।। सा विद्या या विमुक्तये ।।
स्वामी रामानंद तीर्थ मराठवाडा विद्यापीठ, नांदेड
"ज्ञानतीर्थ" परिसर, विष्णुपूरी, नांदेड - ४३१६०६ (महाराष्ट्र)
SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY NANDED
"Dnyanteerth", Vishnupuri, Nanded - 431606 Maharashtra State (INDIA)
Established on 17th September 1994 – Recognized by the UGC U/s 2(f) and 12(B), NAAC Re-accredited with 'A' Grade
ACADEMIC (1-BOARD OF STUDIES) SECTION
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प्रस्तुत विद्यापीठीय संकुलातील विज्ञान व तंत्रज्ञान विद्याशाखेतील पदव्युत्तर स्तरावरील द्वितीय वर्षाचे CBCS Pattern नुसारचे अभ्यासक्रम शैक्षणिक वर्ष २०२०—२१ पासून लागू करण्याबाबत.

प रि प त्र क

या परिपत्रकान्वये सर्व संबंधितांना कळविण्यात येते की, **दिनांक २० जून २०२० रोजी संपन्न झालेल्या ४७व्या मा. विद्या परिषद बैठकीतील विषय क्र.११/४७—२०२०** च्या ठरावानुसार **प्रस्तुत विद्यापीठीय संकुलातील विज्ञान व तंत्रज्ञान विद्याशाखेतील पदव्युत्तर स्तरावरील द्वितीय वर्षाचे** खालील विषयांचे **C.B.C.S. (Choice Based Credit System) Pattern** नुसारचे अभ्यासक्रम शैक्षणिक वर्ष २०२०—२१ पासून लागू करण्यात येत आहेत.

01. M.Sc.-II Year-Botany
02. M.Sc.-II Year-Analytical Chemistry
03. M.Sc.-II Year-Industrial Chemistry
04. M.Sc.-II Year-Medicinal Chemistry
05. M.Sc.-II Year-Organic Chemistry
06. M.Sc.-II Year-Physical Chemistry
07. M.Sc.-II Year-Polymer Chemistry
08. M.Sc.-II Year-Computer Application
09. M.Sc.-II Year-Computer Network
10. M.Sc.-II Year-Computer Science
11. M.C.A.-II Year (Master of Computer Applications)
12. M.Sc.-II Year-Environmental Science
13. M.A./M.Sc.-II Year-Geography
14. M.Sc.-II Year-Geophysics
15. M.Sc.-II Year-Geology
16. M.A./M.Sc.-II Year-Mathematics
17. M.Sc.-II Year-Microbiology
18. M.Sc.-II Year-Physics
19. M.Sc.-II Year-Zoology
20. M.Sc.-II Year-Biotechnology
21. M.A./M.Sc.-II Year-Statistics

सदरील परिपत्रक व अभ्यासक्रम प्रस्तुत विद्यापीठाच्या **www.srtmun.ac.in** या संकेतस्थळावर उपलब्ध आहेत. तरी सदरील बाब ही सर्व संबंधितांच्या निदर्शनास आणून द्यावी.

'ज्ञानतीर्थ' परिसर,
विष्णुपुरी, नांदेड – ४३१ ६०६.
जा.क्र.: शैक्षणिक—१/परिपत्रक/पदव्युत्तर(संकुल)—सीबीसीएस अभ्यासक्रम/२०२०—२१/**५१३**

स्वाक्षरित/—
उपकुलसचिव
शैक्षणिक (१—अभ्यासमंडळ) विभाग

दिनांक : ०८.०८.२०२०.

प्रत माहिती व पुढील कार्यवाहीस्तव :
१) मा. कुलसचिव यांचे कार्यालय, प्रस्तुत विद्यापीठ.
२) मा. संचालक, परीक्षा व मूल्यमापन मंडळ यांचे कार्यालय, प्रस्तुत विद्यापीठ.
३) मा. संचालक, सर्व संबंधित संकुले, प्रस्तुत विद्यापीठ.
४) साहाय्यक कुलसचिव, पदव्युत्तर विभाग, प्रस्तुत विद्यापीठ.
५) उपकुलसचिव, पात्रता विभाग, प्रस्तुत विद्यापीठ.
६) सिस्टम एक्सपर्ट, शैक्षणिक विभाग, प्रस्तुत विद्यापीठ.

Swami Ramanand Teerth Marathwada University

M.Sc. Geology
2 Years (4 Semester Program)
Syllabus
With effective from 2019 – 2020

Department of Geology
School of Earth Sciences
SRTM University
NANDED

M.Sc. Geology
Syllabus Pattern

Syllabus of M.Sc. Geology program offered by the School of Earth Sciences has been prepared considering the syllabi for the UPSC Geologists examination, CSIR-NET examination and the requirements of the industry. The M.Sc. program in Geology is imparted to the students for two academic years consisting of four semesters. Candidates will be examined and evaluated on grade basis at the end of each semester in different theory and practical papers as per the credits offered by each course.

The M.Sc. Geology program consists of (i) Core Subjects (ii) Subject Electives and (iii) Open Elective Courses. The Core Subjects shall be **75%** of the program (***with a total of 100 credits***), which are mandatory for all the students. Students can choose one Subject Elective per semester from the list of Subject Electives provided. A student has to take 8 credits of Open Elective courses within the 2 year term of the program. The Open Electives can be selected from the Open Elective courses offered by the School of Earth Sciences *OR* offered by other Schools from the University Campus. Students are also encouraged to select Open Elective courses from National Educational Platforms such as MOOCS/NPTL/SWAYAM. If a student wishes, he/she can take a few extra courses, which will be considered as add-on credits.

In addition to class-room teaching and laboratory, the M.Sc. Geology program offers geological field training to the students. After completion of field training, students have to submit a filed report to the School. Intensive training/internships in the nationally reputed institutes shall also be provided to the M.Sc. Geology students. The semester breaks can also be utilized for the geological field training and internships.

Students will be assessed through Mid-Term and End-Term examinations. Mode of assessment in the Mid-Term examinations consists of Tutorials, Home Assignments, Seminars, Field studies, Quizzes and Oral presentations. The End-Term examinations will be based on paper-pen pattern and laboratory experiments/calculations.

Every M.Sc. Geology student has to mandatorily submit dissertation thesis. The dissertation work is based on either new data generated for the proposed scientific problem *OR* based on available large global data sets using innovative ideas. The thesis should be based on sound methodology and well defined objectives. Through dissertation work the student should be well-versed with the literature on the chosen topic, independently define a scientific problem, carry out focused study on a research topic, analyze and interpret large data sets, independently write thesis / project proposal and present and defend the dissertation work. The Dissertation must be submitted by the end of fourth Semester with a Seminar presentation in the presence of faculty members, students and external examiners for the purpose of evaluation. The School of Earth Sciences strongly encourages the M.Sc. Geology students to publish their dissertation work in SCI journals.

M.Sc. Geology
I Year - I Semester
Syllabus

M.Sc. Geology, I Year, I Semester (Total Credits = 25)								
Sr. No.	**Subject**	**Code**	**Theory Paper**	**Credits**	**Sr. No.**	**Code**	**Practical Paper**	**Credits**
1	**Core**	GEO-C101	Mineralogy	4	**1**	GEO-C105	Mineralogy	2
2	**Core**	GEO-C102	Structural Geology and Geotectonics	4	**2**	GEO-C106	Structural Geology and Geotectonics	2
3	**Core**	GEO-C103	Palaeontology	2	**3**	GEO-C107	Palaeontology	1
4	**Core**	GEO-C104	Geochemistry	2	**4**	GEO-C108	Geochemistry	1
5	**Subject Elective (Choose any One)**	GEO-E101	Stratigraphy	3	**5**	GEO-E104	Stratigraphy	1
		GEO-E102	Crystallography			GEO-E105	Crystallography	
		GEO-E103	Geology and Tectonic of India			GEO-E106	Geology and Tectonics of India	
6	**Open Elective (for students from all the Schools including School of Earth Sciences)**	GEO-OE101	Fundamentals of Geochemistry	2	**6**	GEO-C109	Seminar/Field Report	1
		GEO-OE102	Earth System Science					
		GEO-OE103	Origin and Evolution Of Life					
			Total	**17**			**Total**	**8**

Department of Geology
School of Earth Sciences
SRTM University
NANDED

GEO-C101: MINERALOGY
(Theory: 4 credits & Practical: 2 credits)

Pre-requisites:

Basic (10+2) knowledge of chemistry and physics + good observational skills.

Course objectives:

1. Minerals are the fundamental blocks of all Earth's solid material and also that of the inner planets of our Solar system. Mineralogy is essential for the courses in igneous, sedimentary and metamorphic petrology, economic geology and for interpretation of geophysical data.

2. This course in Mineralogy would help the students to understand distribution of minerals in different Earth's spheres, evaluate different processes of mineral formation, why some minerals are restricted to particular physic-chemical environments, identify and characterize the minerals based on their physical, crystal chemical and optical properties.

3. The student will study the basic principles behind the arrangement of atoms to form crystal structures, how these atoms are coordinated and bonded and how this is reflected in the external form, chemical composition, and physical properties of the crystals.

4. The student will study how to identify the most common minerals in hand specimen and, by using optical techniques, learn how to identify the common minerals in thin section.

5. The course introduces the minerals, which are of economic significance. The course also introduces the student to sophisticated instruments used in deciphering mineral structure and chemistry.

Course contents:

Unit I: Introduction and Scope

Mineralogy and its scope
Classification of Minerals
Processes of Mineral formation

Unit II: Physical Properties of Minerals

Properties under light
Electrical properties
Magnetic properties
Radioactive properties

Unit III: Chemistry and Structure of Minerals

Chemistry: Basic properties of Elements
Chemical and Geochemical Classification of Elements
Solid solution
Exsolution
Pauling's Rules
Goldschmidt's Rules
Principles and use of EPMA in Mineralogical Studies
Principles and use of ICP-MS in Mineralogical Studies

Structure: Silicate Structures
Polymorphism
Pseudomorphism

Unit IVA: Optical Properties of Minerals

Basic introduction to wave propagation
Isotropy and Anisotropy of Minerals
Petrological Microscope
Optical indicatrices
Orthoscopic properties
Conoscopic properties

Unit IVB: Descriptive Mineralogy

Silicates
Oxides
Carbonates
Sulphides
Precious and Semi-precious stones

GEO-C105: Practical based on GEO-C101 (2 Credits)

1. Study of Rock-forming minerals in Hand Specimen.
2. Study of Rock-forming minerals in Thin Section.
3. Conoscopic Observations of minerals.
4. Calculation of Mineral Chemical Formulae.

Course outcomes:

At the completion of the course students would be able to

1. Explain why different minerals have distinctly different structures.
2. Explain distribution of elements in different structural sites of the minerals.
3. Explain how the properties of chemical elements and their bonds determine the structure and composition of minerals.
4. Demonstrate how the internal structure of minerals affects the external structure and physical properties of minerals.

5. Explain the mineralogical concepts of isomorphism, polymorphism, isostructuralism, solid solution and exsolution.
6. Discuss which mineral identification method is appropriate for solving a mineralogical problem (e.g. polarizing microscope, x-ray diffraction, electron microprobe).
7. Recognize and describe the basic properties and chemistry of common rock-forming minerals.
8. Identify minerals based on megascopic and microscopic observations.
9. Able to calculate mineral formulae based on chemistry.

Prescribed and Reference Books

- ***An Introduction to the Rock-Forming Minerals** by **W.A. Deer, R.A. Howie and J. Zussman (Descriptive Mineralogy)**
- ***Crystallography** by **Walter Borchardt-Ott (X-Ray Diffraction and Crystal Chemistry)**
- ***Manual of Mineralogy** by **C. Klein and C.S. Hurlbut (Prescribed Text Book)**
- ***Rutley's Elements of Mineralogy** by **C.D. Gribble (An Elementary text Book)**
- **An introduction to Mineralogy for Geologists** by **Phillips and Phillips (Crystallography, Crystal Chemistry & Silicate Structures)**
- **Dana's New Mineralogy** by **Gaines, Skinner, Ford, Mason, Rosenzneig (Descriptive Mineralogy)**
- **Heavy Minerals in Colour** by **Mange and Maurer (Good Photographs & brief description of Heavy Minerals)**
- **Introduction to Mineralogy** by **William D Nesse**
- **Mineralogy** by **Berry Mason and Dietrich (Descriptive Mineralogy)**
- **Mineralogy** by **Perkins**
- **Minerals** by **G.W. Robinson (Good Photographs of Minerals)**
- **Optical Mineralogy** by **Paul F. Kerr**
- **Optical Mineralogy** by **P.R.J. Naidu**
- **Optical Mineralogy** by **Phillips andGriffen (Optical Mineralogy)**
- **Principles of Crystal Chemistry** by **E. Cartmell (Crystal Chemistry)**
- **Principles of Mineralogy** by **Blackburn and Denner (X-Ray Crystallography & Descriptive Mineralogy)**
- **Rock and Minerals** by **Dougel Dixon (Good Photographs)**
- **Rock-forming Minerals in Thin Section** by **H. Pichler and C. Schmitt-Riegraf (Thin Section Photographs)**
- **Rocks and Minerals** by **Basil Booth (Good Photographs)**
- **Rocks and Minerals** by **Chris Pellant (Good Photographs)**
- **The Illustrated Encyclopedia of Minerals and Rocks** by **J. Kourimsky (Good Photographs)**

- **Lecture hand-outs**
- **Research papers**

GEO-C102: STRUCTURAL GEOLOGY AND GEOTECTONICS
(Theory: 4 credits & Practical: 2 credits)

Pre-requisites:

Basic (10+2) knowledge of minerals and rocks. The course consists of field work on holidays; wherein student has to work independently. The field tour is a compulsory component of the course.

Course objectives:

1. To interpret the data and identify the structural features.
2. To train the students in identification of structural features, measurement of field data from the structures in the field, plotting and interpreting the data.
3. To train the students in understanding the mechanics of deformations.
4. Measurement of various orientation data from the structures, plotting them in suitable diagrams and make a quantitative analysis.
5. To develop the writing skills based on research pattern/report writing which is useful in research institutes, Government and private organizations.
6. To develop the skills of individual student so that he/she will be competent enough to get job in this field of specialization.

Course contents:

General Information about the Curriculum: This course looks at how one can recognize the structures, how rocks deform and use structures within the rocks to evaluate about the tectonic environment. Students will be introduced to techniques of collecting the field data and interpreting the structural data and plot it on a map. It will help students understand what has happened to the region since its formation. It will help students understand how part of the earth responded to the different types of forces.

Unit I: Stress-strain analysis:

Stress-strain relationships for elastic, plastic and viscous materials; measurement of strain in deformed rocks; Mohr's circle and criteria for failure of rocks; ductile and brittle shears in rocks; kinematic and dynamic analysis of deformation; measurement of strain in deformed rocks; structural analysis of fold, cleavage, boudin, lineation, joint, and fault; stereographic projection of linear and planar structures; calculation of paleostress. Time relationship between crystallization and deformation.

Various states of stresses and their representation by Mohr circles. Techniques of strain analysis, Role of fluids in deformation processes; Rock fabrics- origin, significance, metamorphic tectonites, petrofabrics at microscopic level; use of stereographic and equal area projections.

Unit II: Linear structures – Joints:

Tectonic and non-tectonic joints, columnar and release joints, joint initiation and its mechanics; rock cleavages-axial plane cleavages, their significance, mechanics of rock cleavages, foliations and lineations; boudinage-types and significance; shear zones: types of shear zones; brittle-ductile and ductile structures in shear zones and their kinematic significance, shear zone rocks-mylonite, breccias, etc; planar and linear fabrics in deformed rocks-origin and importance.

Unit III: Structural Features: Folds and Faults

Types and classification of Folds and Faults; identification of Folds and Faults in the field; mechanism of formation of Folds, Faults, Unconformities. application of structural features in other branches.

Unit IV: Geotectonics:

Continents and Oceans: features & origin; Werner's concept of Continental Drift; Wilson cycle; concept of plate, types of plates, plate driving forces, regional tectonic features: ridges, arcs and subduction zone with special reference to Indian examples, hot spots; plate collisions: types, products; tectonics of India with special reference to Himalaya plate convergence and Indian continental deformation; structures at macroscopic level; deformation pattern and magma associations and associated economically important deposits.

GEO-C106: Practical based on GEO-C102 (2 credits)

1. Importance of contour diagrams, investigation and interpretation of geological maps.
2. Stereographic analysis of structural data.
3. Structural problems related to borehole data.
4. Stress-strain analyses.
5. Strain ellipsoids and their significance.
6. Analysing deformations at microscopic level and mesoscopic level.
7. Identification and interpretation of deformations in Deccan Trap and Eastern Dharwar Craton.

Course outcomes:

Students who earn minimum grade should be able to

1. Interpret the field data and interpret structures and deformations.
2. Identify and describe the structures at macroscopic, mesoscopic and microscopic level using specific nomenclature.
3. Understand and describe geometric features formed in the naturally deformed rocks and interpret the type of stress that developed the structure(s).
4. Portray 3D structures on map using different field data.
5. Work individually in the field and produce structural map of a region.
6. Explain the structural features of the region and thereby the geological history of the region.

7. Develop writing skills in writing home assignment, report etc which will be useful in research institutes/govt. organisations/pvt organizations.
8. Understand the methodology of carrying out scientific research in the field of structural geology and geotectonics.
9. Present his/her research findings in the seminars/conferences etc. or publish the research papers at national and international level.

Prescribed and Reference Books

- **An Introduction to Structural Geology** by **A.K. Jain (Geological Society of India publication)**
- **An outline of Structural Geology** by **B.E. Hobbs, W.D. Means and P.F. Williams**
- **Analysis of Geological Structures** by **N.J. Price and J.W. Cosgrove**
- **Aspects of Tectonics -Focus on south central Asia** by **K.S. Valdiya**
- **Basic methods of Structural Geology** by **S. Marshak and G. Mitra**
- **Dynamic Himalaya by K.S. Valdiya**
- **Folding and fracturing of rocks** by **J.G. Ramsay**
- **Geological Structures of SEDVP** by **R.D. Kaplay, Md. Babar, P.R. Wesanekar and T. Vijay Kumar**
- **Geology, Vol. I, Strain Analysis, Academic Press.**
- **Geology, Vol. II, Folds and Fractures, Academic Press.**
- **Geology, Vol. III (Application of continuum mechanics), Academic Press.**
- **Geotectonics by V. V. Beloussov**
- **Global Tectonics. Third Edition (Reprint)** by **P. Keary, K.A. Klepeis and F.J. Vine**
- **Mapping of Geological Structures** by **K. McClay**
- **Mechanics in Structural Geology** by **B. Bayly**
- **Microtectonics** by **C.W. Passchier and R.A.J. Trouw**
- **Our Evolving Planet: Earths History in New Tectonics** by **K.N. Storetvedt**
- **Plate Tectonics and Crustal Evolution, 3rd Ed.** by **K.C. Condie**
- **Structural analysis of Metamorphic tectonites by F.J. Turner and L.E. Weiss**
- **Structural Geology** by **Marland P. Billings**
- **Structural Geology** by **H. Fossen (highly recommended)**
- **Structural Geology of Rocks and Region** by **G.R. Davis**
- **Structural Geology of Rocks and Regions** by **G.H. Davis and S.J. Reynolds**
- **Structural Geology: Fundamental and Modern** by **S.K. Ghosh**
- **Structure and Tectonics** by **P.C. Badgley**
- **Techniques of Modern Structural Geology: Folds and Fractures** by **J.G. Ramsay and M.I. Huber**
- **Tectonics and Structural Geology: Indian Context** by **Soumyajit Mukherjee**
- **Tectonics** by **Eldridge M. Moores and Robert J. Twiss**
- **The Dynamic Earth System** by **A.M. Patwardhan**
- **The Evolving Continents** by **B.F. Windley**
- **Understanding the Earth** by **I.G. Gass**

GEO-C103: PALAEONTOLOGY
(Theory: 2 credits & Practical: 1 credit)

Pre-requisites:

Basic (10+2) knowledge of biology.

Course objectives:

1. Study of paleontology with reference to animal and plant evolution.
2. Application of micropaleontology in oil industries.
3. To develop the writing skills based on research pattern/report writing which is useful in research institutes/govt. organizations/pvt.organizations.
4. To develop the skills of individual student so that he/she will be competent enough to get job in this field of specialization.

Course contents:

Unit I:

General classification of fossils
Evolution - evolutionary pattern based on fossil record
Stratigraphic range and distribution of invertebrate, vertebrate and plant fossils
Fossil record with special reference to India
Significance of marker fossils and fossil assemblages in stratigraphy

Unit II:

Definition and scope of Micropaleontology
Use of Micropaleontology in exploration of fossil fuels
Equipments for micro-paleontological studies
Foraminifera and Ostracoda - their morphology, orientations, growth, reproduction, ecology and palaeo-ecology, classification, evolutionary trends and stratigraphic distribution

GEO-C107: Practical based on GEO-C102 (1 Credit)

1. Megascopic identification and description of invertebrate and vertebrate fossil specimens in the laboratory.
2. Collection, identification and description of different fossils from the field.

Course outcomes:

At the completion of the course student would be able to

1. Identify fossils based on morphological observations.
2. Correlate different stratigraphic units based on fossil record.
3. Classify and characterize different fossils.
4. Better understand origin and evolution of life.
5. Better understand the Palaeo-geography of India.
6. Use microfossils in the exploration for fossil fuels.

Prescribed and Reference Books

- **A Concise Dictionary of Paleontology** by **R. L. Carlton**
- **An introduction to fossils and minerals** by **Jon Erickson**
- **Basic Palaeontology** by **Michael J. Benton and David A.T. Harper**
- **Dynamics of the Earth System: Evolution, Processes and Interactions (2020)** by **D. K. Pandey, (Ed), M. Ravichandran, (Ed) and N. Nair, (Ed)**
- **Elements of Micropaleontology** by **G. Bignot**
- **Fundamentals of Invertebrate Palaeontology** by **S. Jain**
- **Introduction to Marine Micropaleontology** by **Haq and Boersma**
- **Microfossils** by **M.D. Braiser**
- **Micropaleontology in Petroleum Exploration** by **R.W. Jones**
- **Micropaleontology: Principles and Applications** by **Pratul Kumar Sarswati and M.S. Srinivisan**
- **Nature through Time (2020)** by **Martinetto, E. (Ed), Tschopp, E. (Ed), Gastaldo, R. (Ed)**
- **Palaeontology (palaeobiology): Evolution and animal distribution** by **P.C. Jain and M.S. Anantharaman**
- **Principles of palaeontology** by **Stanley Raup**
- **Quaternary Environmental Micropaleontology** by **Simon K. Hasllett**
- **Vertebrate Palaeontology** by **Michael Benton**

GEO-C104: GEOCHEMISTRY
(Theory: 2 credits & Practical: 1 credit)

Pre-requisites:

Basic (10+2) knowledge of chemistry + good analytical skills.

Course objectives:

1. The science of Geochemistry deals with the primordial distribution of elements in different spheres, their migration one sphere to another sphere and the rules governing the distribution and migration of elements.
2. Quantitative estimation of the distribution and migration of elements, in space and time, as the earth evolved.
3. Elements are the fundamental unit of all earth's spheres and also that of the planets of our Solar system.
4. Geochemistry is essential for the courses in igneous, sedimentary and metamorphic petrology, economic geology and for interpretation of geophysical data.
5. This course in Geochemistry would help the students to understand origin of elements, cosmic abundance of elements, what makes Earth's chemical composition unique, primary distribution of elements in different Earth's spheres, evaluate different processes of element migration and how physic-chemical conditions control elemental migration.
6. The course introduces stable and radioactive isotope geochemistry.

Course contents:

Unit I: Introduction to Origin and Distribution of Elements

Origin of elements; Elements and the periodic table and Goldschmidt's classification; Cosmic abundance of elements, Structure and composition of Universe and Solar system; Meteorites-types and composition, Primordial distribution and chemical differentiation of the Earth; Thermodynamic classification of elements; Nernst-Berthelot partition coefficient and bulk partition coefficient; fractionation of elements in minerals/rocks; Fick's laws of diffusion and activity composition relation (Roult's and Henry's law); Geochemistry of different spheres of Earth.

Unit II: Introduction to Isotope Geochemistry

Half-life and decay equation; dating of minerals and rocks with potassium-argon, rubidium-strontium, uranium-lead and samarium-neodymium isotopes; Petrogenetic implications of samarium-neodymium and rubidium-strontium systems; Stable isotope geochemistry of carbon, oxygen and

sulphur and their applications in geology; monazite chemical dating; Geochemical Cycle.

GEO-C108: Practical based on GEO-C104 (1 Credit)

1. Graphical representation of geochemical data.
2. Practical based on Trace element geochemistry.
3. Practical based on Stable and Radiogenic Isotope geochemistry.

Course outcomes:

At the completion of the course student would be able to

1. Explain the origin of elements.
2. Explain distribution of elements in different spheres of the Earth.
3. Explain how the atomic properties of elements and their bonds determine the structure and composition of Earth's spheres.
4. Discuss the role of elements and their isotopes in evaluating Earth's processes.
5. Explain the geochemical processes controlling elemental distribution.
6. Graphical representation of element distribution.

Prescribed and Reference Books

- **Essentials of Geochemistry (2nd Edition)** by **J. Walther**
- **Geochemistry** by **M. White**
- **Geochemistry Pathways and Processes (2nd Edition)** by **H. Y. McSween, S. M. Richardson and M. Uhle**
- **Inorganic Geochemistry - Principles and Applications (3rd Edition)** by **G. Faure**
- **Introduction to Geochemistry** by **Francis Albarede**
- **Introduction to Geochemistry - Principles and Applications** by **K. C. Misra**
- **Inorganic Geochemistry** by **Henderson**
- **Introduction to Geochemical Modeling** by **Francis Albarede**
- **Principles of Geochemistry** by **Brain Mason and Carleton B. Moore**
- **Using Geochemical Data: Evaluation, Presentation, Interpretation** by **Hugh R. Rollinson**

GEO-E101: STRATIGRAPHY
(Theory: 3 credits & Practical: 1 credit)

Pre-requisites:

Basic (10+2) knowledge of geology.

Course objectives:

1. To understood the principles and concept of stratigraphy.
2. To train the students in identification of beds, formations, sedimentary structures, measurement of field, plotting and interpreting them.
3. To train the students to identify and correlate the formations.
4. Measurement of various orientation data from the structures, plotting them in suitable diagrams and make a quantitative analysis.
5. To develop the writing skills based on research pattern/report writing which is useful in research institutes/govt. organisations/Pvt. organizations.
6. To develop the skills of individual student so that he/she will be competent enough to get job in this field of specialization.

Course contents:

Unit I: Introduction

Geological Time Scale; Stratigraphy- development of concept and principles of stratigraphy, Facies Concept in Stratigraphy: Walther's Law of Facies; Concept of lithofacies and biofacies; Transgressions and regression.

Unit II: Methods of Stratigraphic Correlations

Stratigraphic correlation: litho-stratigraphy, bio-stratigraphy, chrono-stratigraphy and magneto-stratigraphy; High Resolution stratigraphic correlation methods (e.g. core and well logging, chemostratigraphy); Concept of Sequence Stratigraphy; Order and duration of sequences; Application of Sequence stratigraphy in hydrocarbon exploration;

Unit III: Stratigraphy of India

Stratigraphy of cratons (Dharwar, Bastar, Singhbhum, Bundhelkhand and Aravalli); Stratigraphy of mobile belts (Eastern Ghat belt, Singhbhum-Chotanagpur belt, Delhi belt Central Indian Tectonic Zone, and Southern Granulite belt); Stratigraphy of Proterozoic basins (Cuddapah and Kurnool basins, Vindhyan basin, Chattisgarh basin); Precambrian/Cambrian boundary. Stratigraphy of the marine Palaeozoic rock formations of India; Permian/Triassic boundary; Stratigraphy of Indian Gondwana basins; Cretaceous/Tertiary boundary; Stratigraphy of Palaeogene and Neogene systems in India; Epoch boundaries of the Cenozoic in India.

GEO-E104: Practical based on GEO-E101 (1 Credit)

In Laboratory:

Study of rocks in hand specimens from known Indian stratigraphic horizons and type localities; Preparation of Stratigraphic correlation maps. Preparation of magneto-stratigraphic and chemo-stratigraphic maps and interpretations.

In Field:

Identification of lithofacies and biofacies in the field.

Course outcomes:

At the completion of the course student would be able to

1. Understand principles of stratigraphic correlation
2. Correlate different strata based on different tools
3. Describe the utility of sequence stratigraphy in hydrocarbon exploration
4. Understand in detail the stratigraphy of India

Prescribed and Reference Books

- **A Manual of the Geology of India and Burma (Vols. I-IV)** by **E.H. Pascoe**
- **Depositional Sedimentary Environments** by **H.E. Reineck and I.B. Singh**
- **Fundamentals of historical geology and stratigraphy of India** by **G. R. Ravindra Kumar**
- **Geology of India and Burma** by **M.S. Krishnan**
- **Geology of India: Volume 1 and Volume 2** by **M. Ramakrishnan and R. Vaidyanathan**
- **Precambrian Geology of India** by **S.M. Naqvi and J.J.W. Rogers**
- **Principles of Sedimentology and Stratigraphy, (Fourth Edition)** by **Sam Boggs Jr.**
- **Principles of Sequence Stratigraphy** by **O. Catenuanu**
- **Principles of Stratigraphy** by **C.O. Danbar and J. Rodgers**
- **Seismic stratigraphy and global changes of sea level: American Association of petroleum Geologists** by **P.R. Vail, R. M. Mitchum, R. G. Todd, J. M. Widmier, S. Thompson, J.B. Sangree, J.N. Bubb and W.G. Hatlelid**
- **Seismic Stratigraphy- Applications to Hydrocarbon Exploration, Memoir of the American Association of Petroleum Geologists 26** by **C.E. Payton**
- **Sequence Stratigraphy** by **D. Emery and K.J. Myers**
- **Stratigraphy: Principles and Methods** by **Robert, M. Schoch**
- **The Cenozoic Era? Tertiary and Quaternary** by **C. Pomerol**
- **The Geology of Stratigraphic Sequences** by **A.D. Miall**
- **The Making of India: Geodynamic Evolution** by **K. S. Valdiya**
- **Unlocking the Stratigraphic Record** by **P. Doyle and M.R. Bennett**

GEO-E102: CRYSTALLOGRAPHY
(Theory: 3 credits & Practical: 1 credit)

Pre-requisites:

Basic knowledge of solid state physics, geology and good observational and analytical skills.

Course objectives:

Crystals are abundant in nature, especially in rock formations as minerals. Crystals enable us to study the structure of matter at the atomic level. The basic objective of this course is to make the student to understand basic concepts of crystal structure of minerals including lattices, symmetries, point groups, and space groups and their interrelationship with physical properties will be explained. The theory and applications of X-ray diffraction (XRD) will be also explained.

Course contents:

Unit I:

Historical development of crystallography and its importance in mineralogy
Crystallography: external and internal symmetry
Introduction to 32 classes of symmetry, description of holosymmetric class of various crystal systems
International system of crystallographic notation
Crystal growth

Unit II:

Symmetry of internal structures – Bravais lattices; Twinning and twin laws, common types of twins and their examples in minerals
Unit Cell, Lattice, Point groups and space groups
Indexing of the diffraction pattern
Liquid crystals and their applications
Group theory and its application
Different types of crystal projections – spherical and stereographic, and their uses

Unit III:

XRD: powder and single crystal diffraction, reciprocal lattice and mathematical crystallography
Diffraction of X-ray by atoms and ideal crystal: Reciprocal lattice and diffraction experiments; single crystal-and powder methods
Crystal defects and chemistry: colour, cause and enhancement techniques, crystal field, molecular orbital and band theories.
Electronic and vibrational spectroscopy methods

GEO-E105: Practical based on GEO-E102 (1 Credits)

1. Study of Classes of Symmetry
2. Study of Unit Cell and Space Lattice

Course outcomes:

At the completion of the course student would be able to

1. Define concepts such as lattice, point and space groups.
2. Recognize and describe the 32 classes of symmetry, description of holosymmetric class of various crystal systems, international system of crystallographic notation.
3. Explain the Unit Cell and Space Lattice.
4. Discuss which mineral identification method is appropriate for solving a mineralogical problem (e.g. x-ray diffraction).

Prescribed and Reference Books

- **An introduction to Mineralogy for Geologists** by **Phillips and Phillips (Crystallography, Crystal Chemistry & Silicate Structures)**
- **Crystallography and Mineralogy: Concepts and Methods** by **Ram S. Sharma and Anurag Sharma**
- **Crystallography** by **Walter Borchardt-Ott (X-Ray Diffraction and Crystal Chemistry)**
- **Heavy Minerals in Colour** by **Mange and Maurer (Good Photographs & brief description of Heavy Minerals)**
- **Manual of Mineralogy** by **C. Klein and C.S. Hurlbut**
- **Principles of Mineralogy** by **Blackburn and Denner (X-Ray Crystallography & Descriptive Mineralogy)**

GEO-E103: GEOLOGY AND TECTONICS OF INDIA
(Theory: 3 credits & Practical: 1 credit)

Pre-requisites:

Basic scientific thinking and geology terminology.

Course objectives:

1. Introduce the students to geotectonics.
2. To understand the geology of India.
3. Application of geotectonic in the making of India
4. To train the students in identification and understanding the Geological formation of India.
5. To train the students to identify and correlate different geologic formations in tectonic perspective.

Course contents:

Unit I: Tectonics of India

Introduction to plate tectonics
Horizontal *versus* Vertical tectonics
Concept of Supercontinentality
Formation of Cratons
Formation of Mobile Belts
Formation of Proterozoic Basins
Formation of Himalayas
India's neighbours in the Precambrian

Unit II: Geology of India: Precambrian

Basement problem
Classification and correlation of Precambrian crystalline rocks of India
Structure and Composition of Archaean crust
Archaean-Proterozoic boundary problem
Proterozoic Mobile belts
Main Proterozoic sedimentary and volcano-sedimentary successions in India

Unit III: Geology of India: Phanerozoic

Gondwana Supergroup
Mesozoic of Peninsular India
Deccan Basalt
Boundary problems: Permo-Triassic, K-T

Tertiary basins of India
Himalayas
Main Quaternary sediments in Peninsular India

GEO-E106: Practical based on GEO-E103 (1 Credit)

1. Preparation of Stratigraphic correlation maps with the help of field data.
2. Preparation and study of geological map on the basis of geological formations.
3. Identification and preparation of geological maps with the help of field surveys.

Course outcomes:

At the completion of the course student would be able to

1. Describe craton, mobile belt, intra-cratonic basins, orogen
2. Understand in detail different geologic domains of India
3. Correlate geology with tectonics.
4. Prepare a geological map.
5. Better understand origin and evolution of Indian subcontinent as a geologic entity.

Prescribed and Reference Books

- **A Manual of the Geology of India and Burma (Vols.I-IV)** by **E.H. Pascoe**
- **Fundamentals of historical geology and stratigraphy of India** by **G. R. Ravindra Kumar**
- **Geology of India and Burma** by **M.S. Krishnan**
- **Geology of India: Volume 1 and Volume 2** by **M. Ramakrishnan and R. Vaidyanathan**
- **Geotectonics** by **V. V. Beloussov**
- **Global Tectonics. Third Edition (Reprint)** by **P. Keary, K.A. Klepeis and F.J. Vine**
- **Precambrian Geology of India** by **S.M. Naqvi and J.J.W. Rogers**
- **The Making of India: Geodynamic Evolution** by **K. S. Valdiya**

GEO-OE101: FUNDAMENTALS OF GEOCHEMISTRY
(Theory: 2 credits)

Pre-requisites:

Basic knowledge of Geology and Chemistry.

Course objectives:

1. Introduce Earth's processes and their products.
2. To introduce student about element abundances in different spheres of earth.
3. To introduce about distribution of elements in Earth and processes controlling the abundance and distribution.
4. Geochemistry of Earth's surface.

Course contents:

Unit I: Introduction

Origin of elements
Elements and the periodic table
Cosmic abundance of elements
Structure and composition of Universe and Solar system
Primordial distribution and chemical differentiation of the Earth

Unit II: Geochemistry of Earth's spheres

Geochemistry of Solid Earth
Geochemistry of Atmosphere
Geochemistry of Hydrosphere
Geochemistry of Biosphere
Geochemical Cycle

Course outcomes:

At the completion of the course student would be able to

1. Explain abundance and distribution of elements in different spheres of Earth.
2. Explain how elements reflect past processes happened on the Earth.
3. Explain processes controlling chemistry of Earth's materials.

Prescribed and Reference Books

- **Earth Materials** by **Cornelis Klein and Anthony Philpotts**
- **Essentials of Geochemistry (2nd Edition)** by **J. Walther**
- **Geochemistry and the Biosphere: Essays** by **Vladimir Vernadsky**
- **Inorganic Geochemistry - Principles and Applications (3rd Edition)** by **G. Faure**
- **Inorganic Geochemistry** by **Henderson**
- **Introduction to Geochemistry - Principles and Applications** by **K. C. Misra**
- **Principles of Geochemistry** by **Brain Mason and Carleton B. Moore**
- **Textbook of Geochemistry** by **Shardendu Kislaya**
- **The Origin and Nature of Life on Earth: The Emergence of the Fourth Geosphere** by **Eric Smith and Harold Morowitz**
- **Using geochemical data: Evaluation, Presentation and Interpretation** by **Hugh R. Rollinson**

GEO-OE102: EARTH SYSTEM SCIENCES
(Theory: 2 credits)

Pre-requisites:

Basic scientific thinking and basic (10+2) knowledge of chemistry, physics and biology.

Course objectives:

1. To introduce student to what makes the planet Earth.
2. Introduce composition and structure of the Earth.
3. Introduce system approach to understand planet Earth.

Course contents:

Unit I: Universe, Solar System and Earth

General characteristics and origin of the Universe, Solar System and its planets
Earth as a planet: Holistic understanding of dynamic planet Earth through Astrophysics, Geology, Meteorology and Oceanography
Introduction to various branches of Earth Sciences
Earth: size, shape, internal structure and composition

Unit II: Lithosphere, Hydrosphere, Atmosphere and Biosphere

Lithosphere
Hydrosphere
Atmosphere
Biosphere
Continental Drift and Plate Tectonics and their consequences

Course outcomes:

At the completion of the course student would be able to

1. Understand origin of Earth.
2. Understand Earth internal structure and composition.
3. Understand different spheres of the Earth and their interaction.
4. Explain the loci of Earthquakes and volcanism on the planet Earth.

Prescribed and Reference Books

- **Blue Planet** by **Skinner and Porter**
- **Earth Materials** by **Cornelis Klein and Anthony Philpotts**
- **Physical Geology** by **Arthur Holmes**
- **The Earth** by **Press and Seiver**

GEO-OE103: ORIGIN AND EVOLUTION OF LIFE

(Theory: 2 credits)

Pre-requisites:

Basic knowledge of Geology and Biology.

Course objectives:

1. Introduce basic geological concepts
2. Introduce students with Fossils.
3. To introduce student to theories on origin and evolution of life on the earth.

Course contents:

Unit I:

Origin of the Universe; Formation of the Elements; Beginnings of Chemistry; Element Abundances of the Planets; Geologic, Hydrologic, and Atmospheric Evolution of the Earth; Earth's Materials and their formation (Minerals, Rocks and Soils); Different spheres of the Earth and their interaction; Geological time scale; Introduction to Fossils and their preservation.

Unit II:

Theories of origin of life (when, where and how?); The Miller-Urey experiment; Possible Roles of Clays and Minerals in the Origin of Life; Evolution of Life based on fossil records; Great Oxygenation event; Carbon fixation and emergence of Continental Life; Cambrian explosion; Entropy and Life.

Course outcomes:

At the completion of the course student would be able to

1. Understand basic geological processes and their products.
2. Comprehend interaction between different Earth spheres.
3. Explain formation and preservation of fossils.
4. Understand different theories of origin
5. Explain evolution of life on the Earth with respect to geological time scale
6. Develop an elementary understanding of relationship between entropy and life

Prescribed and Reference Books

- **Aquagenesis: The Origin and Evolution of Life in the Sea** by **Richard Ellis**
- **Comets and the Origin and Evolution of Life** by **Editors: P.J. Thomas, R.D. Hicks, C.F. Chyba, C.P. McKay**
- **Earth Materials** by **Cornelis Klein and Anthony Philpotts**
- **Evolution of Life: Fossils, Molecules and Culture** by **Editors: Osawa, Syozo, Honjo, Tasuku**
- **Geochemistry and the Biosphere: Essays** by **Vladimir Vernadsky**
- **Origins of Life: On Earth and in the Cosmos** by **Geoffrey Zubay**
- **Palaeontology (palaeobiology): Evolution and animal distribution** by **P.C. Jain and M.S. Anantharaman.**
- **The Origin and Early Evolution of Life** by **Tom Fenchel**
- **The Origin and Nature of Life on Earth: The Emergence of the Fourth Geosphere** by **Eric Smith and Harold Morowitz**

M.Sc. Geology
I Year - II Semester
Syllabus

M.Sc. Geology, I Year, II Semester (Total Credits = 25)									
Sr. No.	**Subject**	**Code**	**Theory Paper**	**Credits**		**Sr. No.**	**Code**	**Practical Paper**	**Credits**
1	**Core**	GEO-C201	Igneous Petrology	4		**1**	GEO-C205	Igneous Petrology	2
2	**Core**	GEO-C202	Thermodynamics and Metamorphic Petrology	4		**2**	GEO-C206	Thermodynamics And Metamorphic Petrology	2
3	**Core**	GEO-C203	Sedimentary Petrology	2		**3**	GEO-C207	Sedimentary Petrology	1
4	**Core**	GEO-C204	Environmental Geology	2		**4**	GEO-C208	Environmental Geology	1
5	**Subject Elective (Choose any One)**	GEO-E201	Computer applications in Geology	3			GEO-E204	Computer applications in Geology	
		GEO-E202 /	Geomorphology and Morphotectonics			**5**	GEO-E205	India as a Geological Entity	1
		GEO-E203	Geostatistics				GEO-E206	Geostatistics	1
6	**Open Elective (for students from all the Schools including School of Earth Sciences)**	GEO-OE202	Geology For Chemists	2		**6**	GEO-C209	Seminar/Field Report	1
		GEO-OE203	Geology For Biologists						
		GEO-OE204	Geology For Physicists						
			Total	**17**				**Total**	**8**

Department of Geology
School of Earth Sciences
SRTM University
NANDED

GEO-C201: IGNEOUS PETROLOGY
(Theory: 4 credits & Practical: 2 credits)

Pre-requisites:

Basic (10+2) knowledge of chemistry and physics + completion of courses GEO-C101 (Mineralogy) and GEO-C104 (Geochemistry).

Course objectives:

General Information about the Curriculum:

Igneous rocks are formed by crystallization of magmas derived from mantle and crust consequently they are the windows to deep Earth composition, structure and processes. Igneous rocks are also significant to understand planetary differentiation. Study of igneous rocks allows us to evaluate mantle-crust differentiation and interactions in space and time. Igneous rocks are fundamental to our understanding of vertical and horizontal tectonics of planet Earth. Volatiles exhaled from the magmas are the building blocks of Earth's primitive atmosphere and hydrosphere and eventually responsible for the origin of life. Finally, igneous rocks are abodes for many large-scale ore deposits.

This course in igneous petrology would help the students to understand

1. Origin of magmas in crust and mantle, evaluate different processes of magma generation
2. Role of temperature, pressure, depth and volatiles on magma composition
3. Application of thermodynamics in understanding igneous rocks
4. Evaluate the role of geochemistry in deciphering magma generation and evolution
5. Correlate magma compositions with plate boundaries
6. Identify and characterize the igneous rocks based on their physical and textural characteristics

Course contents:

Unit I: Igneous Petrology and its scope

From Planetary evolution to the evolution of Lithosphere, Hydrosphere and Biosphere
Major Structural Units of the Earth
Pressure Distribution within the Earth
Temperature Distribution within the Earth
Heat Sources for Magma Generation
Physical Properties of the Magma
Cooling/Crystallization of Magmas and Igneous Textures
Classification Igneous Rocks

Unit II: Magma Generation and Evolution

Sites of Magma Generation
Petrology and Geochemistry of Mantle
Partial Melting and types of mantle melting
Primary Melts
Magmatic differentiation, Zone melting, Contamination, Mixing of magmas
Magmas and Tectonic Environments
Role of Geochemistry in Igneous Petrogenesis

Unit III: Phase Equilibria

Gibb's and Mineralogical Phase Rule
One component system
Two component system
Three component system
Four component system
Role of Volatiles on Phase Equilibria

Unit IV: Petrogenetic Suites and Associations

Komatiites
Basalts
Anorthosites
Layered Complexes
Ophiolites
Lamprophyres, Lamproites, Kimberlites, Carbonatites and Alkaline Rocks
Andesites and Boninites
Granites

GEO-C205: Practical based on GEO-C201 (2 Credits)

1. Study of Igneous Rocks in Hand Specimen.
2. Study of Igneous Rocks in Thin Section.
3. Binary and Ternary Variation Plots.
4. Tectonic discrimination plots.
5. Rare Earth Element and Incompatible Element Normalized Plots.

Course outcomes:

At the completion of the course student would be able to

1. Explain generation of different mantle reservoirs.
2. Explain origin and differentiation of magmas.
3. Apply phase equilibria to the genesis of igneous rocks.
4. Utilize geochemistry in understating igneous processes.
5. Discriminate present- and palaeo-tectonic environments of igneous rocks.
6. Describe crust-mantle differentiation in space and time.
7. Decipher relationship between petrogenesis and ore genesis.

8. Identify and characterize igneous rocks based on megascopic and microscopic observations.
9. Graphically represent geochemical variations in magmas.

Prescribed and Reference Books

- **An Evolution of Igneous Rocks** by **N. L. Bowen (***Classical text based on Experimental Petrology***)**
- **Atlas Igneous Rocks and their Textures** by **McKenzie, Donaldson and Guilford (***Excellent book on texture illustrations***)**
- **Essentials of Igneous and Metamorphic Petrology** by **B. Ronald Frost and Carol D. Frost**
- **Igneous and Metamorphic Petrology** by **Best (***Rock Associations***)**
- **Igneous and Metamorphic rocks under Microscope** by **Shelly (***Good introductory book on petrography***)**
- **Igneous Petrogenesis and Global Tectonic Environments** by **Marjorie Wilson (***Advanced Text on rock associations and tectonic environments***)**
- **Igneous Petrology** by **Anthony Hall (***Phase Equilibria***)**
- **Igneous Petrology** by **D. S. Barker (***Good general text book***)**
- **Igneous Petrology** by **McBirney (***Textures & Rocks***)**
- **Igneous Rocks** by **Gupta (***With Indian examples***)**
- **Inorganic Geochemistry** by **Henderson (***Good introductory book on Geochemistry principles***)**
- **Introduction to Geochemical Modeling** by **Francis Albarede (***Advanced book on geochemical modeling)***)**
- **Petrography** by **William, Turner and Gilbert (***Good introductory book on petrography***)**
- **Petrologic phase equilibria** by **W.G. Ernst**
- **Petrology** by **Nockolds, Knox and Chinner (***Classic introductory book***)**
- **Petrology** by **Raymond (***Good introductory book***)**
- **Petrology of Igneous Rocks** by **Hatch, Wells and Wells (***Good introductory book***)**
- **Petrology of Igneous, Sedimentary and Metamorphic Rocks** by **Ehlers and Blatt (*Good introductory book*)**
- **Phase Diagrams** by **A. R. Morse (***Good introductory book on phase equilibria***)**
- **Principles of Geochemistry** by **G. Faure (***Advanced book on Geochemistry principles***)**
- **Principles of Igneous & Metamorphic Petrology** by **A. R. Philpotts (***physical properties of Magma***)**
- **Principles of Igneous and Metamorphic Petrology** by **Anthony Philpotts and Jay Ague**
- **Principles of Igneous and Metamorphic Petrology** by **John D. Winter**
- **Principles of Igneous Petrology** by **Maaloe (*Good Theoretical text*)**
- **The Principles of Petrology** by **G. W. Tyrrell (*Basic introductory book*)**

GEO-C202: THERMODYNAMICS AND METAMORPHIC PETROLOGY
(Theory: 4 credits & Practical: 2 credits)

Pre-requisites:

Basic (10+2) knowledge of chemistry and physics + completion of courses GEO-C101 (Mineralogy) and GEO-C104 (Geochemistry).

Course objectives:

This course in thermodynamics and metamorphic petrology would help the students to understand

1. Application of thermodynamics to understand metamorphic processes.
2. Formation of metamorphic rocks as controlled by pressure-temperature changes in the deep Earth consequently they are the windows to deep Earth composition, structure and processes.
3. Significance of metamorphic rocks to understand crustal differentiation. Study of metamorphic rocks to evaluate crust differentiation in space and time.
4. Significance of metamorphic rocks to our understanding of vertical and horizontal tectonics of planet Earth.
5. The role of volatiles consumed and released during formation of metamorphic rocks for the continuation of plate tectonics and subduction zone magmatism and formation of many ore deposits.
6. Metamorphism as the fundamental process of altering earlier minerals and formation of new minerals stable in the changed physico-chemical conditions.

Course contents:

Unit I: Thermodynamics

System, Phase, Component and Phase Rule
Enthalpy, Entropy and Gibb's Free Energy
1^{st}, 2^{nd} and 3^{rd} Laws of Thermodynamics
Reaction kinetics
Clausius - Clapeyron Equation and Calculation of Reaction Boundaries
Geothermobarometry
Psuedosections
P-T-t Paths

Unit II: Introduction to Metamorphism

Metamorphism as a process of Earth's differentiation
Metamorphic processes
Role of P/T conditions and fluids in metamorphism
Deformation associated with metamorphism

Migmatites and partial melting
Metamorphic structures and textures
Geochemistry of metamorphic rocks

Unit III: Metamorphic rocks: Grades, Zones and Facies

Types of metamorphism and their products
Metamorphic grades
Metamorphic zones
Metamorphic facies concept
Experimental studies on metamorphic reactions
Characteristics of important metamorphic reactions

Unit IV: Plate tectonics ad Metamorphic rocks

Zeolite- and lawsonite-bearing rocks
Greenstones
Amphibolites
Granulites
Glucophane schists
Eclogites
Paired metamorphic belts
Metamorphic rocks in space and time

GEO-C206: Practical based on GEO-C202 (2 Credits)

1. Study of Metamorphic Rocks in Hand Specimen.
2. Study of Metamorphic Rocks in Thin Section.
3. AKF, ACF and AFM projections.
4. Estimation of P-T conditions based on coexisting minerals.

Course outcomes:

At the completion of the course student would be able to

1. Apply principles of Thermodynamics to metamorphic processes.
2. Explain elemental diffusion and formation of new minerals.
3. Explain differentiation of continental crust.
4. Discriminate present- and palaeo-tectonic environments of metamorphic rocks.
5. Identify and characterize metamorphic rocks based on megascopic and microscopic observations.
6. Graphically represent mineralogical variations in metamorphic rocks.

Prescribed and Reference Books

- **An Introduction to Metamorphic Petrology** by **Bruce W.D. Yardley**
- **Atlas Metamorphic Rocks and their Textures** by **McKenzie, Donaldson and Guilford (***Excellent book on texture illustrations***)**
- **Essentials of Igneous and Metamorphic Petrology** by **B. Ronald Frost and Carol D. Frost**
- **Igneous and Metamorphic Petrology** by **Best (***Rock Associations***)**
- **Igneous and Metamorphic rocks under Microscope** by **Shelly (***Good introductory book on petrography***)**
- **Paired Metamorphic Belts** by **Miyashiro**
- **Petrography** by **William, Turner and Gilbert (***Good introductory book on petrography***)**
- **Petrology** by **Nockolds, Knox and Chinner (***Classic introductory book***)**
- **Petrology** by **Raymond (***Good introductory book***)**
- **Petrology of Igneous, Sedimentary and Metamorphic Rocks** by **Ehlers and Blatt (***Good introductory book***)**
- **Phase Diagrams** by **A. R. Morse (***Good introductory book on phase equilibria***)**
- **Principles of Igneous & Metamorphic Petrology** by **A. R. Philpotts (***Thermodynamics and Facies concept)*
- **Principles of Igneous and Metamorphic Petrology** by **Anthony Philpotts and Jay Ague**
- **Principles of Igneous and Metamorphic Petrology** by **John D. Winter**
- **Principles of Igneous and Metamorphic Petrology** by **John Winter (***Good discussion on all aspects of metamorphic rocks)*

GEO-C203: SEDIMENTARY PETROLOGY
(Theory: 2 credits & Practical: 1 credit)

Pre-requisites:

Basic geology terminology and courses GEO-C101 (Mineralogy).and GEO-C104 (Geochemistry)

Course objectives:

1. To train the students in identification of beds, formations, sedimentary structures, measurement of field, plotting and interpreting them.
2. To train the students to identify and correlate the formations.
3. To train the students in measuring various orientation data from the structures, plotting them in suitable diagrams and make a quantitative analysis.
4. To teach geochemistry of sedimentary rocks.
5. To develop the writing skills based on research pattern/report writing which is useful in research institutes/govt. organizations/ Pvt. Organizations.
6. To develop the skills of individual student so that he/she will be competent enough to get job in this field of specialization.

Course contents:

Unit I:

Classification of sedimentary rocks; Processes and products of sedimentation; Detrital sediments; Chemical precipitates; Volcano-clastic sediments; Sedimentary structures and textures; Particle size of detrital rocks: Definition, measurement, size parameters, grain size distribution and causal factors, grain size distributions and environmental analysis, Sphericity and roundness, Packing and fabric, Porosity and permeability

Unit II:

Depositional environments and the sedimentary products; Palaeocurrents and basin analysis; Basin shape, depth and sedimentation; Geochemistry of sediments and sedimentary rocks; Source and process control on composition of Sedimentary rocks; Plate tectonics and sedimentary rocks

GEO-C207: Practical based on GEO-C203 (1 Credit)

1. Study of Sedimentary Rocks in Hand Specimen.
2. Study of Sedimentary Rocks in Thin Section.
3. Grain size and grain shape analysis of sediments.

Course outcomes:

At the completion of the course student would be able to

1. Correlate different sedimentary strata.
2. Evaluate sedimentary environments.
3. Evaluate the geochemical variations in sedimentary rocks.
4. Understand the sedimentary rocks.
5. Carry out Palaeocurrent analysis.
6. Identify and distinguish different sedimentary rocks.

Prescribed and Reference Books

- **Applied Sedimentology** by **Richard C. Selly**
- **Atlas of Sedimentary Rocks Under the Microscope** by **A. E. Adams, C. Guilford, and W. S. MacKenzie**
- **Depositional Sedimentary Environments** by **H.E. Reineck and I.B. Singh**
- **Geochemistry of Sediments and Sedimentary Rocks: Evolutionary Considerations to Mineral Deposit- Forming Environments Edited** by **David Lentz**
- **Origin of sedimentary rocks** by **Harvey Blatt**
- **Petrography** by **William, Turner and Gilbert (***Good introductory book on petrography***)**
- **Petrology** by **Nockolds, Knox and Chinner (***Classic introductory book***)**
- **Petrology** by **Raymond (***Good introductory book***)**
- **Petrology of Igneous, Sedimentary and Metamorphic Rocks** by **Ehlers and Blatt (*Good introductory book*)**
- **Petrology of sedimentary rocks** by **Sam Boggs**
- **Physical Principles of Sedimentology** by **Kenneth J. Hsü**
- **Principles of Sedimentology and Stratigraphy** by **Sam Boggs**
- **Sedimentary geology** by **Donald Prothero**
- **Sedimentary Petrology: An Introduction to the Origin of Sedimentary Rocks** by **Maurice E. Tucker**
- **Sedimentary Provenance and Petrogenesis: Perspectives from Petrography and Geochemistry** (**GSA special paper)** by **José Arribas**, **Mark J. Johnsson** and **Salvatore Critelli**
- **Sedimentary Rocks** by **F.J. Pettiohn**
- **Sedimentary Rocks** by **Holly Cefrey**
- **Sedimentary Rocks** by **Rebecca Pettiford**
- **Sedimentary rocks in the field** by **Maurice Tucker**
- **Sedimentary Rocks in the Field: A Colour Guide** by **D. A. V. Stow**
- **Sedimentology and Stratigraphy** by **Gary Nichols**
- **Sedimentology** by **Michael McLane**
- **The Principles of Petrology** by **G. W. Tyrrell (*Basic introductory book*)**

GEO-C204: ENVIRONMENTAL GEOLOGY
(Theory: 2 credits & Practical: 1 credit)

Pre-requisites:

Basic (10+2) knowledge of geology, chemistry and physics

Course objectives:

1. Introduce environmental perspective to the geology students.
2. Introduce geology as a tool in the control of environmental pollution.
3. Equip the student with knowledge for societal needs.

Course contents:

Unit I: Introduction and Air Pollution

Introduction, Fundamental Concepts of Environmental Geology: Present is a key to the future, Concepts of Lithosphere, Hydrosphere and Atmosphere and their Physico-chemical characteristics, Ecology- its meaning and Scope, Ecosystem Concept, Energy Flow in Ecosystem, Food chain and Food web, Ecological pyramid.

Classification of Air Pollutants, Sources of Air Pollutants, Indoor Air Pollution, Air Pollution and Meteorology, Air Quality Monitoring, Consequences of Air Pollution- Acid Rain, Ozone Depletion, Green House Effect and Global Warming, Effects of Air Pollution on life.

Unit II: Water and Soil Pollution and Role of Geology in Pollution Control

Types of water pollutants- physical, chemical, biological, Classification of pollutants- Inorganic pollutants, organic pollutants, Biological pollutants, sediments, Oxygen demanding waste, Disease causing agents, Radioactive pollutants. Sources of water pollution- Point sources, Non point sources, Natural and Anthropogenic sources, Sewage and domestic waste, Industrial effluent, Agricultural discharges, Fertilizers, Pesticides, Detergents, Herbicides, Toxic metals, Thermal pollutants. Types of pollution- Groundwater pollution, Surface water pollution- Lake water pollution, River water pollution, Eutrophication, Marine pollution, Effect on life.

Definition, Composition of Soil, Soil formation, Soil profile, Types of Soils, Pedogenic processes, Texture of Soil, Soil pH, saline and alkaline Soil, Cation Exchange capacity, Soil pollution by- urban waste, agricultural practices, chemical and metallic pollutants, Industrial effluent, Detrimental effects on Soil, Integrated Pest Management.

Pollution Control for Air, Water and Soil- Decontamination Procedures and Methods, Remedial Measures and role of Geology, Solid, Liquid, Hazardous Waste Disposal and management, Geological solutions for environmental problems, Geological factors in selection of Sites for Disposal, Environmental Impact Assessment (EIA)

GEO-C208: Practical based on GEO-C204 (1 Credit)

1. Chemical analysis of Water.

Course outcomes:

At the completion of the course student would be able to

1. Understand Air, Water and Soil pollutants.
2. Apply geological methods in pollution control.
3. Select sites for geological disposal of pollutants.
4. Analyze Air, Water and Soil samples for their chemistry.

Prescribed and Reference Books

- **Air Pollution** by **B. K. Sharma**
- **An Introduction to Environmental Pollution** by **B. K. Sharma**
- **Environmental Geology** by **Carla W. Montgomery**
- **Environmental Geology** by **K. S. Valdiya**
- **Environmental Geology, Handbook of Field Methods and Case Studies** by **Klaus Knödel, Gerhard Lange and Hans-Jürgen Voigt**
- **Environmental pollution and control** by **P. Aarne Vesilind**
- **Environmental Pollution Monitoring and Control** by **Shripad Moreshwar Khopkar**
- **Fundamentals of Soil Science** by **Henry D. Foth**

GEO-E201: COMPUTER APPLICATIONS IN GEOLOGY
(Theory: 3 credits & Practical: 1 credit)

Pre-requisites:

Basic knowledge of Geology and Computer + Basic Software.

Course objectives:

1. Teach fundamental concepts in computer organization and growth.
2. Teach application of computers and software in geological sciences.
3. Teach Basic computer programming and software relevant to geology.

Course contents:

Unit I:

Computer organizations, architecture and peripherals, Types of computers; Computer generations, Concept of operating system, MS office – Word, Excel and Power point; Internet

Unit II:

Computer programmers useful for geoscientific studies: application of Surfer, Use of Grapher, Excel, etc.; Windows-based software applications, including word-processing, spreadsheets. Graphic image manipulation, drawing, presentations (MS-Excel, Power Point, Adobe Illustrator, CorelDraw, Photoshop). Elementary concepts on Knowledge Based Expert System, Decision Support System, Neural Network, Fuzzy Logic and Genetic Algorithm.

Unit III:

Use of computers and software as tools in the areas of geological problem-solving, report-writing, and presentations; Specific applications in Geological studies. Geological field data plotting software. Database - definition, structure, and types; Geological database. Construction of geological maps and sections using Adobe Illustrator and Coreldraw. Use of Software Packages in Geology.

GEO-E204: Practical based on GEO-E201 (1 Credits)

1. Mastering MS Office.
2. Processing Large Data Sets using relevant software.
3. Use of Adobe Illustrator and Corel Draw for geological maps and sections.
4. Geological data plotting and interpretation by using softwares.

Course outcomes:

At the completion of the course student would be able to

1. Use MS Office in processing and presenting geological data.
2. Prepare geological maps using Adobe Illustrator and CoralDraw.
3. Process large amount of geological data.
4. Apply ANN to evaluate geological data.

Prescribed and Reference Books

- **Computer Application in the Earth Sciences** by **Daniel Merriam**
- **Computer Applications in Petroleum Geology** by **Joseph E. Robinson**
- **Computer Applications in the Earth Sciences** by Merriam**, Daniel (Ed.)**
- **Computer Fundamentals** by **Pradeep K. Sinha and Preeti Sinha**
- **Computer Modeling of Geologic Surfaces and Volumes (AAPG computer applications in geology)** by **David E. Hamilton**
- **Fundamentals of Computer** by **V. Rajaraman**
- **Use of Microcomputers in Geology (Computer Applications in the Earth Sciences)** by **Hans Kürzl and Daniel F. Merriam (Editors)**

GEO-E202: GEOMORPHOLOGY AND MORPHOTECTONICS
(Theory: 3 credits & Practical: 1 credits)

Pre-requisites:

Basic (10+2) knowledge of surface geological processes, geographical landforms and Geotectonics + good observational skills.

Course objectives:

1. Identification of different geomorphological features and their mode of formation.
2. Exogenous processes and natural agents controlling the surface geology.
3. Concept of landform development and their stages of evolution with time.
4. Continental drift and plate tectonics on global scale.
5. Mode of formation of continental and oceanic crust and their interaction during plate movement.
6. Identification of different tectonic features globally.
7. Endogenous processes and driving forces controlling the tectonic features.
8. Drainage basin analysis and their application.
9. Morphometric and morphotectonic analyses to evaluate landform tectonically active or not.

Course contents:

General Information about the Curriculum:

This course helps students to understand the exogenous (surface geology) and endogenous (internal geology) processes operating on planet Earth; to understand the different geomorphological and tectonic features and their mode of formation. It will also help in understanding stages of landform development since the formation of planet Earth and evaluate whether certain landform is tectonically active or not.

Unit I: Surface Geology

Evolution of Earth; Principle of uniformitarianism; origin, differentiation and internal structure of the Earth and their reflections on surface geology; origin of atmosphere; weathering processes and products. geological action of rivers, wind, glaciers, waves; erosional and depositional landforms; major geomorphic features of India- coastal, peninsular and extra-peninsular. Formation of soil, physiographic features and river basins in India. Hydrographs and flood frequency analysis.

Unit II: Geotectonics

Concepts of Continental drift, sea-floor spreading, Isostasy, orogeny and plate tectonics; Earth's internal structure; earthquakes and volcanoes; hot spot and mantle plume; Concept of plate, types of plates, Plate driving forces, Plate collision: types, products; Wilson cycle; regional tectonic features of continents and ocean; Himalaya formation; Deccan trap formation.

Unit III : Tectonic Geomorphology

Geotectonic endogenous process and features: folds, faults, joints and fractures, volcanoes; global morphotectonics; local morphotectonics; drainage patterns; Morphometric and morphotectonic analyses; drainage basin morphometry; morphometric parameters; morphometric analysis case studies; Structural and lithological controls of landforms and drainage patterns; concept of neo-tectonics.

GEO-E205: Practical based on GEO-E202 (1 Credits)

1. Geomorphological landforms models
2. Introduction to topographical maps
3. Geomorphological and geological map symbols
4. Regional tectonic feature identification on tectonic maps
5. Drainage basin analysis
6. Morphometric analysis parameters
7. Morphotectonic analysis parameters
8. Structural features and their orientation
9. Strike and dip calculation.

Course outcomes:

Students who earn minimum grade should be able to

1. Identify of geomorphological features and their controlling natural agents.
2. Understand the processes of geological weathering and erosion and their acceleration rates at different climatic condition.
3. Understand the mechanism of soil formation and their types.
4. Lithospheric plate movement and their driving forces.
5. Lithospheric plate interaction and their products.
6. Regional tectonic features and their controlling mechanisms.
7. Morphometric analyses to evaluate surface geology.
8. Morphotectonic analyses to evaluate land surface tectonically active or not.
9. Different structural features and their orientation to understand tectonic correlation.

Prescribed and Reference Books

- **Aerial photographs in field geology** by **L.H. Lattman and R.G. Ray**
- **Geomorphology: A systematic Analysis of Late Cenozoic Landforms** by **A.L. Bloom**
- **Introducing Physical Geography** by **Alan Strahler**
- **Introduction to Physical Geology** by **Thompson and Turk.**
- **Morphotectonics** by **Adrian E. Scheidegger.**
- **Physical Geology** by **Diane H. Carlson, Charles C. Plummer and Lisa Hammersley**
- **Principles of Geomorphology** by **William D. Thornbury**
- **Process Geomorphology** by **D.F. Ritter, R.C. Kochel and J.R. Miller**
- **Tectonic Geomorphology** by **Douglas W. Burbank and Robert S. Anderson**
- **Terrain Analysis** by **D.S. Way**

GEO-E203: GEOSTATISTICS
(Theory: 3 credits & Practical: 1 credit)

Pre-requisites:

Basic (10+2) knowledge of Geology and Statistics.

Course objectives:

Basic objective of the course is to make student to

1. Gain knowledge of available statistical methods and their limitations and to make student be able to analyse and prepare the geological data for applying geostatistical models.
2. Characterize geological phenomena, which are complex in their interrelationships and vast in their Spatial and Temporal extension.
3. Utilize statistics in groundwater hydrology, petroleum reservoir characterization and modelling, and also in petrographical studies especially of sedimentary rocks.
4. Statistically analyse and interpret the geological data to unravel Earth's present and past processes.

Course contents:

Unit I: Introduction and Basic Statistics

Definition and scope of statistics; Limitations of statistics; Types of Data: Data collection, frequency distribution; Univariate analysis; Measures of Central tendency: Mean, Median, Mode, Merits and Demerits of Mean, Median and Mode; Measures of dispersion, standard deviation, variance, coefficient of variation.

Unit II: Bivariate and Multivariate Analysis

Bi-variate analysis: Correlation and regression; Types of correlation, correlation coefficient, regression analysis; Probability: Basic concepts; Statistical hypothesis and tests; Type I and Type II errors, F, t, and Chi-square tests; Multivariate analysis.

Unit III: Application of Statistics to Geology

Use of statistics in Petrology; Use of statistics in Geophysical-exploration and Mining Geology; Use of statistics in Hydrogeology; Use of statistics in Petroleum Geology.

GEO-E206: Practical based on GEO-E203 (1 Credit)

1. Study of Measure of Central Tendencies.
2. Study of Bi-variate analysis: Correlation and regression.
3. Study of different types of Errors and Tests.
4. Use of statistics in Geology.

Course outcomes:

At the completion of the course student would be able to

1. Explain and Practice different measures of central tendencies, standard deviation and variance.
2. Explain and Practice Bi-variate analysis of data (Correlation and Regression)
3. Explain and calculate different types of Errors (Type I and Type II Error) and Tests (F- test, T- test etc.)
4. Utilize statistics in Geology.

Prescribed and Reference Books

- **Applied multivariate statistical analysis** by **R.A. Johnson and D.W. Wichern**
- **Basic linear Geostatistics** by **M. Armstrong**
- **Geostatistics A Colloquium** by **Daniel F. Merriam**
- **Introduction to probability and statistics for engineers and scientists** by **S.M. Ross**
- **Mining Geostatistics** by **A.G. Journel and Ch. Huijbregts**
- **Probability and Statistics** by **M.R. Spiegel**
- **Probability and statistics for engineers and scientists** by **R.E. Walpole and R.H. Myers**
- **Statistical data analysis in geology** by **J.C. Davis,**
- **Statistical Methods** by **S.C. Gupta**

GEO-OE201: GEOLOGY FOR CHEMISTS
(Theory: 2 credits)

Pre-requisites:

Basic knowledge of Geology and Chemistry.

Course objectives:

1. Introduce Earth's processes and their products.
2. To introduce student about element abundances in different spheres of Earth.
3. To introduce about distribution of elements in Earth and processes controlling abundance and distribution.
4. Geochemical exploration technique, path-finding elements to ore.

Course contents:

Unit I:

Origin of the Universe; Formation of the Elements; Beginnings of Chemistry; Element Abundances of the Planets; Geochemical classification of elements; Thermodynamic classification of elements; Introduction to radioactive and stable isotopes;

Unit II:

Geochemistry of Lithosphere, Atmosphere, Hydrosphere and Biosphere; Distribution of elements in crust, mantle and core; Geodynamics and transfer of elements; Geochemical and biochemical processes on and near Earth's surface; Geochemical Cycles; Geochemical exploration techniques; Geochemical record of Palaeo-climatic conditions. Geochemistry and Life.

Course outcomes:

At the completion of the course student would be able to

1. Understand basic geological processes and their products.
2. Explain abundance and distribution of elements in different spheres of Earth.
3. Explain use of elements in exploration of ore bodies.
4. Explain how elements reflect Earth's past processes.
5. Explain Processes controlling chemistry of Earth's materials.
6. Explain the relationship between geochemistry and life

Prescribed and Reference Books

- **Comets and the Origin and Evolution of Life** by **Editors: P.J. Thomas, R.D. Hicks, C.F. Chyba and C.P. McKay**
- **Dynamics of the Earth System: Evolution, Processes and Interactions (2020) Edited** by **D. K. Pandey, M. Ravichandran, and N. Nair**
- **Earth Materials** by **Cornelis Klein and Anthony Philpotts**
- **Geochemistry and the Biosphere: Essays** by **Vladimir Vernadsky**
- **Inorganic Geochemistry - Principles and Applications (3rd Edition)** by **G. Faure**
- **Inorganic Geochemistry** by **Henderson**
- **Nature through Time (2020) Edited** by **E. Martinetto, E. Tschopp, and R. Gastaldo**
- **Principles of Geochemistry** by **Brain Mason and Carleton B. Moore**
- **The Origin and Nature of Life on Earth: The Emergence of the Fourth Geosphere** by **Eric Smith and Harold Morowitz**
- **Using geochemical data: Evaluation, Presentation and Interpretation** by **Hugh R. Rollinson**

GEO-OE202: GEOLOGY FOR BIOLOGISTS
(Theory: 2 credits)

Pre-requisites:

Basic knowledge of Geology and Biology.

Course objectives:

1. Introduce basic geological concepts.
2. Introduce students with Fossils.
3. To introduce student to formation and evolution of life on the earth.
4. To introduce with fossil fuels.

Course contents:

Unit I:

Origin of the Universe; Formation of the Elements; Element Abundances of the Planets; Geologic, Hydrologic, and Atmospheric Evolution of the Earth; Earth's Materials and their formation (Minerals, Rocks and Soils); Geological time scale; Introduction to Fossils and their preservation.

Unit II:

Elementary ideas about origin of life; evolution and fossil record; origin of fossil fuels and their exploration; Geodynamics and migration of organisms; Geobiolgical prospecting for mineral deposits; Tree rings and Palaeoclimates; Minerals and Human Health.

Course outcomes:

At the completion of the course student would be able to

1. Understand basic geological processes and their products.
2. Comprehend interaction between different Earth spheres.
3. Explain formation and preservation of fossils.
4. Explain evolution of life on the Earth with respect to geological time scale.
5. Utilize biological tools in exploring geological materials and processes
6. Understand relationship between biology (human) and Geology (minerals)

Prescribed and Reference Books

- **A Concise Dictionary of Paleontology** by **R. L. Carlton**
- **An introduction to fossils and minerals** by **Jon Erickson**
- **Aquagenesis: The Origin and Evolution of Life in the Sea** by **Richard Ellis**
- **Comets and the Origin and Evolution of Life** by **Editors: P.J. Thomas, R.D. Hicks, C.F. Chyba and C.P. McKay**
- **Dynamics of the Earth System: Evolution, Processes and Interactions (2020) Edited** by **D. K. Pandey, M. Ravichandran, and N. Nair**
- **Earth Materials** by **Cornelis Klein and Anthony Philpotts**
- **Evolution of Life: Fossils, Molecules and Culture** by **Editors: Osawa, Syozo, Honjo, Tasuku**
- **Micropaleontology in Petroleum Exploration** by **R.W. Jones**
- **Nature through Time (2020) Edited** by **E. Martinetto, E. Tschopp, and R. Gastaldo**
- **Palaeontology (palaeobiology): Evolution and animal distribution** by **P.C. Jain and M.S. Anantharaman**
- **Principles of palaeontology** by **Stanley Raup**

GEO-OE203: GEOLOGY FOR PHYSICISTS
(Theory: 2 credits)

Pre-requisites:

Basic knowledge of Geology and Physics.

Course objectives:

1. Introduce Earth's processes and their products.
2. Introduce students with simple physical principles for exploring planet Earth.
3. To use of geophysical methods in Ore and Groundwater prospecting.

Course contents:

Unit I:

Introduction to evolution of Universe and our planetary system; Internal structure of the Earth; Different spheres of the Earth and their interaction; Introduction to Geodynamics; Geological time scale.

Unit II:

Basic physical properties of the Earth's material. Polymorphism and phase transformations in Planet Earth; Introduction to Gravity, Electrical, Magnetic and Seismic methods of exploring planet Earth. Introduction to Geomagnetism and Paleo-magnetism; Geophysical methods in Ore and Groundwater prospecting. Physics, Geology and Life.

Course outcomes:

At the completion of the course student would be able to

1. Understand basic geological processes and their products.
2. Comprehend interaction between different Earth spheres.
3. Apply laws of physics in understanding planet Earth.

Prescribed and Reference Books

- **Applied Geophysics** by **W.M. Telford, L.P. Geldart R.E. Sheriff and D.A. Keys**
- **Basic Exploration Geophysics** by **Edwin S. Robinson and Cahit Coruh**
- **Earth Materials** by **Cornelis Klein and Anthony Philpotts**
- **General and Applied Geophysics (An introduction)** by **I.K. Kaul, S. Sengupta and A.K. Bhattacharya**
- **Geophysical Prospecting For Groundwater** by **Sankar Kumar Nath**
- **Global Tectonics. Third Edition (Reprint)** by **P. Keary, K.A. Klepeis and F.J. Vine**
- **Introduction to Geophysics** by **Howell**

M.Sc. Geology
II Year - III Semester
Syllabus

M.Sc. Geology, II Year, III Semester (Total Credits = 25)									
Sr. No.	**Subject**	**Code**	**Theory Paper**	**Credits**		**Sr. No.**	**Code**	**Practical Paper**	**Credits**
1	**Core**	GEO-C301	Economic Geology and Geology of India Mineral Deposits	4		1	GEO-C305	Economic Geology and Geology of India mineral deposits	2
2	**Core**	GEO-C302	Hydrogeology	4		2	GEO-C306	Hydrogeology	2
3	**Core**	GEO-C303	Remote Sensing	2		3	GEO-C307	Remote Sensing	1
4	**Core**	GEO-C304	Geographical Information System	2		4	GEO-C308	Geographical Information System	1
5	**Subject Elective (Choose any One)**	GEO-E301	Principles of Geophysics	3		5	GEO-E304	Principles of Geophysics	1
		GEO-E302	Tectonics and Crustal Evolution				GEO-E305	Tectonics and Crustal Evolution	
		GEO-E303	Engineering Geology				GEO-E306	Engineering Geology	
6	**Open Elective (for students from all the Schools including School of Earth Sciences)**	GEO-OE301	Watershed management	2		6	GEO-C309	Seminar/Field Report	1
		GEO-OE302	Geochemistry of water						
		GEO-OE303	Fundamentals of Remote Sensing						
			Total	**17**				**Total**	**8**

Department of Geology
School of Earth Sciences
SRTM University
NANDED

GEO-C301: ECONOMIC GEOLOGY AND GEOLOGY OF INDIAN MINERAL DEPOSITS

(Theory: 4 credits & Practical: 2 credits)

Pre-requisites:

Basic (10+2) knowledge of chemistry and physics + completion of courses GEO-C101 (Mineralogy), GEO-C104 (Geochemistry), GEO-C201 (Igneous Petrology), GEO-C202 (Thermodynamics and Metamorphic Petrology) and GEO-C203 (Sedimentary Petrology).

Course objectives:

1. Economic Geology is very significant branch of geology directly linked to National Economy.
2. This course in Economic Geology and Indian Mineral Deposits would help the students to understand distribution of economic minerals in Earth's crust, evaluate different processes of economic mineral formation, identify and characterize the minerals based on their physical, chemical and optical properties.
3. The student will study the basic principles behind the formation of ore deposits; how crustal abundance, physic-chemical conditions and fluids play a significant role in the formation of mineral deposits.
4. The course deeply discusses the spatio-temporal and tectonic controls of ore formation both at global level and especially in Indian context.
5. The course offers a detailed account of Indian mineral deposits.
6. The student will study how to identify the most common ore minerals in hand specimen and, by using optical techniques learn how to identify the common ore minerals in thin section.

Course contents:

Unit I: Introduction, Classification and Processes of Ore Formation

Introduction to the Ore deposits
Concept of ore bearing fluids, their origin and migration
Form, mineral assemblage, rock-ore association and relationship
Physical and optical properties of ore minerals
Ore textures
Wall-rock alteration
Classification of Ore deposits

Processes of Ore formation
- Magmatic
- Sublimation

Hydrothermal
Oxidation and Supergene Sulfide Enrichment
Residual and Mechanical Concentration
Sedimentation
Evaporation
Contact Metamorphism
Regional Metamorphism
Bacteriogenic

Fluid inclusions in ore mineral assemblage
Stable isotopes in ore genesis

Unit II: Controls on Ore Formation

Structural, physic-chemical and stratigraphic controls of ore localization
Paragenesis and Zoning
Stratiform and Stratabound deposits
Metallogenic Epochs and Metallogenic Provinces
Platetectonic controls on Distribution of Ore Deposits

Unit III: Indian Ore deposits: Metallic Deposits

Geologic setting, field occurrence, ore mineralogy, association, geochemistry, genesis and tectonic environment of

Cu, Pb, Zn,
Fe, Mn, Cr,
Al, Ba
Sn, W, Mo
Au, Ag
Ni, PGE
Be, Hg
Mg, P

Unit IV: Indian Ore deposits: Non-Metallic Deposits

Geologic setting, field occurrence, ore mineralogy, association, geochemistry, genesis and tectonic environment of Industrial minerals used in

Refractory industry
Fertilizer industry
Ceramic industry
Cement industry
Chemical industry
Glass industry
Paint industry
Abrasives
Building stones

Diamond and other precious and semi precious stones

GEO-C305: Practical based on GEO-C301 (2 Credits)

1. Study of ore minerals and industrial materials in hand specimens.
2. Study of characteristics structures observed in hand specimens.
3. Study of ore minerals, textures and structures in thin and polished sections.
4. Preparation of maps showing distribution of metallic and industrial minerals in India and also classical world mineral deposits.

Course outcomes:

At the completion of the course student would be able to

1. Describe geological distribution of a variety of ore deposits.
2. Understand different processes of mineral deposit formation.
3. Explain why certain ore deposits are restricted to certain epochs, provinces and tectonics.
4. Give a detailed account of Indian mineral deposits.
5. Identify and characterize ore minerals based on megascopic and microscopic observations.
6. Prepare global and Indian mineral deposit distribution.

Prescribed and Reference Books

- **Economic Geology Principles and Practice: Metals, Minerals, Coal and Hydrocarbons – Introduction to Formation and Sustainable Exploitation of Mineral Deposits** by **Walter L. Pohl**
- **Economic Mineral Deposits** by **Mead L. Jensen and Alan M. Bateman**
- **Geochemistry of Hydrothermal Ore Deposits** by **H.L. Barnes**
- **Hand Book of Stratabouond and Stratiform Ore Deposits** by **Wolf, K.H. (1976-1981)**
- **Introduction to Ore-forming processes** by **L. Robb**
- **Metals and Society: An Introduction to Economic Geology** by **Nicholas Arndt, Stephen Kesler and Clément Ganino**
- **Mineral Economics: An Indian Perspective** by **Kirtikumar Randive and Sanjeevani Jawadand**
- **Mineral Resources, Economics and the Environment** by **S.E. Kesler and A.C. Simon**
- **Minerals and Allied Natural Resources and their Sustainable Development: Principles, Perspectives with Emphasis on the Indian Scenario (Springer Geology)** by **Mihir Deb and Sanjib Chandra Sarkar**
- **Ore Genesis – A Holistic Approach** by **A. Mookherjee**
- **Ore Geology and Industrial Minerals – An Introduction** by **A.M. Evans**
- **Ore microscopy and ore petrography** by **James R. Craig and David J. Vaughan**
- **Ore Petrology** by **R.L. Stanton**
- **The Geology of Ore Deposits** by **J.M. Guilbert and C.F. Park Jr.**
- **The Ore Minerals and their Intergrowths** by **P. Ramdohr**
- **The World of Mineral Deposits: A Beginner's Guide to Economic Geology** by **Neukirchen, Florian, Ries, Gunnar**
- **Time and Strata Bound Ore Deposits** by **D.D. Klemm and H.J. Schneider**

GEO-C302: HYDROGEOLOGY
(Theory: 4 credits & Practical: 2 credits)

Pre-requisites:

Basic (10+2) knowledge of chemistry and physics + completion of courses GEO-C101 (Mineralogy), GEO-C102 (Structural Geology and Geotectonics) and GEO-C104 (Geochemistry) and GEO-C203 (Sedimentary Petrology).

Course objectives:

1. To understood the hydro-geological cycle.
2. Occurrence of groundwater on the planet earth.
3. To study the groundwater aquifers, hydro geological properties, and movement of groundwater.
4. Exploration of groundwater occurrence in different geological formations.
5. To develop the writing skills based on research pattern/report writing which is useful in research institutes/govt. organizations/Pvt. organizations
6. To develop the skills of individual student so that he/she will be competent enough to get job in this field of specialization.

Course contents:

Unit I:

Hydrological cycle; Occurrence and distribution of groundwater; Aquifer classification and characteristics of aquifers, Hydrological properties of rocks- Porosity, permeability, hydraulic conductivity, specific yield, storage coefficient, transmissibility, hydraulic resistivity, hydraulic diffusivity.

Unit II:

Classification of rocks from hydrological view- Properties; groundwater conditions in different geological formations. Aquifer parameter analysis; Darcy's Law in homogenous and heterogenous media; Bernoulli equation; Reynold's number; pumping test and aquifer evaluations; Coastal conditions- seawater intrusion and its control;

Unit III:

Groundwater management; methods of recharge; artificial recharge; water budgeting and evaluation of perennial yield; Urbanization and demands on water; Water logging and conjunctive use; excessive use and alkalinity-saltation; Methods of water conservation; sustainable watershed development; groundwater level fluctuations; land subsidence; impact of global climate change on groundwater.

Unit IV:

Groundwater chemistry: Chemical characteristics of groundwater in relation to various uses – domestic, industrial and irrigation; Radioisotopes in hydro-geological studies; Groundwater contamination and problems of arsenic, fluoride and nitrates.

Groundwater exploration: Surface investigation of groundwater - geologic, remote sensing, electrical resistivity, seismic, gravity and magnetic methods; sub-surface investigation of groundwater - test drilling, resistivity logging, spontaneous potential logging, radiation logging.

GEO-C305: Practical based on GEO-C302 (2 Credits)

In Laboratory:

Megascopic identification and description of hydrological properties of rocks. Hydrological problems, hydrochemical analysis of water, plotting the Gibb's diagrams, Piper Tri-linear diagrams etc.

In Field:

Study of weathering pattern with respect to percolation of surface water in to the ground water, study of primary and secondary porosity of rock formation; Well inventory etc.

Course outcomes:

At the completion of the course student would be able to

1. Understand Water-bearing formations.
2. Understand and model the flow of groundwater.
3. Explain chemistry of groundwater as controlled by natural and anthropogenic processes.
4. Detect groundwater potential and understand its management.
5. Analyze water for different chemical components.
6. Graphically represent variations groundwater chemistry.

Prescribed and Reference Books

- **Geochemistry, Groundwater and Pollution** by **C.A.J. Appelo**
- **Geophysical Prospecting For Groundwater** by **Sankar Kumar Nath**
- **Ground Water and Wells** by **F.G. Driscoll**
- **Ground Water** by **H.M. Raghunath**
- **Ground Water Hydrology** by **D.K. Todd**
- **Groundwater Geochemistry** by **J. Merkel Broder**
- **Groundwater Geophysics in Hard Rock** by **Prabhat C. Chandra**
- **Groundwater Prospecting and Management** by **H. P. Patra, Shyamal Kumar Adhikari, and Subrata Kunar**
- **Hydrogeology** by **S.N. Davies and R.J.N. Dc-West**
- **Modern Groundwater Exploration: Discovering New Water Resources in consolidated Rocks Using Innovative Hydrogeologic Concepts, Exploration, Drilling, Aquifer Testing and Management Methods** by **Jay H. Lehr and Robert A. Bisson**

GEO-C303: REMOTE SENSING
(Theory: 2 credits & Practical: 1 credit)

Pre-requisites:

Basic (10+2) understanding of science

Course objectives:

1. To attain fundamental knowledge of basics of Remote Sensing.
2. To identify different features with the help of Photo-interpretation Elements.
3. To apply Remote Sensing knowledge for different applications in Earth Sciences.

Course contents:

Unit I:

Introduction and Aerial Photography:

Introduction to Remote Sensing, Definition, Characteristics of EMR, Platforms, Fundamentals of Aerial Photography, History of Aerial Photographs, Types of Aerial Photographs- Vertical and Oblique Photographs, Aerial Cameras, Flying Plan, Photogrammetry -- Basic Geometric Characteristics- Scale, Overlap, Tilt, Distortion and Displacement of Aerial Photographs, Advantages and Disadvantages of Aerial Photographs, EMR and its interaction with matter, Reflection, Absorption, Transmission, Scattering. Concept of Signatures- Photo Interpretation Elements.

Unit II:

Satellite Remote Sensing and Applications of Remote Sensing:

Principles of Remote Sensing, Process of Remote Sensing, Indian Remote Sensing Programme, Types of Satellites- Sun-synchronous and Geostationary Satellites, Launch Vehicles- PSLV, GSLV, Payloads, Active and Passive Remote Sensing, Classification of Remote Sensors, Resolution- Spatial, Spectral, Radiometric, Temporal, Microwave Sensors, SLAR, Digital Image Processing- Image Classification, Supervised and Unsupervised Classification, Image Enhancement, Filtering, PCA etc.

Applications of Remote Sensing:

Interpretation of Visual and Digital data, Applications in Geology.

GEO-C307: Practical based on GEO-C303 (1 Credit)

1. Toposheet Reading
2. Calculation of the Scale of Aerial photograph and Satellite Imagery.
3. Identification of different features from the Aerial photograph with the help of Photo-interpretation Elements.
4. Identification of different features from Satellite Imagery with the help of Photo-interpretation Elements.
5. Study of Drainage patterns from Aerial Photograph/Satellite Imagery.
6. Preparation of Land use/Land cover Map from Aerial Photograph/Satellite Imagery.

7. Calculation of Land use/Land cover percentage from Aerial Photograph/ Satellite Imagery.

Course outcomes:

At the completion of the course student would be able to

1. Explain the Fundamental principles of Remote Sensing.
2. Explain basic properties of Remote Sensing, Data acquisition, Storage and Processing.
3. Identify different features with the help of Photo interpretation Elements.
4. Apply the knowledge of Remote Sensing for applications in different fields.

Prescribed and Reference Books

- **Image Interpretation in Geology** by **Drury**
- **Introduction to Remote Sensing** by **J. B. Campbell**
- **Photogrammetry** by **Miller and Miller**
- **Principles & Applications of Photogeology** by **S. N. Pande**
- **Remote Sensing & Image Interpretation** by **T. M. Lillesand and W. K Ralph**
- **Remote Sensing in Geology** by **Siegal**
- **Remote Sensing: Principles and Interpretation** by **F. F. Sabins**

GEO-C304: GEOGRAPHICAL INFORMATION SYSTEMS
(Theory: 2 credits & Practical: 1 credit)

Pre-requisites: Basic understanding Geology, Geography and Physics (10 / 10+2 level).

Salient features of the Course:

Geographical information system knowledge is very essential to solve various problems and issues in society. It is map-based decision support system and the students will learn about spatial and non-spatial data and mapmaking techniques using GIS softwares. Currently, it is one the most important and job giving sectors for GIS trained persons both in government and private sectors.

Course objectives:

1. Introduce the students to the fundamental concepts of GIS and GPS technologies
2. It will make them familiar with the most essential GIS techniques with hands on practical experience.
3. Students will learn about creation and organization of spatial and non-spatial data.
4. Learn and use different GIS based techniques to identify and solve the natural, environmental and community problems.
5. Learn application of GIS and GPS in geology.

Course contents:

Unit I:

Introduction to GIS, Definition, History of GIS, Scope and Importance of GIS, Development of GIS, Components of GIS, Data models in GIS - Raster data model, Vector data model, basic entities of GIS: line, point and polygon, Geodatabase, Map Projection, Types and Need of projection system, Spatial and Attribute data, Acquisition of spatial data: Scanning, Georeferencing, concept of layer, digitizing, error detection and correction, DBMS.

Unit II:

Global Positioning Systems, History and developments in GPS, Trilateration process, types of GPS, GPS Surveys, Mapping and layout, Image processing, General processes involved in image processing, mosaic, subset, Point interpolation techniques: Krigging, IDW, Data analysis, network analysis, DEM and DTM, Thematic maps, Geological Applications of GIS and GPS technology

GEO-C308: Practical based on GEO-C304 (1 Credit)

1. Geo-referencing of image.
2. Base layer preparation.
3. Error detection and correction.
4. Preparation of geodatabase and editing data.
5. Use of GPS instrument to collect way-point data.
6. Map Projections.
7. Importing GPS data into the computer using software.
8. Mosaiking.
9. Subsetting.
10. Point Interpolation techniques: Krigging, IDW.
11. Preparation of DEM/DTM.
12. Preparation of thematic maps
13. Practical based on geological applications of GIS.
14. Practical based on geological applications Google Earth.

Course outcomes:

After successful completion of this course, a student should know

1. Differentiate between different data types in GIS.
2. Georeference the spatial data and work on spatial and non-spatial database.
3. Describe various GIS tools and techniques.
4. Explain the fundamental principles behind GPS technology.
5. Visualize GIS outputs in different dimensions.
6. Create digital GIS maps.
7. Apply spatial data analysis for various applications to deal with geological problems.

Prescribed and Reference Books

- **An Introduction to Geographical Information Systems** by **I. Heywood, S. Cornelisus and S. Carver**
- **Concepts Techniques of Geographical Information Systems** by **C. P. Lo and A. W. Yeung Geographical Information Systems and Science** by **P. A. Longley, M. F. Goodchild, D. J. Maguire and D. W. Rhind**
- **Fundamentals of Geographic Information Systems** by **M. N. Demers**
- **Introduction to Geographic Information Systems** by **K. T. Chang**
- **Introduction to Global Positioning Systems** by **Ahmed E. L. Rabbany**
- **Introductory Digital Image Processing** by **J. R. Jensen**
- **Textbook of Remote Sensing and Geographic Information System** by **M. Anji Reddy**
- **Principles of Geographical Information Systems** by **P. A. Burrough and R. A. McDonnell**
- **The GIS Book** by **G. B. Korte**

GEO-E301: PRINCIPLES OF GEOPHYSICS
(Theory: 3 credits & Practical: 1 credit)

Pre-requisites:

Basic knowledge about physical properties like density, magnetism, electrical properties, elastic and radioactive properties, general composition of the earth materials and their physical property variations.

Course Objectives:

The objective of this course is to develop basic knowledge of geophysics and its applications in understanding the Earth processes.

Coarse contents:

Unit I:

Definition and scope of geophysics; Basic principles and concepts of geophysical study; Concepts of physical properties; Basic physical properties in the study of geophysics; Physical properties of different rock formations; Introduction to major geophysical methods; Natural and artificial source geophysical methods. Ground and airborne geophysical methods; Heat flow studies; Gravitational field of the Earth, geoid-spheroid; Isostacy; Introduction to Geomagnetism and Paleo-magnetism; Introduction to seismology, concept of seismic waves and velocities and earthquakes; Geophysics and internal constitution of the Earth

Unit II:

Gravity Method: principles, units, gravity measurements, gravity measuring instruments. Gravity data collection, data presentation, gravity base, concept of gravity anomaly. Gravity data reduction.

Magnetic Method: Principle, units, magnetic elements, instrumentation, concept of magnetic anomaly, magnetic base, survey procedures, corrections.

Gravity and magnetic anomaly presentations, processing and interpretation, Regional and residual anomalies, concepts interpretation, applications of gravity and magnetic anomalies.

Unit III:

Electrical Methods: Principles, various electrical properties used in electrical methods, classification of electrical methods, SP, Resistivity and Electromagnetic Methods – theory, survey procedures, data presentation and their various applications.

Basic principles of seismic methods, Seismic reflection and refraction methods and their applications.

GEO-E304: Practical based on GEO-E301 (1 Credit)

1. Physical property measurement, Variations of Physical property of Earth Materials.
2. Practical problems related to gravity and magnetic anomaly patterns, qualitative interpretation.
3. Electrical anomaly patterns (SP and resistivity) and applications.
4. Seismic data interpretation.
5. Exercises on application of Isostacy.

Course outcomes:

This course aims to enable the students

1. To gain an understanding of the basic principles and practice of exploration geophysics.
2. To gain an understanding of electrical and electromagnetic, gravity and magnetic surveying and well logging.
3. Be capable of explaining the principles of seismic refraction and reflection

Prescribed and Reference Books

- **An Introduction to Geophysical Exploration** by **Philip Kearey, Michael Brooks and Ian Hill**
- **Applied geophysics** by **W.W. Telford**
- **Exploration Geophysics** by **Kaul and Bhattachrya**
- **Fundamentals of Geophysics** by **Lowrie**
- **Geophysical methods in geology** by **G.R. Foulger and C. Peirce**
- **Gravity and Magnetic interpretation in Exploration Geophysics** by **I.V. Radhakrishna Murthy**
- **Gravity and Magnetic methods** by **B.S.R. Rao and I.V.R. Murthy**
- **Introduction to Geophysical prospecting** by **M.B. Dobrin**
- **Introduction to Geophysics – Lecture Notes by Jan Valenta**
- **Outline of Geophysical Prospecting** by **M.B. Ramchandra Rao.**
- **Outlines of Exploration Geophysics** by **V.L.S. Bhimasankaram**

GEO-E302: TECTONICS AND CRUSTAL EVOLUATION
(Theory: 3 credits & Practical: 1 credit)

Pre-requisites:

Basic scientific thinking, Knowledge of plate tectonics and structure of the earth.

Course objectives:

1. Spatial evolution of crust.
2. Temporal evolution of crust
3. Role of vertical and horizontal tectonics in the crustal evolution
4. Application of geotectonics in the making India.

Course contents:

Unit I: Global Tectonics and Crustal evolution

Composition of crust, primitive mantle and core; Belassov and Wilson models of global tectonics and crustal evolution; Stagnant-lid model and plume tectonics; Global deformation patterns and magma associations in Precambrian times. Formation and fragmentation of Supercontinents.

Unit II: Precambrian Crustal evolution

Evolution of lithosphere, hydrosphere, atmosphere, biosphere, and cryosphere; lithological, geochemical and stratigraphic characteristics of granite – greenstone and granulite belts. Stratigraphy and geochronology of the cratonic nuclei, mobile belts and Proterozoic sedimentary basins of India. Life in Precambrian.

Unit III: Phanerozoic Crustal Evolution

Precambrian – Cambrian boundary with special reference to India. Phanerozoic evolution of crust; Atlantic, Andean, Alaskan and Alpine plate boundaries. Opening and closing of oceans. Crustal growth in space and time.

GEO-E305: Practical based on GEO-E302 (1 Credit)

1. Preparation of Stratigraphic correlation maps with the help of field data
2. Preparation and study of geological map on the basis of geological formations
3. Use of field data to study the palaeo-stress, strain and interpretation of tectonics.
4. Geological formation correlation with tectonic settings.
5. Identification and preparation of geological maps with the help of field surveys.

6. Application of different software in tectonic studies.

Course outcomes:

At the completion of the course student would be able to

1. Understand global tectonics.
2. Understand the tectonics evolution of India as a geologic entity.
3. Understand crustal evolution in space and time.
4. Plot and interpret the field data like paleostress data.

Prescribed and Reference Books

- **Geology of India: Volume 1 and Volume 2** by **M. Ramakrishnan and R. Vaidyanathan**
- **Global Tectonics** by **Kearey Phillips and F.J. Vine**
- **Plate Tectonics and Crustal Evolution** by **K.C. Condie**
- **Tectonics** by **Eldridge M. Moores and Robert J. Twiss**
- **The Evolving Continents** by **Brain F. Windley**
- **The Making of India: Geodynamic Evolution** by **K. S. Valdiya**

GEO-E303: ENGINEERING GEOLOGY
(Theory: 3 credits & Practical: 1 credits)

Pre-requisites:

Basic (10+2) knowledge of rocks and their types. Physical properties of rocks + GEO-C101 (Mineralogy) and GEO-C201, GEO-C202 & GEO-C203 (Petrology courses).

Course objectives:

1. Rocks and their types as well as their mode of formation.
2. Physical and mechanical properties of rocks.
3. Textures and structures of rocks.
4. Chemical composition of rocks.
5. Structural features of rocks affecting civil construction.
6. Geological site investigation for civil construction.

Course contents:

Unit I: Geology and Civil Engineering

Engineering properties of rocks, and soils and their classifications and physical characteristics of building stones, concretes and other aggregates- mineral composition, texture, structure, porosity, strength of rocks, permeability, durability, heat resistance, etc.

Unit II: Structural weakness of geological materials

Significance of structures in engineering geology; Concepts of stress, strain, Mohr circle and failure theories. Discontinuities in rock masses. Weathering of rocks; Mass movements with special emphasis on landslides and causes of hill slope instability. Rock slope stability, landslides and stability of structures; Engineering behaviour of rock materials and rock masses; Engineering aspects of weaker geological materials.

Unit III: Geological site investigation

Geological investigations in construction of dams, reservoirs, tunnels, bridges, highways and coastal protection structures; geologic considerations of construction materials. Remedial measures for and reinforcements of weaker geological materials; Seismic design of buildings. Site investigations and important case studies.

GEO-E306: Practical based on GEO-E303 (1 credit)

1. Rock studies in hand specimen, rock studies in thin sections.
2. Mechanical properties of rocks (texture, structure, porosity, strength of rocks, permeability, durability, heat resistance, etc,)

3. Geological cross sections.
4. Structural problems related to borehole data; stress-strain analyses.

Course outcomes:

Students who earn minimum grade should be able to

1. Interpret the field data and interpret structures and deformations.
2. Identify rock properties (mechanical properties).
3. Understand role of structural features of rocks in engineering geology.
4. Carry out geological cross section and interpretation of subsurface geology.
5. Understand role of chemical composition of rocks in engineering geology.
6. Carry out geological site investigation for civil construction.
7. Carry out seismic zone classification and seismic design of building.
8. Understand behaviour of rocks under stress.

Prescribed and Reference Books

- **A Text Book Geology** by **P.K. Mukharjee**
- **Blue Planet** by **Skinner and Porter**
- **Engineering Geology** by **Purbin Singh**
- **Engineering Geology- Principle and Practice** by **Price and David George**
- **Experiments in Engineering Geology** by **K.V.G.K. Gokhale and D.M. Rao**
- **Foundations of Engineering Geology** by **Waltham**
- **Fundamentals of Engineering Geology** by **F.G. Bell**
- **Geology for Civil Engineers** by **McLean and Gribble**
- **Handbook of Mechanical Properties of Rocks** by **V.S. Vutukuri, R.D. Lama and S.S. Saluja**
- **Introduction to the Rock Physics** by **G. Yves and P. Victor**
- **Physical Geology** by **Arthur Holmes**
- **Principle of Engineering Geology** by **Johnson De Graff**
- **Principles of Engineering Geology** by **D.P. Krynine and W.P. Judd**
- **The Earth** by **Press and Seiver**
- **The Fracture of Rocks** by **J.L. Bles and B. Feuga**
- **The Physics of Rocks** by **V.Q. RzLevisky and G. Novik**
- **The Rock Physics** by **M. Garg, T. Mukherjee and J. Dvorkin**
- **Wave Propagation in Elastic solids** by **J.D. Achenbach**

GEO-OE301: WATERSHED MANAGEMENT
(Theory: 2 credits)

Pre-requisites:

Basic knowledge of geology and geography

Course objectives:

1. To understand behaviour different watersheds.
2. To be able to interpret runoff data and quantify erosion by using various modeling methods.
3. To understand land use classification and impact of land use changes on hydrological cycle parameters.

Course contents:

UNIT I:

Definition, concepts, principles, classification by size, Rainfall and runoff, water balance approach, water budgeting.

UNIT II:

Topographic surveying; Water conservation and harvesting methods- importance and techniques; Agriculture and water management- participatory rural appraisal in watershed programmes, community mobilisation.

Course outcomes:

At the end of the course, the student will be able to

1. Identify causes of soil erosion
2. Plan and design soil conservation measures in a watershed
3. Plan and design water harvesting and groundwater recharge structures
4. Plan measures for reclamation of saline soils

Prescribed and Reference Books

- **Land and Water Management** by **V.V.N. Murthy and M.K. Jha**
- **Watershed Hydrology** by **P. E. Black**
- **Watershed Hydrology** by **R. Suresh**
- **Watershed Management** by **J.V.S. Murthy**
- **Watershed Management** by **Madan Mohan Das and M.D. Saikia**

GEO-OE302: GEOCHEMISTRY OF WATER
(Theory: 2 credits)

Pre-requisites:

Basic (10+2) level understanding of chemistry

Course objectives:

1. Explain the principles of geochemistry.
2. Explain the geochemistry of different water reservoirs.
3. Explain the factors controlling Groundwater and surface water Geochemistry.
4. Introduce modelling the geochemistry of groundwater.

Course contents:

Unit I: Introduction to Geochemistry

Periodic Table of Elements
Major, Minor and Trace Elements
Rare Earth Elements
Stable and Radioactive isotopes
Partition of Elements in different spheres of the Earth
Geochemistry of abundant minerals and rocks of the Earth
Graphical representation of geochemical data

Unit II: Geochemistry of Water

Geochemistry of natural water and Water quality standards
Geochemistry Ground- and Surface-water: Pedogenic control
Geochemistry Ground- and Surface-water: Anthropogenic control
Radioisotopes in hydro-geological studies;
Groundwater contamination (arsenic, fluoride and nitrates)
Modeling of Groundwater Geochemistry

Course outcomes:

At the completion of the course student would be able to

1. Understand the behavior of elements.
2. Understand fundamental geochemical principles.
3. Apply geochemical principles to evaluate the geochemistry of water.
4. Understand basic modeling the groundwater geochemistry.

Prescribed and Reference Books

Essentials of Geochemistry (2nd Edition) by **J. Walther**
Geochemistry by **M. White**
Geochemistry Pathways and Processes (2nd Edition) by **H. Y. McSween, S. M. Richardson, and M. Uhle**
Geochemistry, Groundwater and Pollution by **C. A. J. Appelo**
Groundwater Geochemistry by **J. Merkel Broder**
Inorganic Geochemistry - Principles and Applications (3rd Edition) by **G. Faure**
Introduction to Geochemistry - Principles and Applications by **K. C. Misra**
Inorganic Geochemistry by **Henderson**
Principles of Geochemistry by **Brain Mason and Carleton B. Moore**
Textbook of Geochemistry by **Shardendu Kislaya**

GEO-OE303: BASICS OF REMOTE SENSING
(Theory: 2 credits)

Pre-requisites:

Basic (10+2) understanding of science

Course objectives:

1. To attain fundamental knowledge of basics of Remote Sensing.
2. To identify different features with the help of Photo-interpretation Elements.
3. To apply Remote Sensing knowledge for different applications in Earth Sciences.

Course contents:

Unit I

Introduction and Aerial Photography:

Introduction to Remote Sensing, Definition, Characteristics of EMR, Platforms, Fundamentals of Aerial Photography, History of Aerial Photographs, Types of Aerial Photographs- Vertical and Oblique Photographs, Aerial Cameras, Flying Plan, Photogrammetry -- Basic Geometric Characteristics- Scale, Overlap, Tilt, Distortion and Displacement of Aerial Photographs, Advantages and Disadvantages of Aerial Photographs, EMR and its interaction with matter, Reflection, Absorption, Transmission, Scattering. Concept of Signatures- Photo Interpretation Elements.

Unit II

Satellite Remote Sensing and Applications of Remote Sensing:

Principles of Remote Sensing, Process of Remote Sensing, Indian Remote Sensing Programme, Types of Satellites- Sun-synchronous and Geostationary Satellites, Launch Vehicles- PSLV, GSLV, Payloads, Active and Passive Remote Sensing, Classification of Remote Sensors, Resolution- Spatial, Spectral, Radiometric, Temporal, Microwave Sensors, SLAR, Digital Image Processing- Image Classification, Supervised and Unsupervised Classification, Image Enhancement, Filtering, PCA etc.

Applications of Remote Sensing:

Interpretation of Visual and Digital data, Applications of Remote sensing in different fields.

Course outcomes:

At the completion of the course student would be able to

1. Explain the Fundamental principles of Remote Sensing.
2. Explain basic properties of Remote Sensing, Data acquisition, Storage and Processing.
3. Identify different features with the help of Photo interpretation Elements.
4. Apply the knowledge of Remote Sensing for applications in different fields.

Prescribed and Reference Books

- **Image Interpretation in Geology** by **Drury**
- **Introduction to Remote Sensing** by **J. B.Campbell**
- **Photogrammetry** by **Miller and Miller**
- **Principles & Applications of Photogeology** by **S. N. Pande**
- **Remote Sensing & Image Interpretation** by **T. M. Lillesand and W. K Ralph**
- **Remote Sensing in Geology** by **Siegal**
- **Remote Sensing: Principles and Interpretation** by **F. F. Sabins**

M.Sc. Geology
II Year - IV Semester
Syllabus

M.Sc. Geology, II Year, IV Semester (Total Credits = 25)									
Sr. No.	**Subject**	**Code**	**Theory Paper**	**Credits**		**Sr. No.**	**Code**	**Practical Paper**	**Credits**
1	Core	GEO-C401	Coal and Petroleum Geology	4		1	GEO-C404	Coal and Petroleum Geology	2
2	Core	GEO-C402	Geoexploration, Mining Geology and Mineral Economics	4		2	GEO-C405	Geoexploration, Mining Geology and Mineral Economics	2
3	Core	GEO-C403	Dissertation	4		3	GEO-C406	Dissertation	2
4	**Subject Elective (Choose any One)**	GEO-E401	Disaster Management	3		5	GEO-E404	Disaster Management	1
		GEO-E402	Climatology				GEO-E405	Climatology	
		GEO-E403	Marine Geology and Oceanography				GEO-E406	Marine Geology and Oceanography	
5	**Open Elective (for students from all the Schools including School of Earth Sciences)**	GEO-OE401	Geological Resources and Global Socio-Economy	2		6	GEO-C407	Seminar/Field Report	1
		GEO-OE402	Medical Geology						
		GEO-OE403	History of the Earth						
			Total	**17**				**Total**	**8**

Department of Geology
School of Earth Sciences
SRTM University
NANDED

GEO-C401: COAL AND PETROLEUM GEOLOGY
(Theory: 4 credits & Practical: 2 credits)

Pre-requisites:

Basic (10+2) knowledge of chemistry and biology + **GEO-E101** (Stratigraphy) and **GEO-C103** (Palaeontology).

Course objectives:

1. To understood the origin, formation and occurrence of coal.
2. To understood the origin, formation and occurrence of petroleum.
3. To study the geographical and geological distribution of coal and petroleum.
4. To study the geological and geochemical prospecting for coal and petroleum
5. To develop the writing skills based on research pattern/report writing which is useful in research institutes/govt. organizations / pvt. organizations
6. To develop the skills of individual student so that he/she will be competent enough to get job in this field of specialization.

Course contents:

Unit I:

Definition and origin of coal; Sedimentalogy of coal bearing strata; Types of seam discontinuities and structures associated with coal seams; Chemical analysis of coal (proximate and ultimate analysis). Coal Petrology – concept of 'Lithotype', 'Maceral' and 'Microlithotype'; Techniques and methods of coal microscopy; Classification of coal in terms of rank, grade and type.

Unit II:

Indian classification for coking and non-coking coals; International classifications (I.S.O. and Alpern's classification). Geographical and geological distribution of coal and lignite in the world and in India. Indian coal reserves and production of coal in India. Coal bed methane – a new energy resource. Elementary idea about generation of methane in coal beds.

Unit III:

Petroleum and its composition; Theories of Origin of Petroleum; Occurrence of Petroleum; Surface and sub-surface occurrences; Reservoir Rocks: Fragmental, Chemical and Miscellaneous; Marine & Non-Marine Reservoir Rocks; Introduction to pore space, fluid content, reservoir traps; Reservoir Conditions - effect of temperature & pressure.

Unit IV:

Migration & accumulation of Petroleum; Petroleum Provinces - sedimentary basins, carbon-ratio theory, unconformities; Petroleum exploration techniques & strategies; Major Petroleum Provinces. Classification and stratigraphy of petroliferous basins of

India. Oil and source rock correlation. Locating petroleum prospects based on principles of petroleum generation and migration (geological modeling). Quantitative evaluation of oil and gas prospects through geochemical modeling.

GEO-C404: Practical based on GEO-C401 (2 Credits)

In Laboratory:

Megascopic identification, classification and description of coal. coal seam problems; Coal mining problems; Problems related to petroleum deposits. Study of geological maps and sections of important oil fields of India. Calculation of coal reserves; Calculation of oil reserves.

In Field:

Field visit to coal mines; Collection of different coal samples; Study of coal and petroleum prospective areas.

Course outcomes:

At the completion of the course students would be able to

1. Understand the theories of origin of coal and petroleum.
2. Explain distribution of coal and petroleum in different geological environments.
3. Identify different types of coal.
4. Calculate coal and oil reserves.

Prescribed and Reference Books

- **Coal and Coal-bearing strata: Recent Advances. The geological Society of London, Publication no. 32 (1987)** by **A.C. Scott**
- **Coal and organic Petrology** by **Singh, M.P. (Ed.)**
- **Elements of Petroleum Geology** by **R.C. Selley**
- **Hydrocarbon exploration and production** by **F. John, M. Cook and M. Graham**
- **Introduction of Petroleum Geology** by **G.D. Holson and E.N. Tiratso**
- **Micropaleontology in Petroleum Exploration** by **R.W. Jones**
- **Organic Petrology** by **G.H. Taylor, M. A. Teichmuller, Davis, C.F.K. Diesel, R. Little, and P. Robert**
- **Petroleum Formation and Occurrence** by **B.P. Tissot and D.H. Welte**
- **Petroleum Geochemistry and Geology** by **J.M. Hunt**
- **Petroleum Geology** by **F.K. North**
- **Textbook of Coal (Indian context)** by **D. Chandra, R.M. Singh and M.P. Singh**
- **Textbook of Coal petrology** by **E. Stach, M-Th. Mackowsky, G.H. Taylor, D. Chandra, M. Teichumullelr and R. Teichmuller**
- **Thermal Modeling of Petroleum Generation** by **C. Barker**

GEO-C402: GEOEXPLORATION, MINING GEOLOGY AND MINERAL ECONOMICS

(Theory: 4 credits & Practical: 2 credits)

Pre-requisites:

Basic (10+2) knowledge of chemistry and physics + GEO-C101 (Mineralogy) + GEO-E101 (Stratigraphy) and GEO-C201, GEO-C202 & GEO-C203 (Petrology courses).

Course objectives:

1. To understood the concept and scope of geo-exploration.
2. To understood the economy of mineral resources.
3. To study the mineral dispersion and there identification.
4. To understand different mining techniques
5. To develop the writing skills based on research pattern/report writing which is useful in research institutes/govt. organizations / Pvt. organizations.
6. To develop the skills of individual student so that he/she will be competent enough to get job in this field of specialization.

Course contents:

Unit I:

Classification of mineral deposits for exploration. Host rocks of mineral deposits. Methods of exploration - mapping on different scales, surveying, pitting/trenching, drilling, logging, sampling - general principles and methodologies;

Unit II:

Geological exploration: Geological criteria and guides for exploration of mineral deposits. Gossan and capping. Structural, Lithological and Stratigraphic Guides. Geophysical exploration - gravity, magnetic, seismic and electrical methods, field procedures and interpretation of the data; Brief description and application of radioactive methods. Geochemical exploration - soil, bed rock sampling, water sampling. mobility and geochemical associations of elements. Geochemical prospecting methods. Primary and secondary geochemical dispersion patterns. Geo-botanical exploration methods.

Unit III:

Definition, basic concepts, terminology, broad classification of mining methods: Placer mining methods, open pit methods, Underground mining methods, Coal Mining methods and Ocean bottom mining methods; Mining of surface and underground mineral deposits Geological factors considered for the selection of mining method; Mining hazards and safety measures; Mines & Minerals Regulation & Development Act.

Unit IV:

Mineral economics and its concepts. Peculiarities inherent in mineral industry. Tenor, grade and specification. Strategic, critical and essential minerals. Conservation and substitution. Changing pattern of mineral requirement; Importance of minerals in national economy; marine mineral resources and laws of the sea; Indian mineral policy and legislation; Mineral Concession Rules.

GEO-C405: Practical based on GEO-C402 (2 Credits)

In Laboratory:

Estimation of grade and ore reserves: Bedded type and vein type (Extended area and included area methods); Surveying - Plane table survey, chain survey, prismatic compass survey, abney level survey. Bore hole problems; Gravity, magnetic and electrical survey related problems and calculations. Cross section of mines with the help of available data; Preparation of mineral maps of India; Graphical representation of production, export and import of important minerals.

In Field:

Techniques of stream sampling; Magnetic and electrical surveys in the field and interpretation of data; Field report on nearest mines.

Course outcomes:

At the completion of the course students would be able to

1. Understand the different mineral exploration methods.
2. Understand different sampling and mining techniques.
3. Understand the role of minerals in global and national economy.
4. Calculate mineral reserves.
5. Interpret different exploration data sets.
6. Represent mineral data through various graphs.

Prescribed and Reference Books

- **Biological Methods of Prospecting for Minerals** by **R.R. Brooks**
- **Courses in Mining Geology** by **R.P.N. Arogyaswami**
- **Economic Geology Principles and Practice: Metals, Minerals, Coal and Hydrocarbons – Introduction to Formation and Sustainable Exploitation of Mineral Deposits** by **Walter L. Pohl**
- **Elements of Geochemistry, Geochemical Exploration and Medical Geology** by **K.R. Randive**
- **Elements of Mining** by **G.J. Young**
- **Elements of Mining** by **R.A. Lewis and G.A. Clark**
- **Elements of Prospecting and Exploration** by **T.C. Bagchi, D.K. Sengupta and S.V.L.N. Rao**
- **Elements of prospecting for non-fuel mineral deposits** by **P.K. Banerjee and S. Ghosh**
- **Geobotany and Biogeochemistry in Mineral Exploration** by **R.R. Brooks**
- **Geochemical exploration methods for mineral deposits** by **A. A. Beus and S. V. Grigorian**
- **Geological Prospecting & Exploration** by **V. M. Kneiter**
- **Introduction to Mineral Exploration** by **A.M. Evans**
- **Introduction to Mining Engineering** by **H.L. Hartman**
- **Mineral Economics** by **R.K. Sinha and N.L. Sharma**
- **Mineral Economics: An Indian Perspective** by **Kirtikumar Randive and Sanjeevani Jawadand**
- **Mineral Exploration: Principles and Applications** by **Swapan haldar**
- **Mining Geology** by **H.E. Mckinstry**
- **Mining of Mineral deposits** by **L. Sheryanthov**
- **Plants for Geobotanical Prospecting: Indicator Plants Used for Sampling for Geochemical Prospecting** by **Donald Leslie Masson**
- **Principles of Geochemical Prospecting** by **I. I. Ginzburg**
- **Principles of Mine Planning** by **Jayanth Bhattacharya**

GEO-C403: DISSERTATION
(Thesis: 4 credits & Presentation: 2 credits)

Pre-requisites:

Completed all required credits of Theory and Practicals.

Course objectives:

1. To independently work on a scientific problem.
2. To able to generate new data OR able to synthesize and analyze available large global data sets.
3. To interpret the data and derive scientifically robust conclusions.
4. To learn software required for thesis work.
5. To develop the writing skills based on research pattern/report writing which is useful in research institutes / govt. organizations / Pvt. organizations.
6. To develop the analytical and interpretative skills so that he/she will be competent enough to get job in this field of specialization.

Thesis (4 Credits):

Every Post-graduate student has to mandatorily submit dissertation thesis. The dissertation work is based on either new data generated for the proposed scientific problem OR based on available large global data sets using innovative ideas. The thesis should be based on sound methodology and well defined objectives.

GEO-E406: Presentation based on GEO-E403 (2 Credits)

Every student has to present his/her thesis in open house and defend their work.

Course outcomes:

At the completion of the course students would be able to

1. Well versed with the literature on the chosen topic.
2. Independently define a scientific problem.
3. Carry out focused study on a research topic.
4. Analyze and interpret large data sets.
5. Independently write thesis / project proposal.
6. Present and defend the scientific work.

GEO-E401: DISASTER MANGEMENT
(Theory: 3 credits & Practical: 1 credit)

Pre-requisites:

This course may offer specializations in areas like threat response, disaster management, disaster preparedness or public administration. These specialization degrees will require specific prerequisites. It also requires prerequisites in leadership, organizational behavior, emergency services, public administration, strategic planning, and occupational safety and health. Students will learn how to plan for disasters and emergencies while applying the common concepts of disaster management. Students will explore documented case studies in order to understand how real disaster situations interrupt operational efficiency and effectiveness.

Salient features:

The course may be learned by any students of any discipline as Disaster Management (DM) is multi disciplinary and draws its knowledge base from a range of disciplines. The overall aim of this is to provide broad understanding about the basic concepts of Disaster and its management.

Course objectives:

1. The aim of Approaches to Disaster Risk Reduction is to enhance the knowledge by providing existing models in risk reduction strategies to prevent major. causalities during disaster.
2. To promote Prevention and Preparedness plan for disaster mitigation.
3. To undertake the role of individual/volunteer in mitigation & Risk Reduction steps.
4. To prioritize Rescue and Relief operation during disaster.
5. To understand the causes, effects and remedial measures for disaster.

Unit I: Introduction of Disaster

Introduction of Disaster, Types/Classification of Disasters, Natural and Manmade disasters, Flood, Landslide, Earthquake, Volcanism, Cyclones, Drought, Fire, Tsunami, Mining, Wind storms, Nuclear/Biological/Chemical disasters, Environmental pollution, Global warming, Road/Rail accidents, endemic/pandemic disasters etc., Disaster potential in India.

Unit II: Disaster Impacts

Disaster loss, Social and economic impacts, Environmental Impacts, Reconstruction and Rehabilitation problems, Damage assessment, Hazard identification, Disaster Risk and Vulnerability, Disaster risk reduction, Risk analysis techniques, Primary and secondary impacts of disasters etc.

Unit III: Disaster Management and Legislation

Disaster management Act- 2005, National/State/District level disaster management, Disaster prediction, Disaster mitigation strategies, Disaster management cycle, Disaster prevention, Disaster preparedness, disaster preparedness plan for people and infrastructure, community based disaster preparedness plan, Early warning system

model in disaster preparedness, basic components of disaster relief (Water, Food, Sanitation, Shelter, Health, Waste management etc). Disaster mitigation, Role of International agencies, NGO's, Community based Organisations (CBO's), Role of individual, voluntary organization, Disaster monitoring and evaluation, Disaster relief fund, Disaster related case studies, The project/field work is meant for students to understand vulnerabilities and to work on reducing disaster risk, project/case studies are conceived creatively based on the geographic location and hazard profile of given region etc.

GEO-E404: Practical based on GEO-E401 (2 Credits)

In Laboratory:

- Melting of Ice and Sea-level Rise (due to global warming)
  Calculation of the volume of water produced and the height of sea-level rise
- Floods and Reservoir Capacity
  Calculation of the volume of water added to the reservoir due to rainfall and calculation of reservoir capacity and runoff
- Landslides and Road-Cut Safety
  Calculation of the velocity of the landslides and safety factor for the road-cuts
- Earthquakes
  Construction of the Isoseismic maps and identification of the seismic vulnerable zones in India
- Tsunami
  Calculation of the velocity of the Tsunami waves, time taken to travel different areas from the source of origin
- Avalanche
  Calculation of the velocity of the Avalanche

In Field:

Field visits to earthquake, tsunami, landslide flood and avalanche vulnerable areas and visits to National laboratories involved in disaster mitigation and management.

Course outcomes:

1. It helps to learn the concept of Disaster Management and its application during on site and off site emergency.
2. The project/field work is meant for students to understand vulnerabilities and to work on reducing disaster risk, project/case studies are conceived creatively based on the geographic location and hazard profile of given region etc.
3. It may help to individual to create the ability for mitigate the disaster risk.
4. It is important to learn the Preparedness plans for disaster response.
5. It creates the ability monitoring and evaluation plan for disaster response and its functioning at national/state/district level.
6. It may helps to learners to create hazard/risk profile maps of any geographical area.

Prescribed and Reference Books

- **Disaster Management** by **Dr. S. R. Singh**
- **Disaster Management** by **Shailendra K. Singh, Subhash C. Kundu and Shobhue Singh Disaster Preparedness in India** by **Narendra Kumar Jain and Adhyatma Sadhana Kendra**
- **Disaster Management** by **H. Sarvothaman and K. J. Anandha Kumar**
- **Environmental Science** by **S. C. Santra**
- **Natural Disaster** by **R. K. Sharma and G. Sharma (2005) (ed)**
- **Natural Disaster Reduction** by **Girish K.M. and G.C.Mathur**
- **Natural Hazard** by **Bryant Edwards**
- **Space technology for disaster management: A remote sensing and GIS perspective, Indian institute of Remote sensing (NRSA), Dehradhun**

GEO-E402: CLIMATOLOGY
(Theory: 3 credits & Practical: 1 credit)

Pre-requisites:

Student should have the basic idea about atmosphere, oceanography, understanding of geological processes which are directly or indirectly related to atmospheric processes.

Course objectives:

1. Introducing students to climate sciences.
2. To enable students to correlate atmosphere-ocean-land processes.
3. To understand the effect and impact of climate phenomenon on life, land and on oceanic processes.
4. Cosmic, Geological and anthropogenic controls on long-term and short-tern climates

Course contents:

Unit I:

Introduction to climatic geology, atmosphere, lithosphere; Fundamental principles of climatology. Earth's radiation balance; latitudinal and seasonal variation of insolation, temperature, pressure, wind belts, humidity, cloud formation and precipitation, water balance. Air masses, monsoon, Jet streams, tropical cyclones, and ENSO.

Unit II:

Climatic and sea level changes on different time scales. General weather systems of India - Monsoon system, cyclone and jet stream, Western disturbances and severe local convective systems, distribution of precipitation over India.
Classification of climates – Koppen's and Thornthwaite's scheme of classification.
Climate change.

Unit III:

Ocean dynamics; paleo-climate; geo-biology; Antarctica and study of ice sheets global warming, atmospheric aerosols and air pollution, ozone defletion, framework of climate change, Milankovitch cycles and solar activity, climate modeling.

GEO-E405: Practical based on GEO-E402 (2 Credits)

1. Observe and interprets the weather and climate maps.
2. Practical based on temperature, humidity and precipitation data.
3. Temperature lapse rate calculations.
4. Compare, correlate and interprets the precipitation, humidity, temperature, insolation and albedo data in space and time.
5. Atmosphere CO_2 data observation and interpretation.
6. Draw wind pattern in givern map.
7. Weather forecasting.

Course outcomes:

At the completion of the course student would be able to

1. Understand Climate geology and their products.
2. Comprehend interaction between geology-climatology-oceanography.
3. Correlation of geological, climatic and oceanic processes.
4. Understand the direct and/or indirect impact of anthrop on climatic processes.

Prescribed and Reference Books

- **Advances in Climatology** by **Dale Sullivan**
- **Applied Climatology Principles and Practice** by **Allen Perry, Dr Russell Thompson, Russell Thompson**
- **Climatology** by **Anthony J. Vega and Robert V. Rohli**
- **Climatology** by **D.S. Lal**
- **Climatology Concepts and Applications** by **Dale Sullivan**
- **Climatology New Developments** by **Adam Herveoux, Eric Suthland**
- **Climatology: An Atmospheric Science** by **J.E. Oliver and J.J. Hidore**
- **Encyclopedia of World Climatology (Springer series)**
- **General climatology** by **Howard J. Critchfield**
- **Glaciers and climate change** by **J. Oerlemans**
- **Global physical climatology** by **Dennis L. Hartmann**
- **Global Warming** by **John Houghton**
- **Global Warming Myth or Reality?: The Erring Ways of Climatology** by **Marcel Leroux**
- **Inconvenient Truth The Planetary Emergency of Global Warming and What We Can Do About It** by **Al Gore**
- **Meteorology Today: An Introduction to Weather, Climate and the Environment** by **C.D. Ahrens**
- **Principles of Climatology** by **Salem Press**
- **The Earth System** by **L.R. Kump J.F. Kasting and R.G. Crane**
- **Understanding Climatology** by **Salvador Poole**

GEO-E403: MARINE GEOLOGY AND OCEANOGRAPHY
(Theory: 3 credits & Practical: 1 credit)

Pre-requisites:

Basic knowledge of Geology, Oceans, physics and chemistry.

Course objectives:

1. Introducing students to marine geosciences.
2. To understanding oceanography and physico-chemical processes of ocean.
3. To correlate the solid Earth geological processes to oceanic phenomenons.
4. Corelation of geological-atmospheric-oceanic processes.

Course contents:

Unit I:

History of development of marine geology; Origin of ocean basins; A brief account of tectonic history of the oceans; Oceanic crust; Deep ocean-floor topography; Morphology of ocean margins.

Unit II:

Marine sediments, sources and composition, sediment types and distribution; Oceanic sediments and microfossils; Deep sea sediments and their relation to oceanic processes such as productivity, solution and dilution; Sedimentation rates; CCD and ACD.

Unit III:

Oceanic circulation - Surface, intermediate and deep ocean circulation; Forces that produce and effect circulation patterns in world oceans; Important phenomena associated with surface circulation; Formation and movement of deep and bottom waters. Exclusive economic zones, laws of the sea and mineral resources of the sea.

GEO-E406: Practical based on GEO-E403 (2 Credits)

1. Observation and interpretation of oceanographic maps.
2. Practical based on salinity
3. Draw and describe the different oceanographic processes like water current direction, temperature, salinity and ocean gyers.
4. Plot and interprets the thermocline, halocline and picnocline curves based on numerical data.
5. Calculate the residential time of conservative, non-conservative and semi-convervative elements in sea water.

Course outcomes:

At the completion of the course student would be able to

1. Understand Marine geology and their products.
2. Comprehend interaction between geology and oceanography.
3. Correlation of solid earth geological processes to oceanic processes.
4. Understand the physics and chemistry of oceans.

Prescribed and Reference Books

- **An Introduction to Marine Geology** by **Michael John Keen**
- **Elements of Dynamic Oceanography** by **D. Tolmazin**
- **Essentials of oceanography** by **Harold V. Thurman**
- **Introduction to physical oceanography** by **John A. Knauss**
- **Introduction to Oceanography** by **Paul Webb**
- **Laboratory Exercises in Oceanography** by **Bernard F. Pipkin**
- **Marine Geology** by **James P. Kennett**
- **Marine Geology: Exploring the New Frontiers of the Ocean (The Living Earth)** by **Jon Erickson**
- **Oceanography: A view of the Earth** by **M.G. Gross**
- **The Sea Floor: Introduction to Marine Geology** by **E. Seibold and W.H. Berger**

GEO-OE401: GEOLOGICAL RESOURCES AND GLOBAL SOCIO-ECONOMY
(Theory: 2 credits)

Pre-requisites:

Basic (10 / 10+2) knowledge of Geology + Geography + Economics.

Course objectives:

1. Geological resources are directly linked to National Economy.
2. This course in geological resources and global socio-economy would help the students to understand geographical distribution of economic minerals and how it controls national economies.
3. Introduces the students to paradox of availability of geological resources but poverty of the region/nation.
4. Introduces the students to how the geological resources are responsible for making and breaking of many civilizations.
5. Redefining a geological resource based on demand and supply and innovations.
6. Redefining a geological resource based on sustainability and environment protection.

Course contents:

Unit I: Introduction to Geological Resources

What is a Geological Resource?
Classifications of Geological Resources Based on the Use of the Metal or Ore Mineral
Global Distribution of Geological Resources
Global Production and Consumption of Geological Resources
Global Trade of Geological Resources

Unit II: Geological Resources and Socio-Economy

Availability of a Resource and Socio-Economic Development of a Region
Geological Resources and formation and fragmentation of Civilizations
The future socio-economy of geological resources
Geological resources, sustainability, and environmental responsibility

Course outcomes:

At the completion of the course student would be able to

1. Describe a geological resource.
2. Classify geological resources.
3. Relationship between geological resources and human progress.
4. Recognize uneven distribution of global geological resources.
5. Redefine a geological resource based on supply, demand and innovation.
6. Redefine a geological resource based on sustainability and environment.

Prescribed and Reference Books

- **Economic Geology Principles and Practice: Metals, Minerals, Coal and Hydrocarbons – Introduction to Formation and Sustainable Exploitation of Mineral Deposits** by **Walter L. Pohl**
- **Economic Mineral Deposits** by **Mead L. Jensen and Alan M. Bateman**
- **Introduction to Ore-forming processes** by **L. Robb**
- **Metals and Society: An Introduction to Economic Geology** by **Nicholas Arndt, Stephen Kesler and Clément Ganino**
- **Mineral Economics: An Indian Perspective** by **Kirtikumar Randive and Sanjeevani Jawadand**
- **Mineral Resources, Economics and the Environment** by **S.E. Kesler and A.C. Simon**
- **Minerals and Allied Natural Resources and their Sustainable Development: Principles, Perspectives with Emphasis on the Indian Scenario (Springer Geology)** by **Mihir Deb and Sanjib Chandra Sarkar**
- **Ore Geology and Industrial Minerals – An Introduction** by **A.M. Evans**
- **The World of Mineral Deposits: A Beginner's Guide to Economic Geology** by **Neukirchen, Florian, Ries, Gunnar**

GEO-OE402: MEDICAL GEOLOGY
(Theory: 2 credits)

Pre-requisites:

Basic scientific thinking, Knowledge, fundamental ideas about geology, physics and chemistry

Course objectives:

1. To introduce relationship between geology and human health.
2. To understand the sources and impact of toxic materials on life.
3. Pursue the student to use this knowledge in day to day life.

Course contents:

Unit I:

History of medical geology
Subject matter and theoretical principles of medical geology, goal, task and significance of medical geology
Characteristics geological materials and their influence on human health

Unit II:

Subject and task of geological medical disciplines in defining quality of the environment and its influence on human health
Trace elements and human health
Geological health hazards
Mineral medicines in Ayurveda

Course outcomes:

At the completion of the course student would be able to

1. Understand medical ingredients and toxic contents in minerals and rocks.
2. Understand relationship between geology and human health.
3. Utilize the knowledge in day-to-day life.

Prescribed and Reference Books

- **Medical Geology Effects of Geological Environments on Human Health** by **Miomir M. Komatina**
- **Progress in Medical Geology** (2017, Cambridge Scholars Publishing) edited by **Motomu Ibaraki and Hiroko Mori**
- **Essentials of Medical Geology: Impacts of the Natural Environment on Public Health** edited by **Olle Selinus**
- **Elements of Geochemistry, Geochemical Exploration and Medical Geology** by **K.R. Randive**

GEO-OE403: HISTORY OF THE EARTH
(Theory: 2 credits)

Pre-requisites:

Scientific temperament and passion towards science.

Course objectives:

1. Explain the uniqueness Planet Earth in the Solar system and even in the Universe.
2. Explain the main historical events resulting in the uniqueness of the planet Earth.
3. Explain how the Earth's internal and external processes are interconnected.
4. Explain how human is controlling short-term modern history of the planet Earth.

Course contents:

Unit I: Fundamental Questions:

Energy and Matter
Origin of Universe
Origin of Solar System
Formation of Planet Earth and Moon

Unit II: Planet Earth: Past, Present and Future

Geological Time Scale
Continents, Oceans and Atmosphere
Great Oxygenation Event
Origin and Evolution of Life
Mass Extinctions
Snowball Earth
What controls the present Configuration of Planet Earth?
Human angle to Earth's History

Course outcomes:

At the completion of the course student would be able to

1. Develop scientific temperament and enjoy doing science.
2. Understand Earth's processes and products.
3. Respect the planet Earth and natural processes.
4. Realize the responsibility towards planet Earth.

Prescribed and Reference Books

- **Earth Materials** by **Cornelis Klein and Anthony Philpotts**
- **Palaeontology (palaeobiology): Evolution and animal distribution** by **P.C. Jain and M.S. Anantharaman**
- **The Earth System** by **Lee R. Kump, James F. Kasting, Robert G. Crane**
- **The Story of Earth: The First 4.5 Billion Years, from Stardust to Living Planet** by **Robert M. Hazen**
- **The History of Earth: The Indian Version** by **Dr. Prashobh Karunakaran**
- **The History of the Earth: An Illustrated Chronicle of Our Planet** by **William K. Hartmann and Ron Miller**
- **A Short History of Planet Earth: Mountains, Mammals, Fire, and Ice** by
- **J. D. MacDougall**
- **Earth system history (2nd ed.)** by **Steven M. Stanley**
- **Our evolving planet: Earth history in new perspective** by **Karsten M. Storetvedt**