தமிழ்நாடு மத்தியப் பல்கலைக்கழகம்

CENTRAL UNIVERSITY OF TAMIL NADU

तमिलनाडु केन्द्रीय विश्वविद्यालय

ESTABLISHED BY AN ACT OF PARLIAMENT IN 2009

# M.Sc. Geology Programme

# Curriculum Structure

## (Batch 2021-2023 Onwards)


## Department of Geology

## School of Earth Sciences,

## Central University of Tamil Nadu,

## Thiruvarur-610005,

**Email: hodgeology@cutn.ac.in**

# Table of Content

## A. Vision

To produce and sustain the conditions that enables the students to experience the transformative learning in becoming an independent and ideal learner through education of global standards. This would be achieved by maintaining high academic standards, sustaining the quality of scientific teaching and learning offered, and providing an intellectual, personal and social transformative experience to students.

## B. Mission

| | |
|---|---|
| **M1** | To provide student-centric learning environment through scientific and innovative pedagogy |
| **M2** | To create excellent infrastructure facilities and state-of-the-art laboratories |
| **M3** | To encourage research and industry-institute partnerships through collaborative activities for innovation and development |
| **M4** | To promote conferences/seminars/workshops/society development programs for creation of avenues for research exchange and knowledge enhancement in thrust areas |
| **M5** | To enhance leadership qualities, ethical and moral values, research culture and innovative skills among the students by offering high quality education and other services in a competitive manner |

## C. Program Educational Objectives (PEO)

*After two years of successful completion of the program, the student will be able to*

| | |
|---|---|
| **PEO1** | To provide knowledge in geology and their applications |
| **PEO2** | To develop analytical and logical aptitude amongst students to adapt quickly to new work environments, assimilate further information and problem-solving ability |
| **PEO3** | To provide exposure to new technologies to the students and motivate them to take new challenges |
| **PEO4** | To inculcate self-learning, discipline and leadership qualities to introduce them to a holistic approach of working in a team according to the codes of professional practice |
| **PEO5** | High level of technical competence in research that generates, communicates, and applies new knowledge for the betterment of society |

## D. Post-Graduate Attributes for M.Sc. Geology Program

1. **Disciplinary Knowledge:** Content and pedagogical knowledge synchronised with the curriculum frameworks of geology and its application
2. **Communication Skills:** Possess clarity in conveying the ideas
3. **Critical Thinking:** Capacity to apply analytical skills through theory and practical classes
4. **Problem Solving:** in resolving earth related issues.
5. **Co-operation:** Appreciate collaboration and cooperation among various organisations and industries.
6. **ICT Skills:** Selecting and integrating appropriate ICT skills for professional development.
7. **Ethics:** Doing what is right to society. Apply the knowledge of geoscience to identify the societal issue, e.g., Natural hazards, natural resources, etc., and sustainable development

## E. PEO to Mission Statement Mapping

| | PEO1 | PEO2 | PEO3 | PEO4 | PEO5 |
|---|---|---|---|---|---|
| M1 | ✓ | ✓ | ✓ | ✓ | ✓ |
| M2 | ✓ | ✓ | ✓ | ✓ | ✓ |
| M3 | ✓ | ✓ | ✓ | ✓ | ✓ |
| M4 | ✓ | ✓ | ✓ | ✓ | ✓ |
| M5 | ✓ | ✓ | ✓ | ✓ | ✓ |

## F. Program Outcomes (PO)

*On the successful completion of the program, the student will be able to* (for all courses)

| | |
|---|---|
| **PO1** | Become professional in the subject of Geology and apply the principles of the same to the needs of the Employer / Institution /Enterprise/ Society |
| **PO2** | Gain Analytical skills in the field/area of Geology |
| **PO3** | Able to identify, analyse, interpret geological data in multiple perspectives |
| **PO4** | Able to use skills and modern technical tools in the field of Geology |
| **PO5** | Able to work as an individual and as teams with cross-culture perspective with a potentially become leader with practical communication skills |
| **PO6** | Identify, formulate, research literature, and analyse complex problems reaching substantiated conclusions |

## G. PO to PEO Mapping

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| PEO1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| PEO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| PEO3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| PEO4 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| PEO5 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

## H. Programme Structure

| Semester | Courses | | Credits | | | Assessment | |
|---|---|---|---|---|---|---|---|
| | Code | Title | L | P | Total | CIA | ESE |
| | **First Year** | | | | | | |
| I | GLYCC01 | Physical Geology and Geomorphology | 3 | | 3 | 40 | 60 |
| I | GLYCC02 | Structural Geology and Tectonics | 3 | | 3 | 40 | 60 |
| I | GLYCC03 | Mineralogy and Crystallography | 4 | | 4 | 40 | 60 |
| I | GLYCC04 | Geochemistry | 3 | | 3 | 40 | 60 |
| I | GLYCC05 | Stratigraphy | 3 | | 3 | 40 | 60 |
| I | GLYCP01 | Structural Geology and Tectonics | | 2 | 2 | 100* | |
| I | GLYCP02 | Mineralogy, Crystallography and Geochemistry | | 3 | 3 | 100* | |
| I | GE | Generic Elective + | | | | | |
| | | | | **Total** | **21** | **700** | |
| II | GLYCC06 | Igneous and Metamorphic Petrology | 4 | | 4 | 40 | 60 |
| II | GLYCC07 | Sedimentology and Sequence Stratigraphy | 3 | | 3 | 40 | 60 |
| II | GLYCC08 | Palaeontology | 4 | | 4 | 40 | 60 |
| II | GLYCC09 | Remote Sensing and GIS | 4 | | 4 | 40 | 60 |
| II | GLYCP03 | Igneous and Metamorphic Petrology | | 2 | 2 | 100* | |
| II | GLYCP04 | Sedimentology and Paleontology | | 2 | 2 | 100* | |
| II | GLYCP05 | Remote Sensing and GIS | | 2 | 2 | 100* | |
| II | # | Discipline Specific Elective (DSE) | 3 | | 3 | 40 | 60 |
| | | | | **Total** | **24** | **800** | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Second Year** | | | | | | |
| III | GLYCC10 | Economic Geology and Ore Genesis | 3 | | 3 | 40 | 60 |
| III | GLYCC11 | Hydrogeology and Sustainable Development | 3 | | 3 | 40 | 60 |
| III | GLYCC12 | Engineering Geology | 3 | | 3 | 40 | 60 |
| III | GLYCC13 | Fuel Geology | 3 | | 3 | 40 | 60 |
| III | GLYCC14 | Exploration Geology | 3 | | 3 | 40 | 60 |
| III | GLYCP06 | Economic Geology and Fuel Geology | | 2 | 2 | 100* | |
| III | GLYCP07 | Hydrogeology and Engineering Geology | | 2 | 2 | 100* | |
| | | | | **Total** | **19** | **700** | |
| IV | GLYCC15 | Dissertation | | | 8 | 200 | |
| IV | GLYCP08 | Geological Field Study | | | 3 | 100** | |
| | | | | **Total** | **11** | **300** | |
| | | | | **Grand Total** | **75 +** | **2500 +** | |
| # DSE | GLYDSE01 | Oceanography and Marine Geology | 3 | | 3 | 40 | 60 |
| | GLYDSE02 | Geostatistics and Computer Applications in Geosciences | 3 | | 3 | 40 | 60 |
| | GLYDSE03 | Mining Geology | 3 | | 3 | 40 | 60 |
| | GLYDSE04 | Environmental Geology | 3 | | 3 | 40 | 60 |
| | GLYDSE05 | MOOC/ SWAYAM /NPTEL Course | | | 3 | 100 | |

| | |
|---|---|
| L: Lecture | P: Practical |
| CC: Core Course | CP: Core Practical |
| DSE: Discipline Specific Elective | GE: Generic Elective |
| CIA: Continuous Internal Assessment | ESE: End Semester Examination |
| *: Continuous Evaluation; | **: Field visit and Report |
| MOOC: Massive Open Online Course | + Students will opt from other departments |

# I. Common Evaluation Scheme for all the courses

- **Theory course with a credit of 3**

| | CO1 | CO2 | CO3 | Total |
|---|---|---|---|---|
| **Internal** | 14 | 13 | 13 | 40 |
| **External** | 20 | 20 | 20 | 60 |
| **Total** | **34** | **34** | **32** | **100** |

- **Theory course with a credit of 4**

| | CO1 | CO2 | CO3 | CO4 | Total |
|---|---|---|---|---|---|
| **Internal** | 10 | 10 | 10 | 10 | 40 |
| **External** | 15 | 15 | 15 | 15 | 60 |
| **Total** | **25** | **25** | **25** | **25** | **100** |

- **Practical course with a credit of 2**

| | CO1 | CO2 | Total |
|---|---|---|---|
| **Continuous Assessment** | 50 | 50 | 100 |
| **Total** | **50** | **50** | **100** |

- **Practical course with a credit of 3**

| | CO1 | CO2 | CO3 | Total |
|---|---|---|---|---|
| **Continuous Assessment** | 34 | 33 | 33 | 100 |
| **Total** | **34** | **33** | **33** | **100** |

## J. Mapping Course Outcome with Internal Assessment (40 Marks)

- **Theory course with a credit of 3**

| | CO1 | CO2 | CO3 |
|---|---|---|---|
| Assignments | 4 | 3 | 3 |
| Seminar | 4 | 4 | 4 |
| Test | 5 | 5 | 5 |
| Attendance | 1 | 1 | 1 |
| Total | 14 | 13 | 13 |

- **Theory course with a credit of 4**

| | CO1 | CO2 | CO3 | CO4 |
|---|---|---|---|---|
| Assignments | 2 | 2 | 2 | 2 |
| Seminar | 2 | 2 | 2 | 2 |
| Test | 5 | 5 | 5 | 5 |
| Attendance | 1 | 1 | 1 | 1 |
| Total | 10 | 10 | 10 | 10 |

- **Practical course with a credit of 2**

| | CO1 | CO2 |
|---|---|---|
| Laboratory Report/ Assignments | 30 | 30 |
| Viva | 15 | 15 |
| Attendance and Class Interaction | 5 | 5 |
| Total | 50 | 50 |

- **Practical course with a credit of 3**

| | CO1 | CO2 | CO3 |
|---|---|---|---|
| Laboratory Report/ Assignments | 20 | 20 | 20 |
| Viva | 10 | 10 | 10 |
| Attendance and Class Interaction | 4 | 3 | 3 |
| Total | 34 | 33 | 33 |

## K. Common Mapping CO with External Assessment (60 Marks)

- **Theory course with a credit of 3**

| Category | CO1 | CO2 | CO3 |
|---|---|---|---|
| Part – A (Objective - 10 x 1 = 10 marks) | 3 | 4 | 3 |
| Part – B (Short Answer - 5x 4 = 20 marks) | 8 | 4 | 8 |
| Part – C (Essay- 3 x 10 = 30 marks) | 10 | 10 | 10 |
| Total | **20** | **20** | **20** |

- **Theory course with a credit of 4**

| Category | CO1 | CO2 | CO3 | CO4 |
|---|---|---|---|---|
| Part – A (Objective - 10 x 1 = 10 marks) | 3 | 2 | 3 | 2 |
| Part – B (Short Answer - 5 x 4 = 20 marks) | 5 | 5 | 5 | 5 |
| Part – C (Essay- 3 x 10 = 30 marks) | 7 | 8 | 7 | 8 |
| Total | **15** | **15** | **15** | **15** |

## L. Common Rubric for Assignments

| Sl. No. | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Content 50%** | Ideas are detailed, well developed, supported with specific evidence & facts and examples | Ideas are detailed, Developed and supported with evidence and facts mostly specific. | Ideas are presented but not particularly developed or supported. | Content is not sound | Not attended | CO1, CO2, CO3 |
| 2 | **Organiza -tion 50%** | Includes title, introduction, statement of the main idea with illustration and conclusion. | Includes title, introduction, statement of main idea and conclusion. | organizational tools are weak or missing | No organization | Not attended | CO1, CO2, CO3 |

## M. Common Rubric for Seminar

| Sl. No | Criteria | 100% | 75% | 50% | 25% | 0% | Relation to COs |
|---|---|---|---|---|---|---|---|
| 1 | **Knowledge and Understanding 50%** | Exceptional knowledge of facts, terms and concepts | Detailed knowledge of facts, terms and concepts | Considerable knowledge of facts, terms and concepts | Minimal knowledge of facts, terms and concepts | Not Attended | CO1, CO2, CO3 |
| 2 | **Presentation 50%** | Well Communicated with logical sequences, examples and references | Communicated with sequences | Just Communicated | No coherent comunication | Not Attended | CO1, CO3 |

## N. Common Model Question Paper

**Part A** **[10 x 1= 10]**

(Objective type: multiple choice, fill in the blanks, one word answer)

*Answer **ALL** the questions. Each Question carries one mark.*

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

**Part B** **[4 x 5= 20]**

(Short answer type: answer should not exceed 200 words)

*Answer **ALL** the questions. Each Question carries five marks.*

11. (a) or (b)
12. (a) or (b)
13. (a) or (b)
14. (a) or (b)

**Part C** **[3 x 10 = 30]**

(Essay answer type: answer should not exceed 400 words)

*Answer **ALL** the questions. Each Question carries ten marks.*

15. (a) or (b)
16. (a) or (b)
17. (a) or (b)

# O. SEMESTER I

| SEMESTER - I | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLY CC01** | Physical Geology and Geomorphology | 3 | - | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | **Course Outcome** | **Level** |
|---|---|---|
| **CO1** | Understand the Earth processes and features | Understand |
| **CO2** | Analyze the geomorphological process and their characteristics | Analyze |
| **CO3** | Knowledge of geomorphology of India and application of geomorphology in various studies | Apply |

**b. Syllabus**

| **Units** | **Content** | **Hrs.** |
|---|---|---|
| **I** | Solar System; Origin of the Earth: Nebular Hypothesis, Planetesimal Hypothesis, Gaseous Tidal Hypothesis. Binary star Hypothesis; Age of the Earth: Direct and Indirect Methods; Interior of the Earth; The Atmosphere, Hydrosphere, Lithosphere and their Constituents; Fundamental Concepts of Geomorphology; Weathering: Physical weathering, Chemical Weathering, Biological Weathering; Soil Processes: Soil Profile, Climate and Soil Formation, Soil Types; Mass Wasting: Soil Creep and Solifluction, Earth and Mud Flows and Slides; Karst Topography and speleology, slope and catchment erosion processes; An elementary idea about morphogenesis and morphography; Morphometric analysis; Morphochronology, Neotectonics. Geological Time Scale; Geological Process: Exogenetic and Endogenetic processes; Earthquakes: Seismic waves, Origin, Classification and Causes of Earthquake, Earthquake Intensity and Magnitude Scale; Plate Tectonics: Continental Drift, Plates and plate boundaries, Plate Tectonics Model: Paleomagnetism, Sea Floor Spreading, Polar Wandering and Reversal of Earth's Magnetic Field, Convection current hypothesis; Orogeny and Epeirogeny; | 15 |
| **II** | Landforms associated with folds and fault; Fluvial Geomorphology: Stream Erosion, Transportation and Deposition, Stream Erosional and Depositional Landforms, Drainage systems and types of streams, Stages of Valley Development; Drainage response to climate change; Glacial Geomorphology: Types of Glaciers, Movement of Glaciers, Glacial Erosion, Transport by | 15 |

| | | |
|---|---|---|
| | Glaciers, Glacial Deposits; Aeolian Geomorphology: Wind Erosion, Erosional Features, Wind Transport, Wind Deposits, Types of Sand Deposits. | |
| **III** | Coastal Geomorphology: Shorelines, Classification of Coast and shoreline, Costal geomorphic processes, Erosional and Depositional landforms, Features of Ocean basin floor (Mid Ocean Ridge, Deep Ocean Trenches, Abyssal Plains, Sea Mounts); Coral Reefs; Geomorphic response to tectonics, sea level/base-level change, anthropogenic effects; Volcanic Geomorphology: Types of Eruption, Features of Lava fields, Features Associated with Volcanoes; Ash Showers, Volcanic Mudflows or Lahars, Plug Domes; Depression Forms: Craters, Calderas, Volcanic Tectonic Depression; Volcanic Plateaus and Plains; Geomorphology of India: Peninsular, Extra Peninsular, Indo Gangetic Plain; Application of Geomorphology in Mineral Prospecting, Civil Engineering, Military purposes, Hydrogeology and Environmental studies. | 15 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

**Text Book**

1. Bloom, A., (2005), Geomorphology. Pearson. New Delhi
2. Burbank, D. W. & Anderson, R.S., (2016), Tectonic Geomorphology. Wiley India.
3. Hamilton, E. I., (1965), Applied Geomorphology. Academic Press.
4. Holmes, A., (1992), Holmes Principles of Physical Geology Edited by P. Mcl. D. Duff. Chapman and Hall, London
5. Sharma, H. S., (1990), Indian Geomorphology. Concept Publishing Co., New Delhi.
6. Small, R.J., (1978), Study of Landforms: A Textbook of Geomorphology (2nd Edition), Cambridge University Press.
7. Thornbury, W.D., (2002), Principles of Geomorphology, John Wiley and Sons, 2nd Edition, New York.

**Reference Book**

1. Condie, K. C., (1989), Plate Tectonics and Crustal Evolution. 3rd Edition. Butterworth-Heinemann Ltd.
2. Cox, A., (1973), Plate Tectonics, Freeman and Company.
3. Davies, G.F., (1999), Dynamic Earth: Plates, Plumes and Mantle Convection. Cambridge University Press.
4. Kearey P., Klepeis, K. A. & Vine, F.J., (2009),Global Tectonics 3rd Edition. Wiley-Blackwell.
5. Keller, E.A & Pinter, N., (2001), Active Tectonics. 2nd Edition. Pearson Publications.
6. Leopold, L., Wolman, C. And Miller, J. P., (1963), Fluvial Processes in Geomorphology. Freeman.

7. Ritter, D. F., Kochel, R. C., & Miller, J. R., (2002), Process Geomorphology, Waveland press.
8. Robert, S. A., & Suzanne, P. A., (2010), Geomorphology: The mechanics and chemistry of landscapes. Cambridge University Press.
9. Russell, R.D., Jacobs, J.A., & Wilson, J.T., (1974), Physics and Geology. McGraw-Hill Inc., US.
10. Windley B., (1995), The Evolving Continents. 3rd Edition Wiley-Blackwell.

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | | ✓ | ✓ |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO3 | ✓ | | ✓ | ✓ | | ✓ |

| SEMESTER – I | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLY CC02** | Structural Geology and Tectonics | 3 | - | 3 |

### a. Course Outcome (CO)

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Predict the concept of stress forces acting in the earths and its resultant structural changes, explain concept of strain and its significance. | Understand |
| **CO2** | Explain the relation between deformation and crystallization and Geometrical analysis of petrofabric elements. | Analyze |
| **CO3** | Assess the theory of plate tectonics | Apply |

### b. Syllabus

| Units | Content | Hrs. |
|---|---|---|
| **I** | Mechanical properties of rocks; Concept of Stress, stress in two and three dimensions; Mohr diagrams. Concept of Strain; Types of strain ellipses and ellipsoids – their properties and geological significance; Strain markers and methods of strain measurements in naturally deformed rocks. Mechanisms of rock deformation; Mechanics of folding and buckling; Distribution of strain in folds; Superposed folding patterns. Causes and dynamics of faulting; Types and mechanism of faulting: Normal Faults, Reverse Faults, and Strike-slip faults; Thin-skinned deformation; Thrust Geometry and Fault-related folds. | 15 |
| **II** | Geometry and Types of shear zones: Brittle and ductile shear zones; Products of shear zone: Breccia, Cataclastic and Mylonites series. Time relation between deformation and crystallization. Concept of petrofabric; Planar and linear fabrics in deformed rocks: their origin and significance; Stereographic and equal-area projections for presenting fabrics elements, and π and β diagrams; Geometrical analysis of structures on macroscopic scale: use of Universal Stage. | 15 |
| **III** | Introduction to Geotectonics; Continental drift, Seafloor Spreading, Paleomagnetism, Polar wandering, and Reversal of Earth's Magnetic field; Convection current hypotheses. Principal Geotectonic features: Features of the Ocean, Continent and Continental margins. Plates and plate boundaries; Principles of Plate Tectonics; Force Balance and Mantle Plume models of plate movements; Orogeny and Epeirogeny; Anatomy of Orogenic Belts; Geodynamic Evolution of Himalaya. | 15 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

**Text Book**

1. Billings, M. P., (1987), Structural Geology, 4th edition, Prentice-Hall.
2. Fossen, H., (2010), Structural Geology. Cambridge University Press.
3. Ghosh, S.K., (1993), Structural Geology: Fundamentals and Modern Developments. Pergamon Press.
4. Gokhale, N. W. : Theory of Structural Geology. CBS Publishers.
5. Ragan, D.M., (2009), Structural Geology: An Introduction to Geometrical Techniques, 4th Edition. Cambridge University Press.
6. Twiss, R.J. & Moores, E.M., (2006), Structural Geology, 2nd Edition. W. H. Freeman.

**Reference Book**

1. Hobbs, B.E., Means, W.D. & Williams, P.F., (1976), An outline of Structural Geology. John Wiley and Sons. New York.
2. Jayangondperumal, R. Thakur, V.C., Vivek, J., Priyanka, R.S. & Gupta, A.K., (2018), Active Tectonics of Kumaun and Garhwal Himalaya, 151 pp. Springer Natural Hazard Series.
3. Lisle, R.J., (2004), Geological Structures and Maps: A Practical Guide, 3rd Edition. Elsevier.
4. Marshak, S. & Mitra, G., (1988), Basic Methods of Structural Geology. Printice Hall.
5. Novin, C. M. Principles of structural Geology John Willey, New York.
6. Pollard, D.D. & Fletcher, R.C., (2005), Fundamentals of Structural Geology Cambridge University Press
7. Ramsay, J.G. & Huber, M.I., (1983), Techniques of Modern Structural Geology, Vol. I, Strain Analysis. Academic Press.
8. Ramsay, J.G. & Huber, M.I., (1987), Techniques of Modern Structural Geology, Vol. II, Folds and Fractures. Academic Press.
9. Ramsay, J.G., (1967), Folding and fracturing of rocks. McGraw Hill.
10. Rowland, S.M. Duebendorfer, E.M. & Schiefelbein, I.M., (2007), Structural Analysis and Synthesis: A Laboratory Course in Structural Geology, 3rd edition. Wiley-Blackwell.
11. Turner, F.J. & Weiss, L.E., (1963), Structural analysis of Metamorphic Tectonites. McGraw Hill.

## c. Mapping of Program Outcomes with Course Outcomes

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO2 | ✓ | ✓ | | ✓ | ✓ | ✓ |
| CO3 | ✓ | ✓ | ✓ | ✓ | | |

| SEMESTER – I | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLY CC03** | Crystallography and Mineralogy | 4 | - | 4 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Describe the characteristics of different rock forming silicate minerals. | Evaluate |
| **CO2** | Study the key concepts of optical mineralogy | Apply |
| **CO3** | Understand the basics of crystal chemistry and crystal structure and understand the concept of symmetry elements in crystallography | Understand |
| **CO4** | Describe the functioning and application of modern analytical instruments used in mineral analysis | Analyze |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | 32 crystals classes and description of the different normal classes. Different types of crystal projections – spherical and stereographic and their uses. Twinning and Twin Laws: common types of twins and their examples in minerals. Space Lattice and Symmetry of internal structures – 14 Bravais Lattice. Introduction to space group Historical development of X-ray Crystallography Bragg's Law and its derivation. X-rays in mineral science. Application of Electron Micro Probe analyses and scanning electron Microscopy in mineral sciences. | 15 |
| **II** | Mineral Preparation for Microscopic study; Types of Preparation, Materials for Thin Section, The Mineral Slice and Cutting. Plane polarised and cross-polarised light; Isotropic and Anisotropic minerals; Behavior of minerals in cross-polarised light- Birefringence – Uniaxial minerals. Uniaxial and Biaxial Indicatrices; Optical accessories like mica, gypsum and quartz plates – Determination of Optic sign: uniaxial and biaxial minerals- Absorption of light by minerals – Scheme of pleochroism, crystal orientation, 2V and 2E. | 15 |
| **III** | A detailed study of the vital silicate mineral groups (listed below) concerning general and structural formulae, atomic classification structure, polymorphs/structural states, chemistry including the substitution of elements/solid solution and experimental work on pressure-temperature stability of the minerals, modes of occurrence and alterations. Nesosilicates: Olivine group, Garnet group, Aluminosilicate Group (Kyanite, Andalusite and Sillimanite). Sorosilicate: Epidote group, Ring Silicates: Tourmaline – Benitoite- Beryl. | 15 |

| | | |
|---|---|---|
| **IV** | Inosilicates: Pyroxene group- Amphibole group and Wollastonite, Phyllosilicates: Mica group- Chlorite group, Tectosilicates: Quartz -Feldspar group- Feldspathoid group- Zeolite and Scapolite groups, Cordierite. | 15 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

**Text Book**

1. Ford, W. E., (1932), Dana's textbook of mineralogy. CBS
2. Nesse, W. D., (2009), Introduction to optical mineralogy. Oxford University Press, New York, USA
3. Nesse, W.D., (2020), Introduction to Mineralogy. Oxford University Press, New York, USA
4. Perkins, D., (2015), Mineralogy. Pearson Education India.

**References**

1. Deer, W., Howie, R. A., & Zussman, J., (1992), An introduction to the rock-forming minerals (p. 696). Longman.
2. Klein, C., Dutrow, B., Dana, J. D., & Klein, C., (2002), Manual of mineral science (p. 641). New York: Wiley.
3. Kleinn, C. & Hurlbut, C. S. (1993), Manual of Mineralogy. John Wiley & Sons, INC
4. MacKenzie, W. S., Adams, A. E., & Brodie, K. H., (2017), Rocks and Minerals in Thin Section: A Colour Atlas. CRC Press.
5. Putnis, A., (1992), An introduction to mineral sciences. Cambridge University Press.
6. Rogers, A. F., & Kerr, P. F., (1942), Optical mineralogy (p. 390). New York: McGraw-Hill.

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | | ✓ | ✓ | ✓ | ✓ |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO3 | ✓ | | | | ✓ | |
| CO4 | ✓ | ✓ | ✓ | ✓ | | ✓ |

| SEMESTER - I | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| GLYCC04 | Geochemistry | 3 | - | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Understand the fundamentals of geochemistry and various geological processes associated with lithosphere and hydrosphere | Understand |
| **CO2** | Apply the basics of isotope geochemistry in the field of geochronology and petrogenesis | Apply |
| **CO3** | Explain various chemical weathering processes and its effect in the chemical composition of different types of sediments and water | Analysis |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Earth System Science and various reservoirs. Introduction to the chemical composition and properties of atmosphere, lithosphere, hydrosphere and biosphere. Meteorites, their classification, mineralogy and origin. Geochemical cycles. Concept of biogeochemical cycle. Concept of equilibrium. Entropy, enthalpy, Gibbs free energy and laws of thermodynamics. Chemical kinetics in geoscience and its applications: disequilibrium textures and diffusion. | 15 |
| **II** | Geochemical classification of elements. Element partitioning in mineral/rocks formation and concept of distribution coefficient and bulk distribution coefficient. Trace element Geochemistry, Interpretation of REE patterns, The utility of trace elements in the petrogenesis of rocks. Stable isotope geochemistry of carbon and oxygen and its applications to Geology. Radiogenic isotopes, mass fractionation. Decay scheme of K-Ar, U-Pb, Rb-Sr and Sm-Nd. Radiometric dating of single minerals and whole rocks. Petrogenetic implications of Sm-Nd, Rb-Sr systems. Isotopes as petrogenetic indicators, model ages, interpretation of chronological data, isotope reservoirs. | 15 |
| **III** | Acids and bases. Ionisation constants of acids, bases and hydroxides. Estimation of ionic concentration. Introduction to sedimentary geochemistry. Geochemical processes involved in rock weathering and soil formation. Fugacity and activity. Oxidation-Reduction reactions. Redox potential – limits of pH and Eh in nature. Eh-pH diagrams. A brief introduction to the hydro-geochemistry, various graphical representation methods for water analysis data. | 15 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

**Text Book**

1. Albarede, F., (2009), Geochemistry an Introduction, Cambridge Univ. Press, (2nd) 330p
2. Mason, B. & Moore, C. B., (1982), Principles of Geochemistry, Wiley Eastern Ltd., 344p.
3. Misra, K. C., (2012), Introduction to geochemistry: principles and applications. John Wiley & Sons.
4. White, W. M., (2020), Geochemistry. John Wiley & Sons.

**References**

1. Beus, A. A. & Grigorian, S. V., (1977), Geochemical Exploration Methods for Mineral Deposits, Applied Publication, University of California, 287p.
2. Dickin, A. P., (2005), Radiogenic Isotope Geology, Cambridge University Press, 492p (II Ed)
3. Faure, G., & Mensing, T. M., (2005), Principles and applications (p. 897). John Wiley & Sons, Inc.
4. Hawkes, H. E. & Webb, J. S., (1962), Geochemistry in Mineral Exploration, Harper & Row.
5. Krauskopf, K. B. & Bird, D. K., (1995), Geochemistry, McGraw Hill, New York,640p Suggested Reading:
6. Levinson, A.A., (1980), Introduction to Exploration Geochemistry, (2nd Ed) App. Pub., 924p.
7. McSween, H. Y., Richardson, S. M., & Uhle, M. E., (2003), Geochemistry: pathways and processes. Columbia University Press.
8. Rollinson, H. R., (2014), Using geochemical data: evaluation, presentation, interpretation. Routledge.

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | | ✓ | | ✓ | ✓ |
| CO2 | ✓ | ✓ | ✓ | ✓ | | ✓ |
| CO3 | ✓ | | ✓ | | | |

| SEMESTER - I | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLY CC05** | Stratigraphy | 3 | - | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Evaluate the principals of advanced stratigraphy and details of geological time scale | Evaluate |
| **CO2** | Understand and identify the Indian stratigraphic systems | Understand |
| **CO3** | Analyze the age and boundary problems of various ages | Analyze |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Principles of Stratigraphy: Litho-stratigraphy, Biostratigraphy, chrono-stratigraphy, Magneto-stratigraphy and their Applications, Stratigraphic Correlation; Stratotypes and its importance; A new Geologic Time Scale. Paleogeography and important events in Precambrian time; Archaean successions and economic importance of Peninsular India: Dharwar Supergroup, Banded Gneiss complex, Sargur Group, Bundelkhand Group, Singhbhum-Orissa region (Iron ore Group, Singhbhum Group and Proterozoic succession). | 15 |
| **II** | Proterozoic successions and economic importance of Vindhyan Supergroup, Aravalli Supergroup, Delhi Supergroup, Cuddapah Supergroup, Sausar Group, and Lesser Himalayan sedimentary belts; Precambrian-Cambrian boundary. Palaeogeography and important events of the Palaeozoic Era; Palaeozoic stratigraphy of the Himalaya with reference to Palaeozoic succession in Spiti valley, Himachal Pradesh and Kashmir and Gondwana Supergroup. Mesozoic time and important events: Triassic and Jurassic systems, Marine Triassic sequences of the Himalaya with special reference to Spiti Valley, Triassic succession in Kumaun Himalaya; Permian-Triassic boundary; Gondwana Supergroup: Distribution, stratigraphic classification, and economic importance. | 15 |
| **III** | Global events of Jurassic and Cretaceous periods; Geological Succession and economic importance of Jurassic of Western India; Cretaceous successions of Cauvery basin, South India and Narmada valley; Cretaceous-Tertiary boundary; Deccan Traps: Spatio-temporal distribution of volcano-sedimentary sequences, Infra/inter-trappeans beds, Age of Deccan traps, Economic importance; Stratigraphy of Siwalik Group; Palaeogene and Neogene global events and successions in India; Neogene-Quaternary boundary. | 15 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

**Text Book**

1. Dunbar, C.O. & Rodgers, J., (1957), Principles of Stratigraphy. JohnWiley & Sons.
2. Krishnan, M.S., (1982), Geology of India and Burma. C.B.S. Publishers, Delhi
3. Kumar, R., (2018), Fundamentals of Historical Geology and Stratigraphy of India. New Age International Publisher.
4. Naqvi, S.M. & Rogers, J.J.W., (1987), Precambrian Geology of India. Oxford University Press.
5. Vaidyanathan R. & Ramakrishnan M., (2008), Geology of India. Geological Society of India.

**Reference Book**

1. Chetty, T.R.K., (2017), Proterozoic Orogens of India: A Critical Window to Gondwana, Elsevier
2. Doyle, P. & Bennett, M.R., (1996), Unlocking the Stratigraphic Record. John Willey.
3. Naqvi, S.M., (2005), Geology and Evolution of the Indian Plate: From Hadean to Holocene-4 Ga to 4 Ka. Capital Pub., New Delhi.
4. Pascoe, E.H., (1968), A Manual of the Geology of India & Burma (Vols.IN) . Govt. of India Press, Delhi.
5. Pomerol, C., (1982), The Cenozoic Era? Tertiary and Quaternary. Ellis Harwood Ltd., Halsted Press.
6. Schoch, R.M., (1989), Stratigraphy: Principles and Methods. Van Nostrand Reinhold, New York.

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | | ✓ | ✓ | | ✓ |
| CO2 | ✓ | | ✓ | | | ✓ |
| CO3 | ✓ | | ✓ | | ✓ | ✓ |

| SEMESTER - I | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLY CP01** | Structural Geology and Tectonics | - | 2 | 2 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Solve problems based on orthographic and stereographic projections, study of geological maps and sections | Apply |
| **CO2** | Quantification of geological strains and study of dip-isogons. | Analyze |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Preparation and interpretation of Geological maps and sections. | 22.5 |
| **II** | Structural problems based on orthographic and stereographic projections concerning economic deposit. Recording and plotting of the field data. Study of the hand specimen of deformed structures | 22.5 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Laboratory reports
✓ Assignments
✓ Viva

**Text Book**

1. Lisle R.J. &Leyshon, P.R., (2004), Stereographic Projection Techniques for Geologists and Civil Engineers, 2 edition, Cambridge University Press
2. Lisle, R.J., (2004), Geological Structures and Maps: A Practical Guide, Third Edition. Elsevier
3. Turner, F.J. & Weiss, L.E., (1963), Structural Analysis of Metamorphic Tectonites McGraw Hill Book Co.

**Reference Book**

1. Ramsay, J.G. & Huber, M.I., (1983), Techniques of Modern Structural Geology. Vol. I. Strain Analysis. Academic Press.
2. Ramsay, J.G. & Huber, M.I., (1987), Techniques of Modern Structural Geology. Vol. II. Folds and Fractures. Academic Press

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

| SEMESTER - I | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLY CP02** | Mineralogy, Crystallography and Geochemistry | - | 3 | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Identify the rock-forming minerals at megascopic and microscopic levels. | Skill |
| **CO2** | Understand and explain the crystallography symmetry elements of 32 class | Apply |
| **CO3** | Familiar with various modern analytical instruments, geochemical calculations, and interpretation of geochemical results | Analyse |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Identification of rock-forming minerals in hand specimens. | 22.5 |
| **II** | Determination of length fast and length-slow characters of minerals. Scheme of pleochroism and absorption of a given mineral in thin section. Determination of extinction angle and composition of plagioclase. Study of interference figures of uniaxial and biaxial crystals, determination of optic signs. Goniometer and its use in measuring the interfacial angle of crystals and calculation of the axial ratio. Representation of symmetry elements of crystals belonging to 32 classes of symmetry and study of their stereograms. | 22.5 |
| **III** | Chemical elements in the earth's crust; pathfinders and common geochemical associations of elements. Methods of geochemical sampling. Sampling procedures and introduction to important analytical techniques used in geochemistry, Hands on training of solution preparation for analysis, Analytical principles and procedures: XRF, ICP-MS, EPMA and SEM-EDS, sample preparation, presentation of analytical data, geochemical reference materials, accuracy and precision, basic statistics used in geochemistry, oxidation states and volatile, FeO, $Fe_2O_3$ and Total Fe, Mg #, mole conversions and mineral formulae calculations. | 22.5 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Laboratory reports
✓ Assignments
✓ Viva

**Text Book**

1. Deer, W., Howie, R. A., & Zussman, J., (1992), An introduction to the rock-forming minerals (p. 696). Longman.

2. Nesse, W.D., (2020), Introduction to Mineralogy. Oxford University Press, New York, USA
3. Perkins, D., (2015), Mineralogy. Pearson Education India.

**References**

1. MacKenzie, W. S., Adams, A. E., & Brodie, K. H., (2017), Rocks and Minerals in Thin Section: A Colour Atlas. CRC Press.
2. Potts, P.J., (2003), Handbook of Rock Analysis. Viridian Publishing, UK.
3. Rollinson, H. R., (2014), Using geochemical data: evaluation, presentation, interpretation. Routledge.

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | | ✓ | ✓ | ✓ | ✓ |
| CO2 | ✓ | | ✓ | ✓ | ✓ | ✓ |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

# P. SEMESTER II

| SEMESTER - II | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| GLY CC06 | Igneous and Metamorphic Petrology | 4 | - | 4 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Understand the physical and chemical characteristics of magma and various rock types, their classification, petrogenesis and their link to tectonic settings | Understand |
| **CO2** | Understand the concept of melt generation and crystallization mechanisms | Apply |
| **CO3** | Understand the key concepts of chemical thermodynamics | Understand |
| **CO4** | Application of basic concepts in in metamorphic reactions, facies, and P-T-t path. | Apply |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Fundamentals of Igneous petrology, differentiation of the Earth, major structural units of the Earth, energy and mantle heat engine, mantle melting mechanisms- Thermal perturbation, adiabatic uplift and volatile influx, gravity, pressure and geobaric gradient, viscosity of melts, nucleation and crystal growth, vesiculation and fragmentation of magma, igneous rock series. Phase rule in igneous petrology, Simple binary system with no solid solution- Di-An system, binary system with complete solid solution- Ab-An system, binary peritectic system- Fo-Qtz system, Ternary eutectic system- Di-An-Fo system, Ternary system with solid solution- Di-An-Ab system, Ternary peritectic system- Fo-An-Qtz system. Chemical compositions and variation diagrams. Classification of magmatic rocks - based on fabric, field relations, mineralogical and modal, and whole rock compositions, IUGS classification of plutonic, hypabyssal and volcanic rocks, Irvine-Baragar classification of volcanic rocks, Mega, minor and microstructures associated with igneous rocks. | 15 |
| **II** | Melt composition, mantle material, partial melting of the peridotite mantle and magma generation, alkaline magma generation, magma generation in continental crust, differentiation (open and closed systems) and assimilation, hybrid magmas, magma storage, ascent and emplacement, field relations of intrusions. Chemical fractionation, partition coefficient and trace element | 15 |

| | | |
|---|---|---|
| | compatibility, rare earth elements and batch melting models, magma evolution models. Idea of consanguinity, rock suites and their distribution in time and space. Oceanic spreading ridges and related basaltic rocks, mantle plumes and oceanic island volcanic rocks, plume heads and flood basalt plateau lavas, arc magmatism, oceanic island arcs. Igneous rocks associated with convergent plate boundaries, continental flood basalt and large igneous provinces, large layered igneous complexes, continental alkaline rocks, ultra-alkaline and silica poor alkaline rocks, alkaline cratonic associations, ophiolite, and granites, continental rift associations. | |
| **III** | Closed and Open Systems, First law of thermodynamics, enthalpy, entropy, second and third law of thermodynamics, stability (phase) diagrams, thermodynamics of solutions, fugacity and activity, equilibrium constant, silica activity, silica buffers and silica saturation and, alumina saturation. Fe-Ti oxide buffers. Quantitative Geothermobarometry: Diffusion and Kinetics of metamorphic reactions. Overview of different types of metamorphism; Textures and structures in relation to deformation and metamorphism in regional terrains; Dynamic metamorphism Processes and kinetics of thrust and fault rocks; | 15 |
| **IV** | Concept and Classification of Metamorphic Facies and Facies Series; P-T evolution paths of metamorphic rocks. Metamorphism of pelites, mafic, ultramafic and calcareous rocks; High P/T ratio metamorphism, Metasomatism. Nature of Metamorphic Reactions, Isograds and Reaction Isograds, Schrienemakers Rule and Construction of Petrogenetic Grids. Metamorphic Differentiation, Anatexis and Origin of Migmatites in the light of experimental studies, Exhumation and Uplift rates, Erosion, Geodynamics, and the Geomorphology of Metamorphic Terrains. | 15 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

**Text Book**

1. Anthony R. Philpotts & Ague, J. J., (2009), Principles of Igneous and Metamorphic Petrology. Cambridge
2. Cox, K. G., Bell, J. D. & Pankhurst, R. J., (1979), Interpretations of igneous rocks. George Allen and Unwin, London.
3. Mason, R., (1990), Petrology of Metamorphic Rocks, Springer, London.
4. Philpotts, A.R., (2003), Petrography of Igneous and metamorphic rocks. Waveland Pr Inc.
5. Shrivastava, J. P., (2009), Igneous Rocks National Science Digital Library, CSIR, New Delhi.

6. Winter, J. D., (2001), Igneous and Metamorphic Petrology. Prentice Hall
7. Yardley, B.W., (1989), An Introduction to Metamorphic Petrology, Cambridge University Press

**Reference Book**

1. Bucher, K. & Frey, M., (1994), Petrogenesis of Metamorphic Rocks, Springer Verlag.
2. Hall, A., (1997), Igneous Petrology, Longman.
3. McBirney, (1994), Igneous Petrology, CBS Publishers, Delhi.
4. Miyashiro, A., (1994), Metamorphic Petrology, Oxford University Press.
5. Ragland, P. C., (1989), Basic analytical Petrology. Oxford University Press.
6. Shelley D., (1993), Igneous and Metamorphic Rocks Under the Microscope. Chapman and Hall.

### c. Mapping of Program Outcomes with Course Outcomes

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | ✓ | ✓ | |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO4 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

| SEMESTER - II | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLY CC07** | Sedimentology and Sequence stratigraphy | 3 | - | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | **Course Outcome** | **Level** |
|---|---|---|
| **CO1** | Understand the process of formation of siliciclastic and carbonate sediments and sedimentary rocks, their texture and structures, and reconstruction of paleo-environments. | Understand |
| **CO2** | Explain different sedimentary environments and identify their processes and products. | Apply |
| **CO3** | Elaborate the relationship between tectonics and sedimentary basin formation and knowledge of sequence stratigraphy. | Analyze |

**b. Syllabus**

| **Units** | **Content** | **Hrs.** |
|---|---|---|
| **I** | Introduction to sedimentary processes: origin, transport and deposition of sediments, sediment classification; Fundamental of fluid flow: Laminar vs turbulent flow, Reynolds number, Froude Number; particle transport by fluids and sediment gravity flows; Sedimentary texture, textural parameter and significance; Concept of flow regimes and bedforms; Sedimentary structures; Paleocurrent analysis. | 15 |
| **II** | Terrigenous clastic and chemically precipitated rocks and their classification; Siliciclastic rocks: composition, classification, genesis and occurrences of sandstone, shale and conglomerate; lithification and diagenesis; Non-siliciclastic: composition, texture, genesis and diagenesis of limestone and dolomite; genesis and diagenesis of chert, phosphorites, iron-rich sediments and evaporate. | 15 |
| **III** | General idea about depositional environments; fluvial, deltaic, estuarine, tidal-flat and deep sea environments; Sequence Stratigraphy: Concept of sequence stratigraphy; Walther's law; Aggradation, progradation, retrogradation, transgression, regression, onlap, offlap, overlap, toplap; Sequence boundaries; System tracts: lowstand system tract, highstand system tract, transgressive system tract; Parasequences and sedimentary cycle; Maximum flooding surfaces, marine flooding surface; Sea-level in geological history. Basin analysis, tectonics, and sedimentation; Application of isotopes in reconstruction of Paleoenvironments. | 15 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

**Text Book**

1. Boggs, S., (1995), Principles of Sedimentology and Stratigraphy. Print ice Hall, New Jersey.
2. Nichols, G., (1999), Sedimentology and Stratigraphy. Wiley-Blackwell.
3. Pettijohn, F.J., (1975), Sedimentary Rocks. Harper and Row Publm, New Delhi.
4. Prothero, D. R., (2013), Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy (3rd Ed.). W. H. Freeman.
5. Tucker, M.E., (2006), Sedimentary Petrology. Blackwell.

**Reference Book**

1. Allen, P.A., (1997), Earth Surface Processes. Blackwell.
2. Collinson, J.D. & Thompson, D.B., (1988), Sedimentary Structures. Unwin-Hyman, London.
3. Hsu, K.J., (2004), Physics of Sedimentology. Springer Verlag, Berlin.
4. Leeder, M., (2009), Sedimentology and Sedimentary Basins: from Turbulence to Tectonics. John Wiley & Sons.
5. Leeder, M.R., (1982), Sedimentology: Process and Product (344p). George Alien &Unwin, London.
6. Lindholm, R.C., (1987), A Practical Approach to Sedimentology. Allcn ane Unwin, London.
7. Miall, A.D., (1999), Principles of Sedimentary Basin Analysis (3rd Ed.). Springer Verlag, New York.
8. Reading, H.G., (2009), Sedimentary Environments: Processes, Facies and Stratigraphy. John Wiley & Sons.
9. Reineck, H.E. & Singh I.B., (1980), Depositional Sedimentary Environments: With Reference to Terrigenous Clastics. Springer.

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO2 | ✓ | ✓ | ✓ | | ✓ | ✓ |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

| SEMESTER - II | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| GLY CC08 | Palaeontology | 4 | - | 4 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Understand the origin of life and its evolution through geological time | Understand |
| **CO2** | Describe morphology, classification, evolutionary trends and taphonomy record with Indian examples of various fossils | Analyze |
| **CO3** | Study of siliceous, calcareous and phosphatic micro- and nano-fossils | Understand |
| **CO4** | Application of microfossils in hydrocarbon exploration, reconstruction of paleoecology, paleoenvironments and paleogeography and intercontinental correlation | Apply |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Modern systematics, concept and kind of type specimens, species, speciation and adaptive radiation. Ichnofossils - modes of preservation, classifications and ichnofacies. Micro- and macro-evolution, types of heterochrony in evolutionary lineages, application to biochronology with Indian examples. Classification, evolution and modes of life of major invertebrate groups: Mollusca (Bivalvia, Gastropoda and Cephalopoda), Brachiopoda, Echinodermata, Cnidaria, Trilobita; Evolution and biological affinity of Graptolite. | 15 |
| **II** | Approaches to palaeoecological and palaeoenvironmental studies based on benthic communities, trace fossils and taphonomic record with Indian examples. Distribution, migration and dispersal of organisms applied to palaeobiogeography and plate-tectonics with Indian examples. Evolution of man, elephant and horse and their fossils localities in India; Siwalik Vertebrate fauna. Devonian flora, Gondwana flora, and Deccan Inter-trappean flora. | 15 |
| **III** | Definition and scope of the subject; Relationship of micropaleontology with ocean sciences; Modern field and laboratory techniques in the study of microfossils (collection, sampling and processing techniques, scanning electron microscopy and mass spectrometry); A brief account of the concepts and methods for the development of micropaleontological indicators useful in reconstruction of history of past, environmental changes and biostratigraphic correlation. Palynology and its application in palaeoclimatology, and hydrocarbon exploration. | 15 |

| | | |
|---|---|---|
| **IV** | Types of Microfossils. Calcareous Microfossils: Foraminifera - Planktic foraminifera, benthic foraminifera. Calcareous nannofossils - Ostracoda - Pteropods; A brief introduction of calpionellids and calcareous algae. Siliceous Microfossils: Radiolaria, diatoms and silicoflagellate. Phosphatic Microfossils: Conodonts. Introduction to Organic walled microfossils. Biostratigraphic and palaeoenvironmental significance. Application of Micropaleontology in hydrocarbon exploration. Geochemical study of microfossil tests (stable isotopes and elemental composition) and its application in paleoceanography and palaeoclimatology | 15 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

**Text book**

1. Clarksons, E.N.K., (1998), Invertebrate Paleontology and Evolution, Allen and Unwin, London.
2. Haq B. U. and Boersma A., (1998), Introduction to Marine Micropaleontology, Elsevier.
3. Prothero, D.R., (2004), Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.
4. Raup, D.M. & Stanley, S.M., (1985), Principles of Paleontology, CBS Publication

**Reference book**

1. Bignot, G., (1985), Elements of Micropaleontology, London.
2. Boardman, R.S., Cheethan, A.M. & Rowell, A.J., (1988), Fossil Invertebrates, Blackwell.
3. Haslett, S. K., (2002), Quaternary Environmental Micropaleontology, Oxford.
4. Horowitz, A.S. & Potter, E.D., (1971), Introductory Petrography of Fossils, Springer Verlag. Mayr, E., (1971), Population, Species and Evolution, Harvard.
5. Houghton, J., (1997), Global Warming, Cambridge Univ. Press.
6. Jones, T.P. & Rowe, T.P., (1999), Fossil plants and spores, Modern Techniques, Geological Soc. of London
7. Pinet, R ., (1992), Oceanography: An introduction to the Planet Oceanus, West Pub,Co
8. Saraswati, P. K. & Srinivasan M. S., (2016), Micropaleontology: Principles and Applications, Springer.
9. Smith, A.B., (1994), Systematics and Fossil Record – Documenting Evolutionary Patterns, Blackwell.
10. Strean, C.W. & Carroll, R.L., (1989), Paleontology – the record of life, John Wiley.
11. Tolmazin, D., (1985), Elements of Dyanamic Oceanography, Allen and Unwin

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | | | | ✓ | ✓ |
| CO2 | ✓ | | ✓ | ✓ | | |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO4 | ✓ | ✓ | | ✓ | ✓ | ✓ |

| SEMESTER - II | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLY CC09** | Remote Sensing and GIS | 4 | - | 4 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Understand the basic concepts of electromagnetic radiation, its interaction with the earth's surface and atmosphere | Understand |
| **CO2** | Study the resolution properties to interpret, process, and evaluate remotely sensed images | Apply |
| **CO3** | Study the remote sensing and GIS principles and application | Evaluate |
| **CO4** | Interpret images and mapping | Skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Introduction to Remote Sensing: Concepts, Components, Electro Magnetic Radiation/ Spectrum, Theories of EMR; Types of Remote Sensing: Based on Energy source and Electro-Magnetic Spectrum. Energy Interaction with Earth Surface and Atmosphere: Reflection, Absorption Transmission, Spectral Signature: Interaction with soil, water and vegetation and other features; Scattering: Rayleigh, Mie and Non-selective; Absorption, and Refraction; Atmospheric Windows. | 15 |
| **II** | Digital Image Processing: Radiometric correction, Geometric correction, Image enhancement, Filters, Edge enhancement, Vegetation Index analysis, Temporal analysis, multi-image analysis, PC Analysis, Classification – Supervised and Unsupervised and methods of classification algorithms. | 15 |
| **III** | GIS: Definition and Applications; Components and Elements of GIS; Development of GIS technology; theoretical models and framework for GIS, representation of geographic data; coordinate systems, Scale, resolution, map projection. Data Input, Storage and Editing: Nature of geographic data: Spatial and Attribute Data, Concept of vector and raster-based models; geodatabases, data input devices: Digitization; external databases; storage and manipulation of GIS databases, Data quality. Basic Spatial Analysis: Spatial Queries, Neighbourhood analysis; Proximity analysis and buffers; Overlays Analysis – raster and vector-based overlay and their applications; Presentation of GIS output. | 15 |
| **IV** | Application of Geoinformatics in geology – Geological and geomorphological mapping; Hazards Mapping – Flood, Forest Fire and Landslide hazards mapping, DEM, GNSS | 15 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

**Text book**

1. Campbell, J., (2002), Introduction to Remote Sensing, Taylor & Francis, London.
2. Chang, K T., (2006), Introduction to Geographic Information Systems, Tata McGraw-Hill.
3. Gupta, R.P., (2003), Remote Sensing Geology, Springer Nature Switzerland
4. Heywood, I. Cornelius, S. & Carver, S., (2004), An Introduction to Geographic Information Systems, Pearson Education.
5. Lillesand, T. M., Kiefer, R. W. & Chipman, J. W., (2008), Remote Sensing and Image Interpretation, John Wiley & Sons, New Delhi
6. Sabins, Floyd F. Jr., (1997), Remote Sensing: Principles and Interpretation, W.H.Freeman, New York.
7. Jensen, J. R., (2005), Introductory Digital Image Processing, Prentice-Hall, New Jersey
8. Joseph, G., (2004), Fundamentals of Remote Sensing, Universities Press, Hyderabad, India

**Reference book**

1. Anbazhagan S., K. Subramanian, & Xiaojun Yang, (2011), Geoinformatics in Applied Geomorphology, CRC Press., ISBN: 13: 978-1439830482
2. Anbazhagan. S, Venkatachalapathy, R. & Neelakantan, R., (2009), Exploration Geology and Geoinformatics, 1st Edition, Macmillan India Ltd., ISBN: 10:0230-63867-8
3. Anji Reddy, M., (2008), Textbook of Remote Sensing and Geographic Information System, B.S. Publication, Hyderabad
4. Burrough, P.A. & McDonnell, R.A., (1998), Principles of Geographic Information systems, Oxford University Press, Oxford.
5. Curran, Paul J., (1985), Principles of Remote Sensing, Longman, London & New York.
6. De Mers, & Michael N., (1999), Fundamentals of Geographic Information Systems, John Wiley & Sons, NewYork.
7. Drury, S. A., (2001), Image Interpretation in Geology, Blackwell, Oxford
8. Environmental Systems Research Institute (ESRI), (1997), Getting to know Arc View GIS, Cambridge: Geoinformation International.
9. Jensen, J.R., (2004), Remote Sensing of the Environment: An Earth Resource Perspective, Pearson Education.
10. Longley, P.A., Goodchild, M.F., Maguire, D.J. & Rhind, D.W., (2001), Geographic Information Systems and Science, Wiley, Chichester.
11. Maguire, D.J., M.F. Goodchild & D.W. Rhind, (1991), Geographic Information Systems, Longman Scientific and Technical, Harlow.

12. Sarkar, A., (2015), Practical geography: A systematic approach. Orient Black Swan Private Ltd., New Delhi
13. Singh R. B. & Murai S., (1998), Space-informatics for Sustainable Development, Oxford and IBH Pub.
14. Singh, R.B., (1991), Environmental Monitoring: Application of Remote Sensing and GIS, Geocarto Int. Centre, Hong Kong.
15. Wolf P. R. & Dewitt B. A., (2000), Elements of Photogrammetry: With Applications in GIS, McGraw-Hill

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | | | | |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO4 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

| SEMESTER - II | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLY CP03** | Igneous and Metamorphic Petrology | - | 2 | 2 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Understand the genesis of various igneous rocks through study of their mineralogy and texture in both hand specimen and under the microscope | Skill |
| **CO2** | Understand and explain the characteristics of metamorphic rocks for their identification and some understanding on analytical tools. | Skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Study of igneous rocks in hand specimens and under the petrological microscope; Whole rock analysis of igneous rocks using XRF and Norm calculations | 22.5 |
| **II** | Identification of Minerals, reactants and products in Hand specimen and thin sections: metapelites, metabasic and calcareous rocks; Deciphering deformational and metamorphic history in thin sections; Mineral analyses and projections (Practical/homework); Hands on analytical techniques SEM, EPMA, XRF and XRD etc | 22.5 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Laboratory reports
✓ Assignments
✓ Viva

**Text Book**

1. Winter, J. D., (2014), Principles of igneous and metamorphic petrology (Vol. 2). Harlow, UK: Pearson education.
2. Yardley, B.W.D., (1990), Atlas of Metamorphic Rocks and Their Textures, Prentice Hall.

**References**

3. Bucher, K., & Grapes, R., (2011), Petrogenesis of Metamorphic Rocks. Springer-Verlag Berlin Heidelberg.
4. MacKenzie, W. S., Donaldson, C. H., & Guilford, C., (1982), Atlas of igneous rocks and their textures (Vol. 148). Harlow: Longman.

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

| SEMESTER - II | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLY CP04** | Sedimentology and Palaeontology | - | 2 | 2 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Identify, classify and describe clastic and non-clastic sedimentary rocks and sedimentary structures and reconstruction of paleoenvironment. | Skill |
| **CO2** | Identification of important mega and micro-fossils and interpretation of their paleoenvironmental conditions for deposition | Skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Megascopy of Clastic and Non-clastic Rocks; Microscopic Examination of Important Sedimentary Rocks; Grain-size Analysis: Plotting of size-distribution data as Frequency and Cumulative. Curves; Computation of Statistical Parameters and Interpretation; Identification of sedimentary structures and their Palaeo environmental significance; Palaeocurrent Analysis; Classification of sedimentary rocks by plotting the modal and whole-rock chemical compositions in relevant triangular diagrams; Study and interpretation of isopach and facies maps. | 22.5 |
| **II** | Study of the morphological characters of some important invertebrate fossils belonging to Brachiopoda, Bivalvia, Gastropoda, Ammonoidea, Trilobita, Echinoidea and corals;<br>Techniques of separation of microfossils from the matrix; Types of microfossils - calcareous, siliceous, phosphatic and organic-walled microfossils. | 22.5 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Laboratory reports
✓ Assignments
✓ Viva

**Text Book**

1. Murray, J. W., (1985), Atlas of invertebrate macrofossils. Wiley.
2. Reineck, H.E., & Singh, I.B., (1973), Depositional Sedimentary Environments. Springer-Verlag.
3. Tucker, M.E., (1981), Sedimentary Petrology: An Introduction, Wiley & Sons, New York.
4. Tucker, M.E., (1990), Carbonate Sedimentology, Blackwell Scientific Publication.

**References**

1. Bignot, G., (1985), Elements of Micropaleontoogy, London.
2. Collins, J.D., & Thompson, D.B., (1982), Sedimentary Structures. George Allen & Unwin, London.
3. Greensmith, J. T., (1984), Petrology of Sedimentary rocks, Thomas Murby Publ.
4. Jones, T.P. & Rowe, T.P., (1999), Fossil plants and spores, Modern Techniques, Geological Soc. of London.
5. Lindholm, R.C., (1987), A Practical Approach to Sedimentology. Allen & Unwin, London.
6. Miall, A.D., (2000), Principles of Basin Analysis, Springer-Verlag

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

| SEMESTER - II | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLY CP05** | Remote Sensing and GIS | - | 2 | 2 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Interpretation of different satellite data for various applications, and analysis | Apply |
| **CO2** | Carry out the GIS analytical tool for the preparation of thematic maps | Skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | a. Greyscale,<br>b. Histogram generation,<br>c. Linear Stretching,<br>d. Spatial filter,<br>e. Edge enhancement, | 22.5 |
| **II** | f. Vector data generation – Point, line, Polygon<br>g. Image interpretation and applications<br>h. Prepare a report consisting of five exercises on using any RS and GIS Software on above-mentioned themes. | 22.5 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Laboratory reports
✓ Assignments
✓ Viva

**Text Book**

1. Jensen, J. R., (2005), Introductory Digital Image Processing, Prentice-Hall, New Jersey
2. Lillesand, T. M., Kiefer, R. W. & Chipman, J. W., (2008), Remote Sensing and Image Interpretation, John Wiley & Sons, New Delhi
3. Sabins, Floyd F. Jr., (1997), Remote Sensing: Principles and Interpretation, W.H.Freeman, New York.

**References**

1. Burrough, P.A. & McDonnell, R.A., (1998), Principles of Geographic Information systems, Oxford University Press, Oxford.
2. Drury, S. A., (2001), Image Interpretation in Geology, Blackwell, Oxford

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

# Q. SEMESTER III

| SEMESTER - III | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLY CC10** | Economic Geology and Ore Genesis | 3 | - | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | **Course Outcome** | **Level** |
|---|---|---|
| **CO1** | Understand the genetic controls exerted by physical and chemical processes on ore formation in various geologic settings | Understand |
| **CO2** | Recognize common ore and economic minerals and awareness about distribution of mineral deposits in India. | Analyze |
| **CO3** | Explain ores genesis of magmatic, sedimentary and metamorphic affiliations and correlate with world-class ore mineral deposits. | Apply |

**b. Syllabus**

| **Units** | **Content** | **Hrs.** |
|---|---|---|
| **I** | Nature and morphology of ore deposits; Ore textures and its application; Ore-Bearing Fluids; Paragenesis, application of geothermobarometry and Fluid inclusion study: Principles, assumptions, limitations and applications of fluid inclusions in ores; Wall rock alteration; Process of formation and transformation of ores; Controls of ore localization; Classification of ore deposits; Physical and optical properties of ore minerals. | 15 |
| **II** | General characteristics and genesis of magmatic ore deposits – Light rare earth elements ores, chromite deposits, base-metal Ni-Cu sulfide deposits, PGE sulfide deposits, rare-metal pegmatites and diamond deposits associated with kimberlites and lamproite.<br>General characteristics and genesis of hydrothermal, stratiform and strata-bound deposits; skarn and carbonate-replacement deposits; epithermal deposits; volcanic-hosted massive sulfide deposits; orogenic gold deposits; iron oxide-copper-gold (IOCG) deposits; MVT and SEDEX deposits; other deposits of hydrothermal affiliation. | 15 |
| **III** | Ores of sedimentary affiliation: Hydrogene and clastic sedimentation deposits - Iron ores in ironstones; sedimentary-rock-hosted Mn and P deposits; heavy mineral sand deposits; and placer deposits; Residual deposits and supergene enrichment. Ores of metamorphic affiliations. Significance of crustal evolution in the metallogenesis. Occurrence, origin and distribution of the important metallic and nonmetallic mineral deposits of India; Strategic, Critical and Essential minerals; National Mineral Policy of India. | 15 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

**Text Book**

1. Barnes, H.L., (1979), Geochemistry of Hydrothermal Ore Deposits. John Wiley.
2. Bateman, A.M., & Jensen, M. L., (1950), Economic mineral deposits. (Vol. 259) John Wiley & sons.
3. Evans, A.M., (1993), Ore Geology and Industrial Minerals. Blackwell.
4. Park, C.G., (1972), Ore Deposits. McDiarmid.

**Reference Book**

1. Golbert, J.M. & Park, C., (1986), The Geology of Ore Deposits. W.H. Freeman & Co New York.
2. Klemm, D.D. & Schneider, H.J., (1977), Time and Strata Bound Ore Deposits. Springer Verlag.
3. Mookherjee, A., (2000), Ore Genesis - A Holistic Approach. Allied Publisher
4. Pracejus, B., (2015), The ore minerals under the microscope: an optical guide. (Vol. 3, 2nd Ed.) Elsevier.
5. Ramdohr, P., (1969), The Ore Minerals and their Intergrowths. Pergamon Press.
6. Ridley, J., (2013), Ore deposit geology. Cambridge University Press.
7. Stanton, R.L., (1972), Ore Petrology. McGraw Hill.

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | | ✓ | | ✓ | ✓ |
| CO2 | ✓ | | ✓ | | ✓ | ✓ |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

| SEMESTER - III | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| GLY CC11 | Hydrogeology and Sustainable Development | 3 | - | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Basic concepts of the origin and occurrences, distribution, and types of groundwater | Understand |
| **CO2** | Evaluate the properties-Darcy law, Pumping test and characteristics of groundwater | Evaluate |
| **CO3** | Study of groundwater basins, recharge, and management studies | Apply |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Groundwater and genetic types - Meteoric, Juvenile and Connate. Groundwater Distribution (subsurface): Zone of Aeration, Capillary fringe, Zone of Saturation and Water Table- Hydrological Properties of Rocks: Porosity, Permeability, Specific Yield and Specific Retention, Base Flow, Transmissivity and Storage Coefficient - Hydraulic Conductivity – Aquifers: Types - unconfined, confined, leaky and perched aquifers: Darcy's Law: Validity of Darcy's Law - Ground Water Flow Equations: Steady, Unsteady and Radial Flow: Drilling Methods for Groundwater Bore Wells, Tube wells - Physical Parameters of Groundwater Quality - Analysis of Major and Minor Elements in groundwater using APHA standards - Outline of Water Quality Standards and Guidelines: WHO, BIS and ICAR - Water Quality Parameters for Drinking, Agriculture, and Industrial Uses - Graphical Representation and Interpretation of Water Quality Data: WILCOX, USSL, GIBBS plot, Piper Trilinear, Donean and Durov diagrams - Coastal Aquifers: Ghyben-Herzberg relation and Saline Water Intrusion. | 15 |
| **II** | Groundwater: Run off, estimation of run off, reach, Horton overflow, flood and modeling, Different types of water bodies: Lake, river, bond and their linkages, Surface water quality and quantity assessment: Problems due to over-exploitation of groundwater, hard rock aquifer system. Outline of methods of groundwater exploration - Groundwater provinces of India and Tamil Nadu. Application of Geospatial technology in groundwater exploration, Groundwater modeling – Aquifer modeling and prediction, | 15 |
| **III** | Sustainable Development: Rainwater harvesting definition, methods, and design of harvesting structures - Groundwater recharge: natural and artificial methods, Artificial recharge techniques - Groundwater recharge and impacts: | 15 |

| | | |
|---|---|---|
| | Environment, groundwater recharge, benefit the society. Groundwater Budget and estimations: Volume estimation, and budget, Groundwater Management – Watershed: definition, watershed management: Climate change in water resource. | |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

**Text Book**

1. Fetter, C. W., (2007), Applied Hydrology, CBS Publications.
2. Karanth, K. R., (1998), Hydrogeology, Tata McGraw-Hill Publishing Company
3. Karanath, K.R (1987). Groundwater Assessment, Development & Management, Tata Mc Graw Hill.
4. Raghunath, H.M., (2003), Groundwater, New age international publications.
5. Ragunath, H.M (2007). Groundwater, New Age International Publishers, Delhi
6. Todd D. K., & Mays, L. W., (2013), Groundwater Hydrology, Wiley son's publication.

**Reference Book**

1. Anbazhagan, S., Jothibasu, A., & Balamurugan, G., (2019), Climate Change in Water Resources. Allied Publishers, New Delhi, India.
2. Bouwer, H., (2014), Groundwater Hydrology, McGraw hill education private limited.
3. Deman, MCJ. Smith G.S & Verstappen, H. T., (1986), Remote Sensing for resources development and environmental management, A. A. Ballkema Publishers, Totterdam, Netherlands.
4. Gurugnanam, B., (2009), Essentials of Hydrogeology, NIPA publications, New Delhi.
5. Ramakrishnan, S (1998). Groundwater. K.G. Graph Arts, Chennai.
6. Ramakrishnan. S., (1998), Groundwater, CBS Publishers & Distributors.

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | | | | |
| CO2 | ✓ | | ✓ | ✓ | ✓ | ✓ |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

| SEMESTER - III | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| GLY CC12 | Engineering Geology | 3 | - | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Explain various physical and mechanical properties or rocks and soils used in engineering Geology | Understand |
| **CO2** | Study rock failure mechanism, rock mass classifications and the concept of rock slope engineering | Apply |
| **CO3** | Study the soil classification and importance of soil behavior for foundation engineering | Apply |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Introduction to Engineering Geology. Concepts of stress, strain. Engineering properties of rocks – Physical and mechanical properties of rocks; Specific Gravity, Porosity, permeability, Absorption, Strength of rocks, compressive, tensile, shear and triaxial strength, elastic modulus and Poisson's ratio of rocks and their measurement. Mohr's circle of stress and strain and theories of rock failure. Determination of in-situ stresses. Discontinuities in rock masses. Concepts of rock mass classification – RMR and Q systems. | 15 |
| **II** | Geological consideration for evaluation of dams and reservoir sites. Methods of tunneling; Classification of ground for tunneling purposes; various types of support. Rock slope engineering - factors influencing slope stability, analysis of slope failure, monitoring of slope stability, improving slope stability. Landslides – concepts, classification, and analysis. Rock as construction materials and aggregate properties. Engineering Geological investigations related to highways, buildings, bridges. Shoreline engineering geology. | 15 |
| **III** | Soil classification, unified soil classification system, clay minerals and their structure. Weight – volume relationship of soil, Index properties of soil. Consolidation of soil. Strength properties of soils and their determination in laboratory. Atterberg limits. Weathering indices, swelling indices, durability indices. Bearing capacity and California bearing ratio (CBR) of soils and foundations of Engineering Structures. | 15 |
| | **Tasks and Assignments:**<br>Each student is required to undergo the following:<br>✓ Assignments<br>✓ Seminars<br>✓ Class Tests | |

**Text Book**

1. Bell, F.G., (2007), Engineering geology. Taylor & Francis Group.
2. Singh, B., & Goel, R.K., (2011), Engineering rock mass classification. Elsevier Inc.
3. Waltham, T., (2002), Foundations of Engineering Geology. Elsevier Ltd.
4. Wood, D.M., (1990), Soil behaviour and critical state soil mechanics. Cambridge University Press.

**Reference Book**

1. Deb, D., & Verma, A.K., (2016), Fundamental and applications of rock mechanics. PHI Learning Private Limited.
2. Jaeger, J.C., Cook, N.G.W., & Zimmerman, R.W., (2007), Fundamental of rock mechanics. Blackwell Publishing Ltd.
3. Mitchell, J.K., & Soga, K., (2005), Fundamental of soil behaviour. John Wiley & Sons, Inc.
4. Salgado, R., (2008), The Engineering of Foundations. McGraw Hill.

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | | ✓ | ✓ |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO3 | ✓ | ✓ | ✓ | | ✓ | ✓ |

| SEMESTER - III | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| GLY CC13 | Fuel Geology | 3 | - | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Understand the formation, properties, migration, and accumulation of petroleum; origin, occurrence, and classification of coal. | Understand |
| **CO2** | Explain about chemical characterization, industrial and geological problems, and purpose of fuel | Understand |
| **CO3** | Apply the concepts of fuel geology for various unconventional resources. | Apply |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Introduction to fuel geology and its economic strength. Petroleum- Physical and chemical properties; transformation of organic matter into kerogen; origin, nature, generation and migration of oil and gas; surface and subsurface occurrence of petroleum and gas. Characteristics of reservoir rocks and traps and seals (structural, stratigraphic and correlation); Prospecting for oil and gas, drilling, and logging procedures; Oil and gas fields of India; geology of the productive oil and gas fields of India; reservoir characteristics, relationship between porosity, permeability and texture, Correlation of well log parameters with seismic properties. | 15 |
| **II** | Fundamentals of coal petrology. Origin of coal; macroscopic ingredients and microscopic constituents; the concept of maceral and microliths types. sedimentology of coal bearing strata; rank, grade, and type of coal; Chemical characterization: proximate and ultimate analysis; Indian and International classifications of coal; coal petrology and its application in solving industrial and geological problems; preparation of coal for industrial purposes; coal carbonization (coke manufacture) coal gasification and coal hydrogenation, Coal bed – methane: a new energy resource. Shale gas. Indian coal deposits. | 15 |
| **III** | Atomic fuel- Mode of occurrence and methods of prospecting and productive geological horizons in India; nuclear power stations of the country and future prospects; Importance of Fuels in Modem Economy. Impact of atomic Energy over conventional fuels. Conservation of non-renewable & associated Renewable resources. | 15 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

**Text Book**

1. Chandra, D., Singh, R.M & Singh, M.P., (2000), Textbook of Coal (Indian context), Tara Book Agency, Kamachha, Varanasi.
2. Hunt, J. M., (1995), Petroleum Geochemistry and Geology, W.H.Freeman & Co Ltd.
3. Selley, R.C., (1997), Elements of Petroleum Geology, Academic Press.
4. Singh, M.P., (1998), Coal and Organic Petrology. Hindustan Publishing Corporation

**Reference Book**

1. Ahmed, T., (2001), Researvour Engineering. Gulf Professional Publishing
2. Levorsen A.I., (1985), Geology of Petroleum, CBS Publishers and Distributors, Delhi,
3. Thomas, L, (2012), Coal geology, Wiley India Pvt. Ltd.
4. Tissot, B. P. & Welte, D. H., (1984), Petroleum formation and occurrence. Springer-Verlag Berlin Heidelberg.

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | | ✓ | | ✓ | ✓ |
| CO2 | ✓ | ✓ | ✓ | | ✓ | ✓ |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

| SEMESTER - III | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| GLYCC14 | Exploration Geology | 3 | - | 3 |

**a. Course Outcome (CO)**

*At the end of this course, students will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Understand the basics of mineral exploration and drilling techniques. | Understand |
| **CO2** | Describe the reserve estimation and modelling for mineral exploration. | Apply |
| **CO3** | Explain the basics of geochemical and geophysical methods of exploration | Analyse |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Concept of Mineral Exploration, Classification of Resources and Reserves, Selection of minerals for exploration, Criteria and guides for mineral search, Stages of Mineral Exploration, Various types of surveying in exploration, Field equipment used in Exploration geology, Types of sampling - soil sampling, pitting, trenching, channel sampling, grab sampling, muck sampling, and bulk sampling, Objectives of drilling, Types of drilling – Auger drilling, cable-tool drilling, percussion drilling, diamond drilling and wireline drilling. | 15 |
| **II** | Geochemical exploration – mobility of elements, primary and secondary dispersion, geochemical anomaly, pathfinder elements and various geochemical sampling, introduction to geobotanical exploration methods, Geophysical exploration – Gravity Survey, Magnetic survey, Seismic survey, Electrical survey, resistivity method, induced polarization method, self-potential method, electromagnetic survey, radiometric survey, well-logging, and their applications in exploration field. | 15 |
| **III** | Geological and mineable ore reserves, mineable waste and their calculation, fundamentals of geostatistical methods in mineral exploration, interpretation of exploration data, Geological modelling for mineral exploration. | 15 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

**Text Book**

1. Arogyaswami, R.P.N., (1996), Courses in Mining Geology, Oxford & IBH Publishing Co Pvt.Ltd

2. Sinha, R.K. & Sharma, N.L, (1993), An Introduction to Mineral Economics, Wiley Eastern.

**Reference Book**

1. Bagchi, T.C., Sengupta, D.K. & Rao, S.Y.L.N., (1979), Elements of Prospecting and Exploration.
2. Banerjee, P.K. & Ghosh, S., (1997), Elements of prospecting for nonfuel mineral deposits, Allied Publishers Limited.

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO2 | ✓ | ✓ | | ✓ | ✓ | ✓ |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

| SEMESTER - III | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLY CP06** | Economic Geology and Fuel Geology | - | 2 | 2 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Identify the important ore and economic minerals. | Skill |
| **CO2** | Extract the information of petroliferous basins of India and explain various concepts of coal petrography | Skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | 1. Demonstration and study of ore microscope.<br>2. Microscopic observation and description of the common ore minerals.<br>3. Megascopic observation and description of the common ore minerals including asbestos, carbonate, sulphate, phosphate, fluoride, oxide and sulphide minerals. | 22.5 |
| **II** | Exercise based on source rock, reservoirs and traps. Case study of petroliferous basin of India. Coal Petrography | 22.5 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Laboratory reports
✓ Assignments
✓ Viva

**Text Book**

1. Chandra, D., Singh, R.M & Singh, M.P., (2000), Textbook of Coal (Indian context), Tara Book Agency, Kamachha, Varanasi.
2. Craig J. R. & Vaughan, D. J., (1994), Ore Microscopy and Petrography.
3. Thomas, Larry, (2012), Coal geology, Wiley India Pvt. Ltd.

**Reference Book**

1. Cuilbert, J.M. & Park,Jr. C.F., (1986), The Geology of Ore Deposits, Freidman.
2. Ramdhor, P., (1969), The Ore Minerals and their Intergowths, Pergamon Press.
3. Selley, R.C., (1997), Elements of Petroleum Geology, Academic Press.
4. Stanton, R.L., (1972), Ore Petrology, McGraw Hill.
5. Wolf, K.H., (1976-1981), Handbook of Stratabound and Stratiform Ore Deposits, Elsevier Publication

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

| SEMESTER - III | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLY CP07** | Hydrogeology and Engineering Geology | | 2 | 2 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Analyze the rainfall, groundwater, geophysical data using different map and software | Analyze |
| **CO2** | Understand the concept of measurement of various mechanical and physical properties of rocks and soils and have important information about the instrumentation used in engineering geology | Analyze |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Demonstrate the rainfall and its assessment for hydrogeological studies. Explain the water level data assessment. Analyze the problems related to porosity and specific yield and retention. Analyse the water sample for major element studies. Execute the resistivity study in the field and assess the interpretation.<br>▪ Rainfall - Arithmetic mean method Assessment.<br>▪ Rainfall - Thiesson polygon method Assessment.<br>▪ Rainfall – Isohyetal method Assessment.<br>▪ Preparation of water level map and its interpretation<br>▪ Problems - Porosity Specific and Specific yield / retention.<br>▪ Major elements Analysis for water.<br>▪ Graphical interpretation of water quality data.<br>▪ Water Quality - Irrigation use Assessment.<br>▪ Pumping test data interpretation.<br>▪ Isohyetal map generation through surfer software.<br>▪ Resistivity survey and the interpretation for lithology and water resources - Wenner method<br>▪ Resistivity survey and the interpretation for lithology and water resources - Schlumberger method<br>▪ Rock works software applications in Hydrogeology<br>▪ Surfer software and its application in Hydrogeology | 22.5 |
| **II** | Measurement of various mechanical and physical properties of rocks and soils. Instrumentation in engineering geology. Study of properties of common rocks with reference to their utility in engineering projects. Direct and indirect methods of determination compressive, tensile, shear and triaxial strength of | 22.5 |

| | | |
|---|---|---|
| | rock; modulus of elasticity and Poisson's ratio; dynamic modulus of elasticity; porosity of rock. Load cell, extensometer, and strain gauge. Software in the field of rock mechanics. | |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Laboratory reports
✓ Assignments
✓ Viva

**Text Book**

1. Singh, B., & Goel, R.K., (2011), Engineering rock mass classification. Elsevier Inc.
2. Singh, P., (2010), Engineering and General Geology, Eight Revised Edition, Published by S.K. Kataria & Sons.
3. Todd D. K., & Mays, L. W., (2013), Groundwater Hydrology, Wiley son's publication.

**Reference Book**

1. Deb, D., & Verma, A.K., (2016),Fundamental and applications of rock mechanics. PHI Learning Private Limited.
2. Gurugnanam, B., (2009), Essentials of Hydrogeology, NIPA publications, New Delhi.
3. Ramakrishnan. S., (1998), Groundwater, CBS Publishers & Distributors.

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

# R. SEMESTER IV

| SEMESTER - IV | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLY CP08** | Geological Field Study | | 3 | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Handling the different geological field equipment and mapping | Skill |
| **CO2** | Identification of minerals, rocks and fossils and interpretation of their genesis. | Apply |

**b. Syllabus**

| Units | Content | Days |
|---|---|---|
| **I** | Introduction - Literatures and maps - Description of rocks - Physiography - Topographic expressions and relief - Inliers and outliers - requirements of the field - suggestions and precautions. Equipment and Supplies: General, Geological Hammers, Pocket and Hand Lenses, Hydrochloric Acid, Streak Plate, Pocket Magnet, Pocket Knife, Measuring Tapes and Scales, Haversack or Rucksack, Mohs Scale of Hardness, Cold Chisel, Protractors, Pocket Calculator, Cameras, Care and Upkeep of Instruments. The compass and Clinometer: The compass and its uses- Dip of the compass needle - Magnetic declination - Clinometer: Bearing and Reading directions - Measuring altitudes - Handling of the compass.<br>Topographic maps: Base Maps, Scale of maps – Depiction of relief - Latitudes and Longitudes- Map grids - Measurement of mapped areas- Mounting and folding field maps- Marking on maps. Field documentation: Field sketches and Drawings - Field photographs. Basic field procedures: Location - Soils and vegetation- measuring distances - Compass and tape traversing - Determination of slopes and gradients- Measuring difference in elevation - Field identification of rocks - Basic field observations. | 25 |
| **II** | Field Study | |
| **III** | Reports and presentation | |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Field reports
✓ Assignments
✓ Viva

**Text Book**

1. Barnes, J. W., (2004), Basic Geological Mapping. John Wiley & Sons Inc., New Delhi,
2. Coe, A. L., (2010), Geological Field Techniques. Open University Press, Milton Keynes, UK,
3. Gokhale, N.W., (2001), A Guide to Field Geology. CBS Publishers, New Delhi,
4. Mathur, S. M., (2001), Guide to Field Geology. Prentice Hall India. New Delhi.

**References**

1. Compton, R. R., (1985), Geology in the Field, John Wiley & Sons Inc., New Delhi.
2. Freeman, T., (1999), Procedures in Field Geology. John Wiley & Sons Inc., New Delhi.
3. Lahee, F, (1987), Field Geology, CBS Publishers, New Delhi.

### c. Mapping of Program Outcomes with Course Outcomes

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

# S. DEPARTMENT SPECIFIC ELECTIVE

| SEMESTER - II | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLYDSE01** | Oceanography and Marine Geology | 3 | - | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Understand the physical, biological and chemical oceanography | Understand |
| **CO2** | Describe marine geology, classification of coast and its mineral deposits | Understand |
| **CO3** | Analyze the marine environments using marine geological instruments | Apply |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Introduction to oceanography; Physical properties of seawater; Waves: definition, classification and types of waves, origin of surface waves, characteristics, growth and dissipation of wind waves, breakers and surfs, Tides: definition, classification, causes and types of tide, storm surges, seiches, and Tsunami, Currents: definition, classification, causes and types of current, major surface current system of the World Ocean, atmospheric circulation, global wind pattern, Ekman spiral, Ekman transport and upwelling. Introduction to Chemical and Biological Oceanography. | 15 |
| **II** | Marine Geology: Introduction and scope of marine geology, Oceanic profile, oceanic features, beaches. Classification of coast. Waves, Currents and Tides. Coastal protection structures. Classification of marine mineral deposits: Origin and depositional system of marine resources. Beach placers: Shelf deposits, Deep Ocean phosphatic, Polymetallic nodules, Sulphate deposits, Hydrocarbon deposits. | 15 |
| **III** | Ocean circulation, turbidity current, submarine and sedimentation processes. Oceanic sediments and microfossils: Marine stratigraphy, correlation and chronology. Tectonic history of the oceans- Concept of sea-level changes. Seismic stratigraphy and sequence stratigraphy as applied to marine geology. Marine pollution, pathways, resilience time, pollutants in the marine environment. Introduction to Marine geological instruments. | 15 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

**Text Book**

1. Lal D.S., (2013), Climatology and Oceanography, Sharda Pustak Bhavan Publishers and Distributors.
2. Singh, Savindra, (2014), Oceanography, Pravalika Publications.
3. Siddhartha, K., (2016), Oceanography A Brief Introduction, Kisalaya Publications Pvt. Limited.
4. Singh, S., (2020), Oceanography Pravalika Publication, Allahabad

**Reference Book**

1. King. C., (1966), An Introduction to Oceanography. McGraw Hill Book Co, New York.
2. Pickard G.L. & Emery, W.J., (1982), Descriptive Physical Oceanography. Pergamon Press, Oxford.
3. Pickard, G.L., (1963), Description of Physical Oceanography. Pergamon Press, London.
4. Weisberg, J. & Parish, H., (1974), Introduction to Oceanography. McGraw-Hill Kogakusha, Ltd., Tokyo.
5. Yasso, W.E., (1965), Oceanography. Holt, Rinehert and Winston, Inc., New York.

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | | ✓ | | | |
| CO2 | ✓ | | ✓ | | ✓ | ✓ |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

| SEMESTER - II | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLYDSE02** | Geostatistics and computer applications in Geosciences | 3 | - | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Describe the principles of computer, statistical analysis using the computer programming. | Understand |
| **CO2** | Use the Geological software and explain the application of this software in geology. | Apply |
| **CO3** | Apply Geostatistics in geological data interpretation | Skill |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Statistical methods; mean; median and mode; standard deviation; skewness and kurtosis and their interrelationship; scatter diagrams; frequency distribution; histogram; correlation, covariance, correlation coefficient and regression. Distribution of sample variance and chi square distribution; probability; testing normal distribution; students 't' test, 'f' test; confidence interval, analysis; calculation of variance- covariance, simple linear models; cluster analysis. | 15 |
| **II** | Statistical analysis using various statistical software including Excel, Origin. Basic idea of the use of Python for statistical analysis. **Geostatistics:** Meaning, Definition, and History of Geostatistics, **Spatial data**- Definition and Characteristic Types: Point, Line, Polygon, Data interpolation and extrapolation with different methods | 15 |
| **III** | **Exploratory spatial data analysis:** ESDA/EDA - Meaning of Exploratory spatial data analysis (ESDA) and Exploratory data analysis (EDA). **Concepts of data distribution in space** - Data – i. Sampling, ii. Heterogeneity, iii. Dependency, Univariate description. Statistical analysis using various statistical software including Excel, Origin, Stereonet, IIPI2WIN, Surfer, Tri plot, Origin. Geo statistical analysis with case study – Frequency ratio, AHP. Geospatial visualization of geodataset. | 15 |
| **Tasks and Assignments:** Each student is required to undergo the following: ✓ Assignments ✓ Seminars ✓ Class Tests | | |

**Text Book**

1. Davis, J. C., (2002), Statistics and data analysis in geology, third edition, John Wiley & Sons, Singapore.
2. Hohn, M.E., (1988), Geostatistics and Petroleum Geology, New York: Van Nostrand Reinhold,
3. Merriam D.F., (2000), Computer Methods in the Geosciences, Elsevier.
4. Sharma, D. D., (2009), Geostatistics with applications in Earth sciences jointly published with Capital Publishing Company.

**Reference Book**

1. Chapman, S.J., (2008), Fortran for Scientists and Engineers (3rd Edn.) McGraw-Hill.
2. Cressie, N.A.C., (1993), Statistics for Spatial Data, New York: John Wiley & Sons, Inc.
3. Duetsch, C.V. & Journel, A.G., (1992), GSLIB: Geostatistical Software Library and User's Guide, New York: Oxford University Press,
4. Isaaks, E. H. & Srivastava, R.M., (1989), An Introduction to Applied Geostatistics, Oxford University Press,
5. Kitanidis P.K., (1997), Introduction to Geostatistics, Applications in Hydrogeology, Cambridge University Press.
6. Sancheti. D. C. & Kapoor, V. K., (1992) Statistics Theory, Methods and Application. Sultan Chand & Sons publishers P.5.1 to 5.47
7. Simon W., (2000), Houlding Geostatistics: Modeling and Spatial Analysis, Springer: Har/CdrEdition (8 June 2000), CD-ROM: 161 pages, 2000.
8. Tomislav, Hengl, (2009), A Practical Guide to Geostatistical Mapping. ISBN 978-90-9024981-0

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | | ✓ | ✓ | ✓ | ✓ |
| CO2 | ✓ | | ✓ | ✓ | | |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

| SEMESTER - II | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLYDSE03** | Mining Geology | 3 | - | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Understand methods of mining processes, sampling methods and examination | Understand |
| **CO2** | Explain the methods of underground mining | Apply |
| **CO3** | Analyze Mining profits and excavation of Resources | Analyze |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Intersecting loci and ring targets; guides to ore localization. Subsidence and the support of mine excavation; timber treatment; methods of breaking rocks; drilling blast holes; explosives used in mining; blasting practices; shaft sinking; mine drainage; ventilation; illumination | 15 |
| **II** | Alluvial, open- pit and underground mining methods; drifting; cross-cutting; winzing; stoping; room and pillaring; top-slicing; sub-level caving and block caving; ocean bottom mining, mine organization and operation; mine hazards. Factors in evaluating a mineral deposit; mine examination; theory and methods of sampling; sampling calculations; recoverable values. | 15 |
| **III** | Cost of mining; future costs and profits; life of mine; present value of mine and its determination by compound interest and Hoskold formula methods; amortisation; calculations pertaining to valuation of mines of uniform and non-uniform annual income; sale of mineral products; metal prices and mine valuation; valuation of prospects: developed mines and working mines; valuation report. | 15 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

**Text Book**

1. Arogyaswamy R. N. P., (2017), Courses in Mining Geology, Oxford & IBH publishing
2. Young, G.J., (1946), Elements of Mining, McGraw-Hill

**Reference Book**

1. Abzalov, M., (2016), Applied Mining Geology, Springer International Publishing
2. Pivnyak, G., Bondarenko, V., Kovalevs'ka, I., & Illiashov, M., (2013), Mining of Mineral Deposits, CRC Press

### c. Mapping of Program Outcomes with Course Outcomes

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | | ✓ | | | |
| CO2 | ✓ | ✓ | ✓ | ✓ | | |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

| SEMESTER - II | | | | |
|---|---|---|---|---|
| **Course Code** | **Course Name** | **L** | **P** | **Credits** |
| **GLYDSE04** | Environmental Geology | 3 | - | 3 |

**a. Course Outcome (CO)**

*On the successful completion of the course, the student will be able to*

| | Course Outcome | Level |
|---|---|---|
| **CO1** | Understand the basic concepts of environmental geology | Understand |
| **CO2** | Apply the concepts of environment impact by various agents | Apply |
| **CO3** | Assess the environment protection and its sustainbility | Evaluate |

**b. Syllabus**

| Units | Content | Hrs. |
|---|---|---|
| **I** | Branches of Environmental Geology; Basic concepts of environmental geology; Global changes in the ecosystem and climate; Global warming and its causes; The Concept of the Anthropocene; Anthropological impacts on natural environment, Biogeochemical cycles; Weathering, development of soils and soil profiles; Weathering and CO2; Carbon dioxide in atmosphere; Atmospheric CO2 fluctuations throughout the geological history; Impact of circulations in atmosphere and oceans on climate. | 15 |
| **II** | Pollution: water resources and water pollution; air pollution; mineral resources; pollution and environment. Mining: environmental impacts of mining activities and their mitigation; energy resources: fossil fuels and environment, soil and environment, Geological hazards: earthquakes, volcanic eruptions, floods, landslides, cyclones; hazards related to oceans and weather. Fossil fuels and their impact on environment | 15 |
| **III** | Environmental protection acts in India. Applications of environmental geology in environmental protection/management: conservation and restoration of land; geological hazards and planning; risk assessment; Renewable and non-renewable energy. Assessment of mining: mine waste handling, transportation and dumping. Conservation of resources, recycling, water reuse. | 15 |

**Tasks and Assignments:**

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

**Text Book**

1. Davis, N., (1976), Environmental Geosciences, John Wiley and Sons, New York.,

2. Keith, L. H., (1996), Principles of Environmental Sampling. ACS Professional Reference book, Amer. Chem. Soc., Washington DC.
3. Subramanian, V., (2002), A Textbook in Environmental Science, Narosa Publishing House, New Delhi
4. Valdiya, K. S., (2013), Environmental Geology: Ecology, Resource and Hazard Management. McGraw-Hill Education.

**Reference Book**

1. Bennett, M. R. & Doyle, P., (1997), Environmental Geology: Geology and The Human Environment, Wiley India.
2. Detwler, T.R., (1971), Man's Impact on Environment, McGraw Hill Environmental Geology: Ecology, Resource and Hazard Management

**c. Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | | | |
| CO2 | ✓ | ✓ | ✓ | ✓ | | |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |