**ANNAMALAI**  **UNIVERSITY**

**Affiliated Colleges**

**407. M.Sc. Geology**

Programme Structure and Scheme of Examination for affiliated Colleges (under CBCS)

(Applicable to the candidates admitted from the academic year 2023 -2024 onwards)

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **Part** | **Subject Code** | **Study Components & Course Title** | **Credit** | **Hours/ Week** | **Maximum Marks** | | |
| **CIA** | **ESE** | **Total** |
|  |  | SEMESTER – I |  |  |  |  |  |
| Part A | 23PGEOC11 | Core – I Physical Geology and Geomorphology | 5 | 7 | 25 | 75 | 100 |
| 23PGEOC12 | Core – II Mineralogy and Instrumentation Techniques | 5 | 7 | 25 | 75 | 100 |
| 23PGEOP13 | Core – III Mineralogy and Paleontology Practical | 4 | 6 | 25 | 75 | 100 |
| 23PGEOE14 | Elective – I  Stratigraphy of India and its Applications | 3 | 5 | 25 | 75 | 100 |
| 23PGEOE15 | Elective – II  Recent Trends in Paleontology | 3 | 5 | 25 | 75 | 100 |
|  |  | **Total** | **20** | **30** |  |  | **500** |
|  |  | SEMESTER – II |  |  |  |  |  |
| Part A | 23PGEOC21 | Core – IV Structural Geology and Geotectonics | 5 | 6 | 25 | 75 | 100 |
| 23PGEOC22 | Core – V Applied Remote Sensing and GIS | 5 | 6 | 25 | 75 | 100 |
| 23PGEOP23 | Core – VI Structural Geology and Geotectonics Practical and                   Petrology Practical | 4 | 6 | 25 | 75 | 100 |
| 23PGEOE24 | Elective – III  Applied Petrology | 3 | 4 | 25 | 75 | 100 |
| 23PGEOE25 | Elective – IV  Environmental Earth Science | 3 | 4 | 25 | 75 | 100 |
| Part B | 23PGEOS26 | Skill Enhancement Course [SEC] -1 Introduction to Geological software | 2 | 4 | 25 | 75 | 100 |
|  |  | **Total** | **22** | **30** |  |  | **600** |

**Course, Hours, Credits Index**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Part** | **Semester** | **Title of the Course** | **C/E/S** | **Credits** | **Hours** | **Marks** | | |
|  |  |  |  |  |  | **CIA** | **External** | **Total** |
| C | **SEMESTER I** | Physical Geology and Geomorphology | C | 5 | 7 | 25 | 75 | 100 |
| C | Mineralogy and Instrumentation Techniques | C | 5 | 7 | 25 | 75 | 100 |
| C | Mineralogy and Paleontology Practical | C | 4 | 6 | 25 | 75 | 100 |
| E | Elective Paper I – Stratigraphy of India and its Application (Mandatory) | E | 3 | 5 | 25 | 75 | 100 |
| E | Elective Paper II – Recent Trends in Paleontology (Optional) | E | 3 | 5 | 25 | 75 | 100 |
|  |  | **Total** |  | **20** | **30** |  |  |  |
| C | **SEMESTER II** | Structural Geology and Geotectonics | C | 5 | 6 | 25 | 75 | 100 |
| C | Applied Remote Sensing and GIS | C | 5 | 6 | 25 | 75 | 100 |
| C | Structural Geology and Geotectonics Practical and  Petrology Practical | C | 4 | 6 | 25 | 75 | 100 |
| E | Elective Paper III – Applied Petrology (Mandatory) | E | 3 | 4 | 25 | 75 | 100 |
| E | Elective Paper IV – Environmental Earth Science  (Optional) | E | 3 | 4 | 25 | 75 | 100 |
| S | Skill Enhancement Course [SEC] | S | 2 | 4 | 25 | 75 | 100 |
|  |  | **Total** |  | **22** | **30** |  |  |  |

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| **23PGEOC11** | **CORE COURSE - I**  **23PGEOC11 - Physical Geology and Geomorphology** | **H** | **C** |
| **Semester-1** | **7** | **5** |

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| **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. | | |
| **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. | |
|
| **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. | |
| **UNIT**III  Geomorphic Processes – weathering, pedogenesis, mass movement, erosion, transportation and deposition. | |
| **UNIT**IV  Geomorphic landforms – fluvial, glacial, Aeolian, coastal, volcanoes and karst. | |
| **UNIT**V  Quaternary landscapes. Fluvial landscapes, Aeolian landscapes, coastal landscapes. | |
| **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 | RicharHuggett, Fundamentals of Geomorphology | |
| 5 | Strahler, A.N. (1952) Physical Geology. John Wiley & Sons Inc., New York. | |

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| **References Books**  **(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. | RicharHuggett, 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:**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **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**

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| **23PGEOC12** | **CORE COURSE - II**  **23PGEOC12 - Mineralogy and Instrumentation Techniques** | **H** | **C** |
| **Semester-1** | **7** | **5** |

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| **Course Objectives** | | | |
| The students will be able to understand and explain the basic of mineral characteristics.  Will be able to employ their practical knowledge in further studies.  Can recall techniques for certain necessities.  Can evaluate the accuracy and summaries the methods adapted for certain practical activities.  Can explain and summarise problem. | | | |
|  | **Details** | |
| **UNIT** I  Introduction to crystallography – Crystal systems – Symmetry elements – Isometric, Tetragonal, Orthorhombic, Hexagonal, Monoclinic and Triclinic systems – Normal classes. | | |
| **UNIT** II  Stereographic projections – Axial ratio – Zones and zonal symbols – Tautozonal faces – Equation of the normal – Napier’s Theorem – Tangent relations – Sine ratio – Cosine ratio. | | |
| **UNIT**III  Description and composition of the following mineral groups: Quartz, Feldspars, Feldspathoids, Micas, Garnets, Olivine, Pyroxenes, Amphiboles, Zeolites and Carbonate minerals. | | |
| **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. | | |
| **UNIT** V  Spot tests – Paper chromatography – Nephelometry – Turbidimetry – Spectroscopy – Flame photometry – X-ray spectroscopy – UV spectroscopy – Mass spectroscopy – Accelerated mass spectroscopy. | | |
| **Text Books** | | |
| 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](https://en.wikipedia.org/wiki/ISBN_(identifier)) [9780124167100](https://en.wikipedia.org/wiki/Special:BookSources/9780124167100). |

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| **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](https://en.wikipedia.org/wiki/ISBN_(identifier)) [9781316425282](https://en.wikipedia.org/wiki/Special:BookSources/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](https://en.wikipedia.org/wiki/ISBN_(identifier)) [9781108019262](https://en.wikipedia.org/wiki/Special:BookSources/9781108019262). |
| 5. | Laudan, Rachel (1993). From mineralogy to geology : the foundations of a science, 1650-1830 (Pbk. ed.). Chicago: University of Chicago Press. [ISBN](https://en.wikipedia.org/wiki/ISBN_(identifier)) [9780226469478](https://en.wikipedia.org/wiki/Special:BookSources/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: Basic knowledge on crystal structures and bonding and laws

CO2: student can learn about the Silicate structures and their physical and chemical properties

CO3: students get knowledge about the description and composition the minerals

CO4: Student gain knowledge on Optical mineralogical studies

CO5: student 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**

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|  | **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.**

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| **23PGEOP13** | **CORE COURSE - III**  **23PGEOP13 - Mineralogy and Paleontology Practical** | **H** | **C** |
| **Semester-1** | **6** | **4** |

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| **Course Objectives** |
| To identify minerals in hand specimens.  To learn the optical properties of minerals through microscopes.  To determine the three dimensional & visualization of crystals.  To identify pre historic species.  Able to understand the evolution of organism in different periods. |

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| Mineralogy: | 1. Megascopic identification of: Quartz, Feldspar – Orthoclase & Plagioclase, Pyroxene, Amphibole, Mica, Tourmaline, Topaz, Beryl, Zircon, Rutile, Apatite, Calcite, Gypsum. Metamorphic minerals: Garnet, Cordierite, Kyanite, Sillimanite, Andalusite, Sphene, Staurolite, Chondrodite. 2. Microscopic study of: Quartz, Feldspar – Orthoclase & Plagioclase, Pyroxene, Amphibole and other accessory minerals. 3. Optical experiments: 4. Determination of plagioclase orientation in thin section and its Anorthite content from extinction angle measurements. 5. Birefringence of minerals-using Berek compensator. 6. Pleochroic scheme 7. 2V by Mallards method, 8. Optic signs of uniaxial and biaxial minerals. 9. Calculation of molecular and structural formulae of some important minerals. 10. Stereographic projections of crystals of Isometric, Tetragonal, Hexagonal, Orthorhombic, Monoclinic and Triclinic system. Calculation of axial ratios, miller indices of faces application of Weiss zone law, Tangent relationships, Napier's rule, law of anharmonic ratio and equation to normal. |
| **Paleontology:** | 1. **Mollusca: Pelecypoda** - Arca, Glycimeris (Pectenculus) Inoceramus, Ostrea, Alectryonia, Pecten, Spondylus, Trigonia, Pholadomya, Cardita, Hippurites, Cardium, Venus, Unio, Megalodon, Meretrix, Gryphaea, Exogyra. 2. **Gastropoda:-** Natica, Trochus, Turbo, Turritella, Fusus, Conus, Murex, Physa, Busycon 3. **Cephalopoda:** Natilus, Goniatites, Ceratities, Ammonite, Phyiloceras, Acanthoceras, Scaphites, Turrilites, Belemininites 4. **Brachiopoda:** Lingula, Orthis, Productus, Pentamerus, Rhynoconella, Terebratula, Atrypa, Spirifer and Athyris. 5. **Echinoidea:** Cidaris, Hemicidaris, Stigmatophygus, Holaster, Hemiaster, Micraster. 6. **Echinodermata :Crinoids;** Encrinus, Marsupites 7. **Blastoidea:** Pentremites 8. **Arthropoda: Trilobita**; Paradoxides, Olinus, Ollenellus, Calymene, Phacops 9. **Hemichordate: Graptoloidea;** Tetragraptus, didymograptus, Phyllograptus, Diplograptus, Monograptus, Rastites 10. **Plant fossils:** Calamites, Sphenophyllym, lepidodendron, Sigillaria, Glossopteris, Gangamopteris, Gondwanadium, Ptilophyllum. |
| Reading List (Print and Online) | 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. |
| Recommended Texts | 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. |

**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 |

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| **23PGEOE14** | **Elective – I**  **23PGEOE14 - Stratigraphy of India and its Applications** | **H** | **C** |
| **Semester-1** | **5** | **3** |

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| **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. | |
| **UNIT**I  **Stratigraphy of India –**DharwarSupergroup – 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. | | |
| **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. | | |
| **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. | | |
| **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 – 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. | | |
|  | **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**  **(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 DharwarSupergroup – 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**

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|  | **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.**

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| **23PGEOE15** | **Elective - II**  **23PGEOE15 - Recent Trends in Paleontology** | **H** | **C** |
| **Semester-1** | **5** | **3** |

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| **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. |

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| **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. | | |
| **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. | | |
| **UNIT**III  Vertebrate paleontology: 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. | | |
| **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. | | |
| **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. | | |
|  | **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**  **(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, 4thEdt. 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.**

|  |  |  |  |
| --- | --- | --- | --- |
| **23PGEOC21** | **CORE COURSE – IV**  **23PGEOC21 - Structural Geology and Geotectonics** | **H** | **C** |
| **Semester-2** | **6** | **5** |

**Semester- II: Structural Geology and Geotectonics (Ist year)**

|  |  |  |
| --- | --- | --- |
| **Course Objectives**  The student can interpret and evaluate different structures that exist in the earth.  Can critically assess and review the energy needed to cause different structures.  Can describe and explain major and minor structures.  Can understand to compare and contrast structures related to each other.  Can evaluate and explain the causes of different structures. | | |
| **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. | |
| **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. | |
| **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. | |
| **Unit IV**  Major tectonic features and associated structures in extensional-, compressional-, and strike-slip terrains – Joints and unconformities – Penecontemporaneous deformational structures of sedimentary rocks. Plate tectonics – Concept and principles – Continental drift – Geological and geophysical evidences – Mechanics, objections and present status of plate tectonics. | |
| **Unit V**  Gravity and magnetic anomalies at mid-oceanic ridges, deep sea trenches, continental shield areas and mountain chains – Geological and geophysical characteristics of plate boundaries – Geodynamic evolution of the Himalayas – Paleomagnetism – Sea floor spreading and plate tectonics – Island arcs, oceanic islands and volcanic arcs – Isostasy, orogeny and epeirogeny – Geodynamic of the Indian Plate. | |
|  | **Text Books**  **(Latest Editions)** | |
| 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](http://globalchange.umich.edu/ben/ES/earthstructure.htm) (2nd ed.). New York: [W. W. Norton](https://en.wikipedia.org/wiki/W._W._Norton). p. 656. [ISBN](https://en.wikipedia.org/wiki/ISBN_(identifier)) [0-393-92467-X](https://en.wikipedia.org/wiki/Special:BookSources/0-393-92467-X). | | |
| **References Books**  **(Latest editions, and the style as given below must be strictly adhered to)** | | |
| 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](https://en.wikipedia.org/wiki/John_Wiley_%26_Sons). [ISBN](https://en.wikipedia.org/wiki/ISBN_(identifier)) [0-471-52621-5](https://en.wikipedia.org/wiki/Special:BookSources/0-471-52621-5).  5.C.W. Passchier and R.A.J. Trouw (1998). Microtectonics. Berlin: [Springer](https://en.wikipedia.org/wiki/Springer_Science%2BBusiness_Media). [ISBN](https://en.wikipedia.org/wiki/ISBN_(identifier)) [3-540-58713-6](https://en.wikipedia.org/wiki/Special:BookSources/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.**

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| **23PGEOC22** | **CORE COURSE - V**  **23PGEOC22 - Applied Remote Sensing and GIS** | **H** | **C** |
| **Semester-2** | **6** | **5** |

**SEMESTER-II: Applied Remote Sensing and GIS (Ist Year)**

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| **Course Objectives**  Understand the basics of remote sensing, electromagnetic radiation (EMR) and its properties, aerial photography and to list the important merits of these technology tools.  Students will comprehend the core part of remote sensing i.e. spectral properties of earth objects, interaction of EMR with the atmosphere and the acquisition of data by different satellite sensors including the generate of False Color Composite (FCC) imagery.  Based on the understanding of the basics, the students are expected to do thorough interpretation of aerial photographs and FCC imagery for the preparation of various thematic maps.  Acquiring advanced skills on the aspects of digital image processing and the Spatial Information Technology tools, the students are expected to do quantitative analysis on change detection, monitoring of resources etc.  Evaluate the importance of these technology tools over conventional techniques and its way forward. | |
| Unit I  Fundamentals of remote sensing: History of remote sensing technology – Remote sensing system – Electromagnetic radiation – Spectral properties of terrestrial objects – Analysis of spectral reflectance curves – Types of satellites – Image acquisition – Multi-spectral scanners – Remote sensing resolution – Introduction to thermal remote sensing – Introduction to microwave remote sensing and new satellite sensors – Remote sensing in landform and land use mapping, structural mapping, coastal and ocean studies – Global and Indian space missions. | | |
| Unit II  Aerial photography: Introduction – Vertical and oblique photographs – Photoscale – Image displacement due to relief – Parallax in aerial photographs – Aerial photographic procedures – Camera and flight requirement – Flight planning – Filters – Compensation – Stereoscopy – Photomosaics. Photographical studies – Photo recognition elements and keys – Interpretation of lithology, structures and landforms from aerial photographs. | | |
| Unit III  Image processing in remote sensing: Digital data recording – Digital data format. Introduction to digital image processing – Pre-processing techniques – Image classification methods – Image enhancement techniques. | | |
| Unit IV  Applications of remote sensing: Visual interpretation – Different sensors – Data and image interpretation key elements. Exercises on mapping of geology – Land use/land cover and geomorphology based on visual method – Preparation of base maps and transformation of thematic maps. Validation of remote sensing analysis output by ground truth – Accuracy, estimation and introduction to GPS technology. | | |
| Unit V  Fundamentals and application of GIS: Concept of GIS – GIS types – Data storage – Retrieval and analysis. GIS database organization and development – Combined use of remote sensing and GIS. Preparation of spatial decision support system (SDSS).Highlights on different applications using GIS tool with particular reference to Applied Geosciences and Ocean Science. | | |
|  | **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.](https://en.wikipedia.org/wiki/Nicola_Masini) 2012: Satellite Remote Sensing - A new tool for Archaeology. Remote Sensing and Digital Image Processing Series, Volume 16, 364 pp., [ISBN](https://en.wikipedia.org/wiki/ISBN_(identifier)) [978-90-481-8801-7](https://en.wikipedia.org/wiki/Special:BookSources/978-90-481-8801-7). | |
| **References Books**  **(Latest editions, and the style as given below must be strictly adhered to)** | |
| 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](https://en.wikipedia.org/wiki/ISBN_(identifier)) [978-1-57230-640-0](https://en.wikipedia.org/wiki/Special:BookSources/978-1-57230-640-0).  4.Jensen, J. R. (2007). Remote sensing of the environment: an Earth resource perspective (2nd ed.). Prentice Hall. [ISBN](https://en.wikipedia.org/wiki/ISBN_(identifier)) [978-0-13-188950-7](https://en.wikipedia.org/wiki/Special:BookSources/978-0-13-188950-7).  5.Richards, J. A.; X. Jia (2006). Remote sensing digital image analysis: an introduction (4th ed.). Springer. [ISBN](https://en.wikipedia.org/wiki/ISBN_(identifier)) [978-3-540-25128-6](https://en.wikipedia.org/wiki/Special:BookSources/978-3-540-25128-6). | |
| **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: To gain the basic concept of remote sensing

CO2: Students study the Photogeology

CO3: Student get knowledge on Image processing in remote sensing

CO4: Students learn about the Applications of remote sensing

CO5: Students gain knowledge on Fundamentals and application of GIS

**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.**

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| **23PGEOC23** | **CORE COURSE - VI**  **23PGEOC23 - Structural Geology and Geotectonics Practical and Petrology Practical** | **H** | **C** |
| **Semester-2** | **6** | **4** |

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| **Course Objectives**  To preparation and analysis of structure contour maps and isopachs.  To Interpretation of geological maps.  To know the modal analyses of rocks.  Megascopic and microscopic identification rocks.  To learn Thin sections preparation techniques. | | |
| **Structural Geology and Geotectonics Practical**  Determination of attitude of beds – Geometrical, graphical and trigonometric projections – Tabular and nomograph methods. Reconstruction of parallel fold and fault – Preparation and analysis of structure contour map – Isopachs. Construction of perpendicular and vertical sections of plunging fold. | |
| Geochronology – Pi and beta diagrams – Structural complex. Depth to strata – True thickness of beds - Interpretation of geological maps involving normally dipping beds, bore well data. Interpretation of geological maps involving symmetrical and asymmetrical fold, isoclinal fold, recumbent fold, plunging fold, strike fault and step fault. | |
| **Petrology Practical**  Megascopic and microscopic study (textural and mineralogical) of the following igneous rocks: Granite, Syenite, Gabbro, Basalt, Peridotite, Pyroxenite, Dunite. Lamprophyres, Dolerite, Phonolite, Rhyolite, Trachyte, Andesite, Pitchstone, Anorthosite, Aplite, Pegmatite. Introduction to modal analyses of Granite, Basalt and Gabbro. | |
| Megascopic and microscopic study (textural and mineralogical) of the following metamorphic rocks: Low grade metamorphic rocks: serpentinites, albite-epidote-chlorite-quartz schist, slate, talc-tremolite-calcite-quartz schist. Medium to high grade metamorphic rocks: Gneisses, amphibolite, hornfels, garnetiferous schists, sillimanite-kyanite-bearing rocks, Granulites, eclogite, diopside-forsterite marble. Laboratory exercises in graphic plots for petrochemistry and interpretation of paragenetic diagrams. | |
| Megascopic and microscopic study (textural and mineralogical) of the following Sedimentary rocks: Sand stone, Lime stone, Conglomerate, Arkose, mud rocks. | |
| Preparation of Thin sections – Grain size analysis – Statistical parameters in Sedimentology – Frequency and cumulative frequency distribution curves – Moment and graphic measures – Gravel analysis. | |
|  | **Text books** | |
| 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**  **(Latest editions, and the style as given below must be strictly adhered to)** | | |
| 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 | | |
| **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 gain knowledge on find out the true thickness and vertical thickness of beds

CO5: Interpretation of geological maps

**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.**

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| **23PGEOE24** | **Elective – III**  **23PGEOC24 - Applied Petrology** | **H** | **C** |
| **Semester-2** | **4** | **3** |

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| **Course Objectives**  Understanding the basics of the Earth as a System.  To analyze various magmatic compositions to understand the formation of various igneous rocks.  To comprehend the genesis of metamorphic rocks.  To understand the formation of sedimentary rocks, their depositional environments and provenance  Understanding the complete system of the Earth | |
| **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. | | |
| **UNIT** II  Silicate melts 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. | | |
| **UNIT** III  Basic Concepts of Metamorphic Petrology – Types of metamorphism – agents of metamorphism – Zones and grades. Facies concept of metamorphism. Graphical Representation of metamorphic paragenesis. Petrogenesis of important metamorphic rocks – charnockite – eclogite – amphibolite – migmatites – Khondalites – metamorphic belts Textures and structures of metamorphic rocks. Regional and contact metamorphism of pelitic and impure calcareous rocks. Mineral assemblages and P/T conditions.Experimental and thermodynamic appraisal of metamorphic reactions.Characteristics of different grades and facies of metamorphism. Metasomatism and granitization, migmatites.Plate tectonics and metamorphic zones.Paired metamorphic belts. Mineral reactions with condensed phases,solid solutions, mixed volatile equilibria and thermobarometry. | | |
| **UNIT** IV  Earth Surface System: Liberation and flux of sediments, Processes of transport and generation of sedimentary structures, Control on the sedimentary record, Cyclic Sediments, – Classification of sedimentary rocks – Definition, measurements and interpretation of grain size. Evolution of Sedimentary Basins: Classification and definition of Sedimentary basins, Tectonics and Sedimentation – Plate tectonic concepts – Sedimentary basins of India – Paleocurrent and Basin analysis – Provenance and Diagenesis of sediments. | | |
| **UNIT** V  Sedimentary environments and facies, Continental alluvial – fluvial, lacustrine, desert – Eolian and Glacial sedimentary systems; Shallow Coastal Facies, Marine and Continental Evaporates; Shallow water Carbonates; Deep sea basins; Volcanoclasts Petrography of rocks of Clastic, Chemical and Biochemical origin, ClasticPetrofacies, Paleoclimate and Paleoenvironment analyses; Application of trace elements, Rare-earth elements and Stable isotope geochemistry to sedimentological problems. Depositional environments and systems. Paleocurrent analysis. | | |
|  | **Text Books** |
| 1.Philpotts, A., 1992, Igneous and Metamorphic Petrology, Prentice Hall.  2.Turner,F.J., 1980, Metamorphic Petrology, McGraw Hill., New York.  3.Best M.G,IgneousPetrology.Wiley.NewDelhi(2005)  4.Hatch,F.H. et al,Petrology of the Igneous Rooks, CBSDelhi.  5.Hyndman D.W, Petrology of the Igneous and Metamorphic Rocks McGrawHill.NewYork(1985) | |
| **References Books**  **(Latest editions, and the style as given below must be strictly adhered to)** | |
| 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**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **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.**

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| **23PGEOE25** | **Elective – IV**  **23PGEOE25 - Environmental Earth Science** | **H** | **C** |
| **Semester-2** | **4** | **3** |

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| --- | --- | --- |
| **Course Objectives** | | |
| To identify knowledge on various types of environmental issues in relation to the Earth as a System  To explain the various causes of pollution  To explain the various types of pollution  To select the remedial measures to be taken as an individual and a group  Understanding the dynamics of the Earth | | |
| **UNIT** I  Concept of environment – Environmental monitoring – Water as a resource, Water pollution – Point and non-point pollution sources – Ground water pollution. | |
| **UNIT** II  Air pollution – Natural and anthropogenic sources of air pollution – Primary and secondary air pollutants – Anthropogenic activities and air pollution – Indoor air quality – Biological sources of indoor pollution – Health effects – Air quality standards – Case histories – Air quality monitoring – Acid rain – Adverse effects of acid rain – Health effects – Mitigation measures – Roles and responsibilities. | |
| **UNIT** III  Smog – Mechanism of smog formation – Health disorders – Photochemical smog – Ozone and PAN formation – Health effects – Catalytic converters – Greenhouse gases and effect – Processes of removal of greenhouse gases. | |
| **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. | |
| **UNIT** V  Medical geology – Problems associated with fluoride, arsenic, asbestos, mercury, chromium,cadmium,zinc, copper and lead contamination – Alternate energy resources – Climate change. | |
|  | **Text Books** | |
| 1.Fair bridge, 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**  **(Latest editions, and the style as given below must be strictly adhered to)** | | |
| 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*. PragathiPrakasam, 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.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **23PGEOS26** | | **Skill Enhancement Course (SEC)**  **23PGEOS26 - Introduction to Geological software** | **H** | **C** |
| **Semester-2**  **Soft Skills** | | **4** | **2** |
| **Course Objectives**  To gain knowledge on various geological software  To practice with IGPET, WATEQ4F  To get hands on training with PHREEQC and MODFLOW  To apply geostistical software in data interpretation  To understand applications of the softwares used in the interpretation of the geological data | | | | |
| **UNIT** I  Interpretation and analysis of Geological data using MS- office, IGPET, WATEQ4F. | | | | | |
| **UNIT** II  Applications, Principles of data input, processing, interpretation in software like PHREEQC and MODFLOW. | | | | | |
| **UNIT** III  ARCGIS, Mapinfo for spatial analysis and integration of complex geological and geophysical data. ERDAS IMAGINE as image-processing tools for analyzing remotely sensed data. | | | | | |
| **UNIT** IV  Overview of geostatistical analysis using statistical package SPSS, Graphical analytical packages like Surfer and RockWorks for both 2-D surfaces | | | | | |
| **UNIT** V  Data Interpretation: Toposheets, Aerial photographs, Satellite imageries. Interpretation of Meteorology data: rainfall, temperature, wind, humidity; Interpretation of borehole logs, litho log, SP log, Resistivity log, Gamma log, neutron log. | | | | | |
|  | **Text Books**  **(Latest editions)** | | | |
| 1. Wen-Hsing Chaing & Wolgang Kinzelbach "User Manual for Processing MODFLOW", windows version 4.0,1996.  2. Sharon L. Qi, Jennifer B. Sieverling using ArcInfo to facilitate numerical modeling of ground  – water flow,1997.  3. Hill Mc(1992) MODFLOW – A computer program for estimating parameters of a transient, 3-D, Ground flow model using non linear regression, U.S. Geological Survey, open-file report – 91-484.  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**  **(Latest editions, and the style as given below must be strictly adhered to)** | | | | |
| 1. ERDAS: IMAGE 2018, Version 16.5(V 16.5.0.82)  2. PHREEQC Ver.1: Ground water & pollution, II Edition: A.A. Balkana. Publication, Leiden. The     Parkhurst,D.L.,1995,user’s guide to PHREEQC  3. Groundwater Assessment Development and Management, Karanth.K.R. (1987) Tata McGraw     Hill Publishing Company, Ltd. | | | | |
| **Web Resources** | | | | |
| 1.<https://en.wikipedia.org/wiki/Moral_agency>  2. <https://en.wikipedia.org/wiki/Moral_rights>  3. <https://en.wikipedia.org/wiki/Moral_skepticism>  4. [<https://www.nrlc.org/>](https://en.wikipedia.org/wiki/National_Right_to_Life_Committee)  5. <https://en.wikipedia.org/wiki/Haleigh_Poutre> | | | | |

**Course outcome**:

CO1: Gain the knowledge of computer softwares in geology

CO2: Gain the knowledge of applications and interpretation of computer software.

CO3: Students know various geological software

CO4: Students learn the rockworks and 2d software

CO5: Student get involved in system based analysis

**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** | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 3 | 3 |
| **CO 2** | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 3 | 3 |
| **CO 3** | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 3 | 3 |
| **CO 4** | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 3 | 3 |
| **CO 5** | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 3 | 3 |

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