites for the course	Students should have undergone M.Sc. Part I.	
Objective	To impart basic knowledge of 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.	15 hours
	Module 2 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	15 hours
	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	15 hours

	rovers, first lunar landing. International Space station. Seismic method of exploration, remote sensing of physical and chemical attributes of planets.	
Pedagogy	Lectures/ tutorials/ assignments/ self-study	
References/ Readings	1. 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 2. Wood, J. A. (2000). The Solar System (2nd edition) Prentice-Hall 3. Christiansen E. H., and Hamblin, W. K., (1995) *Exploring the Planets (2nd edition).* Prentice-Hall 4. Gunter, F., and Teresa, M., (2007). *Introduction to planetary science: The geological perspective.* M. Springer, the Netherlands. ISBN: 13 978-1-4020-5544-7. 5. Cook, A.H., (1980). *Interiors of Planets.* Cambridge University Press, London. ISBN: 978-0-521- 23214-2 6. Bhardwaj A. (Ed). (2006). *Advances in Geosciences: Planetary Science (Volume 3).* World Scientific Publishing C. Pte. Ltd. Singapore. ISBN: 981-256-983-8. 7. Watters, T.R. and Schultz, R.A, (2010). *Planetary Tectonics*. Cambridge University Press. ISBN 978-0-521-76573-2. 8. Wilhelms, D., (1993). *To a Rocky Moon - A Geologist's History of Lunar Exploration.* University of Arizona Press, Tucson. 9. Cook, A.H., (1973). *Physics of Earth and planets*. London: Macmillian 10. Kaula, W.M., (1996). *Theory of satellite geodesy*. Blaisedell 11. Beatty, J., Petersen C., and Chaikin, A., (1999). *The New Solar System*. Cambridge University Press, Cambridge, England. 12. Lodders K. and Fegley, B., (1998). *The Planetary Scientist's Companion*. Oxford University Press, New York 13. Morrison, D., (1993). *Exploring Planetary Worlds.* Scientific American Library, New York.	
Learning outcomes	Students will be able to discuss the origin of Solar System and its celestial constituents.	

(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-T-P (Hours/week)	Credits (s)	Page Number
Research Specific Optional Course (RSOC)				
AGTE-524	Climate Geology	2-0-0	2	36
AGTE-525	Microplastic Pollution Studies	2-0-0	2	37-38
AGTE-526	Precambrian Crustal Evolution	2-0-0	2	38-39
AGTE-527	Radiogenic Isotope Dating	2-0-0	2	39-40

AGTE-528	Coal Geology	2-0-0	2	40
Discipline Specific Dissertation				
AGPE-529	Dissertation (DSD)/Internship	0-0-4	12	41
AGPE-530	Geological Field Training (Practical) (Skill Based Course)	0-0-4	4	

Title of the Course: Climate Geology
Course Code: AGTE-524 **Number of Credits:** 02
Total Contact Hours: 30 **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 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 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. Oliver, J. E. (2002). *Climatology: An Atmospheric Science, 2/e*. Pearson Education India. 3. Kump, L.R., Kasting, J.F. and Crane, R.G. (2004). *The Earth System*, 2nd ed, Prentice Hall. 4. Oerlemans, J. (2001). *Glaciers and climate change, Balkema.* Rotterdam, Netherlands.	
Learning outcomes	Students will be able to discuss climate and climatic variations on various time scales and create awareness.	

(Back to Index) (Back to Agenda)

Title of the Course: Microplastics Pollution

Course Code: AGTE-525 **Number of Credits:** 02
Total Contact Hours: 30 **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* ***Impact 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.	
Learning Outcomes:	Students will be able to discuss and identify microplastics and create awareness about microplastic pollution.	

Title of the Course: Precambrian Crustal Evolution
Course Code: AGTE-526 **Number of Credits:** 02
Total Contact Hours: 30 **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-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 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	
Learning outcomes	The students will be able to identify different processes that led to the formation of the Precambrian crust.	

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

Title of the Course: Radiogenic Isotope Dating
Course Code: AGTE-527 **Number of Credits:** 02
Total Contact Hours: 30 **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. Faure, G. (1977). *Principles of Isotope Geology*. Wiley, 464 pp. 2. Faure, G. and Mensing, T.M. (2009). *Isotopes Principles and Applications*. Wiley, 896 pp. 3. Dickin, A.P. (2005). *Radiogenic Isotope Geology*. Cambridge University Press, 492 pp.	
Learning outcomes	The student will acquire the knowledge of radiometric dating and will be able to interpret and evaluate radiometric ages.	

(Back to Index) (Back to Agenda)

Title of the Course: Coal Geology
Course Code: AGTE-528 **Number of Credits:** 02
Total Contact Hours: 30 **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*. Gebruderborntraeger.	
Learning outcomes	Students will be able to identify different types of coals, their occurrences, geological environment and tectonic setting.	

(Back to Index) (Back to Agenda)

Generic Elective Course (GEC)

Title of the Course: Dissertation (DSD)/Internship **Number of Credits:**12
Course Code: AGPE- 529 **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.	15 weeks

	A report based of the work will be submitted which will be evaluated by the Discipline Specific Committee.	
Pedagogy:	Project conceptualization, Fieldwork, Skill based training, Laboratory analyses, Data processing, Scientific report writing and presentation.	
Learning Outcomes:	The students will be able to formulate a research proposal and carry out research independently.	

Title of the Course: Geological Field Training (Practical) (Skill Based Course)
Course Code: AGPE-530 **Number of Credits:** 02
Total Contact Hours: 120 **Effective from AY:** 2022-23

Prerequisites for the course:	Students should have undergone M.Sc. Part I.	
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 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.	120 hours
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.	
Learning outcomes	The students will be able to identify the rocks their structures, and prepare geological map and write a detail technical report of the area.	

(Back to Index) (Back to Agenda)

Research Methodology

Title of the Course: Research Methodology in Earth Science

Course Code: ESRM-601 **Number of Credits:** 04

Total Contact Hours: 45 **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. 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. **Module 2** Sampling and Mapping techniques. 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.	15 hours 15 hours

	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.	15 hours

	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. 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. **Module 4** Concept of Groundwater flow lines and flow net and generation of groundwater flownet. Classification of aquifers and confining layers. Procedure of Aquifer test. Physical, chemical, biological properties of water. Quality criteria for different uses. Pollution of surface and groundwater. Procedure for Sampling of groundwater and chemical analysis. Techniques for Groundwater exploration. Software related to Groundwater flow. Marine sediment and classification. Sea level changes: causes and measurements. Paleo-beaches, paleooceanography, coastal geomorphology, coastal surveys and coastal tectonic framework. Marine mineral deposits, gas hydrates, hydro-thermal deposits and polymetallic nodules. References: 1. Appelo, C. A. J., & Postma, D. (2004). *Geochemistry, groundwater and pollution*. CRC press.	15 hours

	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, Marine Geochemistry, 2016, 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	
Learning outcomes	Ph.D. candidate will be able to carry out independent research work.	

(Back to Index) (Back to Agenda)

Advanced Theory

Programme: Ph.D. Earth Science
Title of the Course: Microplastic Pollution studies

Course Code: ESAT-602 **No. of Credits**: 4
Total Contact Hours: 45 hours **Effective from AY**: 2022-23

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. Formation of microplastics: Primary and Secondary. Biotic degradation and biodegradable plastics: degradation of microplastic using micro-organism., 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, lakes, rivers, estuaries; Microplastics in marine environment; Microplastics in snow and atmosphere.	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.	
Learning Outcomes:	The student will be able to decipher the impact of microplastics on environment and humans.	

(Back to Index) (Back to Agenda)