# Course Structure and Detailed Syllabus

# B.Sc. (Honours) in Geology

# (Under Choice Based Credit System [LOCF])

**Effective from 2021-22**


## Rajiv Gandhi University

**Rono Hills, Doimukh**

**Arunachal Pradesh – 761 112**

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# 1. Preamble

The higher education system of our country has undergone substantial structural and functional changes resulting in both quantitative and qualitative development of the beneficiaries. Such changes have gained momentum with the introduction of Choice Based Credit System (CBCS) which further expects learning outcome based curriculum in order to maximize the benefits of the newly designed curriculum. The Learning Outcome Based Curriculum in general and in Geology in particular will definitely help the teachers of the discipline to visualize the curriculum more specifically in terms of the learning outcomes expected from the students at the end of the instructional process. It is pertinent to mention here that the purpose of education is to develop an integrated personality of the individual and the educational system provides all knowledge and skills to the learner for this.

The syllabus developed for B. Sc. (H) in Geology has the provision of ensuring the integrated personality of the students in terms of providing opportunity for exposure to the students towards Core Courses, Discipline Specific Courses, Generic Elective Courses, Ability Enhancement Courses and Skill Enhancement Courses with special focus on technical, communication and subject specific skills through practical and other innovative transactional modes to develop their employability skills.

The syllabus is based on Learning Outcome Based Curriculum and has categorically mentioned very well defined expected outcomes for the programme like core competency, communication skills, critical thinking, affective skills, problem-solving, analytical, reasoning, research-skills, teamwork, digital literacy, moral and ethical awareness, leadership readiness and so on along with very specific learning course outcomes at the starting of each course.

# 2. Choice based credit system (CBCS) in B.Sc. (Honours) Geology

Under the credit-based semester system, the requirement for awarding and conferring a degree is prescribed in terms of number of credits to be completed by the students. The CBCS provides choice for students to select courses from a pool of Elective and Ability enhancement courses offered in other subjects. The learning outcome-based curriculum framework (LOCF) offers a flexibility and innovation in design of the programme, its assessment, and expects graduate attributes demonstrating the level of learning outcome. It is further expected to provide effective teaching-learning strategies including periodic review of the programme and its academic standard. The LOCF based programme will ensure that students get a clear purpose to focus their learning efforts and enable them to make a well-judged choice regarding the course they wish to study. This will enable the students to build a strong foundation in the subject and gain in-depth knowledge that suit the present day needs of students in terms of securing their paths towards higher studies or employment. It would also ensure equal academic standards across the country and broader picture of their competencies.

# 3. Nature and extent of the B.Sc. (H) in Geology Programme

Geology is a broad discipline encompassing various subjects involved with the study of the earth. B.Sc. (Hons.) in Geology programme is designed to provide students with a sound theoretical background and practical training in all aspects of geology and help them develop an

appreciation of the importance of geology in different contexts. To ensure implementation of a holistic pedagogical model, a number of choices for Generic electives from allied disciplines like Physics, Chemistry, Mathematics and Computer Science, have been included in this framework. In addition, considering the employability aspect of B.Sc. Geology graduates, due importance has been given towards their core competency in the subject matter, both theoretical and practical. To expand the employability of graduates, certain Ability enhancement electives to develop language proficiency and many Skill based elective courses from relevant disciplines have been introduced. The syllabus will also enable the students to equip for national level competitive exams that they may attempt in future.

## 4. Aims of the Bachelor's Degree Programme in Geology

The broad aims and objectives of our UG programme in geology are to:

- Create the facilities and environment to introduce and consolidate the knowledge acquired at +2 level and to motivate and inspire the students to create deep interest in geology, to develop broad and balanced knowledge and understanding of geological concepts, principles and theories of stratigraphy, geological mapping, exploration of natural resources and understand earth evolution.
- Learn, design and perform experiments in the labs to demonstrate the concepts, principles and theories learned in the classrooms.
- Develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in theoretical and applied geology.
- Expose the student to the vast scope of geosciences as a theoretical and experimental science with applications in solving most of the geogenic problems in nature spanning from watershed management, climate change, environmental sanitation and mining, etc.
- Emphasize the need for integrating geosciences as one of the most important branches of science for pursuing the interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas.
- Emphasize the importance of geology as the most important discipline for sustaining the existing industries and establishing new ones to create job opportunities at all levels of employment.
- Learn the geological knowledge of the NE India, in particular Arunachal Pradesh and to learn evolution and mineral resources of the eastern Himalaya.
- Equip the students with critical thinking, problem solving, communication skills and team work through intense laboratory classes, fieldworks, group discussions and seminar presentations.

## 5. Programme Learning Outcomes in B.Sc. (Hons.) Geology

The student graduating with the B.Sc. (Honours) Geology degree would be able to:

- Acquire a fundamental/systematic or coherent understanding of the academic field of geology, its different learning areas and applications in basic geology like mineralogy, petrology, stratigraphy, palaeontology, economic geology, hydrogeology, etc. and its

linkages with related interdisciplinary areas/subjects like geography, environmental sciences, physics, chemistry, mathematics, life sciences, atmospheric sciences, remote sensing, computer science, and information technology.

- Acquire procedural knowledge that creates different types of professionals related to the disciplinary/subject area of geology, including professionals engaged in research and development, teaching and government/public service.
- Acquire skills in areas related to one's specialization area within the disciplinary/subject area of geology and current and emerging developments in the field of geosciences.
- Demonstrate the ability to use skills in geology and its related areas of technology for formulating and tackling geosciences-related problems and identifying and applying appropriate geological principles and methodologies to solve a wide range of problems associated with geosciences.
- Recognize the importance of RS & GIS, mathematical modeling simulation and computing, and the role of approximation and mathematical approaches to describing the physical world.
- Plan and execute geology-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories in geology.
- Demonstrate relevant generic skills and global competencies such as
    - problem-solving skills that are required to solve different types of geoscience-related problems with well-defined solutions, and tackle open-ended problems that belong to the disciplinary area boundaries.
    - investigative skills, including skills of independent investigation of geoscience-related issues and problems.
    - communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature.
    - analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to geology and ability to translate them with popular language when needed.
    - ICT skills and
    - personal skills such as the ability to work both independently and in teams
- Demonstrate professional behaviour such as
    - being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behaviour such as fabricating, falsifying or misrepresenting data or committing plagiarism.
    - the ability to identify the potential ethical issues in work-related situations.
    - appreciation of intellectual property, environmental and sustainability issues and
    - promoting safe learning and working environment.

## 6. Duration of Programme: Six semesters (Three years)

## 7. Programme Structure

1. The syllabi for B.Sc. (Honours) in Geology is drafted as per the UGC guidelines for Learning Outcomes based Curriculum Framework (LOCF) based approach with an aim to equip the students with knowledge, skill, values and attitude.

2. Usually a course refers to a 'paper' and is a component of an academic programme.

3. The programmes includes:

(A) ***Core Courses*****:** A core course is a compulsory paper to be studied by all the students to complete the requirements for the undergraduate degree.

(B) ***Elective Courses*****:** Elective course is a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.

(a) ***Discipline Specific Elective (DSE) Courses:*** It shall be supportive to the discipline of study, providing an expanded scope, enabling an exposure to some other discipline/domain, and nurturing student's proficiency/skill.

(b) ***Generic Elective (GE) Course:*** An elective course chosen generally from other discipline(s)/subject(s), with an intention to seek exposure is called a Generic Elective.

(c) ***Ability Enhancement Courses*****:** The Ability Enhancement Courses may be of two kinds:

(i) ***Ability Enhancement Compulsory (AEC) Courses:*** The courses which lead to knowledge enhancement. These courses are mandatory.

(ii) ***Skill Enhancement Courses (SEC):*** These courses are skill-based and/or value-based and aimed at providing hands-on-training, competencies, skills, etc. These courses are mandatory and shall be chosen from a pool of such courses prescribed in the syllabi of various Science and Technology related disciplines/Subjects available in the College/University.

4. To acquire a B.Sc. (H.) Geology degree, a student shall have to study 14 (fourteen) Core Courses, 4 (four) Discipline Specific Elective (DSE) courses, 4 (four) Generic Elective (GE) courses, 4 (four) Skill Enhancement Courses (SEC) along with 2 (two) Ability Enhancement Compulsory (AEC) Courses (Refer to the Table 1).

Table 1: Programme structure for B.Sc. (H) in Geology

| Semester | Core Course | Elective Courses | | | | Semester wise credits |
|---|---|---|---|---|---|---|
| | | DSE | GE | AEC | SEC | |
| **I** | CC 1, CC 2 | | GE 1 | AEC 1 | SEC 1 | 24 |
| **II** | CC-3, CC-4 | | GE 2 | AEC 2 | SEC 2 | 24 |
| **III** | CC 5, CC 6, CC7 | | GE 3 | | SEC 3 | 26 |
| **IV** | CC 8, CC 9, CC 10 | | GE 4 | | SEC 4 | 26 |
| **V** | CC 11, CC 12 | DSE 1, DSE 2 | | | | 24 |
| **VI** | CC 13, CC 14 | DSE 3, DSC 4 | | | | 24 |
| **Total Minimum Credits** | 84 | 24 | 8 | 24 | 8 | **148** |

5. The minimum and the maximum credit requirements for the B.Sc. (H.) Geology degree shall be 148 and 160 respectively. Students may pursue courses for additional 12 credits on their own (Students Refer to "RAJIV GANDHI UNIVERSITY REGULATIONS FOR CHOICE BASED CREDIT SYSTEM FOR UNDER-GRADUATE COURSES, 2021").
6. Semester-wise distribution of courses for B.SC. (Hons.) in Geology programme under CBCS and the Credit Distribution shall be as follows:

| Semester | Course Code | Course Name | Credits | | | |
|---|---|---|---|---|---|---|
| | | | L | T | P | Total |
| I | GOL-CC-111 | Fundamentals of Geology and Understanding the Planet Earth | 4 | 0 | 2 | 6 |
| | GOL-CC-112 | Crystallography and Mineralogy | 4 | 0 | 2 | 6 |
| | XXX-AE-111 | Ability Enhancement Compulsory Course (AEC)-1 (ENG-AE-111 or HIN-AE-111) | 4 | 0 | 0 | 4 |
| | XXX-SE-xxx | Skill Enhancement Course (SEC)-1 | - | - | - | 2 |
| | XXX-GE-xxx | Generic Elective (GE-1) | - | - | - | 6 |
| II | GOL-CC-121 | Structural Geology | 4 | 0 | 2 | 6 |
| | GOL-CC-122 | Igneous and Metamorphic Petrology | 4 | 0 | 2 | 6 |
| | EVS-AE-121 | Ability Enhancement Compulsory Course (AEC)-2 | 4 | 0 | 0 | 4 |
| | XXX-SE-xxx | Skill Enhancement Course (SEC)-2 | - | - | - | 2 |
| | XXX-GE-xxx | Generic Elective (GE-2) | - | - | - | 6 |
| III | GOL-CC-231 | Sedimentology and Principles of Stratigraphy | 4 | 0 | 2 | 6 |
| | GOL-CC-232 | Palaeontology | 4 | 0 | 2 | 6 |
| | GOL-CC-233 | Geological Field Methods and Mapping | 1 | 0 | 5 | 6 |
| | XXX-SE-xxx | Skill Enhancement Course (SEC-3) | - | - | - | 2 |
| | XXX-GE-xxx | Generic Elective (GE-3) | - | - | - | 6 |
| IV | GOL-CC-241 | Global Tectonics and Geodynamics of the Lithosphere | 4 | 0 | 2 | 6 |
| | GOL-CC-242 | Stratigraphy of India, Geology of NE India and Himalayan Geology | 4 | 0 | 2 | 6 |
| | GOL-CC-243 | Economic Geology | 4 | 0 | 2 | 6 |
| | XXX-SE-xxx | Skill Enhancement Course (SEC-4) | - | - | - | 2 |
| | XXX-GE-xxx | Generic Elective (GE-4) | - | - | - | 6 |
| V | GOL-CC-351 | Mining and Mineral Exploration | 4 | 0 | 2 | 6 |
| | GOL-CC-352 | Applied Geophysics and Geodesy | 4 | 0 | 2 | 6 |
| | GOL-DE-35X | Discipline Specific Elective (DSE-1) | 4 | 0 | 2 | 6 |
| | GOL-DE-35Y | Discipline Specific Elective (DSE-2) | 4 | 0 | 2 | 6 |
| VI | GOL-CC-361 | Engineering Geology and Environmental Geology | 4 | 0 | 2 | 6 |
| | GOL-CC-362 | Hydrogeology | 4 | 0 | 2 | 6 |
| | GOL-DE-36X | Discipline Specific Elective (DSE-3) | 4 | 0 | 2 | 6 |
| | GOL-DE-36Y | Discipline Specific Elective/Project Work (Dissertation) (DSE-4) | 4 | 0 | 2 | 6 |

Note: The number of credits is given above is in the form L:T:P, where L, T and P indicates Lecture, Tutorial and Practical laboratory credits respectively. Each lecture credit corresponds to one lecture hour per week, each tutorial credit corresponds to one tutorial hour per week while each laboratory credit corresponds to two laboratory hours per week. For example, 4:0:2 credits indicate that the course has 4 lectures, no tutorial session and two laboratory hours each week.

7. Selection of the following Elective courses shall be governed by "RAJIV GANDHI UNIVERSITY REGULATIONS FOR CHOICE BASED CREDIT SYSTEM FOR UNDER-GRADUATE COURSES, 2021" and students should refer to the provisions mentioned therein.

## 8. Discipline Specific Elective Courses (DSE)

| Semester | Course Code | Course Name | Credits | | | |
|---|---|---|---|---|---|---|
| | | | L | T | P | Total |
| V (DSE-1 & DSE-2) | GOL-DE-351 | Mineral and Energy Resources of India | 4 | 0 | 2 | 6 |
| | GOL-DE-352 | Oceanography and Marine Geology | 4 | 0 | 2 | 6 |
| | GOL-DE-353 | Petroleum Geology | 4 | 0 | 2 | 6 |
| | GOL-DE-354 | Geochemistry and Isotope Geology | 4 | 0 | 2 | 6 |
| VI (DSE-3 & DSE-4) | GOL-DE-361 | Fundamentals of Remote Sensing and GIS | 4 | 0 | 2 | 6 |
| | GOL-DE-362 | Climate Change: Past, Present and Future | 4 | 0 | 2 | 6 |
| | GOL-DE-363 | Quaternary Geology and Geomorphology | 4 | 0 | 2 | 6 |
| | GOL-DE-364 | Dissertation/Research Project | 0 | 0 | 6 | 6 |
| The students shall select 2 DSE each in V and VI semester. Student may opt for Project Work (Dissertation) in lieu of a DSE paper in VI semester (Refer to the above mentioned regulation). | | | | | | |

## 9. Ability Enhancement Compulsory Courses (AEC)

| Semester | Course Code | Course Name | Credits | | | |
|---|---|---|---|---|---|---|
| | | | L | T | P | Total |
| I (Any One) | ENG-AE-111 | Communicative English | 3 | 1 | 0 | 4 |
| | HIN-AE-111 | **हिंदी शिक्षण** | 3 | 1 | 0 | 4 |
| II | EVS-AE-121 | Environmental Studies | 4 | 0 | 0 | 6 |

## 10. Skill Enhancement Courses (SEC)

| Semester | Course Code | Name of Course | Credit | | | |
|---|---|---|---|---|---|---|
| | | | L | T | P | Total |
| I & III | GOL-SE-001 | Optics and Optical Mineralogy | 1 | 0 | 1 | 2 |
| | GOL-SE-003 | Gemology and Gem Testing | 2 | 0 | 0 | 2 |
| | GOL-SE-005 | Surveying and Levelling | 2 | 0 | 0 | 2 |
| | GOL-SE-007 | Watershed Development | 2 | 0 | 0 | 2 |
| II & IV | GOL-SE-002 | Statistics and its applications in Geology | 2 | 0 | 0 | 2 |
| | GOL-SE-004 | Medical Geology | 2 | 0 | 0 | 2 |
| | GOL-SE-006 | Environmental Sanitation | 2 | 0 | 0 | 2 |
| | GOL-SE-008 | Fieldwork | 0 | 0 | 2 | 2 |

A student shall select at least 2 SEC of total 4 credits from his/her concerned discipline. For remaining 4 credits, he/she may select course(s) from either from his/her own discipline or other under-graduate disciplines of Science and Technology in the College/University (Refer to the above mentioned regulation).

## 11. Generic Electives (GE)

| Semester | Course Code | Course Name | Credits | | | |
|---|---|---|---|---|---|---|
| | | | L | T | P | Total |
| I | GOL-GE-001 | Earth and Environment | 4 | 0 | 2 | 6 |
| II | GOL-GE-002 | Geographical Information System | 4 | 0 | 2 | 6 |
| III | GOL-GE-003 | Introduction to Remote Sensing | 4 | 0 | 2 | 6 |
| IV | GOL-GE-004 | Planetary Science | 4 | 0 | 2 | 6 |

GEs given above are for the students of subsidiary disciplines/subjects (Refer to the above mentioned regulation). They shall select one GE in each semester from 1$^{st}$ to 4$^{th}$ semester, either exclusively from one subsidiary discipline or 2 courses each from two subsidiary disciplines.
Students of Geology (Hons.) shall accordingly choose 4 GEC from the available subsidiary disciplines, Physics, Chemistry, Mathematics, Computer Science.

## 12. Teaching Learning Process

These courses shall be delivered through classroom, laboratory work, projects, case studies and field work in a challenging, engaging, and inclusive manner that accommodates a variety of learning styles and tools (PowerPoint presentations, audio visual resources, e-resources, seminars, workshops, models, software). The laboratory training complements the theoretical principles learned in the classroom, hands-on experience with modern instruments, lab based and field based experimentation and studies.

## 13. Assessment Methods and Conduct of Examinations

Academic performance in various courses i.e. core, discipline electives, generic electives and skill enhancement courses are to be considered as parameters for assessing the achievement of students. All students shall be subjected to the process of continuous evaluation and assessment. A number of appropriate assessment methods will be used to determine the extent to which students demonstrate desired learning outcomes (Refer to the above-mentioned regulation and the relevant ordinance(s) of the Rajiv Gandhi University).

# *DETAILED SYLLABUS*

# GOL-CC-111

# Fundamentals of Geology and Understanding of the Planet Earth

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The course is intended to introduce the basic understanding of the solar system, it components and origin. It is also intended to give an overall understanding of the earth system including its components, dynamics and history.

**Course Learning Outcome**

The study of this paper strengthens knowledge with respect to understanding the essentials of the structural dynamics of the earth. They will also understand the origin of solar system, evolution of life and various processes operating in the earth.

**Key Words:** Solar System, Earth, Plate Tectonics, Life, Geological Processes

**Unit 1:** **15 Lectures**

Earth system science: scope and subdivisions in geology; solar system - general characteristics and origin; meteorites; earth - origin, size, shape, mass, density, orbital parameters and magnetic field; introduction to minerals and rocks.

**Unit 2:** **15 Lectures**

Plate tectonics - concepts; internal structure of the earth; rock deformation and tectonic plate movement; volcanism; earthquake and earthquake zones in India.

**Unit 3:** **15 Lectures**

Introduction to historical geology; evolution of the earth's crust, oceans, atmosphere and life forms; sedimentary layering and their significance; fossils; dating geological materials; mass extinction events.

**Unit 4:** **15 Lectures**

Weathering and erosion; soil and soil profile; mass movement; earth's surface processes and associated features.

## Practical

***60 Hours***

1. Study of landforms, contour patterns, topographic maps and profiles.
2. Identifying different types of rocks.
3. Introduction to field geology.
4. Practical records.
5. Viva-voce.

# GOL-CC-111
# Fundamentals of Geology and Understanding of the Planet Earth

**Recommended Books**

Text Books:


1. **A Text Book of Geology** - P.K. Mukherjee, *World Press, Kolkata*
2. **Earth Materials** - Kevin Hefferan and John O'Brien, *Wiley-Blackwell*
3. **Essentials of Geology** - Lutgens, Tarbuck and Tasa, *Pearson*
4. **Fundamentals of Geomorphology** - Richard J. Huggett, *Routledge*
5. **Fundamentals of Physical Geology** - Sreepat Jain, *Springer*
6. **Physical Geology**- Charles C. Plummer, Diane H. Carlson and Lisa Hammersley, *McGraw Hill*
7. **Principles of Physical Geology** - Arthor Holmes, *Champman and Hall, London*
8. **Understanding Earth** - John Grotzinger and Thomas H. Jordan, *Macmillan*


Reference Books:


1. **Earth Science: The Earth, The Atmosphere, and Space** - S. Marshak and R. Rauber, *W.W. Norton & Co.*
2. **Encyclopedia of Geomorphology** - Andrew S. Goudie, *Routledge*
3. **Introduction to Coastal Processes and Geomorphology** - Robin Davidson-Arnott, *Cambridge*
4. **Introduction to Physical Geology**- Thompson and Turk, *Brooks*
5. **Introduction to Planetary Science**- Gunter Faure and Teresa M. Mensing, *Springer*
6. **Looking into the Earth: An Introduction to Geological Geophysics**- Alan E. Mussett and M. Aftab Khan, *Cambridge University Press*
7. **The Earth's Land Surface** - Kenneth J. Gregory, *Sage*

# GOL-CC-112
# Crystallography and Mineralogy

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The course deals with the study of minerals, their chemistry, physical and optical properties and identification. Further, it also deals with the study of crystals with respect to their morphology, symmetry and axes.

**Course Learning Outcome**

The students will learn the basics of mineralogy and crystallography that helps in understanding and building the overall knowledge in geology. The students will be able to identify common rock-forming minerals in hand specimens as well as in thin sections.

**Key Words:** Crystals, Minerals, Optics

**Unit 1:** **15 Lectures**

Crystallography: crystalline and non-crystalline substances; lattices and unit cell; symmetry elements; crystal systems; 32-point groups; space groups; crystal faces and Miller indices; crystal forms; zone and zonal relation.

**Unit 2:** **15 Lectures**

Crystal measurements - interfacial angle; law of constancy of interfacial angle; stereographic projection of crystals; crystal chemistry - types of bonds; atomic structure of minerals; isomorphism and polymorphism; twinning in crystals.

**Unit 3**: **15 Lectures**

Rock forming minerals: minerals - definition and classification, physical and chemical properties; silicate and non-silicate structures; systematic study of common rock-forming minerals.

**Unit 4:** **15 Lectures**

Optical Mineralogy: nature of light; interaction of light and matter; parts of petrological microscope; optical properties of minerals under plane polarized light and crossed polarized light; diagnostic optical properties of important rock-forming minerals.

## Practical ***60 Hours***

1. Study of important crystal models.
2. Stereographic projection of holohedral classes of selected crystal systems.
3. Study of twin crystals.
4. Megascopic identification of rock-forming minerals.
5. Microscopic identification of rock-forming minerals.
6. Practical records.
7. Viva-voce.

# GOL-CC-112
# Crystallography and Mineralogy

**Recommended Books**

Text Books:


1. **An Introduction to the Rock-Forming Minerals** - W.A. Deer, R.A. Howie and J. Zussman, *The Mineralogical Society London*
2. **Crystallography and Mineralogy: Concepts and Methods** - R. S. Sharma and Anurag Sharma, *Geological Society of India*
3. **Introduction to Mineralogy** - William D. Nesse, *Oxford University Press*
4. **Introduction to Optical Mineralogy** - William D. Nesse, *Oxford University Press*
5. **Mineralogy** - Dexter Perkins, *Pearson*
6. **Mineralogy** - L.G. Berry, Brian Mason and R.V. Dietrich, *CBS Publishers and Distributors*
7. **Optical Mineralogy** - B.F. Kerr, *McGraw Hill*
8. **Practical Approach to Mineralogy and Crystallography** - R.N. Hota, *CBS Publishers and Distributors*
9. **The Manual of Mineral Science** - Cornelis Klein and Barbara Dutrow, *Wiley*


Reference Books:


1. **A Key for Identification of Rock-forming Minerals in Thin Section** - Andrew J. Barker, *CRC Press*
2. **A Practical Introduction to Optical Mineralogy** - C. D. Gribble and A. J. Hall, *Springer*
3. **Atlas of Rock-Forming Minerals in Thin Section** - W. S. MacKenzie and C. Guilford, *Routledge*
4. **Dana's Textbook of Mineralogy** - William E. Ford, *CBS Publishers and Distributors*
5. **Earth Materials: Introduction to Mineralogy and Petrology** - Cornelis Klein and Anothony Philpotts, *Cambridge*
6. **Introduction to Mineralogy and Petrology** - S.K. Haldar and Josip Tisljar, Elsevier
7. **Rock Forming Minerals, Volume 3A: Micas** - W. A. Deer, R. A. Howie and J. Zussman, *The Geological Society of London*
8. **Rock Forming Minerals, Volume 4A: Framework Silicates (Feldspars)** - W. A. Deer, R. A. Howie and J. Zussman, *The Geological Society of London*
9. **Rock Forming Minerals, Volume 4B: Framework Silicates (Silica Minerals, Feldspathoids and the Zeolites)** - W. A. Deer, R. A. Howie and J. Zussman, *The Geological Society of London*
10. **Rock-Forming Minerals, Volume 3B: Layered Silicates (Excluding Micas and Clay Minerals)** - W. A. Deer, R. A. Howie and J. Zussman, *The Geological Society of London*
11. **Rock-Forming Minerals, Volume 3C: Sheet Silicates (Clay Minerals)** - W. A. Deer, R. A. Howie and J. Zussman, *The Geological Society of London*
12. **Rocks and Minerals in Thin Section** - W.S. MacKenzie, A.E. Adams and K.H. Brodie, *CRC Press*
13. **Rutley's Elements of Mineralogy** - C.D. Gribble, *CBS Publishers and Distributors*

# GOL-CC-121
# Structural Geology

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The course deals with geological structures resulting from the action of forces on rocks. The course is intended for student to gain knowledge of the geometry of the rock structures, understand the mechanism of the evolution of geological structures that result through the deformation processes operative within the earth.

**Course Learning Outcome**

This course helps the students to understand how to use structures and appreciate the dynamic nature of the Earth's lithosphere. The students will learn the skills of identifying different structure and will be acquainted with field measurements required for geological mapping, learn how to read geologic maps and solve simple map problems and preparations of cross sections.

**Key Words:** Rock Structures, Stress, Strain, Fold, Fault, Joint, Lineation, Unconformity,

**Unit 1:** **15 Lectures**

Structural geology - introduction and scope; primary and secondary structures; planar and linear structures; concept of strike and dip of planar structures; pitch and plunge of linear structural elements; compass-clinometer; unconformities and their types; recognition of unconformities in the field.

**Unit 2:** **15 Lectures**

Basic concept of stress and strain; ductile and brittle deformation; the effects of temperature, time, pressure and pore fluids on rock strength; mechanisms of rock deformation.

**Unit 3:** **15 Lectures**

Ductile structures: folds - geometry and classification; mechanism of folding; shear zones and their types; boudinage; foliation and lineation - types and relation with major structures.

**Unit 4:** **15 Lectures**

Brittle structures: faults - geometry and classification; recognition of faults; joints and fractures - types and significance.

## Practical *60 Hours*

1. Interpretation of geological maps involving different topographic expression.
2. Outcrop pattern of horizontal and dipping beds, fold, fault, unconformity, dyke and sill.
3. Graphical solutions of simple structural problems: dip-strike, true dip-apparent dip.
4. Three point problems and determination of dip and strike from borehole data.
5. Determination of vertical and true thickness of inclined beds.
6. Drawing of vertical geological sections to illustrate different geological structures.
7. Completion of outcrop of maps from partial data.
8. Practical records.
9. Viva-voce.

# GOL-CC-121
# Structural Geology

**Recommended Books**

Text Books:


1. **A Manual of Problems in Structural Geology** - N.W. Gokhale, *CBS Publishers and Distributors*
2. **An Introduction to Structural Geology -** A. K. Jain, *Geological Society of India*
3. **Earth structure: An Introduction to Structural Geology and Tectonics** - B. A. van der Pluijm and S. Marshak, *W. W. Norton & Company*
4. **Structural Geology** - H. Fossen*, Cambridge University Press*
5. **Structural Geology** - R. J. Twiss and E. M. Moors, *W. H. Freeman & Co.*
6. **Structural Geology of Rocks and Regions** - G. H. Davis, S. J. Reynolds and C. Kluth, *Wiley*
7. **Structural Geology: Fundamentals and Modern Developments -** S. K. Ghosh, *Pergamon Press*


Reference Books:


1. **Atlas of Structural Geology** - Soumyajit Mukherjee, *Elsevier*.
2. **Basic Methods of Structural Geology** - S. Marshak and G. Mitra, *Prentice Hall*
3. **Folding and Fracturing of Rocks** - John G. Ramsay, *McGraw Hills Book Company*
4. **Structural Analysis and Synthesis: A Laboratory Course in Structural Geology** - S.M. Rowland, E.M. Duebendorfer and I.M. Schiefelbein, *Blackwell Publishing*.
5. **Structural Geology: An Introduction to Geometrical Techniques** - D. M. Ragan, *Cambridge University Press*
6. **Structural Geology: The Mechanics of Deforming Metamorphic Rocks** - Bruce E. Hobbs and Alison Ord, *Elsevier*
7. **The Techniques of Modern Structural Geology Vol. 1: Strain Analysis** - J. G. Ramsay and M. I. Huber, *Elsevier.*
8. **The Techniques of Modern Structural Geology Vol. 2: Folds and Fractures** - J. G. Ramsay and M. I. Huber, *Elsevier*.
9. **The Techniques of Modern Structural Geology Vol. 3: Applications of Continuum Mechanics in Structural Geology** -J. G. Ramsay and Richard Lisle, *Elsevier.*

# GOL-CC-122
# Igneous and Metamorphic Petrology

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The course is intended for students to gain an understanding of the fundamental petrologic processes and common rock types, their origin, texture and structure, their thermodynamic equilibrium and their importance.

**Course Learning Outcome**

On completion of the course the students will have gained an understanding of the processes involved in the formation of igneous and metamorphic rocks, their textures, structures, classifications. The students will also be able to identify, describe and classify rocks using hand specimens and in thin sections.

**Key Words:** Magma, Rock Classification, Igneous Rocks, Metamorphic Rocks

**Unit 1:** **15 Lectures**

Magma - nature and composition; forms, structures, and textures of igneous rocks; classification of igneous rocks based on physical, mineralogical and chemical attributes; IUGS and CIPW normative classification schemes; TAS diagram; magma generation and differentiation; Bowen's reaction principle.

**Unit 2:** **15 Lectures**

Introduction to thermodynamics; phase rule; phase equilibrium studies of unary, binary and ternary systems and their implications; systematic description of common igneous rocks.

**Unit 3:** **15 Lectures**

Metamorphism - definition, types and agents; structure and texture of metamorphic rocks; zones and grades of metamorphism; facies and facies-series; index minerals; classification of metamorphic rocks; introduction to P-T-t paths; ACF, AKF and AFM diagrams.

**Unit 4:** **15 Lectures**

Systematic description of metamorphic rocks; occurrence of metamorphic rocks in India.

## Practical

***60 Hours***

1. Megascopic identification of igneous and metamorphic rocks.
2. Petrography of igneous and metamorphic rocks.
3. Determination of grade of metamorphism under microscope.
4. Plotting rock compositions in classification diagrams.
5. Practical record.
6. Viva-voce.

## GOL-CC-122
## Igneous and Metamorphic Petrology

**Recommended Books**

Text Books:

1. **Essentials of Igneous and Metamorphic Petrology** - B. R. Frost and C. D. Frost, *Cambridge University Press*
2. **Igneous and Metamorphic Petrology** - Myron G. Best, *Wiley-Blackwell*.
3. **Petrology: The study of Igneous, Sedimentary, and Metamorphic Rocks** - Loren A. Raymond, *Waveland Press Inc*
4. **Principles of Igneous and Metamorphic Petrology** - Anthony R. Philpotts and Jay J. Ague, *Cambridge University Press*
5. **Principles of Igneous and Metamorphic Petrology** - John D. Winter, *Pearson India*

Reference Books:

1. **An Introduction to Metamorphic Petrology** - Bruce W. D. Yardley, *Longman*
2. **Earth Materials -** Cornelis Klein and Anthony R. Philpotts, *Cambridge University Press*
3. **Igneous Petrogenesis: A Global Tectonic Approach -** Marjorie Wilson, *Springer*
4. **Igneous Rocks and Processes: A Practical Guide** - Robin Gill, *Wiley-Blackwell*
5. **Igneous Rocks: A Classification and Glossary of Terms -** R. W. Le Maitre, *Cambridge University Press*
6. **Petrogenesis of Metamorphic Rocks** - Kurt Bucher and Rodney Grapes, *Springer-Verlag*
7. **Petrography of Igneous and Metamorphic Rocks -** Anthony R. Philpotts, *CBS Publishers*
8. **Petrography: An Introduction to the Study of Rocks in Thin Section** - H. Williams, F. C. Turner and C. M. Gilbert, *CBS Publishers*
9. **Petrology: Principles and Practice -** Gautam Sen, *Springer*
10. **Principles of Metamorphic Petrology** - Ron H. Vernon and Geoffrey L. Clarke, *Cambridge University Press*

## GOL-CC-231
## Sedimentology and Principles of Stratigraphy

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

This course is aimed to introduce the students to the processes of formation of sedimentary rocks, their classification, texture and structure. It is also intended to introduce the students to the fundamental principles of stratigraphy.

**Course Learning Outcome**

On completion of the course the students are expected gain basic knowledge of sedimentary processes, interpret sedimentary environment and facies through study of structure and texture, identify sedimentary rocks in hand specimen and in thin section, have the basic understanding of the principles of stratigraphy.

**Key Words:** Sediments, Sedimentary Rocks, Sedimentary Environment, Stratigraphic classification

**Unit 1:** **15 Lectures**

Process of formation of sedimentary rocks: sediment generation, transportation, deposition and diagenesis; classification of sedimentary rocks.

**Unit 2:** **15 Lectures**

Brief description of various syngenetic and diagenetic sedimentary structure; textures of sedimentary rocks: clastic and non-clastic.

**Unit 3:** **15 Lectures**

Basic concept of sedimentary environment and facies; interpretation and reconstruction of sedimentary facies and depositional environment.

**Unit 4:** **15 Lectures**

Principles of stratigraphy; criteria of stratigraphic classification and correlation; concepts of stratotypes; GSSA and GSSP; geological time scale.

### Practical ***60 Hours***

1. Identification of sedimentary rocks in hand specimen.
2. Petrography of sedimentary rocks - texture and mineralogy.
3. Granulometric analysis.
4. Interpretation of geological maps and sections to identify geological events.
5. Practical records.
6. Viva voce.

# GOL-CC-231
# Sedimentology and Principles of Stratigraphy

**Recommended Books**

Text Books:


1. **Applied Sedimentology** - Richard C. Selley, *Academic Press*
2. **Introduction to Sedimentology**- S. M. Sengupta, *CBS Publishers*
3. **Principles of Sedimentology and Stratigraphy**- S. Boggs Jr, *Pearson Education India*
4. **Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy -** D. R. Prothero, *W. H. Freeman and Co.*
5. **Sedimentary Structure** - J. D. Collinson, N. P. Mountney and D. B. Thompson, *Terra Publishing*
6. **Sedimentology and Stratigraphy** - G. Nichols, *CBS Publishers*


Reference Books:


1. **Applied Sedimentology**- R. K. Sukhtankar, *CBS Publishers*
2. **Depositional Sedimentary Environments** - H. E. Reineck and I. B. Singh, *Springer-Verlag*
3. **International Stratigraphic Guide: A Guide to Stratigraphic Classification, Terminology and Procedure** - Amos Salvador, *The International Union of Geological Sciences & Geological Society of America*
4. **Petrology of Sedimentary Rocks** - Sam Boggs Jr., *Cambridge University Press*
5. **Petrology: The study of Igneous, Sedimentary, and Metamorphic Rocks** - Loren A. Raymond, *Waveland Press Inc*
6. **Sedimentary Petrology** - M. E. Tucker, *CBS Publishers*
7. **Sedimentary Rocks** - F. J. Pettijohn, *CBS Publishers*

# GOL-CC-232
# Palaeontology

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

This course is intended to introduce the students to the basic knowledge of fossils, their classification, preservation, morphology, evolution through geological time and their applications in determination of age of rocks.

**Course Learning Outcome**

On completion of the course the students are expected to gain knowledge about different types of fossils, their mode of preservation, taxonomy and evolutionary trend. The knowledge of palaeontology would enable the students to understand the changes that occurred in the history of the earth and relate them to their field observations.

**Key Words:** Fossils, Invertebrates, Vertebrates, Microfossils, Palynology

**Unit 1:** **15 Lectures**

Introduction to palaeontology; fossils - definition, types, modes of preservation and applications; taxonomy and species concept; evidences of early life in rock records; evolution of life through time; habits and habitats of organism.

**Unit 2:** **15 Lectures**

Invertebrates: general morphology, classification, biological attributes, geological evolution and biostratigraphic significance of trilobite, ammonoids, brachiopod, bivalvia, gastropod and cephalopoda.

**Unit 3:** **15 Lectures**

Vertebrates: origin and evolution; introduction to the study of origin and evolution of mammals with special reference to horse and human.

**Unit 4:** **15 Lectures**

Micropalaeontology - definition, scope and importance; brief study of major microfossils groups; palaeobotany - introduction; preservation of early plants in rocks; morphology, classification and significance of Gondwana flora; introduction to palaeopalynology.

## Practical ***60 Hours***

1. Megascopic identification of invertebrate fossils.
2. Megascopic identification of plant fossils.
3. Study of microfossils.
4. Stratigraphic position of important index fossils in Indian context.
5. Practical record.
6. Viva-voce.

# GOL-CC-232
# Palaeontology

**Recommended Books**

Text Books:


1. **Invertebrate Fossils** - Raymond C. Moore, Cecil G. Lalicker and Alfred G. Fischer, *CBS Publishers & Distributors*
2. **Micropaleontology: Principles and Applications** - Pratul K. Saraswati and M.S. Srinivasan, Springer
3. **Palaeontology (Palaeobiology): Evolution and Animal Distribution** - P.C. Jain and M.S. Anantharaman, *Vishal Publishing Co.*
4. **Paleobotany: The Biology and Evolution of Fossil Plants** - E. Taylor, T. Taylor and M. Krings, *Elsevier*
5. **Principles of Invertebrate Paleontology** - Robert R. Shrock and William H. Twenhofel, *CBS Publishers & Distributors*
6. **Principles of Paleontology** - David M. Raup and Steven M. Stanley, *CBS Publishers & Distributors*
7. **Understanding Fossils: An introduction to Invertebrate Palaeontology** - Peter Doyle, *John Wiley & Sons*
8. **Vertebrate Paleontology** - Michael Benton, *Wiley Blackwell*


Reference Books:


1. **Bringing Fossils to Life: An Introduction to Paleobiology** - Donald Prothero, *Columbia University Press*
2. **Fundamentals of Invertebrate Palaeontology: Macrofossils** - Sreepat Jain, *Springer*
3. **Fundamentals of Invertebrate Palaeontology: Microfossils** - Sreepat Jain, *Springer*
4. **Introduction to Paleobiology and the Fossil Record** - Michael J. Benton, David A. T. Harper, *Wiley-Blackwell*
5. **Organic Evolution** - Veer Bala Rastogi, *Medtech*

## GOL-CC-233
## Geological Field Methods and Mapping

*(Credit Distribution L1:T0:P5 = 6 Credits)*

**Course Objective**

This course is devised to provide basic knowledge of geological mapping and surveying techniques to the students. It also is aimed to upgrade and relate the theoretical knowledge of geological aspects to field observations.

**Course Learning Outcome**

On completion of this course the students are expected to understand how preliminary surveys are carried out, fundamental aspects of field geological techniques. They would be trained to use different field equipments for geological mapping.

**Key Words:** Geological Fieldwork, Mapping, Sampling Methods

**Unit 1:** **15 Lectures**

Basics of geological field techniques and mapping; introduction to geological field equipment and their uses; safety in the field; recording of structural, petrological and palaeontological data during fieldwork; field photography; preparation of geological map and field report.

### Fieldwork

The students must carry out geological fieldwork for at about ten (10) days where they will be introduced to the different techniques of observation, sample collection and measurements and recording field data in the notebook. The students, after returning from the field should submit field report either individually or in groups of two/three as decided by the concerned teacher in-charge. The evaluation will be based on internal assessment, field performance, field report and viva-voce. Internal assessment is evaluated based on seminar presentation. The distribution of marks will be as follows:

| | |
|---|---|
| **Internal assessment** | : 20 marks |
| **Field performance** | : 20 marks |
| **Field report** | : 40 marks |
| **Viva-voce** | : 20 marks |

## GOL-CC-233
## Geological Field Methods and Mapping

**Recommended Books**


1. **A Guide to Field Geology** - N. W. Gokhale, *CBS Publishers*
2. **Basic Geological Mapping** - J. W. Barnes and R.J. Lisle*, Wiley-Blackwell*
3. **Field Geology** - F. H. Lahee, *CBS Publishers*
4. **Geological Field Techniques** - Angela L. Coe, *Wiley-Blackwell*
5. **Geology in The Field** - R. R. Compton*, Earthspun Books*
6. **Sedimentary Rocks in the Field** - M. E. Tucker, *Wiley-Blackwell*
7. **Sedimentary Rocks in the Field: A Colour Guide** - D. A. V. Stow, *Manson Publishing*
8. **The Field Description of Igneous Rocks** - D. Jerram and N. Petford, *Wiley-Blackwell*
9. **The Field Description of Metamorphic Rocks** - N. Fry, *Wiley-Blackwell*
10. **The Mapping of Geological Structures** - K. R. McClay, *Wiley-Blackwell*

## GOL-CC-241
## Global Tectonics and Geodynamics of the Lithosphere

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The student will be introduced to the structure of the continental crust vs. oceanic crust and their geodynamic. They will also appreciate the modern concept of plate tectonics and its implications. This course also is expected develops the concepts of plate tectonics on a global scale and analyses the physical processes responsible for the formation and destruction of the plates.

**Course Learning Outcome**

On completion of this course the students will be enabledto appreciate the dynamic nature of the Earth and its processes. They will also be appraised about the geodynamics of the lithosphere and concept of isostasy, ocean floor spreading, continental drift, plate tectonics.

**Key Words:** Plate Tectonics, Continental Drift, Wilson Cycle, Subduction Zones, Mountain Building

**Unit 1:** **15 Lectures**

Interior of the earth: the crust, the mantle and the core; discontinuities; continental and oceanic crust; velocity structure of the earth; lithosphere and asthenosphere; evolution and structure of the lithosphere; concept of isostasy.

**Unit2:** **15 Lectures**

Continental drift; sea floor spreading; plates and plate margins; theory of plate tectonics; relative and absolute plate motion; mantle plume and hotspot; triple junction.

**Unit 3:** **15 Lectures**

Tectonic settings on the earth: mid-oceanic ridge; ocean floor topography; continental rift and rift margin; subduction zones; ocean trenches; island arcs; collision zones.

**Unit 4:** **15 Lectures**

Wilson cycle: supercontinent assembly and breakup; plate tectonics and associated crustal evolution; linkage between plate tectonics and earth's climate.

### Practical ***60 Hours***

1. Identification of plate boundaries.
2. Determination of plate motion from GPS data.
3. Study of sea floor spreading from map.
4. Practical records.
5. Viva voce.

## GOL-CC-241
## Global Tectonics and Geodynamics of the Lithosphere

**Recommended Books**

Text Books:

1. **Geodynamics** - Donald Turcotte and Gerald Schubert, *Cambridge University Press*
2. **Geodynamics of the Lithosphere: An Introduction** - Kurt Stuwe, *Springer*
3. **Global Tectonics** - P. Kearey, K. A. Klepeis and F. J. Vine, *Wiley-Blackwell*
4. **Plate Tectonics and Crustal Evolution** - Kent C. Condie, *Butterworth-Heinemann*
5. **Plate Tectonics: A Comprehensive Introduction** - F. Morrison, *Larsen and Keller Education*
6. **Plate Tectonics: Continental Drift and Mountain Building** - W. Frisch, M. Meschede and R. Blakey, *Springer*
7. **The Dynamics of the Earth System** - A.M. Patwardhan, *Prentice Hall of India*

Reference Books:

1. **Dynamic Earth: Plates, Plumes and Mantle Convection** - Geoffrey F. Davies, *Cambridge University Press*
2. **Making of India** - K.S. Valdiya, *Springer*
3. **Plate Tectonics and Great Earthquakes** - Lynn R. Sykes, *Columbia University Press*
4. **Plate Tectonics: A Very Short Introduction** - Peter Molnar, *Oxford*
5. **Plates vs Plumes: A Geological Controversy** - Gillian R. Foulger, Wiley-Blackwell
6. **Seismology and Plate Tectonics** - David Gubbins, *Cambridge*
7. **Supercontinent** - Ted Nield, *Harvard University Press*

## GOL-CC-242

## Stratigraphy of India, Geology of NE India and Himalayan Geology

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The course intends to introduce students to the various aspects of the geological formations of India, from Precambrian to Recent times. It is also aimed to acquaint the students the detailed study of the geological sequence and structural disposition NE Indian and Himalayan region.

**Course Learning Outcome**

The student will gain knowledge about the stratigraphy and geology of India with emphasis on the lithology, structure, palaeontology and economic importance which will help in understanding the different episodes on the earth during the geologic past.

**Unit 1:** **17 Lectures**

Introduction to physiographic and tectonic subdivisions of India; stratigraphic succession, tectonic evolution and economic importance of Archaean cratons and Proterozoic basins; the Eparchaean unconformity.

**Unit 2:** **18 Lectures**

Palaeozoic succession of India with special reference to Kashmir; Gondwana basins - stratigraphy, structure and economic importance; Mesozoic succession of India with special references to Triassic of Spiti, Jurassic of Kutch and Cretaceous of Trichinopoly; Deccan volcanism.

**Unit 3:** **12 Lectures**

Cretaceous-Palaeogene boundary; Cenozoic Stratigraphy: Kutch basin and Siwalik successions.

**Unit 4:** **13 Lectures**

Geology of NE India: lithostratigraphy, tectonic setting and evolution of Shillong plateau; Shylhet Traps and Abor volcanics; Assam-Arakan basin; introduction to Himalayan geology; outline of tectonic divisions and evolution of the Himalayas.

### Practical ***60 Hours***

1. Map drawing of important geological formations.
2. Plotting important geological formations in graphical log.
3. Study of rocks representing stratigraphic horizons from NE India.
4. Practical record.
5. Viva-voce.

## GOL-CC-242

## Stratigraphy of India, Geology of NE India and Himalayan Geology

**Recommended Books**

Text Books:

1. **Fundamentals of Historical Geology and Stratigraphy of India** - Ravindra Kumar, *New Age International, Delhi*
2. **Geodynamics of Northeastern India and the Adjoining Region** - D.R. Nandy, *Scientific Book Centre, Guwahati*
3. **Geology of Arunachal Pradesh** - G. Kumar, *Geological Society of India*
4. **Geology of Assam** - A. B. Das Gupta and A. K. Biswas, *Geological Society* of *India*
5. **Geology of India (Vol. 1 & 2)** - R. Vaidyanandhan and M. Ramakrishnan, *Geological Society of India*
6. **Historical Geology of India** - S. K. Shah, *Scientific Publishers (India)*
7. **The Making of India: Geodynamic Evolution** - K. S. Validya, *Springer*

Reference Books:

1. **Geology and Evolution of the Indian Plate (From Hadean to Holocene 4 Ga to 4 Ka)** - S. M. Naqvi, *Capital Publishing Company*
2. **Geology and Mineral Resources of Arunachal Pradesh** - *Geological Survey of India*
3. **Geology and Mineral Resources of Assam** - *Geological Survey of India*
4. **Geology of India and Burma** - M. S. Krishnan, *CBS Publishers*
5. **Geology of the Himalayan Belt: Deformation, Metamorphism, Stratigraphy** - B. K. Chakrabarti, *Elsevier*
6. **Understanding an Orogenic Belt: Structural Evolution of the Himalaya** - A. K. Dubey, *Springer*

# GOL-CC-243
# Economic Geology

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

This course is devised to provide basic knowledge about the economic aspects of geology including genesis, mode of occurrences and uses of economically important metallic and non-metallic minerals as well as energy resources.

**Course Learning Outcome**

On completion of the course the students are expected to gain knowledge about various economic minerals, their processes of formation, mode of occurrence and uses.

**Key Words:** Ore Deposits, Ore Genesis, Fossil Fuels, Radioactive Minerals

**Unit 1:** **15 Lectures**

Introduction to economic geology; ore and gangue; grade and tenor; forms of ore bodies - concordant and discordant forms; classification of ore deposits; spatial and temporal distribution of ore deposits; ore-gangue textures.

**Unit 2:** **15 Lectures**

Magmatic processes - early magmatic, late magmatic and residual liquid processes; hydrothermal processes; contact metamorphic processes; metamorphic ore forming processes.

**Unit 3:** **13 Lectures**

Sedimentary processes - allochthonous deposits; autochthonous deposits - chemical precipitates, organic deposits and residual deposits.

**Unit 4:** **17 Lectures**

Fuel geology: petroleum and natural gas - constituents, properties, origin, and uses; coal - physical and chemical constituents, classification, mode of occurrence, origin, and uses; introduction to radioactive minerals.

## Practical ***60 Hours***

1. Megascopic study of ore and industrial minerals.
2. Microscopic identification and textural study of ore and industrial minerals.
3. Preparation of polished ore sections.
4. Practical record.
5. Viva-voce.

## GOL-CC-243
## Economic Geology

**Recommended Books**

Text Books:


1. **Coal Geology -** Larry Thomas, *Wiley Blackwell*
2. **Economic Geology** - Umeshwar Prasad, *CBS Publishers & Distributors*
3. **Economic Geology Principles and Practice** - Walter L. Pohl, *Wiley-Blackwell*
4. **Economic Mineral Deposits** - Mead L. Jensen and Alan M. Bateman, *Book Selection Centre*
5. **Elements of Petroleum Geology**- Richard C. Selley and Stephen A. Sonnenberg, *Academic Press*
6. **Introduction to Ore Forming Processes** - Laurence Robb, *Blackwell Publishing Company*
7. **Introduction to Ore Microscopy** - J. P. Shrivastava and Nishi Rani, *Prentice Hall India*
8. **Ore Microscopy and Ore Petrography** - James R. Craig and David J. Vaughan, *John Wiley & Sons*
9. **Understanding Mineral Deposits** - Kula C. Misra, *Springer Netherlands*


Reference Books:


1. **Geology of Petroleum** - A. L. Leverson, *CBS Publishers*
2. **Hydrothermal Processes and Mineral Systems** - Franco Pirajno, *Springer Netherlands*
3. **Ore Deposit Geology** - John Ridley, *Cambridge University Press*
4. **Ore Deposit Geology and Its Influence on Mineral Exploration** - R. Edwards and K. Atkinson, *Chapman and Hall*
5. **Ore Deposits in an Evolving Earth** - G.R.T. Jenkin, P.A.J. Lusty, I. McDonald, M.P. Smith, A.J. Boyce, and J.J. Wilkinson, *The Geological Society London*
6. **Ore Deposits: Origin, Exploration, and Exploitation** - Sophie Decree and Laurence Robb, *Wiley*
7. **Ore Geology and Industrial Minerals: An Introduction -** Anthony M. Evans, *Wiley India Pvt. Ltd*
8. **The Ore Minerals Under the Microscope: An Optical Guide** - Bernhard Pracejus, *Elsevier*
9. **The World of Mineral Deposits** - Florian Neukirchen and Gunnar Ries, *Springer*
10. **Uses of Metals and Metallic Minerals** - K.K. Chatterjee, *New Age International Publications*

# GOL-CC-351
# Mining and Mineral Exploration

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The course is intended to provide the student essential and basic concepts of mineral exploration techniques, sampling methods, ore reserve estimation and mining methods.

**Course Learning Outcome**

The students are expected to learn basic scientific techniques involved in the exploration of mineral deposits and various exploitation methods. They are expected to have knowledge about policies related to mining activities and conservation of mineral deposits.

**Key Words:** Mineral Prospecting, Exploration, Mining Methods, Mining Acts

**Unit 1:** **15 Lectures**

Elements of mining; stages in the life of a mine; prospecting and exploration; sampling: pitting, trenching and drilling; unit operations in mining.

**Unit 2:** **15 Lectures**

Categories of reserves; estimation of reserves: cross-sectional method, area of influence method, triangulation method and weighted volume estimate method.

**Unit 3:** **15 Lectures**

Classification of mining methods; factors influencing choice of mining method; surface mining methods; underground mining methods; mining of coal; mine safety.

**Unit 4:** **15 Lectures**

Mineral processing; brief outline of mining acts and regulations in India; conservation of mineral resources.

## Practical ***60 Hours***

1. Identification of anomaly.
2. Reserve estimation of mineral deposits with regular geometry.
3. Reserve estimation of mineral deposits with irregular geometry.
4. Estimation of coal reserve.
5. Practical record.
6. Viva-voce.

# GOL-CC-351
# Mining and Mineral Exploration

**Recommended Books**

Text Books:

1. **Courses in Mining Geology** - R. P. N. Arogyaswamy, *Oxford and IBH Publishing*
2. **Introductory Mining Engineering** - Howard L. Hartman, *John Wiley and Sons*
3. **Mineral Exploration: Principles and Applications** - Swapan K. Haldar, *Elsevier*
4. **Surface Mining** - Bruce A Kennedy, *Society for Mining, Metallurgy, and Exploration*
5. **Underground Mining Methods** - W. A. Hustrulid and R. L. Bullock, *Society for Mining, Metallurgy, and Exploration*

Reference Books:

1. **Applied Mining Geology** - M. Abzalov, *Springer*
2. **Essentials of Mineral Exploration and Evaluation** - S. M. Gandhi and B. C. Sarkar, *Elsevier*
3. **Exploration Geophysics** - Mamdouh R. Gadallah and Ray Fisher, *Springer*
4. **Geological Methods in Mineral Exploration and Mining** - Roger Marjoribanks, *Springer*
5. **Introduction to Mineral Exploration** - C. J. Moon, M. K. G. Whateley and A. M. Evans, *Blackwell Publishing*
6. **Mineral Exploration: Practical Application** - G. S. Roonwal, *Springer*
7. **Mineral Resources: From Exploration to Sustainability Assessment** - M.B. Revuelta, *Springer*
8. **Statistical Evaluations in Exploration for Mineral Deposits** - F.W. Wellmer, *Springer*

## GOL-CC-352
## Applied Geophysics and Geodesy

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The course is centered on the topics of Applied Geophysics and use of geodesy and GPS techniques. The geophysical techniques include seismic, gravity, magnetic and electrical methods and their various applications.

**Course Learning Outcome**

After completion of the course, the student will gain first-hand knowledge of geophysical principles and their significance. The students will acquire skills to interpret SoI toposheets and use GPS, to conduct electrical resistivity and other methods for exploration.

**Key Words:** Geodesy, GPS, Geophysical Methods

**Unit 1:** **12 Lectures**

Elements of maps; map scale and map projection; geographic and projected coordinate system; geoid, datum and ellipsoid.

**Unit 2:** **12 Lectures**

Basics of global positioning system (GPS); segments of GPS; source of errors in GPS data; differential GPS; application of GPS.

**Unit 3:** **18 Lectures**

Electrical geophysical techniques: resistivity profiling and vertical electrical sounding; self-potential and induced polarization techniques; principles and applications of magnetic and magnetotelluric methods.

**Unit 4:** **18 Lectures**

Principles of seismic survey; seismic reflection and refraction methods; interpretation of seismic data; principles of gravity; gravity measurement and anomaly; gravity reduction; interpretation and application of gravity anomaly.

### Practical ***60 Hours***

1. Study of Survey of India (SoI) topographic maps.
2. Use of handheld GPS.
3. Interpretation of geophysical data and preparation of structure contour maps.
4. Resistivity survey.
5. Practical record.
6. Viva-voce.

## GOL-CC-352
## Applied Geophysics and Geodesy

**Recommended Books**

Text Books:

1. **An Introduction to Geophysical Exploration** - P. Kearey, M. Brooks and I. Hill, *Wiley-Blackwell*
2. **Applied Geophysics** - W.M. Telford, L.P. Geldart and R.E. Sheriff, *Cambridge University Press*
3. **Basic Geophysics** - E.A. Robinson and D. Clark, *Society of Exploration Geophysicists*
4. **Fundamentals of Geophysics** - W. Lowrie, *Cambridge University Press*
5. **Geophysics for the Mineral Exploration Geoscientist** - M. Dentith and S.T. Mudge, *Cambridge University Press*
6. **Physics for the Earth** - F.D. Stacey and P.M. Davis, *Cambridge University Press*

Reference Books:

1. **Exploration Geophysics** - M.R. Gaddalla and R. Fisher, *Springer*
2. **Geophysical Methods in Geology** - P.V. Sharma, Elsevier
3. **Geophysics: A Very Short Introduction** - William Lowrie, *Oxford University Press*
4. **Groundwater Geophysics: A Tool for Hydrogeology** - Reinhard Kirsch, *Springer*
5. **Introduction to Applied Geophysics** - H.R. Burger, C.H. Jones and A.F. Sheehan, *W.W. Norton & Company*
6. **Practical Seismic Data Analysis** - H.W. Zhou, *Cambridge University Press*

## GOL-CC-361
## Engineering Geology and Environmental Geology

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The course is designed to impart sufficient knowledge of engineering geology so as to enable students to anticipate the technical problems related to geology of various engineering sites and suggest possible remedial measures. It also deals with the natural resources and their degeneration and also geogenic hazards and disasters.

**Course Learning Outcome**

Upon completion of the course, students will become aware of the importance of geological studies and its applicability to various engineering problems. They also will know the fundamentals of earth science as applied to the interaction between human activity and the natural environment in terms of earth resources and earth processes.

**Key Words:** Engineering Geology, Mega Structures, Environment, Natural Hazards, Earth Resource

**Unit 1:** Engineering geology: development and aims; role of engineering geologists; site investigation and characterization in construction of dam and reservoir, tunnel, highways and bridges.

**Unit 2:** Engineering properties of soil - unit weight, specific gravity, bulk density, porosity, void ratio, degree of saturation; shear strength of soil; concept of Atterberg limit; engineering properties of rocks - strength, elasticity, porosity and specific gravity; rock mass rating; concept of rock quality designation (RQD) and tunnelling quality index (Q).

**Unit 3:** Environmental geology: introduction, and fundamental concepts; natural hazards - earthquakes, volcanic activity, floods, landslides and coastal hazards.

**Unit 4:** Earth resources - water, mineral and energy resources; pollution of water and air; global climate change and human activities; geologists' role in environmental health and environmental planning; nuclear waste management.

### Practical *60 Hours*

1. Study of engineering properties of soil and rocks.
2. Computation of reservoir area, catchment area, reservoir capacity and reservoir life.
3. Computation of RQD and Tunnelling Quality Index (Q).
4. Water quality testing.
5. Interpretation of seismogram and determination of epicentre.
6. Seismic zonation map of India.
7. Practical record.
8. Viva-voce.

## GOL-CC-361
## Engineering Geology and Environmental Geology

**Recommended Books**

Text Books:


1. **Engineering and General Geology** - P. Singh, *S. K. Kataria & Sons*
2. **Engineering Geology** - F. G. Bell, *CBS Publishers*
3. **Engineering Geology** - S. Gangopadhyay, *Oxford University Press*
4. **Engineering Properties of Soils and Rocks** - F. G. Bell, *Wiley-Blackwell*
5. **Environmental Geology** - James S. Reichard, *McGraw Hill*
6. **Introduction to Environmental Geology** - Edward A. Keller, *Pearson*
7. **Principles of Engineering Geology and Geotectonics** - D. K. Krynine and W. R. Judd, *CBS Publishers*


Reference Books:


1. **Earthquake Risk and Damage** - B.C. Liu, *Westview*
2. **Elements of Engineering Geology** - H. Rise and T.L. Watson, *John Wiley and Sons*
3. **Engineering Geology: Principles and Practice** - David G. Price, *Springer*
4. **Environmental Geology** - C. Montgomery, *John Wiley and Sons*
5. **Foundations of Engineering Geology** - Tony Waltham, *Spon Press*
6. **Geotechnical Engineering (Soil Mechanics) -** T. G. Sitharam and T. N. Ramamurthy**,** *S. Chand*
7. **Principles of Geotechnical Engineering** - B.M. Das and K. Sobhan, *Cengage Learning*

# GOL-CC-362
# Hydrogeology

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The course is intended to impart knowledge about groundwater, its movement, methods of its exploration, the criteria of its quality, methods of its conservation, recharge of groundwater monitoring of groundwater quantity and quality.

**Course Learning Outcome**

On completion of the course, the student will have gained an understanding of hydrogeological concepts, exploration, exploitation and recharge of groundwater and methods of monitoring groundwater quality and sources of pollution.

**Key Words:** Water, Water Resource, Groundwater Exploration, Groundwater Quality

**Unit 1:** **15 Lectures**

Definition and scope of hydrogeology; hydrologic cycle; utilization of groundwater; surface water-groundwater interaction; rock properties affecting groundwater; vertical distribution and classification of subsurface water; water table and piezometric surface.

**Unit 2:** **12 Lectures**

Types of aquifers; springs; Darcy's law and its validity; intrinsic permeability; hydraulic conductivity; transmissivity; groundwater flow rates and flow directions; groundwater tracers.

**Unit 3:** **15 Lectures**

Well hydraulics and groundwater exploration: concepts related to equilibrium and non-equilibrium conditions for water flow to a well in confined and unconfined aquifers; types of wells; surface investigations of groundwater.

**Unit 4:** **18 Lectures**

Groundwater quality: physical and chemical properties of water; outline of pollution of groundwater; intrusion of saline water; brief introduction to groundwater management; rainwater harvesting and artificial recharge of groundwater.

## Practical ***60 Hours***

1. Preparation and interpretation of water table maps.
2. Study, preparation and analysis of hydrographs for differing groundwater conditions.
3. Water potential zones of India (map study).
4. Graphical representation of chemical quality data and water classification (C-S and Trilinear diagrams).
5. Practical record.
6. Viva-voce.

# GOL-CC-362
# Hydrogeology

**Recommended Books**

Text Books:


1. **Applied Hydrogeology** - C. W. Fetter, *Pearson Education India*
2. **Groundwater** - H.M. Raghunath, *New Age International Publishers*
3. **Groundwater Assessment Development and Management** - K.R. Karanth, *Tata-McGraw Hill*
4. **Groundwater Hydrology** - David K. Todd and Larry W. Mays, *John Wiley & Sons Inc*
5. **Groundwater Resources in India** - Subhajyoti Das, *National Book Trust*
6. **Hydrogeology** - S.N. Davis and R.J.M. Dewiest, *John Willey and Sons*
7. **Hydrogeology: Principles and Practice** - Kevin M. Hiscock and Victor F. Bense, *Wiley Blackwell*
8. **Water Quality: An Introduction** - Claude E. Boyd (Ed), *Springer*


Reference Books:


1. **Groundwater Hydrology: Conceptual and Computational Models** - K. R. Rushton, *Wiley India*
2. **Hydrology: Principles-Analysis-Design** - H. M. Raghunath, *New Age International Publishers*
3. **Hydrogeology: Problems with Solutions** – Nandipati Subba Rao, *Prentice Hall India*
4. **Practical and Applied Hydrogeology** - Zekai Sen, *Elsevier*
5. **Ground Water Assessment, Development and Management** - K. R. Karanth, *McGraw Hill Education*
6. **Field Hydrogeology** - Rick Brassington, *Wiley*
7. **Hydrogeology** - B. Holting and W.G. Coldewey, *Springer*
8. **Practical Hydrogeology: Principles and Field Applications** - W.D. Weight, *McGraw Hill*
9. **Hydrogeology of Deccan Traps and Associated Formation in Peninsular India** - N.J. Pawar, S. Das and R.A. Duraiswami, *Geological Society of India*

# GOL-DE-351
# Mineral and Energy Resources of India

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The course is framed to provide knowledge about the different ore deposits, their nature, characteristics, mode of occurrences and available resources in the in the country. The course will also introduce the knowledge about conventional and non-conventional energy resources of India.

**Course Learning Outcome**

After completion of the course, the student will be expected to have knowledge about the geology, available reserves and distribution of mineral deposits and energy resources of the country.

**Key Words:** India's Mineral Resources, Fossil Fuels in India, Non-conventional Energy Resouces

**Unit 1:** **15 Lectures**

Physical characteristics, mode of occurrences, uses and distribution of various non-metallic minerals in India: limestone, dolomite, magnesite, phosphate, asbestos, clay minerals, barite, graphite, garnet, corundum, silica, mica and feldspar.

**Unit 2:** **15 Lectures**

Physical and chemical characteristics, mode of occurrences, uses and distribution of major and minor metallic deposits of India.

**Unit 3:** **15 Lectures**

Geological and geographical distribution of coal in India; physical and chemical characteristics of Indian coal deposits and their uses; petroliferous basins of India; important oil fields of India.

**Unit 4:** **15 Lectures**

Potential for nonconventional energy resources in India: atomic minerals, geothermal energy, solar energy and wind energy.

## Practical ***60 Hours***

1. Study of physical and chemical properties of important metallic and non-metallic mineral resources of India.
2. Study of the characteristics of Indian coal.
3. Practical records.
4. Viva voce.

## GOL-DE-351
## Mineral and Energy Resources of India

**Recommended Books**

Text Books:


1. **Economic Geology: Economic Mineral Deposits** - U. Prasad, *CBS Publishers and Distributors*
2. **India's Mineral Resources** - S. Krishnaswamy, *Oxford and IBH*
3. **Mineral Resources and Policy in India** - K.N. Jetli, *Ingram*
4. **Minerals and Allied Natural Resources and Their Sustainable Development: Principles, Perspective with Emphasis on the India Scenario** - Mihir Deb and S.C. Sarkar, *Springer*
5. **Non-Conventional Energy Resources** - B.H. Khan, *Tata McGraw-Hill*
6. **Non-conventional Energy Resources** - N.K. Bansal, *Vikas*
7. **World Petroleum Resources and Reserves** - Joseph Riva, *Routledge*


Reference Books:


1. **Hydrocarbon Exploration and Production** (V-46) - Frank Jahn, *Elsevier*
2. **Mineral Economics: An Indian Perspective** - K. Randive and S. Jawadand, *Nova Scientific Series*
3. **Mineral Resources of India** - D.K. Banerjee, *World Press Pvt. Ltd.*
4. **Non-conventional Energy Resources** - S.N. Singh, *Pearson*
5. **The Indian Ocean: Exploitable Mineral and Petroleum Resources** - G.S. Roonwal, *Springer*

# GOL-DE-352
# Oceanography and Marine Geology

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The course will provide essential concepts of oceanography and to study the tectonics, geology, economic resources with respect to the oceans.

**Course Learning Outcome**

A student will understand and learn about the basic concepts, skills related to dealing with the physical and chemical components and phenomena related to oceanography and marine geology.

**Key Words:** Ocean Morphology, Seawater, Ocean Environment, Ocean Resources

**Unit 1:** **15 Lectures**

Oceanography - introduction; seas and oceans; historical development of studies of oceans; continental drift and sea-floor spreading; morphology of ocean floor; bathymetry; properties of sea water; temperature, salinity and density distribution of ocean water.

**Unit 2:** **15 Lectures**

Ocean-atmosphere interaction; Coriolis effect; El-Nino and La-Nina and their effects on Indian subcontinent; ocean waves - properties and wave motions; tsunamis; tides - characteristics and origin; tidal currents.

**Unit 3:** **15 Lectures**

Life in oceans - habits and habitats of ocean organisms; coral reefs and their significance; biological productivity in oceans; submarine volcanism; vent creatures; coastal erosion.

**Unit 4:** **15 Lectures**

Ocean resources: law of the sea; mineral resources; oil and natural gas; sand and gravel; living resources; energy from the sea; identified resources in the Indian Ocean.

## Practical ***60 Hours***

1. Plotting temperature, pressure, salinity and density distribution of the world's oceans.
2. Practical record.
3. Viva-voce.

## GOL-DE-352
## Oceanography and Marine Geology

**Recommended Books**

Text Books


1. **Climatology and Oceanography** - D. S. Lal, *Sharda Pustak Bhawan*
2. **Essentials of Oceanography** - A.P. Trujilo and H.V. Thurman, Pearson
3. **Introduction to Physical Oceanography** - Robert H. Stewart, Prentice Hall
4. **Oceanography: A Brief Introduction** - K. Siddhartha, *Kitab mahal*
5. **Oceanography: An Invitation to Marine Science** – Tom Garrison, Brooks Cole
6. **The Sea Floor: An Introduction to Marine Geology** - Eugen Seibold and Wolfgang Berger, *Springer*


Reference Books


1. **Atmosphere, Ocean and Climate Dynamics: An Introductory Text** - J. Marshall and R.A. Plumb, *Elsevier*
2. **Chemical Oceanography** - F.J. Millero, *CRC Press*
3. **Invitation to Oceanography** - Paul R. Pinet, *Jones and Bartlett Publishers*
4. **Marine Geology: Exploring the New Frontiers of the Ocean** - Jon Erickson, *Facts On File, Inc.*
5. **Oceanography** - Savindra Singh, *Pravalika Publications*

# GOL-DE-353
# Petroleum Geology

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The course is intended to provide geological knowledge of the petroleum resources, their exploration techniques and occurrence in the country.

**Course Learning Outcome**

After completion of the course, the student will learn the geological processes of the origin, migration and trapping of hydrocarbons. They will also learn various methods of exploration and recovery of petroleum resources.

**Key Words:** Petroleum, Natural Gas, Well Logging

**Unit 1:** **18 Lectures**

Introduction to hydrocarbons; kerogen: composition and types; petroleum: physical and chemical characteristics and classification; origin and migration; reservoir properties: porosity and permeability, fluid saturation; characteristics of reservoir rocks, source rocks and cap rocks; petroleum traps.

**Unit 2:** **15 Lectures**

Historical background of petroleum exploration; geophysical exploration for hydrocarbon; oil well drilling and drilling fluids; estimation of oil and gas reserves.

**Unit 3:** **15 Lectures**

Logging: principles and interpretations of spontaneous potential log, natural gamma ray log and resistivity log; primary and enhanced oil recovery.

**Unit 4:** **12 Lectures**

Petroliferous basins of India; geology of productive oil and gas fields of India with special reference to NE India; future prospect of India's petroleum and natural gas resources.

## Practical ***60 Hours***

1. Calculation of oil reserves.
2. Megascopy of petroleum source rocks.
3. Petrography of petroleum source rocks.
4. Practical record.
5. Viva-voce.

## GOL-DE-353
## Petroleum Geology

**Recommended Books**

Text Books:

1. **Elements of Petroleum Geology**- R.C. Selley and S.A. Sonnenberg, *Academic Press*
2. **Field Methods for Petroleum Geologists** - F.A. Assaad, *Springer*
3. **Geology of Petroleum** - A. L. Leverson, *CBS Publishers*
4. **Petroleum Geology** - R.E. Chapman (Ed), *Elsevier*
5. **Petroleum Geoscience: From Sedimentary environments to Rock Physics** - Knut Bjorlykke, *Springer*

Reference Books:

1. **Dynamic Well Testing in Petroleum Exploration and Development** - Huinong Zhuang, Yongxin Han, Hedong Sun and Xiaohua Liu, *Elsevier*
2. **Giant Fields of the Decade 2000-2010** - R.K. Merrill and C.A. Sternbach, *AAPG*
3. **Hydrocarbon Exploration and Production** - F. Jahn, M. Cook and M. Grahan, *Elsevier*
4. **Practical Petroleum Geochemistry for Exploration and Production** - Harry Dembicki, *Elsevier*
5. **Tectonics and Sedimentation: Implications for Petroleum Systems** - D. Gao, *AAPG*
6. **The Petroleum System: From Source to Trap** - L.B. Magoon and W.G. Dow, *AAPG*
7. **Volcanic Reservoirs in Petroleum Exploration** - Caineng Zou, *Elsevier*

# GOL-DE-354
# Geochemistry and Isotope Geology

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The objective of the course is to introduce basic principles of geochemistry and isotope geology to the undergraduate students.

**Course Learning Outcome**

After completion of the course, the student will learn fundamental principles of geochemistry. They will also gain knowledge about principles of isotope geology and their applications.

**Key Words:** Elements, Geochemistry, Radiogenic Isotopes, Stable Isotopes

**Unit 1:** **15 Lectures**

Geochemistry - introduction, historical development and applications; The Big Bang and nucleosynthesis; solar system abundance of elements; atoms and molecules; internal structure of atoms; X-ray emissions by atoms; ionization energy; electronegativity; geochemical classification of elements.

**Unit 2:** **12 Lectures**

Bonding in minerals; ionic crystals; ionic substitution and solid solution; distribution coefficients; law of mass action; concept of mass-balance and mixing theory.

**Unit 3:** **18 Lectures**

Isotope Geology - introduction, historical development and applications; radioactive decay mechanisms; half-life and decay constant; introduction to Rb-Sr, Sm-Nd and U-Pb isotopic systematics and their applications.

**Unit 4:** **15 Lectures**

Introduction to stable isotopic systematics; applications of stable isotopes in earth system science; primary geochemical differentiation of the earth; geochemical and isotopic tools to understand petrogenesis of rocks and crustal evolution.

## Practical ***60 Hours***

1. Identification of selected non-silicate minerals by blowpipe test
2. Preparation and measuring normality of common chemical reagents used in geochemical laboratory.
3. Calculation of ionic radius using coordination number.
4. Calculation of half-life and decay constant.
5. Practical record.
6. Viva-voce.

# GOL-DE-354
# Geochemistry and Isotope Geology

**Recommended Books**

Text Books:


1. **Geochemistry** - William M. White, *Wiley-Blackwell*
2. **Geochemistry: An Introduction -** Francis Albarede, *Cambridge University Press*
3. **Introduction to Geochemistry: Principles and Applications** - Kula C. Misra, *Wiley-Blackwell*
4. **Isotope Geology** - Claude J. Allegre, *Cambridge University Press*
5. **Isotopes: Principles and Applications** - Gunter Faure and Teresa M. Mensing, *John Wiley*.
6. **Principles and Applications of Geochemistry: A Comprehensive Textbook for Geology Students** - Gunter Faure, *Prentice Hall*
7. **Stable Isotope Geochemistry** -Hoefs, *Springer*


Reference Books:


1. **Essentials of Geochemistry** - John V. Walther, *Jones and Bartlett Publishers*
2. **Geochemistry: Pathways and Processes** - Harry Mcsween, Sterven M Ricardson and Maria Uhle, *Columbia University Press*
3. **Inorganic Geochemistry** - Paul Henderson, *Pergamon Press*
4. **Isotope Geochemistry** - William M. White, *Wiley*
5. **Principles of Stable Isotope Geochemistry** - Zachary Sharp, *Pearson Education Inc*.
6. **Radiogenic Isotope Geochemistry: A Guide for Industry Professionals** - Bruce F. Schaefer, *Cambridge University Press*
7. **Radiogenic Isotope Geology,** Alan P. Dickin -*Cambridge University Press*.
8. **Radiogenic Isotopes in Geological Processes** - S.V. Rasskazov, S.B. Brandt and I.S. Brandt, *Springer*.
9. **Stable Isotope Geochemistry** - John W. Valley and David R. Cole, *Mineralogical Society of America*
10. **Treatise on Geochemistry (Vol-I): Meteorites, Comets and Planets** - H.D. Holland and K.K. Turekian, *Elsevier*

## GOL-DE-361
## Fundamentals of Remote Sensing and GIS

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

This course intends to introduce students to the fundamental principles and techniques of remote sensing, basic properties of electromagnetic radiation and its interaction with matter, fundamentals of digital image processing and image interpretation techniques. The course will also introduce the students to the fundamentals of geographical information system.

**Course Learning Outcome**

At the end of this course, the student will be appraised with the theoretical knowledge, information and skills to use remotely sensed data, image processing techniques and application of GIS techniques for geological applications.

**Key Words:** Remote Sensing, Image Processing, GIS

**Unit 1:** **15 Lectures**

Fundamentals of remote sensing; electromagnetic spectrum; interaction of electro-magnetic radiation with Earth's atmosphere and surface features; atmospheric window; sensors and platforms; advantages and limitations of remote sensing.

**Unit 2:** **15 Lectures**

Introduction to optical, thermal, microwave and hyper-spectral remote sensing; satellite remote sensing: geosynchronous and sun synchronous orbit; concept of digital image; sensor resolution; panchromatic and multi-spectral images.

**Unit 3:** **18 Lectures**

Principles of digital image processing: mage pre-processing; image enhancement; multi-image manipulation; image classification; false colour composite (FCC); elements of image interpretation.

**Unit 4:** **12 Lectures**

Fundamentals of geographical information system (GIS); data structure, spatial and attribute data; vector and raster data; spatial and 3D data analysis and visualization.

### Practical ***60 Hours***

1. Digital image processing.
2. Satellite data interpretation.
3. Georeferencing of maps.
4. Extraction of spatial features through digitization.
5. Map composition.
6. Practical record.
7. Viva-voce.

## GOL-DE-361
## Fundamentals of Remote Sensing and GIS

**Recommended Books**

Text Books:


1. **An Introduction to Geographical Information Systems** - I. Heywood, S. Cornelius and S. Carver, *Pearson*
2. **Concepts and Techniques of Geographic Information Systems** - C. P. Lo and A. K. W. Yeung, *Pearson*
3. **Fundamentals of Remote Sensing** - George Joseph and C. Jeganathan, *Universities Press*
4. **Image Interpretation in Geology** - S. A. Drury, *Nelson Thornes*
5. **Principles and Applications of Photogeology** - S. N. Pandey, *New Age International, Delhi*
6. **Principles of Geographical Information Systems** - P. A. Burrough, R. A. McDonnell and C. D. Lloyd, *Oxford University Press*
7. **Remote Sensing and GIS** - B. Bhatta, *Oxford University Press*
8. **Remote Sensing and Image Interpretation** - T. M. Lillesand, R. W. Kiefer and J. W. Chipman, *John Wiley and Sons*
9. **Remote Sensing Geology** - R. P. Gupta, *Springer-Verlag*
10. **Remote Sensing of the Environment** - J. R. Jensen, *Pearson Education*


Reference Books:


1. **Introducing Geographic Information Systems with ArcGIS: A Workbook Approach to Learning GIS** - Michael D. Kennedy, Michael F. Goodchild and Jack Dangermond, *Wiley*
2. **Introduction to Geographic Information Systems** - Kang-tsung Chang, *McGraw-Hill*
3. **Introduction to Microwave Remote Sensing** - Iain H. Woodhouse, *CRC Press*
4. **Introductory Digital Image Processing: A Remote Sensing Perspective** - John R. Jensen, *Pearson Education, Inc.*
5. **Learning QGIS** - Anita Graser, *Packt Publishing Limited*
6. **Remote Sensing Digital Image Analysis: An Introduction** - John A. Richards, *Springer*
7. **Remote Sensing Handbook (Vols. 1-3)** - Prasad S. Thenkabali, *CRC Press*
8. **Remote Sensing Image Fusion: A Practical Guide** - C. Pohl and J.V. Genderen, *CRC Press*

## GOL-DE-362

## Climate Change: Past, Present and Future

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The course is intended to introduce the students to the Earth's climate system and to explore the science of global climate change using different proxies.

**Course Learning Outcome**

Students should be able to describe how the Earth's climate system works and summarize general atmosphere circulation patterns, ocean circulation patterns and climate oscillations. Besides, they will also be in a position to illustrate the Earth's carbon cycle and quantitatively describe how addition of $CO_2$ to the atmosphere due to burning of fossil fuels influences the climate.

**Key Words:** Earth's Climate System, Palaeoclimate, Climate Controls

**Unit 1:** **15 Lectures**

Climate science: introduction and components; climate forcing and response; feedbacks in the climate system; Earth's present climate system.

**Unit 2:** **15 Lectures**

Earth's past climate: climate archives, dating and resolution; climate data; climate models - physical and geochemical models; climate change through geologic time; Quaternary ice age.

**Unit 3:** **15 Lectures**

Climate controls of atmosphere, plate tectonics, greenhouse gases and solar radiation; Milankovitch theory; ionsolation control of monsoon and icesheets; changes in rainfall patterns/intensity vis-à-vis storm surges, cyclone, floods and droughts; evolution of Indian monsoon system; agro-climatic division of Indian subcontinent.

**Unit 4:** **15 Lectures**

Climate and landscape evolution; use of climate proxies to model and motor past and present climate indicators; anthropogenic effects: preindustrial climate and climate change in recent past; future climate change - impacts on greenhouse gases; controlling climate modification.

### Practical ***60 Hours***

1. Calculation of gravity at various levels on the Earth.
2. Calculation of air pressure at various altitudes on the Earth.
3. Calculating amount of moisture in air at given air density and height.
4. Calculate mass of vertical column of air in unit cross section at various altitude levels.
5. Practical record.
6. Viva-voce

## GOL-DE-362
## Climate Change: Past, Present and Future

**Recommended Books**

Text Books:

1. **Climate Change: Past, Present and Future** - M.A. Melieres and C. Marechal, *Wiley-Blackwell*
2. **Earth's Climate: Past and Future** - W.F. Ruddiman, *W.H. Freeman & Co.*
3. **Essentials of Meteorology: An Invitation to the Atmosphere** - C.D. Ahrens, *Cengage Learning*
4. **Paleoclimatology: Reconstructing Climates of the Quaternary** - R.S. Bradley, *Academic Press*
5. **Physics of Climate** - Peixoto and Oort, *American Institute of Physics*
6. **Reconstructing Quaternary Environments** - J.J. Lowe and M.J.C. Walker, *Longman*
7. **Paleoclimatology: From Snowball Earth to the Anthropocene** - C.P. Summerhayes, *Wiley*

Reference Books:

1. **Dynamical Paleoclimatology: Generalized Theory of Global Climate Change** - Barry Saltzman (Eds), *Academic Press*
2. **Encylopedia of Paleoclimatology and Ancient Environments** - Viven Gornitz (Ed), *Springer*
3. **Ice Age Earth: Late Quaternary Geology and Climate (Physical Environment)** - A.G. Dawson, *Routledge*
4. **Late Quaternary Environmental Change: Physical and Human Perspective** - M. Bell and M.J.C. Walker, *Routledge*
5. **Looking Back to Change Track** - Divya Datt and Shilpa Nischal (Eds), *TERI*
6. **Paleoclimatology** - A. Govin, A. Landais, G. Ramstein, N. Bouttes and P. Sepulchre (Eds), *Springer*

# GOL-DE-363
# Quaternary Geology and Geomorphology

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

This course intends to introduce students to the fundamentals of Quaternary geology, climate change and sea level fluctuation during Quaternary period. It also introduces the landforms produced by different geomorphic processes at various scales.

**Course Learning Outcome**

After completion of this course, the student will be acquainted with various geomorphic processes and events took place during Quaternary period as well as the landforms produced as a result of both exogenic and endogenic processes.

**Key Words:** Quaternary Geology, Stratigraphic Significances, Geomorphic Processes

**Unit 1:** **15 Lectures**

Introduction to Quaternary Geology; significance of Quaternary studies; Quaternary period and subdivisions; introduction to Quaternary dating methods.

**Unit 2:** **15 Lectures**

Quaternary climate change and sea level fluctuation; basic principles of morphostratigraphy, oxygen isotope stratigraphy and magnetostratigraphy.

**Unit 3:** **15 Lectures**

Introduction to geomorphology; endogenic and exogenic processes; terrestrial relief features; scales in geomorphology; weathering: physical and chemical; hill slope and hill slope processes.

**Unit 4:** **15 Lectures**

Fluvial processes and landforms; aeolian, coastal and glacial processes and landforms; introduction to tectonic geomorphology; overview of the geomorphology of India.

## Practical

***60 Hours***

1. Study of landforms from contour patterns of topographic maps.
2. Construction of vertical profile.
3. Preparation of longitudinal profile of a river.
4. Practical records.
5. Viva-voce.

## GOL-DE-363
## Quaternary Geology and Geomorphology

**Recommended Books**

Text Books:


1. **Active Tectonics: Earthquakes, Uplift and Landscape -** Edward A. Keller and Nicholas Pinter, *Prentice Hall*
2. **Fundamentals of Geomorphology** - Richard John Huggett, *Routledge*
3. **Geomorphology** - Mateo Gutiérrez, *CRC Press*
4. **Geomorphology: A systematic Analysis of Late Cenozoic Landforms** - A. L. Bloom, *Pearson*
5. **Geomorphology: The Mechanics and Chemistry of Landscapes** - R. S. Anderson and S. P. Anderson, *Cambridge University Press*
6. **Principles of Quaternary Geology and Environmental Study** - A. B. Goswami, *Books Way, Kolkata*
7. **Tectonic Geomorphology** - D. W. Burbank and R. S. Anderson**,** *Wiley-Blackwell*
8. **Understanding Earth** - J. Grotzinger, T. Jordan, F. Press and R. Siever, *W. H. Freeman & Co.*


Reference Books:


1. **Aeolian Geomorphology: A New Introduction** - Ian Livingstone and Andrew Warren, *Wiley-Blackwell*
2. **An Introduction to Coastal Processes and Geomorphology -** Robin Davidson-Arnott, *Cambridge University Press*
3. **Arid and Semi-Arid Geomorphology** - Andrew S. Goudie, *Cambridge University Press*
4. **Coastal Geomorphology: An Introduction**- Eric Bird, *John Wiley & Sons Ltd*
5. **Earth**: **An introduction to Physical Geology** - E. J. Tarbuck, F. K. Lutgens and D. Tasa, *Pearson*
6. **Earth's Climate: Past and Future** - William F. Ruddiman, *W. H. Freeman and Company*
7. **Encyclopedia of Geomorphology -** A. S. Goudie, *Routledge*
8. **Fundamentals of Fluvial Geomorphology -** Ro Charlton, *Routledge*
9. **Introduction to Process Geomorphology** - Vijay K. Sharma, *CRC Press*
10. **Key Concepts in Geomorphology** - Paul R. Bierman and David R. Montgomery, *W. H. Freeman & Co.*
11. **Physical Geology** - C. C. Plummer, D. H. Carlson and L. Hammersle, *McGraw Hill*
12. **Quaternary Dating Methods -** Mike Walker, *Wiley*
13. **Quaternary Geology: Indian Perspective** - U. B. Mathur, *Geological Society of India*
14. **River Dynamics: Geomorphology to Support Management** - Bruce L. Rhoads, *Cambridge University Press*
15. **River Morphology** - R. J. Garde, *New Age International (P) Limited, Publishers*
16. **River Processes: An Introduction to Fluvial Dynamics** - André Robert, *Arnold*
17. **River Variability and Complexity** - Stanley A. Schumm, *Cambridge University Press*
18. **Rivers in the Landscape** - Ellen Wohl, *Wiley-Blackwell*
19. **Tectonically Active Landscapes** - William B. Bull, *Wiley-Blackwell*
20. **The SAGE Handbook of Geomorphology** - Kenneth J. Gregory and Andrew S Goudie, *SAGE Publications Ltd*
21. **Treatise on Geomorphology -** John F. Shroder, Vols. 1- 14, *Academic Press*

## GOL-DE-364
## Dissertation/Research Project

*(Credit Distribution L0:T0:P6 = 6 Credits)*

**Course Objective**

The basic aim of this course is to introduce the students to the early stages of research where they can learn to choose geological problems and solve with appropriate methods.

**Course Learning Outcome**

After the completion of the course, students are expected to be learnt about the basic research procedures, field methods, use of different instruments, interpreting geological data and report writing.

**Project Work**

Students may opt for dissertation in lieu of any one DSE course. The dissertation/project work will be carried out by students individually or in groups under the supervision of a teacher/faculty member of the department. The project work will be allotted at the end of 4$^{th}$ semester by giving due consideration to the choice of the students and the facilities available in the department. Students availing summer internship shall continue the work under the supervision of a teacher/faculty member of the department. However, students may submit the project report by end of 6$^{th}$ semester.

Internal assessment and final evaluation of the dissertation shall be done as per the provisions mentioned in the university regulations.

| | |
|---|---|
| **Internal assessment** | : 20 |
| **Report** | : 50 |
| **Presentation** | : 10 |
| **Viva-voce** | : 20 |

# GOL-SE-001
# Optics and Optical Mineralogy

*(Credit Distribution L1:T0:P1 = 2 Credits)*

**Course Objective**

The course is intended to introduce the students to the basic concepts of optics and optical mineralogy including the interaction of light and geological materials.

**Course Learning Outcome**

After completion of the course, the students will learn about the basic principles involved in optics, behaviour of light in crystals and determination of different optical properties of minerals.

**Key Words:** Optics, Optical Mineralogy

**Unit 1:** **8 Lectures**

Wave theory of light, reflection, refraction, polarisation, double refraction, birefringence; refractive index and its determination.

**Unit 2:** **7 Lectures**

Optical properties of minerals: isotropic and anisotropic minerals; optical indicatrix; pleochroism and pleochroic scheme; sign of elongation; interference in crystals; uniaxial and biaxial minerals; conoscopy: interference figure and its use in determining optic sign.

## Practical *30 Hours*

1. Study of optical properties of rock-forming minerals in thin section.
2. Measurement of extinction angles and determination of sign of elongation.
3. Determination of refractive index using Becke test.
4. Determination of pleochroic schemes with reference to vibration direction.
5. Study of uniaxial and biaxial interference figure and determination of optic sign.
6. Practical records.
7. Viva-voce.

# GOL-SE-001
# Optics and Optical Mineralogy

**Recommended Books**

Text Books:

1. **A Key Identification to Rock-Forming Minerals in Thin Section** - A.J. Barker, *CRC Press*
2. **A Practical Introduction to Optical Mineralogy** - C.D. Gribble and A.J. Hall, *Springer*
3. **Introduction to Optical Mineralogy** - W.D. Nesse, *Oxford University Press*
4. **Optical Mineralogy** - P.K. Verma, *Ane Books Pvt. Ltd.*
5. **Petrography Laboratory Manual: Hand specimen and Thin Section Petrography** - L.A. Raymond, Tom Terranova, *Waveland Press Inc.*
6. **Rocks and Minerals in Thin Section: A Colour Atlas** - W.S. MacKenzie, A.E. Adams and K.H. Brondi, *CRC Press*

Reference Books:

1. **An Introduction to Rock**-Forming Minerals - W.A. Deer, R.A. Howie and J. Zussman, *Mineralogical Society of Great Britain and Ireland*
2. **Introduction to Mineralogy** - W.D. Nesse, Oxford University Press
3. **Mineralogy** - Dexter Perkins, *Pearson*
4. **Mineralogy for Petrologists: Optics, Chemistry and Occurrence of Rock-Forming Minerals** - M. Demanage, *CRC Press*
5. **Minerals in Thin Section** - Dexter Perkins and Kevin Henke, *Pearson*
6. **Optical Mineralogy: Principles and Practice** - C.D. Gribble and A.J. Hall, *Springer*
7. **The Ore Minerals Under the Microscope: An Optical Guide** - Bernhard Pracejus, *Elsevier*

## GOL-SE-002
## Statistics and Its Applications in Geology

*(Credit Distribution L2:T0:P0 = 2 Credits)*

**Course Objective**

The main objective of the course is to introduce students to the fundamentals of statistics and its application in analysing various geological data.

**Course Learning Outcome**

On completion of this course, the students will be able to apply basic statistical tools in analysing different types of geological data.

**Key Words:** Statistics, Statistical Applications

**Unit 1:** **15 Lectures**

Introduction to statistics; graphical representation of geological data; population and sample; measures of central tendency, dispersion, kurtosis and their applications in geology; basic concept of probability and probability distribution of geological data.

**Unit 2:** **15 Lectures**

Correlation and regression; time series analysis; trend surface analysis; distribution of data; test of significance and confidence level; null hypothesis and alternate hypothesis; z-test and t-test.

## GOL-SE-002
## Statistics and Its Applications in Geology

**Recommended Books**

Text Books:

1. **Statistical Methods**- S. P. Gupta, *Sultan Chand*
2. **Statistics and Data Analysis in Geology**- J. C. Davis, *Wiley India*
3. **Geostatistics Explained: An Introductory Guide for Earth Scientists** - Steve McKillup and Melinda Darby Dyar, *Cambridge University Press*
4. **Applied Geostatistics** - Edward H. Isaaks and R. Mohan Srivastava, *Oxford University Press*

Reference Books:

1. **Fundamentals of Mathematical Statistics** - S. C. Gupta and V. K. Kapoor, *Sultan Chand*
2. **Geostatistics with Applications in Earth Sciences -** D. D. Sarma, *Springer*
3. **Statistics and Analysis of Scientific Data** - Massimiliano Bonamente, *Springer*

# GOL-SE-003
# Gemology and Gem Testing

*(Credit Distribution L2:T0:P0 = 2 Credits)*

**Course Objective**

The objective of the course is to introduce the basic concepts involved in the study of gem stones, their identification and testing methods.

**Course Learning Outcome**

After completion of the course, the students will learn physical characteristics, identification and occurrence of gemstones. They will also learn about the different techniques involved in identification of natural and synthetic gemstones.

Key Words: Gems, Gem Testing

**Unit 1:** **15 Lectures**

Gemmology: introduction to gems; basic properties of gems; formation of gem stones, use of refractometers, polariscope, and dichroscope; causes of colours in gemstones; introduction to special optical properties like chatoyancy, asterism, luminescence, play of colours, labradorescence, inclusions etc.; distinction between synthetic and natural gem stones.

**Unit 2:** **15 Lectures**

Use of gem testing instruments: hand lens (10x), detection of double refraction, by observing pleochroic colours with the dichroscope; identification of gemstones on the basis of pleochroic colours; detection of double refraction, interference figures and internal strain with the polariscope; study of the fluorescent colours exhibited by various gemstones under ultraviolet (long wave and short wave) light; measurement of refractive indices and birefringence tests using a gem-testing refractometer.

# GOL-SE-003
# Gemology and Gem Testing

**Recommended Books**

Text Books:

1. **Diamonds and Their Source Rocks in India** - Fareeduddin and R. H. Mitchell, *Geological Society of India*
2. **Diamonds in India** - T.M. Babu, *Geological Society of India*
3. **Gem Testing** - B. Anderson, *Read Books Pvt. Ltd.*
4. **Gemmology** - P. G. Read, *Butterworth-Heinemann Ltd.*
5. **Gems and Gem Industry in India** - R.V. Karanth, *Geological society of India*
6. **Gems: Their Sources, Descriptions and Identification**- B.W. Anderson (Ed.), *Butterworth-Heinemann Ltd.*
7. **Gemstones: Enchanting Gifts of Nature** - R.V. Karanth, *Geological Society of India*
8. **Mineralogy: A First Course** - J. Sinkankas, *Van Nostrand Reinhold Company*

Reference Books:

1. **Beginner's Guide to Gemmology** - Peter G. Read, *Heinemann Professional Publishing*
2. **Color Encylopedia of Gemstones** - Joel Arem, *Springer*
3. **Dictionary of Gems and Gemology** - M. Manutchehr-Danai, *Springer*
4. **Gem Identification Made Easy: A Hands-on Guide to More Confident Buying & Selling** - A. Matlins and A.C. Bonnano, *Gemstone Press*
5. **Popular Gemology** - Richard M. Pearl, *Read Books Pvt. Ltd.*

# GOL-SE-004
# Medical Geology

*(Credit Distribution L2:T0:P0 = 2 Credits)*

**Course Objective**

The course is designed to introduce the basic concepts of medical geology, interaction between abundances of elements and isotopes and the health of humans and plants. The course provides a basic understanding or geogenic and anthropogenic distribution of trace elements, their toxic effects on human health and that of flora and fauna.

**Course Learning Outcome**

On completion of the course the student will be able to understand the distribution of trace elements and its cyclic movement through the abiotic-biotic environment and their influence on human health, flora and fauna.

**Key Words:** Element Distribution, Health Hazards

**Unit 1:** **15 Lectures**

Basic concepts of medical geology; natural distribution and abundance of elements; anthropogenic sources of elements; element consumption by humans; biological functions and responses of elements; geological impacts on nutrition.

**Unit 2:** **15 Lectures**

Geospatial analysis as a tool in epidemiology; health hazards associated with volcanic eruptions; global dust flux and respiratory problems; impacts of radon, arsenic, selenium, mercury, iodine, and uranium on physiological function; carcinogenic associations with coal and fibrous minerals; geological effects on animal health, and geophagy (human ingestion of soil materials as a dietary supplement).

# GOL-SE-004
# Medical Geology

**Recommended Books**

Text Books:

1. **Environmental Radioactivity from Natural, Industrial, and Military Sources** - M. Eisenbud and T. Gesell, *Academic Press*
2. **Essentials of Medical Geology: Impacts of the Natural Environment on Public Health** - Olle Selinus, *Academic Press*
3. **Introduction to Medical Geology** - C. B. Dissanayake and R. Chandrajith, *Springer-Verlag*
4. **Medical Geochemistry: Geological Materials and Heath** - P. Censi, T.H. Darrah and Y. Erel (Eds), *Springer*
5. **Medical Geology: Effects of Geological Environments on Human Health (Vol. 2)** – Miomir Komatina, *Elsevier*

Reference Books:

1. **A History of Geology and Medicine** - C.J. Duffin, R.T.J. Moody and C.G.-Thorpe (Eds), *The Geological Society London*
2. **Elements of Geochemistry, Geochemical Exploration and Medical Geology** - K.R. Randive, *Research Publishing*
3. **Geology and Health**: Closing the Gap – H. Catherine, W. Skinner and A. R. Berger (Eds), *Oxford University Press*
4. **Medical Geology: A Regional Synthesis** - O. Selinus, R. B. Finkelman and J.A. Centeno, *Springer*
5. **Practical Applications of Medical Geology** - M. Siegel, O. Selinus and R. Finkelman (Eds), *Springer*
6. **Progress in Medical Geology** - M. Ibaraki and H. Mori (Eds.), *Cambridge Scholars Publishing*

# GOL-SE-005
# Surveying and Levelling

*(Credit Distribution L2:T0:P0 = 2 Credits)*

**Course Objective**

The objective of the course is to introduce the students to the basic principles and different methods involved in surveying and levelling techniques.

**Course Learning Outcome**

After completion of the course, students will be able to learn different techniques of surveying and levelling using various instruments.

**Key Words:** Surveying, Instruments, Levelling

**Unit 1:** **15 Lectures**

Surveying: definitions and objectives of surveying; measurement of horizontal and vertical angle; measurement of distance; open traverse and close traverse in surveying; theodolite and total station.

**Unit 2:** **15 Lectures**

Levelling: definitions of terms used in levelling; principles of levelling: simple and differential; levelling operations and steps in levelling; characteristics of a dumpy level and a levelling staff; bench marks and change points; reduction of levels: collimation method and rise and fall method.

## GOL-SE-005
## Surveying and Levelling

**Recommended Books**

Text Books:

1. **Surveying (Vol. I & II)** - B.C. Punmia, *Standard Publishers*
2. **Surveying (Vol. I & II)** - K.R. Arora, *Standard Book House*
3. **Surveying (Vol. I & II)** - S.K. Duggal, *Tata McGraw-Hill*
4. **Surveying and Levelling (Part I)** - T.P. Kanetkar and S.V. Kulkarni, *Vidhyarthi Griha Prakashan*

Reference Books:

1. **A Textbook of Surveying and Levelling** - R. Agor, *Khanna Publishers*
2. **Surveying and Levelling** - R. Subramanian, *Oxford University Press*

# GOL-SE-006
# Environmental Sanitation

*(Credit Distribution L2:T0:P0 = 2 Credits)*

**Course Objective**

The course introduces the students to learn about fundamentals of environmental sanitation as well as sanitary and hygienic aspects in the context of Swacch Bharat programme.

**Course Learning Outcome**

On completion of the course, the student will gain knowledge and skills necessary for creating impact in the field of environmental sanitation.

**Key Words:** Environment, Sanitation, Solid Waste Management

**Unit 1:** **15 Lectures**

Introduction to sanitation; sanitation systems and services; sanitation and public health; epidemiology; community sanitation measures: sanitation of camps, festivals, schools, swimming pools etc.; food and milk sanitation; hotel management with reference to sanitation; food preservation; pasteurization methods and plants; housing needs: lighting and ventilation, natural and artificial provisions.

**Unit 2:** **15 Lectures**

Solid wastes: characteristics, collection, disposal by landfill, composting, incineration and other methods; handling and disposal of hazardous wastes; industrial hygiene: occupational hazards, various operations in industrial units; engineering and safety measures; radiological health: radioactive wastes and disposal; noise pollution and control: engineering and medical divisions, various programmes; rural sanitation: various methods of collection and disposal of faecal matter, community toilets, septic tanks and soak pits - biogas plant; advanced wastewater treatment and reuse.

# GOL-SE-006
# Environmental Sanitation

**Recommended Books**

Text Books:

1. **Elements of Environmental Engineering** - K.N. Duggal, *S. Chand and Co., New Delhi*
2. **Environmental Engineering and Sanitation** - Salvato Joseph A, *John Wiley & Sons*
3. **Environmental Protection** - Emil T. Chanlett, *McGraw Hill Inc.*
4. **Faecal Sludge Management** - Linda Strande, Mariska Ronteltap and Damir Brdjanovic, IWA Publishing. https://www.un-ihe.org/faecal-sludge-management-4\
5. **Manual of Sewage and Sewage Treatment** - CPHEEO
6. **Municipal and Rural Sanitation: Sanitary Science & Water Engineering** - V. M. Ehlers and Ernest W. Steel, *Tata McGraw-Hill*
7. **Waste Water Engineering: Collection, Treatment and Disposal** - Metcalf and Eddy, *Tata-McGraw Hill Inc., New York*
8. **Water Supply and Sanitary Engineering** - G.S. Birdie and J.S. Birdie, *Dhanpat Rai and Sons, New Delhi*

Reference Books:

1. **Environmental Sanitation** - J.S. Salvato, *Wiley*
2. **Environmental Sanitation Health and Panchayat Raj** - B.D. Sinha and P.S.K. Menon, *Concept Publishing Company, New Delhi*
3. **Water and Sanitation-Related Diseases and the Changing Environment** - J.M.H. Selendy, *Wiley-Blackwell*

# GOL-SE-007
# Watershed Development

*(Credit Distribution L2:T0:P0 = 2 Credits)*

**Course Objective**

The objective of the course is to introduce the fundamental concepts, principles and planning of watershed development. The course also provides inputs for integrated watershed management.

**Course Learning Outcome**

Upon completion of this course, the students will acquire skills to undertake watershed development and integrated watershed management thereby enhancing their employability with NGOs, government agencies, etc. working in the fields of watershed and rural development.

**Key Words:** Watershed, Watershed Management

**Unit 1:** **15 Lectures**

Watershed development: concept and characteristics of watershed; importance of water resources in watershed; concept of watershed development in relation to water resources; salient features of development measures like contour bunding, gully plugs, stream bunds, percolation tank, subsurface dams, afforestation etc.; significance of geology in watershed development; assessment of water resources in a watershed: rainfall-runoff and ground water analysis; soil erosion estimation; role of NGOs and State Government in watershed development.

**Unit 2:** **15 Lectures**

Watershed management: concept of watershed management in relation to water resources; water balance equation for watershed; sustainability of water resources; conjunctive use of surface and groundwater resources; concepts of people's participation in community-based watershed management; watershed modelling; drought assessment and management; integrated watershed management.

# GOL-SE-007
# Watershed Development

**Recommended Books**

Text Books:

1. **Hydrology and the Management of Watersheds** - K.N. Brooks, P.F. Ffolliott and J.A. Magner, *John Wiley & Sons*
2. **Watershed Management** - J.V.S. Murthy, *New Age International Publisher*
3. **Integrated Watershed Management: Principles and Practice** - I.W. Heathcote, *John Wiley & Sons Ltd.*
4. **Watersheds: Processes, Assessment and Management** - P. A. Debarry, *Wiley*
5. **Watershed Management: Balancing Sustainability and Environmental Change** - R.J. Naiman, *Springer*
6. **Sustainable Use and Development of Watersheds** - I.E. Gonenc, A. Vadineanu and J.P. Wolflin, *Springer*

Reference Books:

1. **Coastal Watershed Management** - Ali Fares and A.I. El-Kadi (Eds), *WIT Press*
2. **GIS for Water Resources and Watershed Management** – J.G. Lyon (Eds), *Taylor & Francis*
3. **Groundwater** - H.M. Raghunath, *New Age Education*
4. **Groundwater Assessment Development and Management** - K.R. Karanth, *Tata-McGraw Hill Education*
5. **Groundwater Hydrology** - D. K. Todd and L. W. Mayo, *Wiley*
6. **Integrated Approaches to Sustainable Watershed Management in Xeric Environments: A Training Manual** - V.R. Reddy, G.J. Syme and C. Tallapragada, *Elsevier*
7. **Watershed Management** - M.M. Das and M.D. Saikia, *Prentice Hall India*

# GOL-SE-008
# Fieldwork

*(Credit Distribution L0:T0:P2 = 2 Credits)*

**Course Objective**

The objective of the course is to introduce the students to different geological terrains to learn sampling methods, to understand disposition of different rock formations and economic mineral deposits and mining operations.

**Course Learning Outcome**

After the completion of the course, students will be expected to have knowledge about different geological terrains, mineral deposits and operation of mines. They will also develop report writing and presentation skills.

The students shall carryout fieldwork in diverse geological terrains of India, visit to geologically important areas where exploration and mining activities are going on as well as to engineering construction sites. The duration of the actual fieldwork shall be of at least 7 (seven) days. The evaluation will be based on field performance, field report and viva voce. The distribution of marks will be as follows:

| | |
|---|---|
| **Field Performance** | : 10 marks |
| **Field Report** | : 30 marks |
| **Viva-voce** | : 10 marks |

## GOL-SE-008
## Fieldwork

**Recommended Books**


1. **A Guide to Field Geology** - N. W. Gokhale, *CBS Publishers*
2. **Economic Geology** - Umeshwar Prasad, *CBS Publishers and Distributors*
3. **Field Geology** - F. H. Lahee, *CBS Publishers*
4. **Geological Field Techniques** - A. L. Coe, *Wiley-Blackwell*
5. **Geology in The Field** - R. R. Compton, *Earthspun Books*
6. **Geology of India (Vol. 1 & 2)** - R. Vaidyanandhan and M. Ramakrishnan, *Geological Society of India*
7. **Mineral Resources of India** - D. K. Banerjee, *World Press, Kolkata*
8. **Sedimentary Rocks in the Field** - M. E. Tucker, *Wiley-Blackwell*
9. **Sedimentary Rocks in the Field: A Colour Guide** - D. A. V. Stow, *Manson Publishing*
10. **The Field Description of Igneous Rocks** - D. Jerram and N.Petford, *Wiley-Blackwell*
11. **The Field Description of Metamorphic Rocks** - N. Fry, *Wiley-Blackwell*
12. **The Making of India: Geodynamic Evolution** - K. S. Validya, *Springer*

# GOL-GE-001
# Earth and Environment

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The course is intended to introduce the students to the fundamental aspects of the planet earth, plate tectonics, different geological processes, minerals, rocks and ores.

**Course Learning Outcome**

After completion of the course, the students would be able to understand basic characteristics of the Earth, plate tectonic activities and resulting geological phenomena, and endogenic and exogenic geological processes. They will also able to understand various earth materials such as minerals, rocks and ores. A fair knowledge about natural hazards such as earthquakes, volcanoes etc and their causes would be expected.

**Key Words:** Earth, Minerals, Rocks, Geological Processes, Earth Resources

**Unit 1:** **15 Lectures**

Earth - physical characteristics, origin, and its place in the Universe; Earth as a system; Earth through geologic time; internal structure of the Earth; discovery of plate tectonics; Earth's major plates and plate boundaries; mantle convection and plate tectonics.

**Unit 2:** **15 Lectures**

Earth materials: minerals - definition, atomic structure and physical properties; rock forming minerals; rocks - types of rocks; rock cycle; primary and secondary rock structures.

**Unit 3:** **15 Lectures**

Endogenic processes: earthquakes and volcanoes - causes, hazards and prediction; earthquake zones in India; exogenic processes: hydrologic cycle; weathering and erosion; mass wasting; rivers; glaciers; soil profile and soil types; morphology of the ocean floor.

**Unit 4:** **15 Lectures**

Earth resources: mineral resources; oil and natural gas; coal; other energy resources; India's major metal deposits, and coal and petroleum resources; human impact on Earth's environment.

## Practical ***60 Hours***

1. Measuring attitude of planar features.
2. Identification of three different rock types.
3. Megascopic identification of important rock-forming minerals.
4. Practical records.
5. Viva-voce.

## GOL-GE-001
## Earth and Environment

**Recommended Books**

Text Books:


1. **A Text Book of Geology** - P.K. Mukherjee, *World Press, Kolkata*
2. **Earth Materials** - Kevin Hefferan and John O'Brien, *Wiley-Blackwell*
8. **Environmental Geology** - James S. Reichard, *McGraw Hill*
3. **Essentials of Geology** - Lutgens, Tarbuck and Tasa, *Pearson*
4. **Fundamentals of Geomorphology** - Richard J. Huggett, *Routledge*
5. **Fundamentals of Physical Geology** - Sreepat Jain, *Springer*
9. **Introduction to Environmental Geology** - Edward A. Keller, *Pearson*
6. **Physical Geology**- Charles C. Plummer, Diane H. Carlson and Lisa Hammersley, *McGraw Hill*
7. **Principles of Physical Geology** - Arthor Holmes, *Champman and Hall, London*
10. **Understanding Earth** - John Grotzinger and Thomas H. Jordan, *Macmillan*


Reference Books:


1. **Encyclopedia of Geomorphology** - Andrew S. Goudie, *Routledge*
2. **Introduction to Coastal Processes and Geomorphology** - Robin Davidson-Arnott, *Cambridge*
3. **Introduction to Physical Geology** - Thompson and Turk, *Brooks*
4. **Introduction to Planetary Science** - Gunter Faure and Teresa M. Mensing, *Springer*
5. **Looking into the Earth: An Introduction to Geological Geophysics** - Alan E. Mussett and M. Aftab Khan, *Cambridge University Press*
6. **The Earth's Land Surface** - Kenneth J. Gregory, *Sage*

# GOL-GE-002
# Geographical Information System

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The course is aimed to introduce the students to the basics of geographical information system, GIS data structure, data processing and applications.

**Course Learning Outcome**

After completion of the course, the students are expected to learn about basic principles of GIS, vector and raster data models, spatial and attribute data, data input, data processing and interpretation.

**Key Words:** GIS, GIS Data, Map Projection

**Unit 1:** **15 Lectures**

Introduction to GIS; components of GIS; hardware and software requirements; GIS data structure; concept of spatial and attribute data.

**Unit 2:** **15 Lectures**

Vector data model - point line and polygon features; concept of topology; raster data model; regular and irregular tessellation; digital elevation model and triangulated irregular network.

**Unit 3:** **15 Lectures**

GIS data source; data input and editing; vector data analysis; raster data analysis; 3D data analysis; data output; GIS data quality and data errors.

**Unit 4:** **15 Lectures**

Concept of map projection; geographic and projected coordinate system; concept of datum and ellipsoid; application of GIS.

## Practical ***60 Hours***

1. Georeferencing of maps.
2. Digitization from maps and satellite imagery.
3. Vector data editing and analysis.
4. Map composition.
5. Practical records.
6. Viva voce.

## GOL-GE-002
## Geographical Information System

**Recommended Books**

Text Books:


1. **An Introduction to Geographical Information Systems** - I. Heywood, S. Cornelius and S. Carver, *Pearson*
2. **Concepts and Techniques of Geographic Information Systems** - C. P. Lo and A. K. W. Yeung, *Pearson*
3. **Principles of Geographical Information Systems** - P. A. Burrough, R. A. McDonnell and C. D. Lloyd, *Oxford University Press*
4. **Remote Sensing and GIS** - B. Bhatta, *Oxford University Press*


Reference Books:


1. **Introducing Geographic Information Systems with ArcGIS: A Workbook Approach to Learning GIS** - Michael D. Kennedy, Michael F. Goodchild and Jack Dangermond, *Wiley*
2. **Introduction to Geographic Information Systems** - Kang-tsung Chang, *McGraw-Hill*
3. **Learning QGIS** - Anita Graser, *Packt Publishing Limited*
4. **Remote Sensing Digital Image Analysis: An Introduction** - John A. Richards, *Springer*

# GOL-GE-003
# Introduction to Remote Sensing

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

This course intends to introduce students to the fundamental principles and techniques of remote sensing, basic properties of electromagnetic radiation and its interaction with matter, fundamentals of digital image processing and image interpretation techniques.

**Course Learning Outcome**

At the end of this course, the student will be appraised with the theoretical knowledge, information and skills to use remotely sensed data, image processing techniques and interpretation.

**Key Words:** Remote Sensing, Sensors and Platforms, Digital Image Processing

**Unit 1:** Introduction to remote sensing; electromagnetic radiation and spectrum; interaction of electro-magnetic radiation with Earth's atmosphere and surface features; atmospheric window; advantages and limitations of remote sensing.

**Unit 2:** Concept of sensors and sensor resolution; remote sensing platforms; geosynchronous and sun synchronous orbit; concept of digital image; panchromatic and multi-spectral images.

**Unit 3:** Introduction to thermal remote sensing; hyper-spectral remote sensing; microwave remote sensing and SAR technology.

**Unit 4:** Principles of digital image processing: image pre-processing; image enhancement; multi-image manipulation; image classification; false colour composite (FCC); elements of image interpretation.

## Practical

***60 Hours***

1. Familiarization to different remote sensing software.
2. Displaying satellite images from various sources with proper enhancement.
3. Performing basic image processing techniques.
4. Satellite image interpretation.
5. Practical records.
6. Viva voce.

## GOL-GE-003
## Introduction to Remote Sensing

**Recommended Books**

Text Books:


1. **Fundamentals of Remote Sensing** - George Joseph and C. Jeganathan, *Universities Press*
2. **Image Interpretation in Geology** - S. A. Drury, *Nelson Thornes*
3. **Principles and Applications of Photogeology** - S. N. Pandey, *New Age International, Delhi*
4. **Remote Sensing and GIS** - B. Bhatta, *Oxford University Press*
5. **Remote Sensing and Image Interpretation** - T. M. Lillesand, R. W. Kiefer and J. W. Chipman, *John Wiley and Sons*
6. **Remote Sensing Geology** - R. P. Gupta, *Springer-Verlag*
7. **Remote Sensing of the Environment** - J. R. Jensen, *Pearson Education*


Reference Books:


1. **Introduction to Microwave Remote Sensing** - Iain H. Woodhouse, *CRC Press*
2. **Introductory Digital Image Processing: A Remote Sensing Perspective** - John R. Jensen, *Pearson Education, Inc.*
3. **Remote Sensing Digital Image Analysis: An Introduction** - John A. Richards, *Springer*
4. **Remote Sensing Handbook (Vols. 1-3)** - Prasad S. Thenkabali, *CRC Press*
5. **Remote Sensing Image Fusion: A Practical Guide** - C. Pohl and J.V. Genderen, *CRC Press*

# GOL-GE-004
# Planetary Science

*(Credit Distribution L4:T0:P2 = 6 Credits)*

**Course Objective**

The objective of the course is to introduce the students to the broad outline of the solar system, its origin and evolution, characteristics of planetary bodies and different methods of exploring the solar system.

**Course Learning Outcome**

After completion of the course, the students are expected to have knowledge about the basic aspects of the solar system, evolution and stability of the solar system and planets and occurrence of life. They will also learn about the different techniques used in the study of extra-terrestrial bodies.

**Key Words:** Solar System, Planets, Satellites

**Unit 1:** Solar System: introduction, architecture and its place in the galaxy; origin of Solar System; nucleosynthesis; early stages of planetary growth; formation of terrestrial, giant planets, and asteroid belt; meteorites; planetary satellites; extrasolar planets.

**Unit 2:** Dynamics of the Solar System: Keplerian motion; two body problem; chaotic motion of planets; orbital evolution of minor bodies; stability of the Solar System; rotation of planets - origin and long-term spin evolution; rotational flattening of planets.

**Unit 3:** Sun - structure, temperature distribution and magnetic field; sunspots; solar flares; sun's radiation; volcanism in planetary bodies; magnetic fields and atmosphere of planets; evolution of planetary interiors; life in the Solar System.

**Unit 4:** Strategies in the Solar System exploration - present and future; introduction to various techniques used in Solar System exploration - nuclear spectroscopy, geophysical tools, stereophotogrammetry, etc.

## Practical

***60 Hours***

1. Determination of distance, mass, density and size of planets.
2. Practical record.
3. Viva-voce.

# GOL-GE-004
# Planetary Science

**Recommended Books**

Text Books:

1. **Encylopedia of the Solar System** - T.Spohn, D. Breuer and T.V. Johnson, *Elsevier*
2. **Fundamental Planetary Science** - J.J. Lissauer and Imke de Pater, *Cambridge University Press*
3. **Introduction to Planetary Science: The Geological Perspective** - G. Faure and T.M. Mensing, *Springer*
4. **Planetary Science: The Science of Planets Around Stars** - G.H.A. Cole and M.M. Woolfson, *CRC Press*
5. **Solar Planetary Systems: Stardust to Terrestrial and Extraterrestrial Planetary Sciences** - A.S. Bhattacharya and J.M. Lichtman, *CRC Press*

Reference Books:

1. **Asteroids: Astronomical and Geological Bodies** - Thomas H. Burbine, *Cambridge University Press*
2. **Introduction to Earth and Planetary System Science** - Naotatsu Shikazono, *Springer*
3. **Planetary Crusts: Their Composition, Origin and Evolution** - S.R. Taylor and S.M. McLennan, *Cambridge University Press*
4. **Planetary Exploration and Science: Recent Results and Advances** - S. Jin, N. Haghighipour and Wing-Huen Ip (Eds), *Springer*
5. **Planetary Surface Processes** - H. Jay Melosh, *Cambridge University Press*
6. **Planetary Tectonics** - T.R. Watters and R.A. Schultz, *Cambridge University Press*
7. **Principles of Planetary Climate** - Raymond T. Pierrreuhmbert, *Cambridge University Press*