# M.SC.,
# GEOLOGY

## SYLLABUS

## FROM THE ACADMIC YEAR

## 2023-2024

**TAMILNADU STATE COUNCIL FOR HIGHER EDUCATION,**
**CHENNAI – 600 005**

**TANSCHE REGULATIONS ON LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK FOR POSTGRADUATE EDUCATION**

# M.SC. GEOLOGY

**SYLLUBUS**
**FROM THE ACADMIC YEAR**
**2023-2024**

| | |
|---|---|
| **Programme** | **M.Sc. Geology** |
| **Programme Code** | |
| **Duration** | **PG - 2 years** |
| **Programme Outcomes (Pos)** | **PO1: Problem Solving Skill**<br>Apply knowledge of Management theories and Human Resource practices to solve business problems through research in Global context.<br>**PO2: Decision Making Skill**<br>Foster analytical and critical thinking abilities for data-based decision-making.<br><br>**PO3: Ethical Value**<br>Ability to incorporate quality, ethical and legal value-based perspectives to all organizational activities.<br><br>**PO4: Communication Skill**<br>Ability to develop communication, managerial and interpersonal skills.<br><br>**PO5: Individual and Team Leadership Skill**<br>Capability to lead themselves and the team to achieve organizational goals.<br>**PO6: Employability Skill**<br>Inculcate contemporary business practices to enhance employability skills in the competitive environment.<br><br>**PO7: Entrepreneurial Skill**<br>Equip with skills and competencies to become an entrepreneur.<br><br>**PO8: Contribution to Society**<br>Succeed in career endeavors and contribute significantly to society.<br><br>**PO 9 Multicultural competence**<br>Possess knowledge of the values and beliefs of multiple cultures and a global perspective.<br><br>**PO 10: Moral and ethical awareness/reasoning**<br>Ability to embrace moral/ethical values in conducting one's life. |

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| **Programme Specific Outcomes (PSOs)** | **PSO1 – Placement**<br>To prepare the students who will demonstrate respectful engagement with others' ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions.<br><br>**PSO 2 - Entrepreneur**<br>To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations.<br><br>**PSO3 – Research and Development**<br>Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development.<br><br>**PSO4 – Contribution to Business World**<br>To produce employable, ethical and innovative professionals to sustain in the dynamic business world.<br><br>**PSO 5 – Contribution to the Society**<br>To contribute to the development of the society by collaborating with stakeholders for mutual benefit. |

**ALAGAPPA UNIVERSITY, KARAIKUDI**
**NEW SYLLABUS UNDER CBCS PATTERN (w.e.f. 2023-24)**

**M.Sc. GEOLOGY-PROGRAMME STRUCTURE**

| S.No | Paper Code | Courses | Title of the paper | T/P | Credits | Hours/ Week | Marks | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | **I Semester** | | | | **I** | **E** | **Total** |
| I | 23MGE1C1 | Core 1 | Physical Geology and Geomorphology | T | 5 | 6 | 25 | 75 | 100 |
| | 23MGE1C2 | Core 2 | Mineralogy and Instrumentation techniques | T | 5 | 6 | 25 | 75 | 100 |
| | 23MGE1P1 | Core 3 | Mineralogy and Palaeontology-Practical | P | 4 | 8 | 25 | 75 | 100 |
| | 23MGE1E1 | DSE-1 | Stratigraphy of India and its application | T | 3 | 5 | 25 | 75 | 100 |
| | 23MGE1E2 | DSE-2 | Recent trends in Palaeontology | T | 3 | 5 | 25 | 75 | 100 |
| | | | | | **20** | **30** | **125** | **375** | **500** |
| | | | **II Semester** | | | | | | |
| II | 23MGE2C1 | Core 4 | Structural Geology and Geotectonics | T | 5 | 6 | 25 | 75 | 100 |
| | 23MGE2C2 | Core 5 | Applied Petrology | T | 5 | 6 | 25 | 75 | 100 |
| | 23MGE2P1 | Core 6 | Structural Geology and Petrology - Practical | P | 4 | 6 | 25 | 75 | 100 |
| | 23MGE2E1 | DSE-3 | Applied Remote Sensing and GIS | T | 3 | 4 | 25 | 75 | 100 |
| | 23MGE2E2 | DSE-4 | Environmental Earth Science | T | 3 | 4 | 25 | 75 | 100 |
| | 23MGE2S1 | SEC-1 | Disaster Management | T | 2 | 4 | 25 | 75 | 100 |
| | | | | | **22** | **30** | **150** | **450** | **600** |
| | | | **III Semester** | | | | | | |
| III | 23MGE3C1 | Core 7 | Economic Geology | T | 5 | 6 | 25 | 75 | 100 |
| | 23MGE3C2 | Core 8 | Geophysics | T | 5 | 6 | 25 | 75 | 100 |
| | 23MGE3P1 | Core 9 | Remote Sensing and GIS, Geophysics and Geochemistry - Practical | P | 4 | 6 | 25 | 75 | 100 |
| | 23MGE3P2 | Core 10 | Economic Geology & Geological field mapping - Practical | P | 4 | 6 | 25 | 75 | 100 |
| | 23MGE3E1 | DSE-5 | Geochemistry | T | 3 | 3 | 25 | 75 | 100 |
| | 23MGE3S1 | SEC-2 | Petroleum Exploration and Mud logging | T | 2 | 3 | 25 | 75 | 100 |
| | 23MGE3I/ 23MGE3IA | | Internship/Industrial Activity | PR | 2 | - | 25 | 75 | 100 |
| | | | | | **25** | **30** | **175** | **525** | **700** |
| | | | **IV Semester** | | | | | | |
| IV | 23MGE4C1 | Core 12 | Engineering Geology and Mining Geology | T | 5 | 6 | 25 | 75 | 100 |
| | 23MGE4P1 | Core 13 | Engineering Geology, Mining Geology and Hydrogeology - Practical | P | 5 | 6 | 25 | 75 | 100 |
| | 23MGE4PR | Core 14 | Project with Viva-Voce | PR | 6 | 10 | 25 | 75 | 100 |
| | 23MGE4E1 | DSE-6 | Hydrogeology | T | 3 | 4 | 25 | 75 | 100 |
| | 23MGE4S1 | SEC-3 | Oceanography and Climatology | T | 2 | 4 | 25 | 75 | 100 |
| | 23MGE4FT 23MEA4 | | Geological field training / Extension Activity | P | 2 | - | 25 | 75 | 100 |
| | | | | | **23** | **30** | **150** | **450** | **600** |
| | | | **Total** | | **90** | **120** | **600** | **1800** | **2400** |

Core Courses : DSE – Discipline Specific Elective SEC- Skill Enhancement Course Dissertation- Marks -Vivo-voce (50) + thesis (100) + internal (50) = 200 // Internship report – Marks -Vivo-voce (25) + reports (50) + internal (25) = 100 *AEC- Ability Enhancement Courses (may be included by altering the surplus credits and hours of other courses)

**SEMESTER – I: Physical Geology and Geomorphology ( I year)**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE1C1** | **PHYSICAL GEOLOGY AND GEOMORPHOLOGY** | Core | Y | - | - | - | 5 | 6 | 25 | 75 | 100 |
| **Course objectives** | | | | | | | | | | | |
| | To interpret natural processes which act on the Earth's surface and the landforms. | | | | | | | | | | |
| | To recall the types of landforms and quaternary landscapes | | | | | | | | | | |
| | To employ geomorphological studies for structural and mineral exploration | | | | | | | | | | |
| | To understand the pedochemical process responsible for the dissolution rate. | | | | | | | | | | |
| | To identify different processes involved different geological landforms. | | | | | | | | | | |
| | **Details** | | | | | | | **No. of Hours** | | **Course Objectives** | |
| **UNIT I** | Earth and its internal structure, composition, size and shape. An overview of plate tectonics including elementary concepts of plates, lithosphere, asthenosphere, types of plate boundaries and associated important geological features like oceanic trenches, volcanic arcs, accretionary wedges, topography of mid-ocean ridges and transform faults. Palaeomagnetism and its application for determining palaeoposition of continents. Isostasy, Orogeny and Epeirogeny. | | | | | | | 12 | | CO1 | |
| **UNIT II** | Concepts of geomorphology. Landforms in relation to climate, rock type, structure and tectonics. Earthquakes and related landscape alterations, Seismic belts of the earth. Seismicity at plate boundaries. Principles of Geodesy. | | | | | | | 12 | | CO2 | |
| **UNIT III** | Geomorphic Processes – weathering, pedogenesis, mass movement, erosion, transportation and deposition. | | | | | | | 12 | | CO3 | |
| **UNIT IV** | Geomorphic landforms – fluvial, glacial, Aeolian, coastal, volcanoes and karst. | | | | | | | 12 | | CO4 | |
| **UNIT V** | Quaternary landscapes. Fluvial landscapes, Aeolian landscapes, coastal landscapes. | | | | | | | 12 | | CO5 | |
| | **Total** | | | | | | | **60** | | | |
| **Text Books** | | | | | | | | | | | |
| 1. | Holmes, D.L. (1981) Principles of Physical Geology.ELBS Edition. | | | | | | | | | | |
| 2. | Pethick, J. (1984) An Introduction to Coastal Geomorphology. Arnold, London. | | | | | | | | | | |
| 3 | Thornbury, W.D. (1969) Principles of Geomorphology.Wiley Eastern Ltd. | | | | | | | | | | |
| 4 | Richar Huggett, Fundamentals of Geomorphology | | | | | | | | | | |
| 5 | Strahler, A.N. (1952) Physical Geology. John Wiley & Sons Inc., New York. | | | | | | | | | | |

| References Books<br>(Latest editions, and the style as given below must be strictly adhered to) | |
|---|---|
| 1. | Holmes, D.L. (1981) Principles of Physical Geology.ELBS Edition. |
| 2. | Pethick, J. (1984) An Introduction to Coastal Geomorphology. Arnold, London. |
| 3. | Thornbury, W.D. (1969) Principles of Geomorphology.Wiley Eastern Ltd. |
| 4. | Richar Huggett, Fundamentals of Geomorphology |
| 5. | Strahler, A.N. (1952) Physical Geology. John Wiley & Sons Inc., New York. |
| **Web Resources** | |
| 1. | https://journals.sagepub.com/home/jom |
| 2. | https://www.americangeosciences.org/ |
| 3. | https://www.egu.eu/ |
| 4. | https://www.geosociety.org/ |

**Course outcome**:

CO1: Basic knowledge about the internatl structure of earth,
CO2: Students Studied the plate tectonics theory.
CO3: Get knowledge about the Landform: exogenic and endogenic processes •
CO4: Learn the Landform and tectonics • Drainage pattern, sea level change and geomorphic cycle.
CO5: Students can introduce the basis of Quaternary landscapes

**In order to avoid pull the score down of each PO, it is suggested that the usage L-Low (1) to the minimum.**

**The S, M, L is based on the course outcome. The mapping is based on the revised Bloom's Taxonomy Verbs used to describe your course outcome.**

- **Remember and Understanding – Lower level**
- **Apply and Analyze – Medium Level**
- **Evaluate and Create – Strong Level**

**Mapping with Programme Outcomes:**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** |
|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 |
| **CO 2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO 3** | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 1 |
| **CO 4** | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO 5** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |

**S-Strong-3 ; M-Medium -2 ; L-Low-1.**

**Program Specific Outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 |
|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 3 | 3 |
| **CO 2** | 3 | 3 | 3 | 3 | 3 |
| **CO 3** | 3 | 3 | 3 | 3 | 3 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

**Semester- I: Mineralogy and Instrumentation Techniques ( I year)**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE1C2** | **MINERALOGY AND INSTRUMENTATION TECHNIQUES** | Core | Y | - | - | - | 5 | 6 | 25 | 75 | 100 |

| **Course objectives** | | | |
|---|---|---|---|
| | To understand the concepts of geometric crystallography. | | |
| | To describe and understand various methods of studying crystals. | | |
| | To understand the physical properties and chemical compositions of various minerals present in each rock-forming mineral group. | | |
| | To study the interaction of light with minerals and the resultant optical properties of minerals. | | |
| | To understand the operation procedure, process and techniques of various instruments used for mineral identification. | | |
| | **Details** | **No. of Hours** | **Course Objectives** |
| **UNIT I** | Introduction to crystallography – Crystal systems – Symmetry elements, Axial ratio – Zones and zonal symbols – Isometric, Tetragonal, Orthorhombic, Hexagonal, Monoclinic and Triclinic systems – Normal classes. Derivation of 32 Crystal classes. Irregularities in crystals. | 12 | CO1 |
| **UNIT II** | Unit cell, motif, lattice - Plane lattice and Space lattice. Shoenflion notation and Hermann Mauguin symbols. Stereographic projections — Tautozonal faces – Equation of the normal – Napier's Theorem – Tangent relations – Sine ratio – Cosine ratio. X-rays - X-ray diffraction-Powder diffraction. | 12 | CO2 |
| **UNIT III** | Description and composition of the following mineral groups: Quartz, Feldspars, Feldspathoids, Micas, Garnets, Olivine, Pyroxenes, Amphiboles, Zeolites and Carbonate minerals. Structural classification of silicate minerals – Isomorphism – Exsolution – Order, disorder relations – Polymorphism - Pseudomorphism – Fluorescence in minerals – Metamict state – Staining techniques and micro chemical tests. | 12 | CO3 |

| | | | |
|---|---|---|---|
| **UNIT IV** | Introduction to Optical Mineralogy Electrical, magnetic and optical properties of minerals – Properties of light – Transmissivity and Reflectivity – Polarization – Extinction – Dichroism – Pleochroism – Interference colors – Refringence and Birefringence – Order of interference – Conoscopy – Interference figures - Concepts of crystal field theory and mineralogical spectroscopy. | 12 | CO4 |
| **UNIT V** | Spot tests – Paper chromatography – Nephelometry – Turbidimetry – Spectroscopy – Flame photometry – X-ray spectroscopy – UV spectroscopy – Mass spectroscopy – Accelerated mass spectroscopy. | 12 | CO5 |
| | **Total** | **60** | |
| 1. | Donald Bloss F. (1971) Crystallography and Crystal Chemistry – An Introduction published by Holt, Rinehart and Winston, Inc., New York. | | |
| 2. | William M. Blackburn and William H. Dennen (1988) Principles of Mineralogy (Second Edition) published by WCB Publishers England. | | |
| 3. | Kerr P.F, Optical Mineralogy, 4th ed McGraw Hill New York (1977) | | |
| 4. | Gribble C.D. &A.J. Hall, A. Practical Introduction to Optical Mineralogy,Springer.London(1985) | | |
| 5. | *Tisljar, S.K. Haldar, Josip (2013). Introduction to mineralogy and petrology. Burlington: Elsevier Science.* ISBN 9780124167100. | | |
| **References Books (Latest editions, and the style as given below must be strictly adhered to)** | | | |
| 1. | Cornelis Klein and Cornelius S. Hurlbut, Jr. (1993) Manual of Mineralogy published by John Wiley & Sons, Inc. Singapore. | | |
| 2. | Paul F. Kerr (1967) Optical Mineralogy, John Wiley & Sons, New York. | | |
| 3. | *Wenk, Hans-Rudolf; Bulakh, Andrey (2016). Minerals: Their Constitution and Origin. Cambridge University Press.* ISBN 9781316425282. | | |
| 4. | *Whewell, William (2010). "Book XV. History of Mineralogy". History of the Inductive Sciences: From the Earliest to the Present Times. Cambridge University Press. pp. 187–252.* ISBN 9781108019262. | | |
| 5. | *Laudan, Rachel (1993). From mineralogy to geology : the foundations of a science, 1650-1830 (Pbk. ed.). Chicago: University of Chicago Press.* ISBN 9780226469478. | | |
| **Web Resources** | | | |
| 1. | https://mineralogy-ima.org/ | | |
| 2. | https://www.socminpet.it/dwl.php?file=SIMP/GNM/SIMP_ELEM.pdf | | |
| 3. | https://www.mineralogicalassociation.ca/ | | |
| 4. | https://www.cambridge.org/core/societies/mineralogical-society-of-great-britain-and-ireland | | |
| 5. | http://www.minsocam.org/ | | |

**Course outcome**

CO1: Students acquire basic knowledge on crystal structures and laws of bonding
CO2: Student can learn about the silicate structures of minerals and their physical and chemical properties
CO3: Students get knowledge about the description and composition the minerals
CO4: Students gain knowledge on optical properties of minerals
CO5: student can apply the instrumentation techniques in mineralogical studies

**Mapping with Programme Outcomes:**

**Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 2** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 3** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 4** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 5** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |

**S-Strong-3 ; M-Medium -2 ; L-Low-1.**

**Program Specific Outcomes**

| CO/PO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 |
|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 3 | 3 |
| **CO 2** | 3 | 3 | 3 | 3 | 3 |
| **CO 3** | 3 | 3 | 3 | 3 | 3 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

**Semester- I: Mineralogy and Palaeontology - Practical (I year)**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| 23MGE1P1 | MINERALOGY AND PALAEONTOLOGY - PRACTICAL | Practical | Y | - | - | - | 4 | 8 | 25 | 75 | 100 |

**Course objectives**

| | |
|---|---|
| | To understand the characters of symmetry elements, linear and angular relation of faces and their mathematical relation. |
| | To understand and identify minerals through physical, chemical and optical properties. |
| | To identify selected fossils of Invertebrates, Vertebrates and plant fossils |
| | To identify the evolutionary trends in selected fossils and interpret the palaeo-environment |
| | To study bio-stratigraphic assemblages |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| | **MINERALOGY**<br><br>Stereographic projections of faces and symmetry elements of normal classes in six systems<br><br>Problems related to mathematical relations of crystals: Tangent relation, Anharmonic ratio, Napier's theorem and equation of the normal.<br><br>Zones and Zonal relations. Weiss Parameter and Indices and Unit Cell Problems.<br><br>Megascopic study of important rock-forming silicates<br><br>Microscopic study on identification of Pinacoidal sections of Feldspars, Pyroxenes and Amphiboles.<br><br>Determination optic sign of uniaxial and biaxial minerals.<br><br>Numerical problems in relation to composition of minerals – Determination of mineral formula, Triangular plots.<br>**PALAEONTOLOGY**<br><br>**Identification and description of the following fossils.**<br><br>1. Morphological descriptions, illustrations, chronological arrangement, and evolutionary trends of representative fossils belonging to<br>**Invertebrates -** Coelenterata, Brachiopoda, Mollusca (Pelecypoda, Gastropoda and Cephalopoda), Arthropoda | | |

| | | | |
|---|---|---|---|
| | (Trilobita), Echinodermata (Crinoidea, Blastoidea and Echinoidea), Hemichordata (Graptoloidea)<br>**Vertebrates -** Horse, Elephant, Fishes and Dinosaurs<br>**Palynology -** Gymnospermae and Angiospermae<br>**Micropalaeontology:** Protozoa, Porifera and Ostracods<br><br>**Palaeo-environmental and biostratigraphicstudies**<br>• Problems with paleoclimate and palaeoenvironment based on fossil data.<br>• Assignment on biostratigraphic zonal classification<br>• Identification of source, reservoir and seal facies with fossil data. | | |
| | **Total** | **60** | |


| | |
|---|---|
| 1. | Dana, E.S. (1949). A text book of Mineralogy. Asia Publishing House. |
| 2. | Mineralogy – Dexter Perkins (2014), 3rd edition, Pearson New International Edition. |
| 3. | Phillips, P.C. (1963). An introduction to Crystallography. Longmans Green & Co. |
| 4. | Sharma R.S. & Sharma, A (2013) Crystallography and Mineralogy – Concepts and methods. Geological Society of India Publication, Bangalore. |
| 5. | Wade, F.A & Mattox, R.B (1960). Elements of Crystallography and Mineralogy. Harper & Bros. |
| 6. | Tisljar, S.K. Haldar, Josip (2013). Introduction to mineralogy and petrology. Burlington: Elsevier Science. ISBN 9780124167100. |
| 7. | Amold C.A. (1947). An introduction to palaeobotany. McGraw Hill Book Company Inc. |
| 8. | Bignot G. (1985). Elements of Micro Palaeontology Graham Trotman, 1985. |
| 9. | Charles sehuchert& Dunbar C.O (1960). Historical Geology, John willey and Sons |
| 10. | Clarkson E. N. K. (2017). Invertebrate Palaeontology and Evolution, Wiley-Blackwell, 5th Edition. |
| 11. | Donald R. Prothero. (2013). Bringing Fossils to Life: An Introduction to Paleobiology, McGraw-Hill Higher Education, 3rd edition. |
| 12. | Gary Nichols (2009). Sedimentology and Stratigraphy, John Wiley and Sons |
| 13. | Gregory J.N & Barrot B.H. (1913) General stratigraphy, Methuen & Co., London |
| 14. | Howard A. Armstrong, Martin D. Brasier (2013). Microfossils, Blackwell Publishing Ltd., 2nd Edition |
| 15. | Amold C.A. (1947). An introduction to palaeobotany. McGraw Hill Book Company Inc. |
| 16. | Bignot G. (1985). Elements of Micro Palaeontology Graham Trotman, 1985. |
| 17. | Amold C.A. (1947). An introduction to palaeobotany. McGraw Hill Book Company Inc. |
| 18. | Bignot G. (1985). Elements of Micro Palaeontology Graham Trotman, 1985. |


**References Books**
**(Latest editions, and the style as given below must be strictly adhered to)**


| | |
|---|---|
| 1. | Cornelis Klein and Cornelius S. Hurlbut, Jr. (1993) Manual of Mineralogy published by John Wiley & Sons, Inc. Singapore. |
| 2. | Paul F. Kerr (1967) Optical Mineralogy, John Wiley & Sons, New York. |
| 3. | Wenk, Hans-Rudolf; Bulakh, Andrey (2016). Minerals: Their Constitution and Origin. Cambridge University Press. ISBN 9781316425282. |
| 4. | Whewell, William (2010). "Book XV. History of Mineralogy". History of the Inductive Sciences: From the Earliest to the Present Times. Cambridge University Press. pp. 187–252. ISBN 9781108019262. |
| 5. | Laudan, Rachel (1993). From mineralogy to geology : the foundations of a science, 1650-1830 (Pbk. ed.). Chicago: University of Chicago Press. ISBN 9780226469478. |
| 6. | Michael Benton (2014). Vertebrate Palaeontology, Wiley-Blackwell, 4th Edition. |

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|---|---|
| 7. | Moore R.C., Lalicker, C.D. & Fischer, A.G. (1952) Invertebrate Fossils. McGraw Hill. |
| 8. | Morley Davies (2008) An Introduction to Palaeontology, Read Books |
| 9. | Ramkumar M. (2015) Chemostratigraphy: Concepts, Techniques and Applications. Elsevier |
| 10. | Romer A.S. (1960) Vertebrate Palaeontology, Chicago press. |
| 11. | Sam Boggs (2006) Principles of sedimentology and stratigraphy, Pearson Prentice Hall |
| 12. | Shrock. R.R. &Twenhofel W.H (1953) Principles of invertebrate Palaeontology, Amold publication |
| 13. | Michael Benton (2014). Vertebrate Palaeontology, Wiley-Blackwell, 4th Edition. |
| **Web Resources** | |
| 1. | https://mineralogy-ima.org/ |
| 2. | https://www.socminpet.it/dwl.php?file=SIMP/GNM/SIMP_ELEM.pdf |
| 3. | https://www.mineralogicalassociation.ca/ |
| 4. | https://www.cambridge.org/core/societies/mineralogical-society-of-great-britain-and-ireland |
| 5. | http://www.minsocam.org/ |
| 6. | https://www.digitalatlasofancientlife.org/ |
| 7. | https://paleobiodb.org/#/resources |
| 8. | https://www.youtube.com/user/TheCMNH |


**Course outcome**

CO1: Students will obtain knowledge in nature of forms and their mathematical relation in geometric crystallography

CO2: Students can identify and classify each rock forming minerals by studying their physical and chemical properties

CO3: Students can identify and describe the characteristics of selected fossils of Invertebrates, Vertebrates and plant fossils

CO4: Students will be able to predict the paleoclimate as well as paleoenvironmental information based on fossil data.

CO5: Students gain knowledge on bio-stratigraphic assemblages

**Semester-I: Stratigraphy of India and its Applications ( Iyear)**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE1E1** | **STRATIGRAPHY OF INDIA AND ITS APPLICATION** | Elective I | Y | - | - | - | 3 | 5 | 25 | 75 | 100 |
| **Course objectives** | | | | | | | | | | | |
| | Can recall the Stratigraphy of India. | | | | | | | | | | |
| | Can differentiate different deposits of geological time. | | | | | | | | | | |
| | To understand and compare different applications related to Stratigraphy. | | | | | | | | | | |
| | Can interpret the sequence of stratigraphic column. | | | | | | | | | | |
| | Can identify different processes involved during different geological time. | | | | | | | | | | |
| | **Details** | | | | | | | **No. of Hours** | | **Course Objectives** | |
| **UNIT I** | **Stratigraphy of India –**Dharwar Supergroup – Mineral riches of Archaean. Cuddapah system and its mineral riches. Vidhyan system and its mineral riches. Cambrian System – Salt Range and Age of Saline Series. Ordovician and Silurian systems. | | | | | | | 12 | | CO1 | |
| **UNIT II** | **Stratigraphy of India (Contd.) -** Devonian system. Carboniferous system. The Gondwana Group – Structure of the Gondwana Basin – Climate and Sedimentation – Economic minerals in the Gondwanas. Upper Carboniferous and Permian systems – Triassic system – Lilang system - Jurassic system – Jurassic of Kutch - Cretaceous system – Cretaceous of Trichinopoly. | | | | | | | 12 | | CO2 | |
| **UNIT III** | **Stratigraphy of India (Contd**.) - Deccan traps – Lameta beds – Infra-trappean and Inter-trappean beds – Age of Deccan traps – Economic riches of Deccan traps. Tertiary group – Rise of the Himalayas – Eocene system and its Economic minerals – Oligocene and Lower Miocene systems and Petroleum – Middle Miocene and Lower Pleistocene – Siwalik system – Pleistocene and Recent – Culture, Climate and deposits in India – Human evolution and Culture – Glaciation and Human Culture – Chronology of Glaciation – Karewa formation – Potwar silts and Loess – Indo-Gangetic alluvium – Coastal deposits – Aeolian and other deposits – Recent deposits – Useful Mineral deposits of Pleistocene and Recent – Soils – Recent changes of level along the coast – Changes in the courses of rivers. | | | | | | | 12 | | CO2 | |
| **UNIT IV** | **Applications of Stratigraphy –** Geological time - Geologic time Units – Geochronology. Chronostratigraphy - Golden spikes – Global Standard Section and Point (GSSP) – Stratigraphic Units. Lithostratigraphy - Stratigraphic relationships - Lithostratigraphic Units – Lithodemic units – | | | | | | | 12 | | CO2 | |

| | | | |
|---|---|---|---|
| | Application of Lithostratigraphy – Gaps in the record. Biostratigraphy – Fossils and Stratigraphy – Classification of organisms – Evolutionary trends – Biozones and Zone fossils – Taxa used in Biostratigraphy – Biostratigraphic correlation – Biostratigraphy in relation to other stratigraphic techniques. | | |
| **UNIT V** | **Applications of Stratigraphy** (Contd.) - dating and correlation techniques – Radiometric dating – Application of radiometric dating – Other isotopic and chemical techniques – Chemostratigraphy – Magnetostratigraphy – Dating in the quaternary. Sequence stratigrphy - Sea-level changes – Sea level changes and sedimentation – Depositional sequences and systems tracts – Parasequences and its components of system tracts – Carbonate sequence stratigraphy – Sequence stratigraphy in non-marine basins – Alternative schemes in sequence stratigraphy – Applications of sequence stratigraphy – Causes of sea level fluctuations. | 12 | CO2 |

| | **Text Books** |
|---|---|
| 1. | Geology of India and Burma M.S. Krishnan, (2010), 6th Edi., C.B.S publishers and Distributors, Delhi |
| 2. | Geology of India, D.N. Wadia, (1966), McMillan company, London |
| 3. | Vaidyanadhan.R&M.Ramakrishnan, Geology of India. Geological Society of India. Bangalore(2008) |
| 4. | MehdirattaR.C,Geology of India, Pakisthan, Bangladesh and Burma. Atma Ram &Sons.Delhi(1974) |
| 5. | Geology& Mineral Resources of the States of India. Misc Pub.No.30.Geological Survey of India. Kolkota. (Several individual volumes available online at GSI portal) GSI(2005). |
| | **References Books**<br>**(Latest editions, and the style as given below must be strictly adhered to)** |
| 1. | Fundamentals of Historical Geology and Stratigraphy of India, Ravindrakumar (1985), Wiley Eastern ltd, New Delhi. |
| 2. | Principle of Stratigraphy, Dunbar and Roggers, (1964), John Wiley and co, New York |
| 3. | An Introduction in Stratigraphy, Stamp L.D, (1964), Thomas Murby, Museum St, WCI, London. |
| 4. | Stratigraphic Principles and Practices, Weller, J.M, (1962), Harper & Bros, New York |
| 5. | Kumar R,Fundamentals of Historical Geology and Stratigraphy of India,WiIey.New Delhi (1988). |
| | **Web Resources** |
| 1. | https://stratigraphy.org/ |
| 2. | https://www.sepm.org/ |
| 3. | https://www.geosocindia.org/ |
| 4. | https://www.moes.gov.in/ |
| 5. | https://isegindia.org/ |

**Course outcomes:**

CO1: Students studied and gain knowledge on Dharwar Supergroup – Mineral riches of Archaean.
CO2: Students able to understand about the Gondwana Group and its stratigraphy
CO3: Students get knowledge on Deccan traps
CO4: Students understand the Stratigraphy of India
CO5: Students used to study the Applications of Stratigraphy

**Mapping with Programme Outcomes:**

**Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 3 | 1 | 3 | 3 | 1 | 3 | 2 | 3 | 2 |
| **CO 2** | 2 | 3 | 1 | 3 | 3 | 1 | 3 | 2 | 3 | 2 |
| **CO 3** | 2 | 3 | 1 | 3 | 3 | 1 | 3 | 2 | 3 | 2 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |

**S-Strong-3 ; M-Medium -2 ; L-Low-1.**

**Program Specific Outcomes**

| CO/PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 |
|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 3 | 3 |
| **CO 2** | 3 | 3 | 3 | 3 | 3 |
| **CO 3** | 3 | 3 | 3 | 3 | 3 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

**Semester-I : Recent Trends in Palaeontology - Elective ( I year)**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE1E2** | **RECENT TRENDS IN PALAEONTOLOGY** | Elective II | Y | - | - | - | 3 | 5 | 25 | 75 | 100 |

| | **Course objectives** | | |
|---|---|---|---|
| | Learn about the origin and evolution of life, understanding species concept and study of the major events in the history of Precambrian and Phanerozoic life. Detailed study about vertebrate paleontology. | | |
| | Learn about the morphology, classification, evolutionary trend, composition and structure of shells of selected groups of organisms. | | |
| | To explain about geological history, geographical distribution and description of more important genera | | |
| | Demonstrating the sampling methods and sample processing techniques of micropaleontology. | | |
| | To know about the application of micropaleontology in hydrocarbon exploration. | | |
| | **Details** | **No. of Hours** | **Course Objectives** |
| **UNIT I** | Fossil record and geological time-scale. Evolutionary changes in molluscs and mammals in geological time. Principles of evolution.Use of species and genera of foraminifera and Echinodermata in biostratigraphic correlation. Different microfossil groups and their distribution in India. Functional morphology, evolution and significance of Plant Fossils, Fishes, Horse, Elephant and Man. Dinosaurs and their extinction. Taphonomy and environmental factors, Oxygen and Carbon isotope studies of fossils and paleoclimates – Palaeobiogeographic Provinces. | 12 | CO1 |
| **UNIT II** | Theories on origin and evolution of life – Phylogenetic and Ontogenic Analysis – Species Concept – Types of Fossils and Types of Species – Palingensis – Coenogensis – Proterogenesis - Thanatocoenosis – Biocoenosis – Sidocoenosis - Biomineralisation and Trace Fossils – Fossils and their uses – Biometrics – Major events in the history of Precambrian and Phanerozoic life. | 12 | CO2 |
| **UNIT III** | Vertebrate palaeontology: Succession of vertebrate life through geologic time. Broad classificationand study of some characteristic Indian vertebrate genera.Indian pre-Tertiary vertebrate - their distribution and paleogeographic implication; extinction of dinosaurs.Indian Tertiary vertebrate - Siwalik mammals; phylogeny - Equidae and Proboscidae.Indian fossil Hominoides and modern theories regarding human evolution. | 12 | CO2 |

| | | | |
|---|---|---|---|
| **UNIT IV** | Invertebrate paleontology: an overview. Morphology, classification, evolutionary trend, composition and structure of shells of selected groups of organisms - Porifera, Bryozoa, Mollusca, Brachiopoda.Geological history, geographical distribution and description of more important genera of Trilobita, Echinoides, Coelenterata and Graptoloidea. | 12 | CO2 |
| **UNIT V** | Micropaleontology: Sampling methods and sample processing techniques. Types of microfossils.Calcareous Microfossils - Foraminifera - major morphologic groups; Benthic Foraminifera; depth biotopes, value in paleobathymetric determination. Larger foraminifera – their utility in Indian stratigraphy.Planktonic foraminifera and calcareous nannofossils.Ostracoda - outline morphology, paleoecology & geological history. Brief knowledge about pteropods, calpionellids and calcareous algae.Application of micropaleontology in hydrocarbon exploration. | 12 | CO2 |
| | **Text Books** | | |
| 1. | Palaeontology Evolution and animal distribution. .C. Jain and M.S. Anantharaman, (1996), Vishal Publications, Jalandhar. | | |
| 2. | Invertebrate Palaeontology - H.Woods, (1985), CBS Publishers and Distributors, New Delhi. | | |
| 3. | Agashe, S.N, Paleo botany, Oxford & IBH. Delhi(1995) | | |
| 4. | Stewart W.N. & G.W. Rothwell, Palaeobotany, Cambridge University Press. D 2005) | | |
| 5. | Moore R.C. et al., Invertebrate Fossils. CBS. Delhi (1952). | | |
| | **References Books**<br>**(Latest editions, and the style as given below must be strictly adhered to)** | | |
| 1. | Principles of Invertebrate Palaeontology, Shrock R.R and Twenohofel W.H, (2005), CBS Publishers and Distributors, New Delhi. | | |
| 2. | Invertebrate Fossils. Moore R.C, Lalicker C.G and Fisher A.G (1952) McGraw Hill. | | |
| 3. | The Vertebrate Story, Romer A.S, (1959) University of Chicago Press, 4$^{th}$Edt. Chicago. | | |
| 4. | Palaeontology An Introduction, E.W.Nield and V.C.T.Tucker (1985) Pergamon Press, Oxford. | | |
| 5. | Colbert E.H. et al.,Evolution of the Vertebrates, Wiley. New Delhi 2002) | | |
| | **Web Resources** | | |
| 1. | https://en.wikipedia.org/wiki/Age_of_Earth | | |
| 2. | https://www.lyellcollection.org/doi/10.1144/GSL.SP.2001.190.01.14. | | |
| 3. | https://digitalatlas.cose.isu.edu/geo/basics/fossil.htm | | |
| 4. | https://www.sciencedirect.com/topics/immunology-and-microbiology/hemichordata | | |
| 5. | https://www.qm.qld.gov.au/Explore/Research/Biodiversity | | |

**Course outcome:**

CO1: Student can understand about the fossil record and geological time-scale
CO2:To get knowledge about the theory and Origin of life
CO3: Stundents get more knowledge about vertebrate paleontology
CO4: Stundents get more knowledge about Invertebrate paleontology
CO5: Student gain knowledge on micropaleontology: Sampling methods and sample processing techniques

**Mapping with Programme Outcomes:**

**Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 3 | 1 | 3 | 3 | 1 | 3 | 2 | 3 | 2 |
| **CO 2** | 2 | 3 | 1 | 3 | 3 | 1 | 3 | 2 | 3 | 2 |
| **CO 3** | 2 | 3 | 1 | 3 | 3 | 1 | 3 | 2 | 3 | 2 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |

**S-Strong-3 ; M-Medium -2 ; L-Low-1.**

**Program Specific Outcomes**

| CO/PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 |
|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 3 | 3 |
| **CO 2** | 3 | 3 | 3 | 3 | 3 |
| **CO 3** | 3 | 3 | 3 | 3 | 3 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

## Semester- II: Structural Geology and Geotectonics

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE2C1** | **STRUCTURAL GEOLOGY AND GEOTECTONICS** | Core | Y | Y | - | - | 5 | 6 | 25 | 75 | 100 |

| **Course Objectives** | |
|---|---|
| | To interpret and evaluate different structures that exist in the earth. |
| | To critically assess and review the causes of different structures. |
| | To describe and explain major and minor structures, and to compare and contrast them |
| | To study concepts and evidences of plate tectonics |
| | To understand the mechanism of sea floor spreading and associated anomalies. |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| **UNIT I** | Theory of stress and strain – Behavior of rocks under stress – Mohr's circle – Various states of stress and their representation by Mohr's circles – Different types of failure and sliding criteria – Geometry and mechanics of fracturing and conditions for re-activation of pre-existing discontinuities – Paleostress analysis – Common types of finite strain – Ellipsoids – L-, L-S-, and S-tectonic fabrics. | 12 | CO1 |
| **UNIT II** | Techniques of strain analysis – Particle paths and flow patterns – Progressive strain history and methods for its determination. Deformation mechanisms – Role of fluids in deformation processes – Geometry and analysis of brittle-ductile and ductile shear zones – Petrofabric analysis – Field and laboratory techniques – Point and percentage diagrams – Preparation of petrofabric diagrams of quartz, biotite and calcite – Symmetry of fabric – Symmetry of movement. | 12 | CO2 |
| **UNIT III** | Rotated minerals – Syn-, pre- and post-kinematic – Differential movement in rocks using rotated minerals – Oscillatory movements – Characteristics – Neotectonics – Indian and global evidences – Methods of study of neotectonics. Sheath folds – Geometry and mechanics of development of folds – Boudins – Foliation and lineation – Interference patterns and structural analysis in areas of superposed folding – Fault-related folding – Geometry and mechanics of faults – Gravity-induced structures.<br>– Joints and unconformities – Penecontemporaneous deformational structures of sedimentary rocks. | 12 | CO2 |
| **UNIT IV** | Plate tectonics – Concept and principle. Continental drift – Geological and geophysical evidences. Mechanics and present status of plate tectonics. Isostasy, orogeny and epeirogeny – Geodynamics of the Indian Plate. Major tectonic features and associated structures in extensional, compressional and strike-slip terrains. | 12 | CO2 |

| | | | |
|---|---|---|---|
| **UNIT V** | Sea floor spreading and plate tectonics. Gravity and magnetic anomalies at mid-oceanic ridges, deep sea trenches, continental shield areas and mountain chains. Island arcs, oceanic islands and volcanic arcs. Geodynamic evolution of the Himalayas. Paleomagnetism. | 12 | CO2 |
| | **Text Books** | | |
| 1. | Billings, M.P. (2014) *Structural Geology*. Prentice-Hall, Inc., Learning Pvt. Ltd., Delhi. 3rd Edition. ISBN: 978-81-203-0059-03. | | |
| 2. | Beloussov, V.V. (1962).*Basic Problems in Geotectonics*. McGraw-Hill Book Co., New York. | | |
| 3 | Badgeley, P.C. (1965) *Structural and Tectonic Principles*. Harper & Row Publishers, New York. ASIN: BOOBXTMTK6. | | |
| 4 | Twiss, R.J. and Moores, E.M. (2007).*Structural Geology*. W.H.Freeman and Company, New York. 2nd Edition. ISBN: 10: 0-7167-4951- | | |
| 5 | B.A. van der Pluijm and S. Marshak (2004). Earth Structure - An Introduction to Structural Geology and Tectonics (2nd ed.). New York: W. W. Norton. p. 656. ISBN 0-393-92467-X. | | |
| | **References Books** | | |
| 1. | Suppe, J. (1985) *Principles of Structural Geology*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. ISBN: ISBN 0137105002. | | |
| 2. | Marshak, S. and Mitra, G. (1988) *Basic Methods of Structural Geology*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. ISBN: 0130651788. | | |
| 3. | *M. King Hubbert (1972). Structural Geology. Hafner Publishing Company.* | | |
| 4. | *G.H. Davis and S.J. Reynolds (1996). The structural geology of rocks and regions (2nd ed.).* Wiley. ISBN 0-471-52621-5. | | |
| 5. | *C.W. Passchier and R.A.J. Trouw (1998). Microtectonics. Berlin:* Springer. ISBN 3-540-58713-6. | | |
| | **Web Resources** | | |
| 1. | http://www.labotka.net | | |
| 2. | http://www.patnasciencecollege.org | | |
| 3. | https://geomorphology.org.uk | | |
| 4. | https://gradeup.co | | |
| 5. | https://www.nps.gov>subjects>gla | | |

**Course outcome**:

CO1:To gain knowledge about the geological structures like fold, fault, unconformity, foliation and lineation and its causes and mechanisms.
CO2: Gain knowledge on techniques of strain analysis
CO3: Student learn about the Methods of study of neotectonics
CO4: Student understand on Major tectonic features and associated structures in extensional-, compressional-, and strike-slip terrains – Joints and unconformities

CO5: Student gain knowledge on Gravity and magnetic anomalies at mid-oceanic ridges, deep sea trenches, continental shield areas and mountain chains.

**Mapping with Programme Outcomes:**

**Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 |
| **CO 2** | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 |
| **CO 3** | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 |
| **CO 4** | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 |
| **CO 5** | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 |

**S-Strong-3 ; M-Medium -2 ; L-Low-1.**

**Program Specific Outcomes**

| CO/PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 |
|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 3 | 3 |
| **CO 2** | 3 | 3 | 3 | 3 | 3 |
| **CO 3** | 3 | 3 | 3 | 3 | 3 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

## Semester II- Applied Petrology

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE2C2** | **APPLIED PETROLOGY** | Core | Y | Y | - | - | 5 | 6 | 25 | 75 | 100 |
| **Course Objectives** | | | | | | | | | | | |
| | To understand the basics of the Earth as a System. | | | | | | | | | | |
| | To study various magmatic compositions and understand the formation of various igneous rocks. | | | | | | | | | | |
| | To study various metamorphic rocks with respect to types, facies, zones, grades, and textures and structures. | | | | | | | | | | |
| | To understand the formation of sedimentary rocks, their textures, structures and classification | | | | | | | | | | |
| | To study the depositional environments and provenance of sedimentary rocks | | | | | | | | | | |
| **UNIT** | **Details** | | | | | | | **No. of Hours** | **Course Objectives** | | |
| **UNIT I** | Forms, textures and structures of igneous rocks. Petrology and geotectonic evolution of granites, basalts, andesites and alkaline rocks. Petrology of gabbros, kimberlites, anorthosites and carbonatites.Origin of primary basic magmas. Classification of igneous rocks. Steady-state geotherms. Genesis, properties, emplacement and crystallization of magmas. Phase equilibrium studies of simple systems, effect of volatiles on melt equilibria. Magma -mixing, - mingling and -immiscibility. Generation of magmas. Factors affecting their evolution and their relation to plate tectonics– Magmatic differentiation and Assimilation. Variation diagrams. | | | | | | | 12 | CO1 | | |
| **UNIT II** | Silicate melt equilibria, binary and ternary phase diagrams. Experimental Petrology - Phase equilibrium of binary and ternary silicate systems and its petrological implications – Effect of Pressure on silicate systems – Trace elements in magmatic crystallization – Trace element modelling. Petrogenetic aspects of important rock suites of India, such as the Deccan Traps, layered intrusive complexes, anorthosites, carbonatites, charnockites, alkaline rocks, Kimberlites, ophiolites and granitoids. | | | | | | | 12 | CO2 | | |
| **UNIT III** | Basic concepts of Metamorphic Petrology – Types of metamorphism – agents of metamorphism – Zones, grades and facies concepts of metamorphism. Characteristics of different grades and facies of metamorphism.Textures and structures of metamorphic rocks. Graphical representation of metamorphic paragenesis. Petrogenesis of important metamorphic rocks – charnockite, eclogite,amphibolite, migmatites andKhondalites. Regional and contact metamorphism of pelitic and impure calcareous rocks-mineral assemblages and P/T conditions.Metasomatism, granitization and migmatites.Plate tectonics and metamorphic zones.Paired metamorphic belts.Experimental and thermodynamic appraisal of metamorphic reactions.Mineral reactions with condensed | | | | | | | 12 | CO2 | | |

| | | | |
|---|---|---|---|
| | phases,solid solutions, mixed volatile equilibria and thermobarometry. | | |
| **UNIT IV** | Earth Surface System: Tectonics and Sedimentation. Cyclic Sediments.Classification of sedimentary rocks. Textures and structures of sedimentary rocks. Definition, measurements and interpretation of grain size. Definition,evolution / origin and classification of sedimentary basins. Sedimentary basins of India. Paleocurrent and Basin analysis. Provenance and Diagenesis of sediments. | 12 | CO2 |
| **UNIT V** | Sedimentary environments and facies: Continental- fluvial, lacustrine, desert, eolian and glacial sedimentary systems. Shallow Coastal Facies. Marine - Continental Evaporates, Shallow water Carbonates, Deep sea facies.Volcanoclasts. Petrography of rocks of Clastic, Chemical and Biochemical origin, Clastic Petrofacies, Paleoclimate and Paleoenvironment analyses. Application of trace elements, Rare-earth elements and Stable isotope geochemistry to sedimentological problems. | 12 | CO2 |
| | **Text Books** | | |
| 1. | H.Blatt, Gerard Middle ton &R.Murray, 1972 – Origin of sedimentary rocks, Prentice Hall Publishers | | |
| 2. | J.J.Greensmith, 1971 – Petrology of sedimentary rocks, George Allan and Unwin ltd | | |
| 3. | Holly Cefrey, 2003 – Sedimentary Rocks, The Rosen Publishing Group | | |
| 4. | Rebecca Faulkner, 2008 – Sedimentary Rock, Raintree | | |
| 5. | Huang, W.T. – 1962 – Petrology, McGraw Hill. | | |
| 6. | Pettijohn, F.J. – 1967 – Sedimentary Rocks, Harpers and Bros | | |
| 7. | Gary Nichols (2009) Sedimentology and Stratigraphy, 2nd ed. Wiley-Blackwell. | | |
| 8. | Sengupta, S.M. (2007) Introduction to Sedimentology, 2nd ed. CBS Publishers. | | |
| 9. | Philpotts, A., 1992, Igneous and Metamorphic Petrology, Prentice Hall. | | |
| 10. | Turner,F.J., 1980, Metamorphic Petrology, McGraw Hill., New York. | | |
| 11. | Best M.G,IgneousPetrology.Wiley.NewDelhi(2005) | | |
| 12. | Hatch,F.H. et al,Petrology of the Igneous Rooks, CBSDelhi. | | |
| 13. | Hyndman D.W, Petrology of the Igneous and Metamorphic Rocks McGrawHill.NewYork(1985) | | |
| | **References Books** | | |
| 1. | Bose, M.K., 1997, Igneous Petrology., World Press. | | |
| 2. | Bucher, K and Frey, M., 1994, Petrogenesis of Metamorphic Rocks, Springer – Verlag. | | |
| 3. | Winter,J.D,Principles of Igneous and Metamorphic Petrology, PHI.New | | |
| 4. | Middlemost E.A.K,Magmas and Magmatic Rocks.Longman UK(1985) | | |
| 5. | Winkler,H.G.F, Petrology of the Metamorphic Rocks. Springer,New Delhi(1970) | | |
| | **Web Resources** | | |
| 1. | https://minerva.union.edu/hollochk/c-petrology/resources.html | | |
| 2. | https://topex.ucsd.edu/es10/lecture/lecture10/lecture10.html | | |
| 3. | https://geology.com/rocks/igneous-rocks.shtml | | |
| 4. | https://course.lumenlearning.com/wmopen-geology/chapter/outcome-metamorphic-rocks/ | | |
| 5. | https://serc.carleton.edu/NAGTWorkshops/coursedesign/goalsdb/10875.html | | |

**Course outcome**:

CO1:To gain knowledge about the study of rocks - igneous, metamorphic, and sedimentary - and the processes that form and transform them.
CO2: Students gain on Silicate melt equilibria, binary and ternary phase diagrams.
CO3: students learn about the Basic Concepts of Metamorphic Petrology
CO4: Students learn Definition, measurements and interpretation of grain size
CO5: Students get knowledge on Sedimentary environments and facies

**Mapping with Programme Outcomes:**

**Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO 2** | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 1 | 3 |
| **CO 3** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| **CO 5** | 1 | 1 | 2 | 3 | 3 | 3 | 2 | 1 | 2 | 2 |

**S-Strong-3 ; M-Medium -2 ; L-Low-1.**

**Program Specific Outcomes**

| **CO/PSO** | **PSO 1** | **PSO 2** | **PSO 3** | **PSO 4** | **PSO 5** |
|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 3 | 3 |
| **CO 2** | 3 | 3 | 3 | 3 | 3 |
| **CO 3** | 3 | 3 | 3 | 3 | 3 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

## Semester-II:Structural Geology & Petrology Practical

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE2P1** | **STRUCTURAL GEOLOGY & PETROLOGY PRACTICAL** | Core | Y | - | Y | - | 4 | 6 | 25 | 75 | 100 |

| **Course objectives** | |
|---|---|
| CO1 | To calculate and present the primary and secondary structures through projections. |
| CO2 | To work out the problems related to the thickness of the strata |
| CO3 | To work out problem related to deformation and dislocation of rocks and their section preparation. |
| CO4 | To study different rock types by means of megascopic and microscopic characteristics |
| CO5 | To study the mineralogy of rocks using petrographic techniques<br>To carry out grain size analysis to distinguish depositional environments. |

| **UNIT** | **Details** | **No. of Hours** | **Course Objectives** |
|---|---|---|---|
| **UNIT I** | Determination of attitude of beds – Geometrical, graphical and trigonometric projections – Tabular and nomograph methods. Reconstruction of parallel fold and fault – Preparation and analysis of structural contour map. Isopach. Geochronology of events. | 12 | CO1 |
| **UNIT II** | Depth to strata – True thickness of beds - Interpretation of geological maps involving normally dipping beds, bore well data. | 12 | CO2 |
| **UNIT III** | Interpretation of geological maps involving symmetrical and asymmetrical fold, isoclinal fold, recumbent fold, plunging fold, strike fault and step fault. Construction of perpendicular and vertical sections. | 12 | CO2 |
| **UNIT IV** | Megascopic and microscopic study (textural and mineralogical) of the igneous, sedimentary and metamorphic rocks. Laboratory exercises in graphic plots for petrochemistry and interpretation of paragenetic diagrams. Preparation of Thin sections and polished ore mounts. | 12 | CO2 |
| **UNIT V** | Statistical parameters in Sedimentology-Grain size analysis–Frequency and cumulative frequency distribution curves – Moment and graphic measures – Gravel analysis. Harker's, Larsen's variation diagrams – Peacock's Alkali-Lime Index – Niggli's variation diagram. | 12 | CO2 |


| | |
|---|---|
| 1. | Brian Simpson. (1968).*Geological Maps*. Pergamon Press Limited, Oxford. |
| 2. | Lisle, R.J. (1988).*Geological Structures and Maps*. Pergamon Press, Oxford. |

| | |
|---|---|
| 3 | Gass, J.G., Butcher, N.E., Clark, P., Francis, P.W., Jackson, D.E., McCurry, P., Skipsey, E., Smith, P.J., Stevenson, J., Thorpe, R.S., Turner, C., Wilson, R.C.L., Wright, J.B. (1972). *Field Relations – A Second Level Course in Science*. The Open University Press, London. |
| 4. | Structural geology, Billing. M.P. (1974), Prentice Hall, New Delhi |
| 5. | An outline of Structural Geology, Hobbs, B.E., Means, W.D. and Williams, P.F. (1976):, John Wiley, New York. |
| 6 | Vernon R. H. and Clarke G. L. 2008. Principles of metamorphic Petrology. Cambridge publication. |
| 7 | John D. Winter 2001. An Introduction to Igneous and Metamorphic Petrology. |
| 8 | Wenk,H.R&A. Bulakh, Minerals, Cambridge University Press,New Delhi(2006) |
| 9 | Perkins D, 3rd ed. Prentice Hall India, NewDelhi(2010) |
| 10 | HaIdar,S.K.&J.Tisjlar, Introduction to Mineralogy and Petrology, Elsevier,(2014) |
| **References Books** | |
| 1. | Bhattacharya, D.S. and Bagchi, T.C. (1973).*Elements of Geological Map Reading and Interpretation with Exercises*. Orient Longman Limited, Calcutta. |
| 2. | Gokhale, N.W. (2006).*A Manual of Problems in Structural Geology*. CBS Publishers and Distributors, New Delhi. |
| 3. | Basic Problems of GeotectonicsBelousov.V.V. (1962):, McGraw Hill, New York |
| 4. | Structural Geology De Sitter. L.U. (1956):, McGraw Hill, New York |
| 5. | Elements of Structural Geology Hill. E.S. (1972):, John Wiley, New York |
| 6 | Yardley, B W D. 1990. An introduction to metamorphic petrology. ELBS publication. |
| 7 | Best, M.G. 2002. Igneous and metamorphic petrology. Wiley publication. |
| 8 | An Introduction to Rock forming Minerals, Deer, Howie and Hussmann, (1982), 2nd Edit., Orient Longman, London. |
| 9 | Deer,W.A.,R.A.Howie&J.Zussman. An Introduction to the Rock-Forming Minerals. ELBS.London(1992) |
| 10 | Berry L.G.,B.Mason&R.V. Dietrich, Mineralogy, CBS New Delhi (1985). |
| **Web Resources** | |
| 1. | https://stratigraphy.org/ |
| 2. | https://www.sepm.org/ |
| 3. | https://www.geosocindia.org/ |
| 4. | https://www.moes.gov.in/ |
| 5. | https://isegindia.org/ |

**Course outcome**:

CO1: Students workout on the determination of attitude of beds
CO2:Student gain knowledge on preparation and analysis of structure contour map
CO3:Students learn about the Construction of perpendicular and vertical sections of plunging fold
CO4: Students study the different rock types by means of megascopic and microscopic characteristics
CO5:Students study the mineralogy of rocks using petrographic techniques and carry out grain size
analysis to distinguish depositional environments of sediments.

**Mapping with Programme Outcomes:**

**Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 2 | 3 | 1 | 3 | 2 | 3 | 1 | 1 |
| **CO 2** | 3 | 3 | 2 | 3 | 1 | 3 | 2 | 3 | 1 | 1 |
| **CO 3** | 3 | 3 | 2 | 3 | 1 | 3 | 2 | 3 | 1 | 1 |
| **CO 4** | 3 | 3 | 2 | 3 | 1 | 3 | 2 | 3 | 1 | 1 |
| **CO 5** | 3 | 3 | 2 | 3 | 1 | 3 | 2 | 3 | 1 | 1 |

**S-Strong-3 ; M-Medium -2 ; L-Low-1.**

**Program Specific Outcomes**

| CO/PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 |
|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 3 | 3 |
| **CO 2** | 3 | 3 | 3 | 3 | 3 |
| **CO 3** | 3 | 3 | 3 | 3 | 3 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

## Semester-II: Applied Remote Sensing and GIS

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE2E1** | **APPLIED REMOTE SENSING AND GIS** | DSE | Y | Y | - | - | 3 | 4 | 25 | 75 | 100 |

| **Course objectives** | |
|---|---|
| CO1 | To gain adequate knowledge on aerial remote sensing and to understand the basics of aerial photography. |
| CO2 | To enable the learner to gain knowledge on satellite remote sensing, Thermal, Microwave, Hyperspectral Remote Sensing andtheir application in resource exploration and management. |
| CO3 | To enable the students to learn the applications of satellite science. |
| CO4 | To impart knowledge on digital image processing technologies |
| CO5 | To teach the concepts and componentsof GIS and its application as a tool for mapping.<br>To learn the methods of data generation, analysis and management using opensource software. |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| **UNIT I** | Fundamentals of Remote Sensing: Definition, types. Aerial Photography- definition, history, types of aerial photographs, scale, causes for the variation of scale, flight procedure, overlap and side lap. Factors affecting results, annotation of photographs, mosaics, types of mosaics, aerial cameras, types of films and filters. Photogrammetry-definition, stereoscopy and stereovision. photographic instruments-pocket stereoscope, mirror stereoscope, area measurement, relief displacement and parallax. Vertical exaggeration, factors affecting vertical exaggeration. An account on applications of aerial photography in geological studies. | 12 | CO1 |
| **UNIT II** | Satellite Remote Sensing: Energy sources and radiation principles. Electromagnetic spectrum – Divisions - Stefan Boltzmann's law – Blackbody. EMR interaction with atmosphere and earth surface features. Platforms and sensors. Active and passive remote sensing system. Resolutions of sensors - spatial, spectral, radiometric and temporal. Spectral reflectance curve - Data acquisition, receiving and recoding. Thermal, Microwave and Hyper spectral remote sensing and their applications. | 12 | CO2 |
| **UNIT III** | Types of satellites, Scanning systems and detectors: Across-track and along track scanning systems, FOV & IFOV, charge couple devices. Data products - photographic and digital map. Sensor characteristics of LANDSAT, SPOT, IRS series of satellites and other high resolution satellites. Indian space programme: past, present and future. Fundamental of LIDAR remote sensing, ALTM, LIDAR and UAV based mapping. | 12 | CO2 |

| | | | |
|---|---|---|---|
| **UNIT IV** | Elements of image interpretation, interpretation strategies and keys. Digital interpretation. Digital image processing- Image restoration and rectification. Geometric and radiometric corrections and noise removal. Image enhancement: contrast manipulation, grey level thresholding, level slicing, contrast stretching, principal component analysis, NDVI, spatial feature manipulation, spatial filtering, edge enhancement. Multispectral band ratio and differencing, color space transformation. Image classification: supervised, unsupervised and hybrid classifications. Description of data merging and GIS integration, Data fusion. | 12 | CO2 |
| **UNIT V** | Geographic Information System: Basic principles of GIS. Elements, concepts and usefulness of GIS, Components of GIS, Hardware and Software. Data source, spatial data, Raster and Vector data. Topology - data analysis and application. Remote Sensing and GIS Applications in Geology: Interpretation for lithological and structural mapping, geomorphological studies, mineral exploration, groundwater exploration, land use / land cover mapping, hazard zonation mapping: earthquakes, volcanoes and landslides. | 12 | CO2 |

| | |
|---|---|
| | **Text Books** |
| 1. | Asrar, G. (1989) *Theory and Applications of Optical Remote Sensing*. John Wiley & Sons, New York. |
| 2. | Curran, P.J. (1984) *Principles of Remote Sensing*. Longman Group Ltd. |
| 3 | Lillesand, T.M., Kiefer, R.W. and Chipman, J.W. (2007) *Remote Sensing and Image Interpretation.* Wiley India, 763. |
| 4 | Paul R. Wolf. (1986) *Elements of Photogrammetry*, McGraw-Hill Book company. 628. |
| 5. | Lasaponara, R. and Masini N. 2012: Satellite Remote Sensing - A new tool for Archaeology. Remote Sensing and Digital Image Processing Series, Volume 16, 364 pp., ISBN 978-90-481-8801-7. |
| | **References Books** |
| 1. | Sabins, F.F. (1998) *Remote Sensing Principles and Interpretation*. W.H.Freeman& Co |
| 2. | Agarwal, C.S. and P.K. Garg (2000) *Textbook on Remote Sensing In natural resources monitopring and management,* Wheeler Publishing, 196. |
| 3. | *Campbell, J. B. (2002). Introduction to remote sensing (3rd ed.). The Guilford Press.* ISBN 978-1-57230-640-0. |
| 4. | *Jensen, J. R. (2007). Remote sensing of the environment: an Earth resource perspective (2nd ed.). Prentice Hall.* ISBN 978-0-13-188950-7. |
| 5. | Richards, J. A.; X. Jia (2006). Remote sensing digital image analysis: an introduction (4th ed.). Springer. ISBN 978-3-540-25128-6. |
| | **Web Resources** |
| 1. | https://elearning.iirs.gov.in/ |
| 2. | https://www.nrsc.gov.in/ |
| 3. | https://www.geosocindia.org/ |
| 4. | https://www.moes.gov.in/ |
| 5. | https://www.isro.gov.in/ |

Course outcome:

CO1: Students gained adequate knowledge on aerial remote sensing
CO2: Students learned the basic knowledge on satellite remote sensing
CO3: Students learned the applications of satellite science
CO4: Students gained knowledge on digital image processing technologies
CO5: Students gained knowledge on concepts and components of GIS and its application as a tool for mapping

**Mapping with Programme Outcomes:**

**Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | S | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 |
| **CO 2** | S | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO 3** | S | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 |
| **CO 4** | S | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **CO 5** | S | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 |

**S-Strong-3 ; M-Medium -2 ; L-Low-1.**

**Program Specific Outcomes**

| **CO/PSO** | **PSO 1** | **PSO 2** | **PSO 3** | **PSO 4** | **PSO 5** |
|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 3 | 3 |
| **CO 2** | 3 | 3 | 3 | 3 | 3 |
| **CO 3** | 3 | 3 | 3 | 3 | 3 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

**Semester – II: Environmental Earth Science**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE2E2** | **ENVIRONMENTAL EARTH SCIENCE** | DSE | Y | Y | - | - | 3 | 4 | 25 | 75 | 100 |

| **Course Objectives** | |
|---|---|
| | To gain knowledge on various types of environmental issues in relation to the Earth as a system |
| | To explain various types of pollution |
| | To explain various causes of pollution and their remedial measures. |
| | To know various waste disposal management practices |
| | To understand the problems related to medical geology |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| **UNIT I** | Concept of environment – Environmental monitoring – Water as a resource-Water pollution – Point and non-point pollution sources – Ground water pollution. | 12 | CO1 |
| **UNIT II** | Air pollution – Natural and anthropogenic sources of air pollution – Primary and secondary air pollutants – Anthropogenic activities and air pollution.Air quality standards – Indoor air quality-Biological sources of indoor pollution-Health effects -Air quality monitoring. Acid rain – Adverse effects of acid rain – Health effects – Mitigation measures – Roles and responsibilities. | 12 | CO2 |
| **UNIT III** | Smog – Mechanism of smog formation – Health disorders – Photochemical smog – Ozone and PAN formation – Health effects – Catalytic converters.Climate change-Greenhouse gases and effect – Processes of removal of greenhouse gases– Alternate energy resources. | 12 | CO2 |
| **UNIT IV** | Methods of waste disposal – Landfills – Trash compactors – Incineration – Recycling – Biological processing – Mulch and compost – Energy production – Waste reduction – Waste handling and transport – Waste management – Concept of waste hierarchy – Education and awareness. | 12 | CO2 |
| **UNIT V** | Medical geology – Problems associated with fluoride, arsenic, asbestos, mercury, chromium, cadmium, zinc, copper and lead contamination. | 12 | CO2 |

| | Text Books |
|---|---|
| 1. | Fairbridge, R.W. (1972) *Encyclopedia of Geochemistry and Environmental Science*. John Wiley. |
| 2. | Keller, Edward A. (1996) *Environmental Geology*. New Jersey: Prentice-Hall |
| 3. | Coppola D.P, Introduction to International Disaster Management, Butterworth Heinemann(2007) |
| 4. | Pine,J.C, Natural Hazards Analysis: Reducing the Impact of Disasters, CRC Press, Taylor and Francis Group(2009) |
| 5. | Smith K, Environmental Hazards: Assessing Risk and Reducing Disaster Rout ledge Press(2001) |
| | **References Books** |
| 1. | Strahler, A.N. and Strahler, A.H. (1973) *Environmental Geoscience – Interaction between Natural Systems and Man*. Hamilton Publishing Co., Santa Barbara, California. |
| 2. | Kudesia, V.P. (1980) *Water Pollution*. Pragathi Prakasam, Meerut. |
| 3. | Groundwater Assessment Development and Management, Karanth.K.R. (1987) Tata McGraw Hill Publishing Company, Ltd. |
| 4. | Miller T.G. Environmental Science. Wadsworth Publishing.US(2004). |
| 5. | Coates,D.R. Environmental Geology. McGraw Hill.NewYork(1984) |
| | **Web Resources** |
| 1. | https://www.britannica.com/science/geology/sedimentary-petrology |
| 2. | https://limk.springer.com/chapter/10 |
| 3. | https://www.geo.mtu.edu/UPSeis/hazards.html |
| 4. | https://www.omafra.gov.on.ca/english/engineer/facts/ |
| 5. | https://geology.com/rocks/rock-salt.shtml |

**Course Outcome:**

**CO1:** To know the basic knowledge about theClimate: Classification, Global warming and climate change
CO2: Student get knowledge on Pollution Monitoring studies
CO3:Studnets know about the Environmental Healh hazard
CO4: Students learn the Waste management studies
CO5:Student get involved in Medical geology applications

**Mapping with Programme Outcomes:**

**Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | 1 | 2 | 3 | 3 | 1 | 2 | 2 | 3 |
| **CO 2** | 3 | 2 | 1 | 2 | 3 | 3 | 1 | 2 | 2 | 3 |
| **CO 3** | 3 | 2 | 1 | 2 | 3 | 3 | 1 | 2 | 2 | 3 |
| **CO 4** | 3 | 2 | 1 | 2 | 3 | 3 | 1 | 2 | 2 | 3 |
| **CO 5** | 3 | 2 | 1 | 2 | 3 | 3 | 1 | 2 | 2 | 3 |

**S-Strong-3 ; M-Medium -2 ; L-Low-1.**

**Program Specific Outcomes**

| CO/PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 |
|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 3 | 3 |
| **CO 2** | 3 | 3 | 3 | 3 | 3 |
| **CO 3** | 3 | 3 | 3 | 3 | 3 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

**Semester-II: Disaster Management**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE2S1** | **DISASTER MANAGEMENT** | SEC | Y | Y | - | - | 2 | 4 | 25 | 75 | 100 |

| **Course objectives** | |
|---|---|
| | To understand the basics of natural hazards, distinguish hazards and disasters, global trends, vulnerable communities, importance of inter-disciplinary studies. |
| | To make students comprehend the core part of disaster management i.e. geotechnical aspect, community aspect and environmental aspect and its inter-linkages |
| | To assimilate the complexity of climate change induced disasters, mapping and monitoring techniques including risk zonation and appropriate technology tools for mitigation. |
| | To acquire knowledge on community-based disaster management, disaster risk reduction (DRR), community resilience and the importance of hazard mapping. |
| | To evaluate the importance of this inter-disciplinary course through case study experiences and to use these skills in the real-world scenario |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| **UNIT I** | General introduction to natural hazards and disasters: Physical and geodynamic characteristics of earthquakes, tsunamis and storm surges, tropical cyclones, monsoonal floods, landslides. Droughts - different types – monitoring and management and wildfires. Worldwide trends in natural catastrophes and occurrence. | 12 | CO1 |
| **UNIT II** | Global Climate Change: Global warming and environmental change – Threat of sea level changes on global coasts - Impact on natural resources, environment Social impact of disasters – Gender, food security, poverty and Climate Change Adaptation. | 12 | CO2 |
| **UNIT III** | Assessment: Hazard-prone areas identification Application of remote sensing and GIS tools – Hazard mapping – Risk modeling – Risk zonation and case studies. | 12 | CO2 |
| **UNIT IV** | Preparedness: Risk reduction concepts – Pre and postdisaster comparison and analysis – Understanding the disaster cycle – Stakeholders' participation and preparation of comprehensive management plans – Community-based disaster risk management – Participatory risk assessment – Coastal regulations – Coastal management in tsunami reconstruction – National and international scenarios. | 12 | CO2 |
| **UNIT V** | Mitigation and recovery: Inter-relationship between mitigation and recovery – Process for developing hazards mitigation plan, implementation of comprehensive mitigation strategies – Disaster recovery planning – Disaster emergency preparedness on recovery and reconstruction – Disaster Risk Reduction (DRR) approaches - Early warning systems. | 12 | CO2 |

| | Text Books |
|---|---|
| 1. | Handbook of Disaster Research Eds. H. Rodriguez et al., (2006). |
| 2. | Rajib Shaw and Krishnamurthy, R.R. (2008) Disaster Management – The Global Challenges and Local Solutions, Universities Press, Hyderabad, pp. 560. |
| 3. | Groundwater Assessment Development and Management, Karanth.K.R. (1987) Tata McGraw Hill Publishing Company, Ltd. |
| 4. | Miller T.G. Environmental Science. Wadsworth Publishing US(2004). |
| 5. | Coates,D.R. Environmental Geology. McGraw Hill.NewYork(1984) |
| | **References Books** |
| 1. | Shaw, R. and Rouhban, B. (2005) Disaster Reduction and Human Security. UNESCO & Kyoto University. |
| 2. | Babar, Md. (Ed.) (2007) Environmental Changes and Natural Disasters. New Delhi Publishing Agency. |
| 3. | Coppola D.P, Introduction to International Disaster Management, Butterworth Heinemann(2007) |
| 4. | Pine,J.C, Natural Hazards Analysis: Reducing the Impact of Disasters, CRC Press, Taylor and Francis Group(2009) |
| 5. | Smith K, Environmental Hazards: Assessing Risk and Reducing Disaster Rout ledge Press(2001) |
| | **Web Resources** |
| 1. | https://www.britannica.com/science/geology/sedimentary-petrology |
| 2. | https://limk.springer.com/chapter/10 |
| 3. | https://www.geo.mtu.edu/UPSeis/hazards.html |
| 4. | https://www.omafra.gov.on.ca/english/engineer/facts/ |
| 5. | https://geology.com/rocks/rock-salt.shtml |

**Course Outcome:**

CO1: Understand the need and significance of studying disaster management

CO2: Understand the different types of disasters and causes for disasters.

CO3: Gain knowledge on the impacts Disasters on environment and society

CO4: Study and assess vulnerability of a geographical area.

CO5: Students will be equipped with various methods of risk reduction measures and risk mitigation

**Mapping with Programme Outcomes:**

**Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 |
| **CO 2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO 3** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 |
| **CO 4** | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **CO 5** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 |

**S-Strong-3 ; M-Medium -2 ; L-Low-1.**

**Program Specific Outcomes**

| CO/PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 |
|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | 3 | 3 |
| **CO 2** | 3 | 3 | 3 | 3 | 3 |
| **CO 3** | 3 | 3 | 3 | 3 | 3 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | 15 | 15 | 15 | 15 | 15 |
| **Weighted percentage of Course contribution to Pos** | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |

**SEMESTER – III**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE3C1** | **ECONOMIC GEOLOGY** | Core | Y | Y | - | - | 5 | 6 | 25 | 75 | 100 |

| **Course objectives** | |
|---|---|
| CO1 | To provide knowledge on economically relevant minerals and metals |
| CO2 | To explain the ore genesis responsible for the economic deposits |
| CO3 | To provide practical knowledge on the minerals and metals |
| CO4 | To detail on the methods applied for mineral exploration |
| CO5 | To summarise the radioactive mineral deposits |

| UNIT | Details | No. of Hours | Course objectives |
|---|---|---|---|
| **UNIT** I | **Ore Genesis**. Ore deposits and ore minerals. Magmatic processes of mineralization. Porphyry, skarn and hydrothermal mineralization. Fluid inclusion studies, sedimentary, supergene enrichment, placer. Mineralisation associated with – (i) ultramafic, mafic and acidic rocks (ii) greenstone belts (iii) komatiites, anorthosites and kimberlites and (iv) submarine volcanism. Magma related mineralization through geological time. Stratiform and stratabound ores. Ores and metamorphism – cause and effect relations. Metallogeny and mineral belts. SedEx deposits. | 12 | CO1 |
| **UNIT** II | **Mineral Exploration**. Principles of mineral prospecting and exploration - conceptualization, methodology and stages; sampling, subsurface sampling including pitting, trenching and drilling, core and non-core drilling, planning of bore holes and location of bore holes on ground. Core logging, geochemical exploration- nature of samples anomaly, strength of anomaly and controlling factors, coefficient of aqueous migration. | 12 | CO2 |
| **UNIT** III | Mineralogy and geochemistry of radioactive minerals.Origin and Mineralogy and geochemistry of radioactive minerals.Instrumental techniques of detection and measurement of radioactivity.Radioactive methods for prospecting and assaying of mineral deposits. Distribution of radioactive minerals in India. Radioactive methods in petroleum exploration — well logging techniques. Nuclear waste disposal — geological constraints. | 12 | CO2 |
| **UNIT** IV | **Coal and petroleum Geology**. Coal and its properties: Different varieties and ranks of coal. Origin of coal. Coalification process and its causes. Fundamentals of coal petrology. Origin, migration and entrapment of natural hydrocarbons. Characters of source and reservoir rocks. Structural, stratigraphic and mixed traps. Techniques of exploration. Structural, stratigraphic and mixed traps. Techniques of exploration. Methods of petroleum exploration. Petroliferous basins of India. | 12 | CO2 |

| | | | |
|---|---|---|---|
| **UNIT** V | **Industrial Geology**. Identification and description of ore and industrial minerals. Geological studies in Coal industries; Petroleum industries; Geological investigation in mining industries. Need of Geologist in industrial sectors. Role of geologist in NLC, ONGC, GSI, WIHG, NIO, NGRI, PRL, RRL, Soil Survey of India, BSIP, Archaeological survey of India. | 12 | CO2 |

| | **Reference Books** |
|---|---|
| 1. | Aiyengar, N. K. N. (1964). *Minerals of Madras*. Dept. of Industries & Commerce. |
| 2. | Banerjee, P. K., & Ghosh, S. (1997). *Elements of prospecting for non-fuel mineral deposits*. Allied Publishers Ltd. |
| 3. | Bateman, A. M., & Jensen, M. L. (1981). *Economic mineral deposits*. John Wiley & Sons. |
| 4. | Chatterjee, K. K. (1993). *An introduction to mineral economics*. Wiley Eastern Ltd. |
| 5. | Craig, R. C., & Vaughan, D. V. (1985). *Ore microscopy and ore petrography*. Wiley. |
| 6. | Krishnasamy, S. (1988). *India's mineral resources*. Oxford & IBH. |
| 7. | Krishnaswamy, S. (1979). *India's mineral resources*. Oxford-IBH Publishers. |
| 8. | Prasad, U. (2003). *Economic mineral deposits*. CBS. |
| 9. | Sharma, N. L., & Sinha, R. K. (1985). *Mineral economics*. Oxford & IBH. |
| 10. | Sinha, R. K. (1986). *Industrial minerals*. Oxford & IBH Pub. Co. |
| | **Web Resources** |
| 1. | https://www.britannica.com/topic/economic-geology |
| 2. | https://en.m.wikipedia.org/wiki/supergene-(geology) |
| 3. | https://energymining.sa.gov.au/minerals/mineral-commodities |
| 4. | https://www.slideshare.net/mobile/monokaonaBoruah/magmatic-deposits-economic-geology |
| 5. | https://link.spring.com/ |

**Course outcome:**

CO1: Students will have the knowledge and skills to recognise common ore minerals in hand samples and under the microscope.

CO2: Demonstrate familiarity with a wide range of mineral deposits, including recognising the overall geometry, zonation and alteration patterns associated with specific classes of metallic mineral deposits,

CO3: To get awareness on geochemistry of radioactive minerals

CO4:Fundamentals of coal petrology, Gain knowledge on the Origin, migration and entrapment of natural hydrocarbons

CO5: Student learns more knowledge on industrial aspects in geological studies.

**Mapping with Programme Outcomes:**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 2** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 3** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 4** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 5** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |

- **Remember and Understanding – Lower level (1)**
- **Apply and Analyze – Medium Level (2)**
- **Evaluate and Create – Strong Level (3)**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE3C2** | **GEOPHYSICS** | Core | Y | Y | - | - | 5 | 6 | 25 | 75 | 100 |

| **Course objectives** | |
|---|---|
| CO1 | To understand the basic principle of geophysics and how it applies in mineral exploration; method of radiometric exploration. |
| CO2 | To get basic ideas of Gravity method, its filed procedure and application in exploration. |
| CO3 | To understand the Electrical method, its filed procedure and application in exploration. |
| CO4 | To understand the basic principle of rock behaviour for elastic waves; thier application in mineral exploration. |
| CO5 | To get basic idea of magnetic method,itsfiled procedure and application in exploration. |

| UNIT | Details | No. of Hours | Course objectives |
|---|---|---|---|
| **UNIT** I | Introduction – Physical basis of geophysical exploration, various surface and sub-surface methods and their classification. Physical properties of rocks and minerals used in exploration and factors that control them. Geophysical anomaly. Principles of radioactive prospecting. Radioactive decay, radioactivity of rocks and minerals. Instruments, field procedure and interpretations employed in radioactive survey. Application of radiometric methods. A brief account of radiometric logging methods and their applications. | 12 | CO1 |
| **UNIT** II | Gravity Prospecting: Gravity prospecting – Principles, the Earth's gravitational field and units, its variation, Newton's Law – Geoid, spheroid and normal gravity field, figure of earth. Order of anomalies produced by geological discontinuities, absolute and relative measurement of gravity, gravimeters and their operation in the field. Field procedure, reduction and correction of gravity field data, separation of regional and residuals, upward and downward continuation, interpretation of gravity data obtained over spherical and cylindrical objects, sheet, dike and faults – Applications of gravity methods. | 12 | CO2 |
| **UNIT** III | Electrical methods – Electrical properties of earth materials – Conduction in rocks, conduction in water-bearing rocks, description of geoelectric sections, classification of electrical methods. Resistivity method – Ohm's Law, resistivity, factors affecting resistivity, effect of homogenous earth, various configurations for resistivity methods, configuration factor, response over a layered earth. AC and DC type resistivity meters, field procedure for electrical profiling and sounding, logarithmic curve matching, advantages of plotting the data on a logarithmic graph paper. Interpretation of profiling and sounding field data, use of modelling in electrical methods, introduction to self-potential, induced polarization methods. | 12 | CO2 |

| | | | |
|---|---|---|---|
| **UNIT** IV | Seismic methods – Fundamentals of elasticity – Young's modulus, Bulk modulus, Poisson's ratio, elastic waves, laws of reflection and refraction, Huygen's principle, Fermat's principle, Principle of superposition, Seismic wave theory – Helmhotz's theorem and seismic wave propagation – Body and surface waves – Primary, Secondary, Rayleigh and Love waves – Seismic energy sources – Detectors – Seismic noises and noise profile analysis – Reduction to a datum and weathering corrections - Seismic instruments – Seismic channel – Details of geophones – Filters, Amplifier and reproducible and non-reproducible recording – Seismic timer field layout – Arc shooting – Fan shooting – Profile shooting. Data processing – Corrections applied to seismic field data Simple interpretation of field data – Seismic refraction and reflection data processing – Applications. | 12 | CO2 |
| **UNIT** V | Basic concepts and principles of magnetic prospecting. Magnetism of the earth and palaeomagnetism. Magnetic susceptibility of rocks. Magnetic effects from buried magnetic bodies. Instruments employed in magnetic prospecting. Magnetic survey on land and sea. Corrections and interpretation of magnetic data. Air-borne magnetic survey. | 12 | CO2 |

**Reference Books**


| | |
|---|---|
| 1. | Bozorgnia, Y., & Bertero, V. V. (2004). *Earthquake engineering: From engineering seismology to performance-based engineering*. CRC Press. |
| 2. | Davies, G. F. (2001). *Dynamic Earth: Plates, plumes and mantle convection*. Cambridge University Press. |
| 3. | Dobrin, M. B. (1984). *An introduction to geophysical prospecting*. McGraw-Hill. |
| 4. | Hardy, S. J., & Goodman, R. E. (2005). Web resources in the history of geophysics. *American Geophysical Union*. Archived from the original on April 27, 2013. Retrieved September 30, 2011. |
| 5. | Keller, G. V., & Frischknecht, F. C. (1982). *Electrical methods in geophysical prospecting*. Pergamon Press. |
| 6. | Kivelson, M. G., & Russell, C. T. (1995). *Introduction to space physics*. Cambridge University Press. |
| 7. | Lowrie, W. (2004). *Fundamentals of geophysics*. Cambridge University Press. |
| 8. | Pedlosky, J. (1987). *Geophysical fluid dynamics* (2nd ed.). Springer-Verlag. |
| 9. | Rama Rao, B. S., & Murthy, I. V. R. (1978). *Gravity and magnetic methods of prospecting*. Arnold Heinemann Publishers. |
| 10. | Telford, W. M., Geldart, L. P., Sheriff, R. E., & Keys, D. A. (1976). *Applied geophysics*. Oxford-IBH Publishing Co. Pvt. Ltd. |


**Web Resources**

| | |
|---|---|
| 1. | https://iugg.org/associations-commissions/commissions/sedi/ |
| 2. | https://iugg.org/ |
| 3. | https://www.usgs.gov/programs/geomagnetism |
| 4. | https://www.udemy.com/course/learn-seismic-data-processing/ |
| 5. | https://seg.org/Default.aspx?TabId=176&language=en-US |

**Course Outcome:**

CO 1: Students will be able to apply the principles of geophysics to mineral exploration.
CO 2: Be able to carry out gravity method of exploration
CO 3: Be able to do electrical method of exploration
CO 4: Be able to study the geological characteristics of sub-surface layers and their mineral potential using seismic waves.
CO 5: Be able to do magnetic method of exploration

**Mapping with Programme Outcomes:**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 2** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 3** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 4** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 5** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |

- **Remember and Understanding – Lower level (1)**
- **Apply and Analyze – Medium Level (2)**
- **Evaluate and Create – Strong Level (3)**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE3P1** | **REMOTE SENSING AND GIS, GEOPHYSICS AND GEOCHEMISTRY - PRACTICAL** | Core | Y | - | P | - | 4 | 6 | 25 | 75 | 100 |

| **Course objectives** | |
|---|---|
| CO 1 | To learn Photogrammetry<br>To learn to interpret lithology, geological structures, landforms and drainage networks from satellite imagery<br>To learn to apply GIS and other open-source software tools for geological analysis. |
| CO 2 | To interpret VES Data using curve matching techniques. |
| CO 3 | To create gravity contour to visualise sub-surface structures. |
| CO 4 | To do geochemical analysis of rocks, minerals, ores and water. |
| CO 5 | To do radioactive dating calculation. |

| UNIT | Details | No. of Hours | Course objectives |
|---|---|---|---|
| | **Remote Sensing and GIS**<br>Elementary exercises relating to photogrammetry, use of pocket and mirror stereoscopes, photo scale, overlap, side lap, height measurements, annotation of aerial photographs; Interpretation-lithology, geological structures, landforms, drainage network, landuse/land cover features. Interpretation of satellite imagery and GIS applications for mapping.<br><br>**Electrical Resistivity methods**: Interpretation of vertical electrical sounding data obtained over 2- and 3-layered earth using the S-line, curve matching and auxiliary point chart method – Field demonstration of resistivity, seismic SP and magnetic prospecting techniques.<br>.<br>**Gravity Methods:** Computation of gravity response over a sphere – Exercises on drift correction, separation of regional and residual of gravity data – Contouring of gravity data – Calibration of magnetometer – Interpretation of field magnetic data over a dike. Interpretation of seismic refraction data obtained over 2- and 3-layered earth – Computation of configuration constant.<br><br>**Geochemistry:** Analysis of rocks/minerals/ores – Analysis of water – Elemental analysis – Flame photometry – Spectrophotometry –Analysis of trace elements using AAS – ICPMS – radioactive dating methods | | |

| | **Reference Books** |
|---|---|
| 1. | Anderson, M. P., & Woessner, W. W. (1992). *Applied groundwater modeling*. Academic Press. ISBN: 0-12-059485-4. |

| | |
|---|---|
| 2. | Davis, S. N., &DeWeist, R. J. M. (1966). *Geohydrology*. John Wiley & Sons. |
| 3. | De Marsily, G. (1986). *Quantitative hydrogeology: Groundwater hydrology for engineers*. Academic Press. ISBN: 0-12-208916-2. |
| 4. | Domenico, P. A., & Schwartz, W. (1998). *Physical and chemical hydrogeology* (2nd ed.). Wiley. ISBN: 0-471-59762-7. |
| 5. | Driscoll, F. (1986). *Groundwater and wells*. US Filter / Johnson Screens. ISBN: 0-9616456-0-1. |
| 6. | Fetter, C. W. (2018). *Applied hydrogeology* (4th ed.). Waveland Press. ISBN: 9781478637448. |
| 7. | Freeze, R. A., & Cherry, J. A. (1979). *Groundwater*. Prentice-Hall. |
| 8. | LaMoreaux, P. E., & Tanner, J. T. (Eds.). (2001). *Springs and bottled water of the world: Ancient history, source, occurrence, quality and use*. Springer-Verlag. ISBN: 3-540-61841-4. |
| 9. | Porges, R. E., & Hammer, M. J. (2001). *The compendium of hydrogeology*. National Ground Water Association. ISBN: 1-56034-100-9. |
| 10. | Todd, D. K., & Mays, L. W. (2013). *Groundwater hydrology* (3rd ed.). John Wiley & Sons. ISBN: 978-81-265-3003-8. |
| **Web Resources** | |
| 1. | https://iah.org/ |
| 2. | https://gw-project.org/books/groundwater-resource-development/ |
| 3. | https://info.aquaclara.org/what-are-the-most-common-water-contaminants |
| 4. | https://www.usgs.gov/mission-areas/water-resources |


**Course Outcome:**

1. Students will learn the techniques of photogrammetry and able to work with aerial photos to calculate scale, measure the height and slope, and to do annotations; learn to interpret satellite image to identify and classify the lithology, land forms, geological structures and drainage network; learn to use GIS and open-source software tools to do mapping.
2. Students will be able to interpret VES data;create gravity contour to visualize hidden geological structures.
3. Students will learn the methods of analysis of rocks, minerals, ores and water; andradioactive dating calculation.

**Mapping with Programme Outcomes:**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 2** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 3** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 4** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 5** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |

- **Remember and Understanding – Lower level (1)**
- **Apply and Analyze – Medium Level (2)**
- **Evaluate and Create – Strong Level (3)**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| 23MGE3P2 | ECONOMIC GEOLOGY & GEOLOGICAL FIELD MAPPING - PRACTICAL | Core | Y | - | P | - | 4 | 6 | 25 | 75 | 100 |

| Course objectives | |
|---|---|
| | To identify and study ore minerals using physical and optical properties |
| | To learn the field techniques of mapping the geological formations and structure |

| UNIT | Details | No. of Hours | Course objectives |
|---|---|---|---|
| | **Economic Geology**<br>Megascopic identification of important ore minerals. Calculation of ore reserves.<br>**Ore Microscopy**<br>Study of optical properties and identification of selected ores by reflected light-Description and interpretation of ore textures.<br><br>**Geological Mapping**<br>A Geological field training for not less than 7 working days should be conducted in selected and popular igneous, sedimentary and metamorphic terrains of India to impart field knowledge to students on lithological and structural mapping during first or second year of the course. Participation in Geological Mapping programme by students under the guidance of teachers is mandatory. At the end of the programme, every student has to submit his/her individual report duly signed by the teachers accompanied him/her to the field to the Head of the Department. Reports thus submitted will be evaluated by Examiners and marks will be awarded. | | |

| | References Books |
|---|---|
| 1. | S.Krishnaswamy, 1972 – Indian mineral resources, Oxford and IBH publishing company |
| 2. | |
| 3. | Smirnov, 1976 – Geology of mineral deposits, Mir publishers, Moscow |
| 4. | David Page, 2010 - Economic Geology: Ore Geology in Its Relations to the Arts and |
| 5. | Manufactures, BiblioBazaar |
| 1. | Kula C. Misra, 2000 - Understanding mineral deposits, Springer |
| 2. | L. J. Robb, 2005 - Introduction to ore-forming processes, Wiley-Blackwell |
| 3. | Bateman, A.M. – 1995 – Economic Mineral Deposits, Willey. |
| 4. | Lindgren, W – 1993 – Mineral Deposits, McGraw Hill. |
| 5. | Cameron, E.N. – 1961 – Ore Microscopy, Wiley. |
| | Sinha, R.K. & Sharma, N.L. – 1976 – Mineral Economics Oxford and IBH. |

**Course Outcome:**

1. Students will be able to identify various ores; interpret origin from ore textures; do ore reserve estimation calculations.
2. Geological fieldwork provides a unique learning environment (to gain first-hand experience in the geosciences) where students develop practical skills and deepen their understanding of Earth processes. Students learn how to collect data directly from the field, including rock samples, fossils, and other relevant materials. They learn how to measure and describe the sections of geological formations accurately. By examining rock formations, faults, folds, and other structures, students gain insights into the Earth's history and tectonic processes. Students learn how to read and use the geological maps effectively during fieldwork. Fieldwork challenges students to solve real-world geologic problems. They learn to apply their knowledge to identify patterns, make connections, and draw conclusions based on field observations. Many field experiences involve group work. Students learn to collaborate with peers, share responsibilities, and communicate effectively while conducting field investigations. Fieldwork emphasizes safety protocols, risk assessment, and emergency procedures. Students learn to navigate hazards such as steep slopes, weather conditions, and wildlife. Fieldwork integrates various investigative approaches (theoretical, analytical, experimental, and modelling). Students learn to apply information from multiple sources to interpret natural phenomena.

**Mapping with Programme Outcomes:**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 2** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 3** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 4** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 5** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |

- **Remember and Understanding – Lower level (1)**
- **Apply and Analyze – Medium Level (2)**
- **Evaluate and Create – Strong Level (3)**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE3E1** | **GEOCHEMISTRY** | DSE -V | Y | Y | - | - | 3 | 3 | 25 | 75 | 100 |

| **Course objectives** | |
|---|---|
| CO 1 | To know the distribution of elements in the universe and the Earth |
| CO 2 | To study the classification of elements |
| CO 3 | To study the laws of thermodynamics |
| CO 4 | To learn geochemical exploration principles and techniques |
| CO 5 | To study the basic principles and applications of isotope geology |

| **UNIT** | **Details** | **No. of Hours** | **Course objectives** |
|---|---|---|---|
| **UNIT** I | Brief History of Geochemistry-Universe and Earth–Nature of universe, Age and composition of universe, Composition of planets, Composition of meteorite, Cosmic abundance of elements, Origin of elements. Major and trace element composition of upper crust, middle crust, lower crust, upper mantle, lower mantle and core. Major, trace and REE element composition of igneous, sedimentary and metamorphic rocks. | 12 | CO1 |
| **UNIT** II | Geological classification of elements: Volatile elements, semi-volatile elements, alkali and alkaline earth elements, REE and Y elements, HFS elements, Transition metals, Noble metals, Goldschmit classification of elements – Sideropile, chalcopile, lithopile and atmopile. | 12 | CO2 |
| **UNIT** III | Thermodynamic systems and equilibrium: First law of thermodymanics - energy and work. Second law of thermodynamics - entropy, enthalpy, heat capacity, heat content. Third law and absolute entropy. Gibbs Free energy - P-T dependence of free energy. Equilibrium and equilibrium constants. Chemical potential, fugacity, activity. Phase rule and phase diagrams. | 12 | CO2 |
| **UNIT** IV | Geochemical exploration: Principles of geochemical prospecting: Geochemical cycle, geochemical environments, geochemical dispersion, geochemical mobility, geochemical anomalies and path finder elements. A short account on principles, sampling, chemical analysis and interpretation of anomalies of various geochemical exploration methods: lithogeochemical, hydrogeochemical, pedogeochemical (stream sediments, lake sediments, glacial sediments, heavy minerals) and Biogeochemical exploration. Geobotanical indicators for mineral prospecting. | 12 | CO2 |

| | | | |
|---|---|---|---|
| **UNIT** V | Geochronology : Isotope geology-Introduction to isotopes and nuclear systematic-Stable and radiogenic isotopes-Isotope Geology of Sr, Nd, Pb and Ar and their applications - Applications of stable isotopes in geothermometry and geobarometry– Isotopes in mineral exploration and paleoclimate evaluation –Cosmogenic nuclides and their applications. | 12 | CO2 |
| | **Reference Books** | | |
| 1. | Gunter Faure, (1998).*Principles and applications of Geochemistry*. Prentice Hall. | | |
| 2. | Hawkes, H.E. & Webb, U.S. (1962).*Geochemistry in mineral Exploration*. Harer | | |
| 3. | Mason, B. (1966).*Principles of Geochemistry.* Willey Toppan. | | |

**Course Outcome:**

**CO 1:** Students would have an overall understanding of the distribution pattern and concentration of elements in the Universe, particularly in the Earth.

**CO 2:** Have abroad understanding on various kinds of elements and their groups

**CO 3:** Have clear understanding on thermodynamic laws and their application

**CO 4:** Acquire knowledge on geochemical exploration procedures

**CO 5:** Would know application and use of isotopes in geological problems

**Mapping with Programme Outcomes:**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 2** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 3** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 4** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 5** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |

- **Remember and Understanding – Lower level (1)**
- **Apply and Analyze – Medium Level (2)**
- **Evaluate and Create – Strong Level (3)**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE3S1** | **PETROLEUM EXPLORATION AND MUD LOGGING** | SEC - II | Y | Y | - | - | 2 | 3 | 25 | 75 | 100 |

| **Course objectives** | |
|---|---|
| CO 1 | To give an overview of hydrocarbon exploration |
| CO 2 | To learn the techniques and procedures of oil well drilling |
| CO 3 | To know the wellsite geological operations |
| CO 4 | To learn mud logging operations |
| CO 5 | To learn electro logging procedures |

| UNIT | Details | No. of Hours | Course objectives |
|---|---|---|---|
| **UNIT** I | Overview of hydrocarbon Exploration: Introduction to hydrocarbon exploration - Preliminary Exploration-Identification of Sedimentary basins using Geo-physical prospecting methods, Introduction to seismic data acquisition, Petroleum system, Geo chemical evaluation of regional source rocks, Introduction to geological interpretation of possible hydrocarbon traps. | 12 | CO1 |
| **UNIT** II | Oil Well drilling: Introduction for drilling an Oil Well - Onshore rigs & offshore rigs, well types, well profiles, drill string, drill bits, drilling fluids - Mud Rheology, Significance during drilling etc., Well complications - Well Activity-Kick & Mud losses, Stuck-up, Fishing, casing & cementation, Well completion & testing, QHSE, Worksite Environmental Hazards. | 12 | CO2 |
| **UNIT** III | Wellsite Geology: Roles & responsibilities of a Wellsite Geologist - Well monitoring, implementation of geological work program, preparation of periodic & end of well reports etc., Geo-technical order, Evaluation of cutting samples for rock - Lithological & Mineralogical & hydrocarbons - Fluorescence & Solvent cut test during drilling. Borehole Volume Calculation - Displacement, Lag time, cycle time etc, Coring operations - Picking up a coring point, objective of coring & core analysis, Wellsite Visit - Industrial Visit, if possible. | 12 | CO3 |
| **UNIT** IV | Mud logging: Brief introduction to mud logging - Sensors &its working principle, Commissioning, calibration & troubleshooting of mud logging sensors. Roles & responsibilities of a mud logger - Monitoring, reporting & forecasting geological hazards. Geological Surveillance – Ditch sample collection techniques, Gas Sampling – Hydrocarbon Gas Analysis, Calcimetry, Genesis of abnormally pressured zones - Sur-normal & Sub-normal, Real time pore pressure prediction during drilling. | 12 | CO4 |

| | | | |
|---|---|---|---|
| **UNIT** V | Electro logging: Basic logs (Gamma Ray (GR), Self-potential (SP), Caliper (CAL), Resistivity logs, Neutron log, Density log & Sonic log) working principle & geological interpretation, Introduction to advanced logs -Formation Micro Imager (FMI), Elemental capture spectroscopy (ECS), Combinable Magnetic Resonance (CMR) etc.). Modular dynamic tester (MDT)/Reservoir characterization instrument (RCI) (Formation pressure tester & fluid sampler). Introduction to Measurements While Drilling (MWD) & Logging while drilling (LWD). Geo-steering. Lithology reconstruction, Facies analysis, interpretation of depositional environments, Sequence Stratigraphic surfaces, litho& Chrono stratigraphy from Logs. | 12 | CO5 |
| **Reference Books** | | | |
| 1. | Bhagwan Sahay. (1997). Petroleum Exploration and Exploitation Practices (2nd ed.). Allied Publishers Limited, Chennai. | | |
| 2. | Frehner, B. (2011). Finding Oil: The Nature of Petroleum Geology, 1859–1920. University Nebraska Press, 232 p. | | |
| 3. | GEOLOG International B.V. (Mudlogging Training Manuals). | | |
| 4. | Geological Survey of India. (2005). Geology & Mineral Resources of the States of India. Misc Pub. No. 30. Kolkota. (Several individual volumes available online at GSI portal). | | |
| 5. | Levorsen, A. J. (2004). Geology of Petroleum (2nd ed.). CBS Publishers and Distributors Pvt Ltd., Chennai. | | |
| 6. | Stamp, L. D. (1964). An Introduction in Stratigraphy. Thomas Murby, Museum St, WCI, London. | | |
| 7. | Wadia, D. N. (1953). Geology of India. McMillan India, Delhi. | | |
| 8. | Weller, J. M. (1962). Stratigraphic Principles and Practices. Harper & Bros, New York. | | |
| 9. | Whittaker, A. (The Mudlogging Handbook). | | |
| **Web Resources** | | | |
| 1. | https://stratigraphy.org/ | | |
| 2. | https://www.sepm.org/ | | |
| 3. | https://www.geosocindia.org/ | | |
| 4. | https://www.moes.gov.in/ | | |
| 5. | https://isegindia.org/ | | |

**Course Outcome:**

**CO1:** Students gain knowledge about the hydrocarbon exploration

**CO2:** Student gain knowledge about Oil Well drilling

**CO3:**Students learn about task of a Wellsite Geologist

**CO4:** Students get knowledge on MudloggingServices, Mudlogging Sensors –Operations – Maintenance

**CO5:** Students know about the Electro logging

**Mapping with Programme Outcomes:**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 2** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 3** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 4** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 5** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |

- **Remember and Understanding – Lower level (1)**
- **Apply and Analyze – Medium Level (2)**
- **Evaluate and Create – Strong Level (3)**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE3I** | **Internship** | PR | Y | - | - | - | 2 | - | 25 | 75 | 100 |
| | | | | | | | | | | | |
| **Course Objective** | Students should go to various mines and mining industries, Research and Development institutions across the country to interact with the subject/technical experts in various industries and organisations involved in various geological research and exploration programme to gain first hand field/industry experience. | | | | | | | | | | |
| **Course Outcome** | Students by making academic visits to mines, industries and R & D institutions, would come to know practically how the concepts of geology are being applied in real world scenario. They would also interact with experts to broaden their understanding of the subject. Experience of such nature would motivate students further if they want to become professional geologists. | | | | | | | | | | |

**SEMESTER – IV**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE4C1** | **ENGINEERING GEOLOGY AND MINING GEOLOGY** | Core | Y | T | - | - | 5 | 6 | 25 | 75 | 100 |

| **Course objectives** | |
|---|---|
| CO 1 | To study engineering properties of rocks; learn the methods of geological investigations for major civil engineering projects |
| CO 2 | To briefly summarise the properties and significance of different Earth materials on the basis of engineering geology |
| CO 3 | To teach students the methods of open cast and alluvial mining |
| CO 4 | To make students learn underground mining methods |
| CO 5 | To teach student various coal mining methods |

| **UNIT** | **Details** | **No. of Hours** | **Course objectives** |
|---|---|---|---|
| **UNIT** I | Engineering geology: Engineering properties of rocks, soft sediments and soils – Geological investigations pertaining to bridges, buildings, dams, highways and airfields – Types of reservoirs – Geological investigations of reservoir sites. | 12 | CO1 |
| **UNIT** II | Problems pertain to tunnelling in hard and soft grounds – Geological investigations preceding tunnelling – Geological investigations pertaining to harbours, docks, coastal erosion – Shoreline engineering – Construction of retaining walls – Problems and solutions. | 12 | CO2 |
| **UNIT** III | Mining geology: Terminology used in metal mines – Terminology used in coal mines – Prospecting and exploration – Alluvial mining methods – Quarrying – Opencast mining – Mine supports – Mine atmosphere. | 12 | CO2 |
| **UNIT** IV | Methods of underground metal mining: Without artificial supports – With artificial supports – Cut and fill methods – Shrinkage stoping – Caving methods. | 12 | CO2 |
| **UNIT** V | Coal mining: Longwall advancing – Longwall retreating – Board and Pillar method – Horizon mining. | 12 | CO2 |

| | **Reference Books** |
|---|---|
| 1. | Arogyaswamy, R. N. P. (1996). Courses in Mining Geology (4th ed.). Oxford and IBH Publishing Co., New Delhi. |
| 2. | Miller, T. G. Jr. (Year). Environmental Science. Wadsworth Publishing Co. (TB). |
| 3. | Peters, W. C. (1978). Exploration and Mining Geology (2nd ed.). John Wiley & Sons, New York. |
| 4. | Thomas, R. T. (1986). Introduction to Mining Methods. McGraw Hill, New York. |
| 5. | Vitousek, P. M. (Year). Global Change and Natural Resource Management: Beyond Global Warming: Ecology and Global Change. Ecology, 75, 1861-1876. |

| Web Resources | |
|---|---|
| 1. | https://link.springer.com/chapter/10.1007/ |
| 2. | https://www.sciencedirect.com/sciencedirect.com/science/article/pii/ |
| 3. | https://www.google.com/ur1?sa=t&source=web&rct=j&ur1=https//mines.gov.in/ |
| 4. | https://www.ncbi.nml.gov/books/ |
| 5. | https://www.sciencedirect.com/sciencedirect.com/science/article/pii/ |

**Course Outcome:**

**CO1:** Students would understand the engineering properties of rocks
**CO2:** Student can apply the knowledge and ideas on geological investigations for major engineering constructions
**CO3:** Students **g**ain knowledge onopen cast and alluvial mining methods
**CO4:** Acquire knowledge onundergroundmining methods
**CO5:** Acquire knowledge ontechniques of coal mining

**Mapping with Programme Outcomes:**

**Mapping with Programme Outcomes:**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 2** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 3** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 4** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 5** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |

- **Remember and Understanding – Lower level (1)**
- **Apply and Analyze – Medium Level (2)**
- **Evaluate and Create – Strong Level (3)**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE4P1** | **ENGINEERING GEOLOGY, MINING GEOLOGY AND HYDROGEOLOGY - PRACTICAL** | Core | Y | - | P | - | 5 | 6 | 25 | 75 | 100 |

| **Course objectives** | |
|---|---|
| | To give hands on training to student to<br>calculate engineering properties of rocks<br>estimate ore reserves<br>estimate aquifer parameters<br>assess geochemical characteristics of water |

| UNIT | Details | No. of Hours | Course objectives |
|---|---|---|---|
| | **Engineering Geology**: Determination of specific gravity, porosity, void ratio, moisture content, degree of saturation, Atterberg limits, and unit weights. Granulometric curves – Uniformity co-efficient – Dry and wet density curves – Mohr's stress circle – Ultimate and safe bearing capacity of cohesive and non-cohesive soils.<br><br>**Mining Geology**: Assaying – Determination of average grade – Determination of average width – Uniform sampling – Variable sampling – Influence of interval. Drilling: Core and sludge recovery – Estimation of ore reserves – Determination of coal pillar size – Determination of ideal shaft location.<br><br>**Aquifers and Aquitards**:Factors affecting infiltration and ground water flow: Porosity – Permeability - Grain size – Specific yield – Specific retention – Hazen method for Hydraulic conductivity - Storativity<br><br>**Groundwater flow**: Specific discharge – Average linear velocity – Flow net – Flow across water table –Steady unidirectional flow – Unsteady radial flow.<br><br>**Water chemistry**: Solubility –Ionic strength of groundwater - Trilinear diagram – Oxidation potential Eh. Laboratory – Uses of Multiparameter – On field water parameter analysis techniques – Preparation of standards for analysis. | | |

| References Books | |
|---|---|
| 1. | Aiyengar, N. K. N. (1964). *Minerals of Madras*. Guindy, Madras: Dept. of Industries & Commerce. |
| 2. | Arogyaswamy, R. N. P. (1980). *Courses in Mining Geology* (2nd ed.). Oxford and IBH Publishing Co., New Delhi. |
| 3. | Craig, R. C., & Vaughan, D. V. (1985). *Ore Microscopy and Ore Petrography*. Wiley. New York. |
| 4. | Dobrin, M. B. (1981). *Introduction to Geophysical Prospecting*. McGraw–Hill. |
| 5. | Govett, G. J. S. (Ed.). (1983). *Handbook of Exploration Geochemistry*. Publisher Name. |
| 6. | Hawkes, H. E., & Webb (1965). *Geochemistry in Mineral Exploration*. Harper and Row Publishers. |
| 7. | Krynine, D. P., & Judd, W. R. (1957). *Principles of Engineering and Geotechniques*. McGraw-Hill Book Co., New York. |
| 8. | Legget, H. F. (1962). *Geology and Engineering*. McGraw-Hill Book Co., New York. |
| 9. | Mason, B. (1966). *Principles of Geochemistry*. Willey Toppan. |
| 10. | Zaruba, Q., & Menci, V. (1976). *Engineering Geology*. Elsevier Scientific Publishing Co., Amsterdam. |
| **Web Resources** | |
| 1. | 1. https://www.Sciencedirect.com |
| 2. | https://www.geos.iitb.ac.in |
| 3. | https://pubs.usgs.gov |
| 4. | https://www.britannica |
| 5. | https://www.intechopen.com |

**Course Outcome:**

CO1: Students will be able to appraise the rocks with respect to their engineering properties n to find their suitability to engineering constructions.

CO2: Students learn sampling procedures; ore reserve calculations

CO3: Students learn how to find elemental concentrations in water using various analytical instruments.

**Mapping with Programme Outcomes:**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 2** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 3** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 4** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 5** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |

- **Remember and Understanding – Lower level (1)**
- **Apply and Analyze – Medium Level (2)**
- **Evaluate and Create – Strong Level (3)**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE4PR** | **PROJECT WITH VIVA-VOCE** | PR | | - | - | - | 6 | 10 | 25 | 75 | 100 |

**Course objectives**

| UNIT | Details | Course objectives |
|---|---|---|
| | **Dissertation**<br><br>During final semester, every student, in consultation with Research Supervisor allotted, has to identify a geological problem and work on it adopting standard methodology to arrive at a solution/conclusion. The entire work is to be submitted in the form a scientific report in not more than 100 pages excluding Contents, Acknowledgements, List of Figures, Tables and Plates, Annexures, etc. within a stipulated time to be announced by the Head of the Department.<br>To carry out the research, student can go to any of the Scientific Laboratories/Institutions/Universities where research facilities pertaining to the problem selected are available. In such case, student and/or Internal Research Supervisor has/have to fix up an External Supervisor from the institution in which the student wish to carry out his/her research and a consent letter from the External Research Supervisor has to be obtained before taking up research work and submitted to the Head of the Department**.** | To make students learn to identify geological problems; devise suitable methodology; handle analytical instruments; generate and present data; interpret the graph/curve/figure; report writing and dissertation making. |

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE4E1** | **HYDROGEOLOGY** | DSE - VI | Y | T | - | - | 3 | 4 | 25 | 75 | 100 |

| **Course objectives** | |
|---|---|
| CO 1 | To define different terms and parameters involved in Hydrogeology |
| CO 2 | To enumerate the concept and to interpret the processes involved in groundwater |
| CO 3 | To describe the importance of groundwater and summarise the occurrence of groundwater |
| CO 4 | To interpret the conditions of water resources and to select some areas where the groundwater is being exploited against the natural laws |
| CO 5 | To critically assess different factors/aspects involved |

| UNIT | Details | No. of Hours | Course objectives |
|---|---|---|---|
| **UNIT** I | **Introduction to Hydrogeology:** Water on Earth - Types of water - Distribution of water - Hydrological cycle and its components: precipitation, evaporation, evapotranspiration, infiltration, surface runoff and sub-surface distribution and movement of ground water and their estimation for the purpose of assessing water availability. Water-bearing properties of rock formations: aquifer- isotropic and anistropic, porosity, permeability, compressibility of rocks. | 12 | CO1 |
| **UNIT** II | **Occurrence and movement of Groundwater:** Vertical distribution of groundwater: zone of aeration and zone of saturation – Geological formations as aquifers – Springs - Darcy's experiment and its limitations, fluid pressure, hydraulic conductivity, transmissitivity – Reynolds Number - Barometric and tidal efficiency of aquifers – Ground water flow- Groundwater flow direction –Unsaturated flow –Steady and unsteady state flow. | 12 | CO2 |
| **UNIT** III | **Water wells:** Types of wells - Well hydraulics – Cone of depression, radius of influence, drawdown and specific capacity - Drilling of shallow wells and deep wells – Well Completion – Well development – Testing wells for yield- Protection and rehabilitation of well- Collector wells and Infiltration galleries - Tracer tests and slug tests - Ground water budgeting – Ground water levels and water level maps – Safe yield and Conjunctive uses – Artificial recharge and methods. | 12 | CO2 |
| **UNIT** IV | **Groundwater Quality and Pollution:** Chemical constituents in groundwater: sources and effects - Quality criteria for different uses -Geochemical cycle of surface water and ground water- Graphical presentation of groundwater quality data- Dissolved gases in groundwater- Impact of solar energy on groundwater – Sources and causes for pollution of groundwater – Pollution attenuation – Treatment for contaminated groundwater. | 12 | CO2 |
| **UNIT** V | **Exploration techniques and Saline water intrusion:** Methods for exploration of ground water – Geological methods, Remote Sensing techniques, geomorphological inputs, gravity, magnetic, seismic and electrical methods – Basics of ground water modeling – Physical, analog and mathematical models, finite difference modeling –Hydrogeology of arid zones of India – Hydrogeology of wetlands. Hydrodynamic equilibrium of fresh and saline water – Ghyben-Herzberg relation- Control of saline water intrusion. | 12 | CO2 |

| Reference Books | |
|---|---|
| 1. | Anderson, M. P., & Woessner, W. W. (1992). *Applied Groundwater Modeling*. Academic Press. |
| 2. | Davis, S. N., &DeWeist, R. J. **(**1966). *Geohydrology*. John Wiley & Sons, New York. |
| 3. | De Marsily, G**.** (1986). *Quantitative Hydrogeology: Groundwater Hydrology for Engineers*. Academic Press, Inc., Orlando, Florida. |
| 4. | Domenico, P. A., & Schwartz, W. (1998). *Physical and Chemical Hydrogeology* (2nd ed.). Wiley. |
| 5. | Driscoll, F. (1986). *Groundwater and Wells*. US Filter / Johnson Screens. |
| 6. | Fetter, C. W. (2018). *Applied Hydrogeology* (4th ed.). Waveland Press. |
| 7. | Freeze, R. A., & Cherry, J. A. (1979). *Groundwater*. Prentice-Hall, London. |
| 8. | LaMoreaux, P. E., & Tanner, J. T**.** (Eds.). (2001). *Springs and Bottled Water of the World: Ancient History, Source, Occurrence, Quality and Use*. Springer-Verlag. |
| 9. | Porges, R. E., & Hammer, M. J. (2001). *The Compendium of Hydrogeology*. National Ground Water Association. |
| 10. | Todd, D. K., & Mays, L. W. (2013). *Groundwater Hydrology*. John Wiley & Sons, New York. |

| Web Resources | |
|---|---|
| 1. | https://iah.org/ |
| 2. | http://www.groundwateruk.org/ |
| 3. | https://gw-project.org/books/groundwater-resource-development. |
| 4. | https://www.epa.gov/dwreginfo/drinking-water-regulations. |
| 5. | https://www.guidelinegeo.com/groundwater-prospection |

**Course Outcome:**

CO1: This study helps to understand the Hydrological cycle, Aquifer; flow rates and flow directions, Groundwater fluctuation: types, controlling factors

CO2: Occurrence and movement of Groundwater

CO3: Groundwater wells, types and methods

CO4: Groundwater chemistry: Components of groundwaterpollution: Arsenic,fluoride and Nitrate

CO5: Salinity in Groundwater, Seawater intrusion and Ghyben-Herzberg Relation

**Mapping with Programme Outcomes:**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 2** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 3** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 4** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 5** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |

- **Remember and Understanding – Lower level (1)**
- **Apply and Analyze – Medium Level (2)**
- **Evaluate and Create – Strong Level (3)**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE4S1** | **OCEANOGRAPHY AND CLIMATOLOGY** | SEC - III | Y | T | - | - | 2 | 4 | 25 | 75 | 100 |

| **Course objectives** | |
|---|---|
| CO 1 | To learn the physical and chemical components and phenomena related to oceanography and climatology |
| CO 2 | To understand the morphologic and tectonic domains of the ocean floor |
| CO 3 | To compare and contrast cloud physics and physical meteorology |
| CO 4 | To critically assess the ocean current patterns and cloud-climate classifications |
| CO 5 | To differentiate and understand the different oceanic currents |

| UNIT | Details | No. of Hours | Course objectives |
|---|---|---|---|
| **UNIT** I | Oceans and Atmosphere: Hypsography of the continents and ocean floor –continental shelf, slope, rise and abyssal plains. Physical and chemical properties of sea water and their spatial variations. Residence times of elements in sea water. Ocean currents, waves and tides, important current systems, thermohaline circulation and the oceanic conveyor belt. Major water masses of the world's oceans. Biological productivity in the oceans. | 12 | CO1 |
| **UNIT** II | Structure and chemical composition of the atmosphere, lapse rate and stability, scale height, geopotential, greenhouse gases and global warming. Cloud formation and precipitation processes, heat budget, radiation balance. El Nino Southern Oscillation (ENSO). General weather systems of India, - Monsoon system, cyclone and jet stream, Western disturbances and severe local convective systems, distribution of precipitation over India. Marine and atmospheric pollution, ozone depletion. | 12 | CO2 |
| **UNIT** III | Morphologic and tectonic domains of the ocean floor. Structure, composition and mechanism of the formation of oceanic crust. Hydrothermal vents-. Ocean margins and their significance. Ocean Circulation, Coriolis Effect and Ekman spiral, convergence, divergence and upwelling, El Nino – La Nina, Indian Ocean Dipole Thermohaline circulation and oceanic conveyor belt. | 12 | CO3 |
| **UNIT** IV | Physical Meteorology: Thermal structure of the atmosphere and its composition. Radiation: basic Laws - Rayleigh and Mie scattering, multiple scattering, radiation from the sun, solar constant, effect of clouds, surface and planetary albedo. Emission and absorption of terrestrial radiation, radiation windows, radiative transfer, Greenhouse effect, net radiation budget; Clausius – Clapeyron equation. | 12 | CO4 |
| **UNIT** V | Cloud Physics: Cloud classification, condensation nuclei, growth of cloud drops and ice-crystals, precipitation mechanisms: Bergeron, Findeisen process, coalescence process. Atmospheric turbulence: Mixing length theory, planetary boundary layer equations, surface layer, Ekman layer, eddy transport of heat. Richardson criterion. | 12 | CO5 |

| Reference Books | |
|---|---|
| 1. | Benjamin Franklin. (Year). Sundry Maritime Observations. Retrieved from source. |
| 2. | Boling Guo, D., & Huang, D. (2014). Infinite-Dimensional Dynamical Systems in Atmospheric and Oceanic Science. World Scientific Publishing. ISBN 978-981-4590-37-2. |
| 3. | Hamblin, J. D. (2005). Oceanographers and the Cold War: Disciples of Marine Science. University of Washington Press. ISBN 978-0-295-98482-7. |
| 4. | Kennett, J. P. (1982). Marine Geology. Prentice Hall, London. |
| 5. | Lang, M. A., Macintyre, I. G., &Rützler, K. (Eds.). (2009). Proceedings of the Smithsonian Marine Science Symposium. Smithsonian Contributions to the Marine Sciences, No. 38. Washington, D.C.: Smithsonian Institution Scholarly Press. |
| 6. | Rice, A. L. (1999). The Challenger Expedition. In M. Deacon, T. Rice, C. Summerhayes (Eds.), Understanding the Oceans: Marine Science in the Wake of HMS Challenger (pp. xx-xx). Routledge. |
| 7. | Roorda, E. P. (Ed.). (2020). The Ocean Reader: History, Culture, Politics. Duke University Press. URL |
| 8. | Seibold, E., & Berger, W. H. (1982). The Sea Floor. Springer Verlag, Berlin. |
| 9. | Sverdrup, H. U., Johnson, M. W., & Fleming, R. H. (1942). The Oceans, Their Physics, Chemistry, and General Biology. New York: Prentice-Hall. |
| 10. | Strahler, A. N. (1974). Physical Geography (4th ed.). John Wiley & Sons, New York. |
| **Web Resources** | |
| 1. | https://en.wikipedia.org/wiki/British_Oceanographic_Data_Centre |
| 2. | https://psl.noaa.gov/data/gridded/tables/ocean.html |
| 3. | http://www.vega.org.uk/video/ |
| 4. | https://unesdoc.unesco.org/ark:/48223/pf0000030893 |
| 5. | http://www.mcirano.ufba.br/ftp/books/baum_04.pdf |

**Course Outcome:**

CO1: Students learn about physical and chemical properties of sea water
CO2: Students learn about the structure and chemical composition of the atmosphere
CO3:Students gain knowledge on morphology and tectonics of the ocean floor
CO4: Students will be introduced to physical meteorology
CO5: Students gain knowledge on cloud physics

**Mapping with Programme Outcomes:**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 2** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 3** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 4** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |
| **CO 5** | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 2 |

- **Remember and Understanding – Lower level (1)**
- **Apply and Analyze – Medium Level (2)**
- **Evaluate and Create – Strong Level (3)**

| Subject Code | Subject Name | Category | L | T | P | O | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23MGE4FT/ 23MEA4** | **GEOLOGICAL FIELD TRAINING / EXTENSION ACTIVITY** | | Y | - | - | - | 2 | - | 25 | 75 | 100 |

| | |
|---|---|
| **Course objectives** | To study the mode of occurrence of mineral deposits in various mines across the country.<br>To comprehend various mining methods being adopted in the country.<br>To interpret the occurrence of mineral resources and their relationship with various geological processes.<br>To acquire practical knowledge through field/industry visits and interaction with subject/technical experts.<br>To evaluate the importance of various mineral exploration techniques. |
| | **Details** |
| | Geological field training should be conducted for a minimum of 14 and a maximum of 21 working days under the guidance of teachers during the first or final year of the course. Fieldwork includes study of Geology in natural set up and collection of samples/specimens. Students can be taken to open cast and underground mines and other sites of Geological interests in any parts of India. Students can also be taken to National laboratories like NIO-Goa, NGRI-Hyderabad, NRSA-Hyderabad, BSIP-Lucknow, PRL, SAC-Ahmedabad, CIMFR-Dhanbad, ISRO- Bangalore and similar such institutes in any parts of India.<br>Each student at the end of the field programme has to submit a 'geological filed report' along with the samples/specimens collectedfor an assessment and award of marks by internal and external examiners. |
| **Course outcomes** | Geological fieldwork provides a first-hand experience in the geosciences. Students develop practical skills and deepen their understanding of Earth, its processes and products. Students learn how to collect data directly from the field, including rock samples, fossils, and other relevant materials. They learn how to measure and describe the sections of geological formations accurately. By examining rock formations, faults, folds, and other structures, students gain insights into the Earth's history and tectonic processes. Students learn how to read and use the geological maps effectively during fieldwork. Fieldwork challenges students to solve real-world geologic problems. They learn to apply their knowledge to identify patterns, make connections, and draw conclusions based on field observations. Many field experiences involve group work. Students learn to collaborate with peers, share responsibilities, and communicate effectively while conducting field investigations. Fieldwork emphasizes safety protocols, risk assessment, and emergency procedures. Students learn to navigate hazards such as steep slopes, weather conditions, and wildlife. Fieldwork integrates various investigative approaches (theoretical, analytical, experimental, and modelling). Students learn to apply information from multiple sources to interpret natural phenomena. |