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# BANASTHALI VIDYAPITH

## Master of Science (Geology)


### Curriculum Structure

First Semester Examination, December-2020
Second Semester Examination, April/May-2021
Third Semester Examination, December-2021
Fourth Semester Examination, April/May-2022

**BANASTHALI VIDYAPITH**
**P.O. BANASTHALI VIDYAPITH**
**(Rajasthan)-304022**

July, 2020

**95**

**No. F. 9-6/81-U.3**

**Government of India**
**Ministry of Education and Culture**
**(Department of Education)**

New Delhi, the 25th October, 1983

# N O T I F I C A T I O N

In exercise of the powers conferred by Section 3 of the University Grants Commission Act, 1956 (3 of 1956) the Central Government, on the advice of the Commission, hereby declare that Banasthali Vidyapith, P. O. Banasthali Vidyapith, (Rajasthan) shall be deemed to be a University for the purpose of the aforesaid Act.

Sd/-
**(M. R. Kolhatkar)**
Joint Secretary of the Government of India

# N O T I C E

Changes in Bye-laws/Syllabi and Books may from time to time be made by amendment or remaking, and a Candidate shall, except in so far as the Vidyapith determines otherwise, comply with any change that applies to years she has not completed at the time of change.

# Programme Educational Objectives

Banasthali Vidyapith is an epitome of tradition and modernity. Vidyapith aims to preserve and inculcate the essential values and ideals of Indian culture. It believes in simple living and high thinking. Our educational ideology is based on the concept of fivefold education focusing on physical, practical, aesthetic, moral and intellectual aspects in order to develop a balanced personality. Geology is one of the disciplines of Earth Sciences that incorporates the scientific aspects of origin, evolution, nature, composition and structure of the Earth. It includes physical chemical and biologically active processes that shape the surface and interior of the Earth.

Geologists are involved in identification of minerals, rock and fossils. They provide systematic approach in understanding of minerals composition and structure. They also emphasizes on occurrence and genesis of rocks, deformational history, geotectonic events within the geological time scale, landforms, fossils and available economic Earth resources.

This Postgraduate curriculum is designed to provide an advanced knowledge in geology, and incorporates the ideas transfer from other sciences to geological problems. The Course provides hands on experience in practical knowledge from laboratory works and fieldwork as required for industry and academia. The curriculum promotes research projects from specialized area of geosciences and provides essential competencies to analyze and synthesize geosciences related problems.

**The main objectives of the M.Sc. Geology program are:**

- To promote advanced study and original research in one or more areas of Geology, Geophysics, Hydrogeology and Engineering Geology.
- To produce technically qualified, well-rounded geologist trainee for mining, engineering, ground water and petroleum, with the potential to become leaders of industry, enterprises, and state institutions.

- To become licensed Professional Geologists for new startups with in India and abroad.
- To recognize public issues related to geological hazard and be ready and able to contribute to their resolution for society.
- To develop a basic understanding of energy resources and their formation, availability and exploration techniques.
- To acquire information about modern analytical and exploration techniques.
- To inculcate effective skills for presentation of data, models, hypothesis, communication and management skills; required for professional development in the sphere of academic, research and job perspective.

## Programme Outcomes (PO)

**PO1:** **Geology Knowledge:** Possess knowledge and comprehension of the core and basic knowledge associated with the Earth Sciences' profession, including public sector and private sector, viz. mining industries; civil engineering department, petroleum Industries, and groundwater departments.

**PO2:** **Planning Abilities**: Demonstrate effective planning abilities including time management, resource management, during field training based studies, which is an integral part of the program designed to consolidate the students understanding by applying classroom-taught concepts in the field.

**PO3:** **Problem Analysis**: Utilize the principles of scientific inquiry, thinking analytically, clearly and critically, while solving problems and making a decision during real-time geo-research problems.

**PO4:** **Modern Tool Usage**: Learn, select, and apply appropriate methods and procedures, resources, and modern geo-research-related analytical and computing tools.

**PO5:** **Leadership Skills**: Understand and consider the human reaction to change, motivation issues, leadership and team building when planning changes required for fulfillment of geological practice (including civil engineering mega-structure construction, mining activity related to geo-recourse exploitation), professional and societal responsibilities.

**PO6:** **Professional Identity**: Understand, analyze and communicate the value of their professional roles in society as Geoscientists in public sector as well as in private sectors to search new reserves, evaluate its economic viability and find out judicious techniques to extract it.

**PO7:** **Geological Ethics**: Honor personal values and apply ethical principles in professional and social contexts. Demonstrate the highest standards of integrity, morality, professional conscience, and moral responsibility while making decisions.

**PO8:** **Communication**: Acquire necessary competence in both oral written communication required to convey the results, advice, and recommendations from geological investigations to a variety of end users (e.g., policymakers, the stake holders, the public, and the media).

**PO9:** **The Geologists and Society**: Understand the role of Geology in service of the society of an instrumental view of nature contributing to its exploitation, and helping providing the raw materials needed for economic development, frequently with high ecological impacts.

**PO10:** **Environment and Sustainability**: Understand and apply information related to environmental geology and geo resource conservation in issues of environmental contexts and sustainable development.

**PO11:** **The Geology and Economics**: Geology plays an essential role in many areas of the economy. Economic growth and sustainability, as well as societal well-being, requires reliable supplies of energy and mineral resources, the supply of clean water and the secure and sustainable production of food. All this will be contingent on sustained investment in technology, infrastructure, education, and skills development.

**PO12:** **Life- Long Learning**: Acquire lifelong learning with the aim of improving knowledge, skills, and competencies within a personal, civic, social and/or employment-related perspective.

# Curriculum Structure

## Master of Science (Geology)

### First Year

**Semester - I**

| Course Code | Course Name | L | T | P | C* |
|---|---|---|---|---|---|
| GEOL 411 | Geochemistry and Isotope Geology | 4 | 0 | 0 | 4 |
| GEOL 414 | Geomorphology | 4 | 0 | 0 | 4 |
| GEOL 416 | Geotectonics and Structural Geology | 4 | 0 | 0 | 4 |
| GEOL 419 | Mineralogy and Analytical Techniques | 4 | 0 | 0 | 4 |
| GEOL 421 | Sedimentary Petrology | 4 | 0 | 0 | 4 |
| GEOL 412L | Geology Lab - I with Field Work | 0 | 0 | 12 | 6 |
| | **Semester Total:** | **20** | **0** | **12** | **26** |

**Semester - II**

| Course Code | Course Name | L | T | P | C* |
|---|---|---|---|---|---|
| GEOL 415 | Geophysics and Exploration Method | 4 | 0 | 0 | 4 |
| GEOL 417 | Igneous Petrology | 4 | 0 | 0 | 4 |
| GEOL 418 | Metamorphic Petrology | 4 | 0 | 0 | 4 |
| GEOL 420 | Ore Genesis and Economic Geology | 4 | 0 | 0 | 4 |
| GEOL 422 | Stratigraphy | 4 | 0 | 0 | 4 |
| GEOL 413L | Geology Lab - II | 0 | 0 | 12 | 6 |
| | **Semester Total:** | **20** | **0** | **12** | **26** |

## Second Year

**Semester - III**

| Course Code | Course Name | L | T | P | C* |
|---|---|---|---|---|---|
| GEOL 516 | Hydrogeology | 4 | 0 | 0 | 4 |
| GEOL 522 | Palaeontology | 4 | 0 | 0 | 4 |
| GEOL 523 | Remote Sensing and GIS in Geology | 4 | 0 | 0 | 4 |
| GEOL 515L | Geology Lab - III with Field Work | 0 | 0 | 12 | 6 |
| | Discipline Elective | 4 | 0 | 0 | 4 |
| | Open Elective | 4 | 0 | 0 | 4 |
| | Reading Elective - I | 0 | 0 | 4 | 2 |
| | **Semester Total:** | **20** | **0** | **16** | **28** |

**Semester - IV**

| Course Code | Course Name | L | T | P | C* |
|---|---|---|---|---|---|
| GEOL 525P | Project | 0 | 0 | 48 | 24 |
| | Reading Elective - II | 0 | 0 | 4 | 2 |
| | **Semester Total:** | **0** | **0** | **52** | **26** |

## List of Discipline Elective

| Course Code | Course Name | L | T | P | C* |
|---|---|---|---|---|---|
| GEOL 512 | Environmental Geology | 4 | 0 | 0 | 4 |
| GEOL 519 | Marine Geology | 4 | 0 | 0 | 4 |
| GEOL 520 | Mining and Engineering Geology | 4 | 0 | 0 | 4 |
| GEOL 513 | Fuel Geology | 4 | 0 | 0 | 4 |
| GEOL 524 | Geological Field Methods | 4 | 0 | 0 | 4 |

**List of Reading Elective**

| Course Code | Course Name | L | T | P | C* |
|---|---|---|---|---|---|
| ENVS 512R | Agroforestry | 0 | 0 | 4 | 2 |
| ENVS 513R | Energy Resources and Conservation | 0 | 0 | 4 | 2 |
| ENVS 515R | Man and Environment | 0 | 0 | 4 | 2 |
| ENVS 517R | Water and Sustainable Development | 0 | 0 | 4 | 2 |
| GEOG 513R | Environmental Challenges and Disaster Management | 0 | 0 | 4 | 2 |
| GEOG 514R | India: Socio-Political and Environmental Scenario | 0 | 0 | 4 | 2 |
| GEOG 515R | Rajasthan: Challenges and Prospects | 0 | 0 | 4 | 2 |
| GEOG 517R | Transforming India | 0 | 0 | 4 | 2 |
| GEOL 514R | Geo Tourism | 0 | 0 | 4 | 2 |
| GEOL 517R | Indian Mineral Deposits, Economics and Mining Ethics | 0 | 0 | 4 | 2 |
| GEOL 518R | Innovation and Entrepreneurship in Earth Sciences | 0 | 0 | 4 | 2 |
| GEOL 521R | Natural Hazards and Disasters | 0 | 0 | 4 | 2 |
| GEOG 518R | Health, Space and Ecology | 0 | 0 | 4 | 2 |

**List of Online Reading Electives**

| Course Name |
|---|
| Non-Conventional Energy Resources |
| Mineral Resources: Geology, Exploration, Economics and Environment |
| Natural Hazards Part-I |

*** L - Lecture hrs/week; T - Tutorial hrs/week; P-Project/Practical/Lab/All other non-classroom academic activities, etc. hrs/week; C - Credit Points of the Course**

**Note :** Student can opt open (Generic) elective from any discipline of the Vidyapith with prior permission of respective heads and time table permitting.

Every Student shall also opt for:

Five Fold Education: Physical Education I, Physical Education II, Five Fold Education: Aesthetic Education I, Aesthetic Education II, Five Fold Education: Practical Education I, Practical Education II one each semester

## Project Evaluation Scheme

| Duration | Course Code | Course Name | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 Semesters (5 months) 1 Jan - 31 May | GEOL 525P | Project | 0 | 0 | 48 | 24 |

**Continuous Assessment (40 Marks)**

| | |
|---|---|
| 1. Joining report, brief project outlay | - 10 Marks |
| 2. Synopsis | - 10 Marks |
| 3. Mid-term evaluation by Supervisor | - 10 Marks |
| 4. Further evaluation by Supervisor | - 10 Marks |
| **Total** | **- 40 Marks** |

**End Semester Assessment (60 Marks)**

| | |
|---|---|
| 1. Project Report | - 20 marks |
| 2. Presentation | - 20 Marks |
| 3. Viva-voce | - 20 Marks |
| **Total** | **- 60 Marks** |

# Five Fold Activities

| Aesthetic Education I/II | | Physical Education I/II | |
|---|---|---|---|
| BVFF 101 | Classical Dance (Bharatnatyam) | BVFF 201 | Aerobics |
| BVFF 102 | Classical Dance (Kathak) | BVFF 202 | Archery |
| BVFF 103 | Classical Dance (Manipuri) | BVFF 203 | Athletics |
| BVFF 104 | Creative Art | BVFF 204 | Badminton |
| BVFF 105 | Folk Dance | BVFF 205 | Basketball |
| BVFF 106 | Music-Instrumental (Guitar) | BVFF 206 | Cricket |
| BVFF 107 | Music-Instrumental (Orchestra) | BVFF 207 | Equestrian |
| BVFF 108 | Music-Instrumental (Sarod) | BVFF 208 | Flying - Flight Radio Telephone Operator's Licence (Restricted) |
| BVFF 109 | Music-Instrumental (Sitar) | BVFF 209 | Flying - Student Pilot's Licence |
| BVFF 110 | Music-Instrumental (Tabla) | BVFF 229 | Aeromodelling |
| BVFF 111 | Music-Instrumental (Violin) | BVFF 210 | Football |
| BVFF 112 | Music-Vocal | BVFF 211 | Gymnastics |
| BVFF 113 | Theatre | BVFF 212 | Handball |
| **Practical Education I/II** | | BVFF 213 | Hockey |
| BVFF 301 | Banasthali Sewa Dal | BVFF 214 | Judo |
| BVFF 302 | Extension Programs for Women Empowerment | BVFF 215 | Kabaddi |
| BVFF 303 | FM Radio | BVFF 216 | Karate - Do |
| BVFF 304 | Informal Education | BVFF 217 | Kho-Kho |
| BVFF 305 | National Service Scheme | BVFF 218 | Net Ball |
| BVFF 306 | National Cadet Corps | BVFF 219 | Rope Mallakhamb |
| | | BVFF 220 | Shooting |
| | | BVFF 221 | Soft Ball |
| | | BVFF 222 | Swimming |
| | | BVFF 223 | Table Tennis |
| | | BVFF 224 | Tennis |
| | | BVFF 225 | Throwball |
| | | BVFF 226 | Volleyball |
| | | BVFF 227 | Weight Training |
| | | BVFF 228 | Yoga |

Every Student shall also opt for:
Five Fold Education: Physical Education I, Physical Education II,
Five Fold Education: Aesthetic Education I, Aesthetic Education II,
Five Fold Education: Practical Education I, Practical Education II
one each semester

**Evaluation Scheme and Grading System**

| Continuous Assessment (CA) (Max. Marks) | | | | | End-Semester Assessment (ESA) (Max. Marks) | Grand Total (Max. Marks) |
|---|---|---|---|---|---|---|
| Assignment | | Periodical Test | | Total (CA) | | |
| I | II | I | II | | | |
| 10 | 10 | 10 | 10 | 40 | 60 | 100 |

In all theory, laboratory and other non classroom activities (project, dissertation, seminar, etc.), the Continuous and End-semester assessment will be of 40 and 60 marks respectively. However, for Reading Elective, only End semester exam of 100 marks will be held. Wherever desired, the detailed breakup of continuous assessment marks (40), for project, practical, dissertation, seminar, etc shall be announced by respective departments in respective student handouts.

Based on the cumulative performance in the continuous and end-semester assessments, the grade obtained by the student in each course shall be awarded. The classification of grades is as under:

| Letter Grade | Grade Point | Narration |
|---|---|---|
| O | 10 | Outstanding |
| A+ | 9 | Excellent |
| A | 8 | Very Good |
| B+ | 7 | Good |
| B | 6 | Above Average |
| C+ | 5 | Average |
| C | 4 | Below Average |
| D | 3 | Marginal |
| E | 2 | Exposed |
| NC | 0 | Not Cleared |

Based on the obtained grades, the Semester Grade Point Average shall be computed as under:

$$SGPA = \frac{CC_1 * GP_1 + CC_2 * GP_2 + CC_3 * GP_3 + ---- + CC_n * GP_n}{CC_1 + CC_2 + CC_3 + ---- + CC_n} = \frac{\sum_{i=1}^{n} CC_i * GP_i}{\sum_{i=1}^{n} CC_i}$$

Where n is the number of courses (with letter grading) registered in the semester, $CC_i$ are the course credits attached to the $i^{th}$ course with letter grading and $GP_i$ is the letter grade point obtained in the $i^{th}$ course. The courses which are given Non-Letter Grades are not considered in the calculation of SGPA.

The Cumulative Grade Point Average (CGPA) at the end of each semester shall be computed as under:

$$CGPA = \frac{CC_1 * GP_1 + CC_2 * GP_2 + CC_3 * GP_3 + ----+ CC_n * GP_n}{CC_1 + CC_2 + CC_3 + ----+ CC_n} = \frac{\sum_{i=1}^{n} CC_i * GP_i}{\sum_{i=1}^{n} CC_i}$$

Where n is the number of all the courses (with letter grading) that a student has taken up to the previous semester.

Student shall be required to maintain a minimum of 4.00 CGPA at the end of each semester. If a student's CGPA remains below 4.00 in two consecutive semesters, then the student will be placed under probation and the case will be referred to Academic Performance Review Committee (APRC) which will decide the course load of the student for successive semester till the student comes out of the probationary clause.

To clear a course of a degree program, a student should obtain letter grade C and above. However, D/E grade in two/one of the courses throughout the UG/PG degree program respectively shall be deemed to have cleared the respective course(s). The excess of two/one D/E course(s) in UG/PG degree program shall become the backlog course(s) and the student will be required to repeat and clear them in successive semester(s) by obtaining grade C or above.

**After successfully clearing all the courses of the degree program, the student shall be awarded division as per following table.**

| Division | CGPA |
|---|---|
| Distinction | 7.50 and above |
| First Division | 6.00 to 7.49 |
| Second Division | 5.00 to 5.99 |
| Pass | 4.00 to 4.99 |

**CGPA to % Conversion Formula: % of Marks Obtained = CGPA *10**

# First Semester

## GEOL 411 Geochemistry and Isotope Geology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Describe the composition of the Earth and processes by which the chemical elements have been synthesized over the history of the cosmos.
- Explain the origin and geochemical evolution of atmosphere, biosphere, hydrosphere and major global geochemical cycles.
- Describe the major principles and methods involved in geochemical prospecting.
- Explain the structure of atomic nuclei, its effects on nuclear stability, fractionation of stable isotopes, radiogenic isotopes geochemistry and their application in dating and palaeoclimate reconstruction.

**Course Content:**

**Section A**

Introduction to Geochemistry : Origin of elements. Cosmic abundance of elements. Pregeological history of the Earth. Structure and composition of Earth. Geochemical classification of elements. Principles of ionic substitutions in minerals.

**Section B**

Geochemistry of hydrosphere, biosphere and atmosphere. Geochemical cycles: Carbon, Oxygen, Nitrogen, Phosphate. Geochemical prospecting. Geochemical anomalies. Meteorites: classification, mineralogy, origin, and significance of meteorites.

**Section C**

Isotope Geochemistry: Introduction and physics of the nucleus. Radioactive decay and Law. Radioactive decay scheme of Rb-Sr method, Sm-Nd method, K-Ar method, Ar-Ar method, U-Th-Pb method, Fission tracking dating. Stable isotope geochemistry of oxygen, nitrogen, carbon and sulphur.

**Recommended Books:**


1. Albarede, F. (2003). *An introduction to geochemistry*(2nd ed.). New York, NY: Cambridge University Press.
2. Faure, G. & Mensing, T.M. (2005). *Isotope, principles and applications (*3rd ed.). New York, NY: John Wiley & Sons.
3. Hoefs, J. (1986). *Stable isotope geochemistry* (3rded.). Berlin, Germany: Spriger- Verlag,
4. Krauskopf, K. B. (1979). *Introduction to Geochemistry*. New York, NY: McGraw Hill.
5. Mason, B., & Moore, C.B. (1982). *Introduction to Geochemistry* (2nded.). New York, NY : Wiley Eastern.
6. Mason, B. (1982). *Principles of Geochemistry* (3rded.). New York, NY: John Wiley & Sons.


**Suggested e-learning materials:**

1. Geochemical Prospecting

   https://pubs.usgs.gov/bul/1000f/report.pdf

2. Origin of Elements
   https://www2.lbl.gov/abc/wallchart/chapters/10/0.html

# GEOL 414 Geomorphology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Explain erosion and deposition features formed due to various geomorphic process
- Delineate various climatic conditions that helps to modify the landforms.
- Describe the application of geomorphology in multidiscipline such as civil engineering, hydrology.
- Explain the interaction between climate, tectonics and sea level interaction in fluvial environment.

**Course Content:**

**Section A**

Introduction to Geomorphology, fundamental concepts, geomorphic agents and processes. Geomorphic models of landscape evolution. Weathering: types and weathering products. Mass wasting.

**Section B**

Erosional and depositional landforms: fluvial, glacial, aeolian, coastal and karst landscape. Geomorphology of India-Peninsular, extra peninsular and Indo-Gangetic Plain.

**Section C**

Geomorphic response to tectonics, sea level/base level change, anthropogenic affects. Climate change and geomorphic response of fluvial systems of arid and humid regions. Introduction to Anthropocene.

**Recommended Books:**

1. Allision, R.J. (2002). *Applied Geomorphology*. New York, NY: Wiley and Sons.

2. Leopold, L.B. (1976). *Fluvial processes in geomorphology*. New Delhi, India: E.P.H.

3. Mc Duff, L.D. (Ed.). (1992). *Principles of Physical Geology*. London, UK: Chapman and Hall.

4. Pitty, A.F. (1971). *Introduction to geomorphology*. London,UK: Methuen.

5. Sharma, H.S. (1990). *Indian Geomorphology*. New Delhi, India: Concept.

6. Thornbury, W.D. (1980). *Principles of Geomorphology* (2nd ed.). New York, NY: Wiley Eastern.

**Suggested e-learning materials:**

1. Anthropocene
https://www.cambridge.org/core/books/geomorphology-in-the-anthropocene

2. Geological Agents
http://www.ncert.nic.in/ncerts/l/kegy207.pdf

3. Glossary of landforms
https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=41992.wba

## GEOL 416 Geotectonics and Structural Geology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Recognize and interpret the geological structure of deformed continental regimes, from mildly deformed upper crustal regimes to complexly deformed deeper crustal regimes.

- Interpret the relative timing of formation of structures, the kinematics of deformation, and the progressive deformation histories in these regimes.
- Interpret stress regimes strain rate and fluid pressure histories during continental deformation.
- Apply the information of structural geology in the mining and resource exploration environment.

**Course Content:**

**Section A**

Introduction and tectonic framework of Earth crust. Continental drift hypothesis, Supporting evidences and criticism. Convection currents, Sea floor spreading and Palaeomagnetism. Introduction to plate tectonics: types of plate boundaries and plate boundary processes. Tectonic features of extensional, compressional and strike-slip terrain. Hotspots and mantle plumes. Tectono-structural subdivisions of Himalaya and Himalayan Orogeny.

**Section B**

Mechanical properties of rocks. Concept of stress and strain. Behavior of material under stress. Theory of rock failure. Brittle and Ductile deformation. Classification and Mechanism of Folding and Faulting. Recognition criteria of faulting. Boudinage structures.

**Section C**

Unconformities: types, formation and significance in stratigraphic correlation. Joints: Genetic classification, criteria for recognition and tectonic significance. Concept and types of Lineation, Foliations, Cleavages and their significance. Shear Zones: Characteristics, Geometry and types. Brittle and ductile shear sense indicators.

**Recommended Books:**

1. Billings, M.P. (1972). *Structural Geology* (3rd ed.). New York, NY: Prentice Hall.

2. Condie, K.C. (2016). *Earth as An Evolving Planetary System* (3rd ed.). Amsterdam, Netherland: Elsevier Academic Press.

3. Dennis, G.J. (1987). *Structural Geology An Introduction*. Iowa, IA: Wm. C. Brown.

4. Fossen, H. (2010). *Structural Geology* (2nded.). Cambridge, UK: Cambridge University Press.

5. George, H. D., Stephen J. R., & Charles F. K. (2013). Structural Geology of Rocks and Region (3rded.). New York, NY: John Wiley and Sons.

6. Ghosh, S. K. (1993), Structural Geology Fundamentals and Modern Developments. London, UK: Pergamon Press.

7. Hobbs, B.E., Means, W.D., & Williams, P. F. (1976). An Outline of Structural Geology. New York, NY: John Wiley and Sons.

8. Kerey, P., Kleperis, & K. A., Vine, J. F. (2009). Global Tectonics (3rded.). New Jersey, NJ: Wiley Blackwell.

9. Park, R.G. (1989). Foundations of Structural Geology, (3rded.). New York, NY: Chapman & Hall.

10. Passchier, C. W., & Trouw, R. A. J. (2005). Microtectonics (2nded.). New York, NY: Springer Berlin Heidelberg.

11. Pluijm B. A., & Marshak, S. (2004). *Earth Structure An Introduction to Structural Geology and Tectonics*(2nd ed.). New York, NY: W. W. Norton & Company.

12. Ramsay, J.G., & Huber, M. I. (1987). *The Techniques of Modern Structural Geology*: *Strain Analysis* (Vol. 1). New York, NY: McGraw Hill.

13. Ramsay, J.G., & Huber, M. I. (1987). *The Techniques of Modern Structural Geology:Folds and Fractures* (Vol. 2). New York, NY: McGraw Hill.

14. Ramsay, J.G., & Lisle, R. J. (2000). *The Techniques of Modern Structural Geology*: *Application of Continuum Mechanics in Structural Geology* (Vol. 3). London, UK: Elsevier Academic Press.

15. Twiss, R. J., & Moores, E. M. (2007). Structural Geology. (2nd ed.). New York, NY: WH Freeman.

**Suggested e-learning materials:**

1. Geological Map Interpretation

   https://ocw.tudelft.nl/courses/structural-geology-map-interpretation/

2. Geologic Structures

   https://nptel.ac.in/courses/105105106/2,https://nptel.ac.in/courses/105104152/18

3. Continuum mechanics, Fault and Ductile Deformation Notes
   https://ocw.mit.edu/courses/earth-atmospheric-and-planetary-sciences/12-113-structural-geology-fall-2005/lecture-notes/

4. Structural Geology and Tectonics
   http://www.uh.edu/~jbutler/anon/anoncoursestructure.html

## GEOL 419 Mineralogy and Analytical Techniques

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Explain the crystal structure, physical and optical properties of minerals.
- Demonstrate the relationship between the internal structure of minerals with their external form and effect on physical properties.
- Explain the mineralogical concepts of polymorphism, solid solution, exsolution and twinning.
- Discuss the various analytical technique used for identification and detection of minerals and rocks.

**Course Content:**

**Section A**

Introduction and scope. Isomorphism and Polymorphism, Exsolution and Solid solution. Physical properties of minerals. Polarization of light. Behaviour of isotropic and anisotropic minerals in polarized light. Double refraction and birefringence. Sign of elongation. Interference figures. Extinction and its types. Relief and Pleochroism. Twinning: Cause, types and laws. Accessory Plates.

**Section B**

Silicates: structure and classification. A detailed study of the following important minerals with reference to structural formulae, crystal structure, chemistry, physical and optical properties and mode of occurrence.

Silicates: Olivine, Garnet, Melilite, Kyanite, Andalusite, Sillimanite, Beryl, Pyroxene, Amphibole, Serpentine, Mica, Kaolinite, Chlorite, Talc, Feldspar.

Non-silicates: Calcite, Aragonite, Dolomite, Apatite, Gypsum, Barite, Spinel, Rutile.

**Section C**

Definition of Crystal. Classification of crystal into crystal systems. Introduction to analytical techniques like XRD (X-ray diffraction), Scanning Electron Microscope (SEM), Electron Probe Micro Analyser (EPMA), Thermogravimetric Analysis (TGA), Transmission Electron Microscope (TEM), Mass spectrometry (MS),Atomic absorption spectrometry (AAS) and their application in mineral characterization.

**Recommended Books:**

1. Berry, L.G, Mason, B., & Dietrich, R. V. (1982). *Mineralogy*. New Delhi, India: CBS.

2. Gill, R. (1977). *Modern analytical geochemistry.* London, UK: Rouledge.

3. Gribble, C.D. (1991). *Rutley's Element of Mineralogy* (27th ed.). Delhi, India: CBS.

4. Kerr, P.F. (1959). *Optical Mineralogy* (4th ed.). New Delhi, India: McGraw Hill.

5. Klein, C., & Dutrow, B. (2007). *Mineral science* (23rd ed.). New York, NY: John Wiley & Sons.

6. Perkins, D. (2010). *Mineralogy* (3rd ed.). USA, Pearson.

7. Perry, D.L. (1990). *Instrumental Surface Analysis of Geologic Materials*. New York, NY:VCH.

8. Phillips, Wm, R., &Griffen, D.T. (1986). *Optical Mineralogy* (5th ed.). New Delhi, India: CBS.

9. Read, H.H. (Ed.). (1968). *Rutley's Element of Mineralogy* (24th ed.). London, UK: Thomas Murby and Co.

10. Rollinson, H. (1993). *Using Geochemical Data-Evaluation, Presentation, Interpretation.* New York, NY: Longman Scientific & Technical.

11. Skoorg, D.A., West, D. M., Holler, F.J., & Crouch, S.R. (2004). *Fundamentals of analytical chemistry.* (8th ed.). California, CA: Thomson Brooks Cole.

**Suggested e-learning materials:**

1. Mineral forms
   http://www.galleries.com/minerals

2. Gemstones and gemology resources
   http://www.galleries.com/gemstones
   http://farlang.com/gems

3. Mineral properties
   https://naturalhistory.si.edu/research/mineral-sciences

# GEOL 421 Sedimentary Petrology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Describe the principles of sedimentary petrology, the characteristics and the origin of the sedimentary rocks.
- Explain formation of sediments, transportation, deposition and formation of sedimentary rocks.
- Depict the classification of sedimentary basins with reference to plate tectonics and sedimentation.
- Identify the provenance for the sediments.

**Course Content:**

**Section A**

Sedimentary rocks: Textures, structure and classification. Grain size analysis. Palaeocurrent analysis. Trace fossils and stromatolites: classification and environment of deposition. Provenance and diagenesis of sediments. Heavy mineral analysis.

**Section B**

Field and laboratory techniques in sedimentology. Genesis and classification of sedimentary rocks: Clastic rocks- conglomerate, breccia, sandstone and shale. Non-clastic rocks- limestone, dolomite, evaporite, phosphorite, chert.

**Section C**

Definition and classification of sedimentary basins.Sedimentary basins of India. Principles and applications of C-14 and OSL dating. Sedimentary environment and facies modeling for marine, non-marine and mixed sediments.

**Recommended Books:**


1. Blatt, H., Middleton, G.V., & Murray, R.C. (1980). *Origin of Sedimentary Rocks*. New Jersey, NJ: Prentice Hall.
2. Blatt, H., Tracy, R.J., & Owens, B.E. (2006). *Petrology: Igneous, Sedimentary and Metamorphic* (3rd ed.). New York, NY: W.H. Freeman and Company.
3. Collins, J.D., & Thompson, D.B. (1982). *Sedimentary Structures*. London, UK: George Allen & Unwin.
4. Pettijohn, F.J. (1975). *Sedimentary Rocks* (3rd ed.). New Delhi, India: Harper and Row.
5. Reineck, H.E., & Singh, I.B. (1973). *Depositional Sedimentary Environments.* Berlin, Germany: Springer-Verlag.
6. Folk, R.L. (1981). *Petrology of Sedimentary Rocks* (2nd ed.). Austin, TX: Hemphill.
7. Selley, R.C. (2000). *Applied Sedimentology*. San Diego, CA: Academic Press.
8. Tucker, M.E. (1981). *Sedimentary Petrology: An Introduction* (3rd ed.). New York, NY: Wiley & Sons.


**Suggested e-learning materials:**

1. Sedimentary Texture and Structures

   https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000448GO/P000594/M022660/ET/1505973116E-TextSedimentaryStructures.pdf

2. Basin depositional environment
   https://link.springer.com/chapter/10.1007/978-3-662-04029-4_1

## GEOL 412L Geology Lab-I with Field Work

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **12** | **6** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Interpret the toposheets for civil engineering purposes.

- Interpret the geological history of the given area supplemented with structural data in geological maps.
- Make systematic descriptions of minerals in hand-specimen & thin-section and elaborate the laboratory methods for preparation of mineral or rock sections.
- Determine the average slope angle and river morphometry.
- Describe the petrography of common sedimentary rocks both at macroscopic and microscopic level.
- Analyze and interpret geochemistry of common sedimentary rocks using various plots and graphs.

**Course Content:**

**Geotectonics and Structural Geology**

1. Toposheet Indexing
2. Study of symbols used in Structural maps
3. Preparation of geological map, cross profile and their interpretation
4. $\beta$ & $\pi$ diagrams
    a) Plotting of Planes and Line
    b) Plunging and non-plunging folds
    c) Determination of angle between planes
    d) Determination of pitch and plunge
    e) Determination of positions of $\sigma_1$ $\sigma_2$ $\sigma_3$ in conjugate fracture planes
5. Preparation of map showing tectonic and seismic zones of India
6. Elementary Idea of stereo plot software

**Mineralogy and Analytical Techniques**

1. Identification of rock forming minerals in hand specimens and under polarizing microscope

2. Goniometer and its use in measuring interfacial angle of crystals and calculation of axial ratio

3. Preparation of thin sections of rocks and minerals

**Geomorphology**

1. Drainage morphometry and determination of average slope angle

**Sedimentary Petrology**

1. Megascopic and microscopic study of clastic and non-clastic rocks

2. Grain size analysis by sieving method: Plotting of size distribution data as frequency and cumulative curves, computation of statistical parameters and interpretation

**Geological Field Work**

* Note: Scientific calculators are permitted during examination.

**Recommended Books:**

1. Billings, M. P. (1972). *Structural Geology* (3rd ed.). New York, NY: Prentice Hall.

2. Blatt, H., Middleton, G.V., & Murray, R.C. (1980). *Origin of Sedimentary Rocks*. New Jersey, NJ: Prentice Hall.

3. Cornelis, K., & Barbara, D. (2007). *Mineral science.* New York, NY: John Wiley & Sons.

4. Folk, R.L. (1981). *Petrology of Sedimentary Rocks* (2nd ed.). Austin, TX:Hemphill.

5. Gribble, C.D. (1991). *Rutley's Element of Mineralogy* (27th ed.). Delhi, India: CBS.

6. Kerr, P.F. (1959). *Optical Mineralogy* (4th ed.). New Jersey, NJ: McGraw Hill.

7. Lisle, R. J., Brabham, P.J., & Barnes J. W. (2011). *Basic Geological Mapping* (5th ed.). London, UK: Wiley Blackwell.

8. Perry, D.L. (1990). *Instrumental Surface Analysis of Geologic Materials*. New York, NY: VCH.

9. Pettijohn, F.J. (1975). *Sedimentary Rocks* (3rded.). New Delhi, India: Harper and Row.

10. Phillips, W. R., &Griffen, D.T. (1986). *Optical Mineralogy* (5thed.). New Delhi, India: CBS.

11. Ragan, M. D. (2009). *Structural Geology an Introduction to Geometrical Techniques* (3rded.). New York, NY: Cambridge University Press.

12. Rowland, S.M., Duebendorfer, E. M., &Ilsa, M. S. (2007). *Structural Analysis and Synthesis A Laboratory Course in Structural Geology* (3rded.). Victoria, Australia: Blackwell.

13. Survey of India Toposheets

14. Thornbury, W.D. (1980). *Principles of Geomorphology* (2nded.). New York, NY: Wiley Eastern.

15. Tucker, M.E. (1981). *Sedimentary Petrology: An Introduction* (3rded.). New York, NY: Wiley & Sons.

**Suggested e-learning materials:**

1. Stereonet Software
   https://app.visiblegeology.com/stereonetApp.html

2. Mineral forms
   http://www.webmineral.com/

3. Map interpretation
   https://ocw.tudelft.nl/courses/structural-geology-map-interpretation/

4. Field Mapping
   http://www.geosci.usyd.edu.au/users/prey/FieldTrips/BrokenHillOlary/Mapping.html

5. Geologic maps and stratigraphic Sections, Mineralogy and Sedimentary petrology
   https://nptel.ac.in/courses/105105106/3

# Second Semester

## GEOL 415 Geophysics and Exploration Method

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Develop integrated overview of exploration methods and the physics of waves, focusing on seismic reflection and refraction.
- Explain the principal theories and specialized techniques used in land and marine survey.
- Detect economically viable deposits such as ore minerals, fossil fuels and reservoirs.
- Work in academic, research and industries related with geophysical exploration.

**Course Content:**

**Section A**

Introduction to Geophysics. Shape and size of Earth. Gravitational field of the Earth.Variation of gravity on the Earth. Principles of gravity methods and instruments used. Gravity field surveys. Corrections applied to gravity data: Bouguer anomaly, Regional and residual anomalies, Gravity anomaly, anomaly maps and their interpretation.

**Section B**

Geomagnetic field of the Earth. Magnetic properties of rocks. Principles of magnetic methods. Instruments of magnetic surveying. Fluxgate magnetometer, Proton precision magnetometer, Alkali vapour magnetometer. Aeromagnetic surveys.

**Section C**

Electrical methods: Basic principles and various types of electrode configuration. Electrical and resistivity surveying. Field procedures: profiling and sounding. Seismic methods: principles and instruments used. Seismic velocity and interpretation of seismic data. Seismic refraction and reflection method. Well logging: Types.

**Recommended Books:**


1. Dobrin, M. B. (1976). *Introduction to Geophysical Prospecting* (4thed.). London, UK: McGraw Hill.
2. Haldar, S. K. (2013). *Mineral Exploration: Principles and Applications*. Amsterdam, Netherland: Elsevier.
3. Lilly, R. J. (1998). *Whole Earth Geophysics*. London, UK: Pearson.
4. Lowrie, W. (1997). *Fundamentals of Geophysic*s (2nded.). London, UK:Cambridge University press.
5. Mishra. D. C. (2011). *Gravity and Magnetic Methods for Geological Studies: Principles, Integrated Exploration and Plate Tectonics*, Hyderabad, India: CRC Press.
6. Parasnis, D.S. (1975). *Principles to applied Geophysics* (5thed.). New Delhi, India: Chapman and Hall.
7. Ramakrishna T.S. (2006). *Geophysical Practice in mineral exploration and mapping.* Banglore, India:Geological Society of India, Memoir 62.
8. Sharma, P.V. (1986). *Geophysical Methods in Geology*. London, UK: Elsevier.
9. Telford, W.M., Geldart L.P., & Sheriff, R.E. (1990).*Applied Geophysics* (2nded.). Cambridge, UK: Cambridge University Press.

**Suggested e-learning materials:**

1. International Geomagnetic Reference Field http://wdc.kugi.kyoto-u.ac.jp/igrf/index.html
2. World Magnetic Model Calculator

   http://www.geomag.bgs.ac.uk/data_service/models_compass/wmm_calc.html

## GEOL 417 Igneous Petrology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Explain the various physical and chemical processes forming igneous rocks.
- Describe and apply phase equilibria principles to common igneous rock.
- Describe the various geochemical indices for mineralogical and petrological evolution of igneous rocks.
- Describe the petrography and petrogenesis of important igneous rocks of Indian occurrence.

**Course Content:**

**Section A**

Magma- its nature and composition. Generation of magma. Factors controlling evolution of magma. Influence of volatiles and role of oxygen fugacity in magmatic crystallizations. Phase equilibrium studies of binary and ternary systems (Di-Ab-An and An-Di-Fo).

**Section B**

Major and minor elements. Trace and Rare Earth elements. Trace element partitioning. Normative minerals. Variation diagrams and discrimination diagrams. Forms, textures and structures of igneous rocks. IUGS classification of Igneous rocks. Plutonic, Volcanic and Ultramafic and Mafic.

**Section C**

Petrology and petrogenesis of major igneous rock types giving Indian examples of ultramafic, basaltic, granitic, ophiolite, carbonatite, lamprophyres and layered mafic intrusions.

**Recommended Books:**


1. Best M. G. (2002). *Igneous and Metamorphic Petrology* (2nd ed.). Oxford, UK: Wiley-Blackwell.
2. Blatt, H., Tracy, R.J., & Owens, B.E. (2006). P*etrology: Igneous, Sedimentary and Metamorphic* (3rd ed.). New York, NY: W.H. Freeman and Company.
3. Bose, M.K. (1997). *Igneous Petrology*. Kolkata, India: World Press.
4. Hall, A. (1997). *Igneous Petrology*. Harlow, UK: Longman.
5. LeMaitre, R.W. (2002). *Igneous Rocks: A classification and glossary of Terms* (2nd ed.). New York, NY: Cambridge University Press.
6. Phillpotts, A.R. (1994). *Principles of Igneous and Metamorphic Petrology* (2nd ed.). Cambridge, UK: Cambridge University Press.
7. Wilson, M. (1989). *Igneous Petrogenesis*. London, Unwin Hyman.
8. Winter, J.D. (2001). *An Introduction to Igneous and Metamorphic Petrology* (2nd ed.). New Jersey, NJ: Prentice hall.


**Suggested e-learning materials:**

1. Igneous- textures
   https://swayam.gov.in/course/3948-petrology
2. Igneous rock-slides
   http://funnel.sfsu.edu/courses/geol426/
   http://www.geolab.ie/

# GEOL 418 Metamorphic Petrology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Identify metamorphic mineral assemblages, texture, structures to decipher the order of crystallization of minerals.
- Describe the metamorphic reaction responsible for metamorphism of rock.
- Recognize pressure-temperature-time (P-T-t) path associated with tectonic setting of metamorphosed rocks.
- Describe composition of the fluid phase in the rock during metamorphism.

**Course Content:**

**Section A**

Metamorphism and metamorphic processes. Mineralogical phase rule of closed and open system and its application. Metamorphic Reactions. Reaction mechanisms and types. Evolution of facies concept, metamorphic facies series and concept of paired metamorphic belts. Metamorphic zones and Isograds.

**Section B**

Metamorphic structures and textures. Replacement textures and reaction rims. Diagrammatic representation of mineral reactions and paragenesis: ACF, AKF, AFM diagrams. Progressive, regional and thermal metamorphism of pelitic, calcareous and basic igneous rocks. Charnockites.

**Section C**

Experimental petrology and its application to anatexis and formation of granitic magmas. Geothermometer and Geobarometer. Pressure-

Temperature-Time-Depth path models for metamorphism. Regional metamorphism in relation to the theory of Plate Tectonics. Ocean floor metamorphism. Metamorphic Processes associated with Orogenic Belts of India.

**Recommended Books:**


1. Best, M. G. (2002). *Igneous and Metamorphic Petrology* (2nd ed.). Oxford, UK, Blackwell Science.
2. BhaskarR. B. (1986). *Metamorphic Petrology*. New Delhi, India:Oxford& IBH.
3. Blatt, H., Tracy, R. J., & Owens, B. E. (2006). *Petrology: Igneous, Sedimentary and Metamorphic* (3rd ed.). New York, NY: W.H. Freeman and Company.
4. Bucher, K., & Frey, M. (1994). *Petrogenesis of Metamorphic Rocks. (*6th ed.). New York, NY: Springer-Verlag.
5. Edger, A.D. (1973). *Experimental Petrology*. Oxford, UK: Clarendon Press.
6. Phillpotts, A.R. (1994). *Principles of Igneous & Metamorphic Petrology* (2nd ed.). Cambridge, UK: Cambridge University Press.
7. Spry, A. (1969). *Metamorphic Textures*. London, UK: Pergamon Press.
8. Turner, F.J. (1968). *Metamorphic Petrology*. *Mineralogical and Field Aspeats.* New York, NY: McGraw Hill.
9. Winkler, H.G.E. (1979). *Petrogenesis of metamorphic rocks*. New York, NY: Springer Verlag.
10. Winter, J.D. (2001). *An introduction to Igneous and Metamorphic Petrology* (2nd ed.). New Jersey, NJ: Prentice hall.
11. Yardley, B.W.D. (1990). *An Introduction to Metamorphic Petrology*. London, UK: ELBS, Longman.

**Suggested e-learning materials:**

1. Introduction to Metamorphism
   http://www.geol.ucsb.edu/faculty/hacker/geo102C/lectures/part2.html
2. Entropy, Gibb's Free Energy and Clausius-Clapeyron equation

   https://epgp.inflibnet.ac.in/ahl.php?csrno=448
3. Graphical Representation of Minerals Assemblages ACF (Metamorphic Petrology)

   https://swayam.gov.in/courses/5105-metamorphic-petrology
4. Metamorphism of Mafic Rocks, Metamorphism
   https://ocw.mit.edu/courses/earth-atmospheric-and-planetary-sciences/12-109-petrology-fall-2005/lecture-notes/Dec1notes.pdf

   http://vidyamitra.inflibnet.ac.in/index.php/content/index/5a3a2aeb8007bef10465cb33

## GEOL 420 Ore Genesis and Economic Geology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Describe the minerals that can be used for economic and/or industrial purposes.
- Identify and describe the precious and base metals, nonmetallic minerals and building stone.
- Explain the ore formation processes and its geological setting.
- Estimate the resource and reserves availability.

**Course Content:**

**Section A**

Introduction to Ore forming processes, Magmatic processes of mineralization, hydrothermal mineralization, oxidation and supergene enrichment. Prophyry, skarn. Fluid inclusion studies. Stratiform and stratabound ores.

**Section B**

Occurrence and distribution of metalliferous deposits of India: iron, manganese, aluminium, chromium, gold, nickel, lead, zinc, copper, tungsten. Indian deposits of non-metals: mica, asbestos, barytes, gypsum, graphite. Minerals used in different industries: fertilizer, paint, ceramic and cement industries.

**Section C**

Resources, Reserve and Classification of Ore Reserve (Russian, UNFC System and USGS/USBM Classification), Parameters for Reserve Estimation, Stages of Exploration, Ore Reserve Calculation Methods, National Mineral Policy. Mineral Concession Rules. Marine Mineral Resources and Law of Sea.

**Recommended Books:**

1. Evans, A.M. (1993). *Ore Geology and Industrial Minerals* (3rd ed.). London, UK: Blackwell.

2. Gokhale, K.Y.G.K., & Rao, T.C. (1978). *Ore deposits of India their distribution and processing.* New Delhi, India: Tata-McGraw Hill.

3. Guilbert, J.M., & Park Jr., C.F. (1986). *The Geology of Ore deposits*. New York, NY: Freeman & Co.

4. Jensen, M.L. & Bateman, A.M. (1981). *Economic Mineral Deposit*s (3rd ed.). New York, NY: John Wiley.

5. Krishnaswamy, S. (1979). *India's Mineral resources*. New Delhi, India: Oxford & IBH.

6. Mookherjee, A. (2000). *Ore Genesis-A holistic approach*. New Delhi, India:Allied.

7. Prasad, U. (2015). *Economic Geology: Economic Mineral Deposits* (2nd ed.). New Delhi, India:CBS.

8. Sen, A.K., & Guha P.K. (1981). *A Handbook of Economic Geology*. Calcutta, India:Modern Book Agency.

9. Tiwari, S. K. (2010). *Ore Geology, Economic Minerals and Mineral Economics* (Vol. 1). New Delhi, India: Atlantic.

10. Tiwari, S. K. (2010). *Ore Geology, Economic Minerals and Mineral Economics* (Vol. 2). New Delhi, India: Atlantic.

**Suggested e-learning materials:**

1. Economic Minerals
   https://epgp.inflibnet.ac.in/ahl.php?csrno=448

2. Indian mineral occurrence
   https://nptel.ac.in/courses/105105170/

## GEOL 422 Stratigraphy

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Explain rock successions and their interpretation in terms of geological time scale.
- Elaborate its application in petroleum geology and archaeology.
- Identify various sedimentary basins of India.
- Explain the straigraphic boundary problems in India.

**Course Content:**

**Section A**

Stratigraphic classification (Lithostratigraphy, Biostratigraphy and Chronostratigraphy). Sequence stratigraphy, magneto-stratigraphy, Earth's climatic history.

**Section B**

Nature and evolution of early crust. Cratons: Dharwar, Bastar, Singhbhum, Aravalli and fold belts: Eastern Ghat Mobile Belt (EGMB), Pandayan Mobile Belt and Satpura Mobile Belt of India with special reference to tectonics and stratigraphy.

**Section C**

Stratigraphy of the Palaeozoic, Mesozoic and Cenozoic formations of India. Stratigraphy boundary problems in India: demarcation of Precambrian-Cambrian, Permian-Triassic, Cretaceous-Tertiary and Neogene-Quaternary boundaries in relation to mechanisms of extinction and evolution.

**Recommended Books:**

1. Boggs, S. (2014). *Principles of Sedimentology and Stratigraph*y (5th ed.). New York. NY: Merrill.
2. Catuneanu, O. (2006). *Principles of Sequence Stratigraphy.* Oxford, UK: Elsevier.
3. Danbar, C.O., & Rodgers, J. (1957). *Principles of Stratigraphy*. New York, NY: John Wiley & Sons.
4. Krishnan, M. S. (2012). *Geology of India and Burma* (6th ed.). Delhi, India: CBS.
5. Kumar R. (1978). *Historical Geology and Stratigraphy of India*. New Delhi. India: New Age International.
6. Lemon, R.R. (1990). *Principles of Stratigraphy*. New York, NY: Merrill.
7. Naqvi, S.M., & Rogers, J.J.W. (1987). *Precambrian Geology of India*. New York, NY: Oxford University Press.

8. Ramakrishnan, M., & Vaidyanathan, R. (2010). *Geology of India* (Vol. 1). Bangalore, India: Geological Society of India.

9. Ramakrishnan, M., & Vaidyanathan, R. (2010). *Geology of India* (Vol. 2). Bangalore, India: Geological Society of India.

10. Rogers, J.J.W. (1993). *A history of Earth*. Cambridge, UK: Cambridge University Press.

11. Roy, A.B., & Jakhar, S.R. (2012). *Geology of Rajasthan* (Northwest India) *Precambrian to Recent*. Jodhpur, India: Scientific.

**Suggested e-learning materials:**

1. Boundary Problems
https://books.google.co.in/books/about/Stratigraphic_Boundary_Problem_in_India.html

## GEOL 413L Geology Lab-II

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **12** | **6** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Describe the petrography of common igneous and metamorphic rocks both at macroscopic and microscopic level.
- Interpret the gravity, bore-hole and seismic data used in exploration geophysics.
- Analyze and interpret geochemistry of common igneous and metamorphic rocks using various plots and graphs.
- Identify different rock types in various stratigraphic horizons of India.
- Develop a systematic procedure for megascopic identification and description of economic fuel minerals their origin, mode of occurrence and utilization.
- Prepare map showing distribution of metallic, non-metallic, fuel and Industrial mineral in India.

**Course Content:**

**Geophysics and Exploration Method**

1. Interpretation of Seismic and resistivity data
2. Study of gravity data maps and their interpretation

**Igneous Petrology**

1. Megascopic and microscopic study of different igneous rocks
2. Calculation of CIPW Norms

**Metamorphic Petrology**

1. Megascopic and microscopic study of different metamorphic rocks
2. Graphic construction of ACF, AKF and AFM diagrams

**Stratigraphy**

1. Study of rocks in hand specimens from known Indian Stratigraphic horizons and type localities
2. Map Preparation of important lithotectonic units of India

**Ore Genesis and Economic Geology**

1. Megascopic study of metallic ore minerals in hand specimen
2. Preparation of maps showing distribution of metallic, non metallic and industrial minerals in India
3. Numericals based on reserve estimation
4. Megascopic study of different types of coal
5. Study of geological maps and sections of important oilfields of India, petroliferous basins, coal seams and radioactive minerals (U and Th) in India

*** Note: Scientific calculators are permitted during examination.**

**Recommended Books:**


1. Bose, M. K. (1997). *Igneous Petrology.* Kolkata, India: World Press.
2. Bucher, K., & Frey, M. (1994). *Petrogenesis of Metamorphic Rocks (*6th ed.). New York, NY: Springer-Verlag.
3. Chandra, D., Singh, R.M., & Singh, M.P. (2000). *Textbook of coal* (Indian context), Varanasi, India:Tara.
4. Krishnaswamy, S., (1979). *India's Mineral Resources.* New Delhi, India: Oxford IBH.
5. Kumar, R. (1978). *Historical Geology and Stratigraphy of India*. New Delhi, India:New Age International.
6. LeMaitre, R.W. (2002) *Igneous Rocks: A classification and glossary of Terms (*2nd ed.). New York, NY: Cambridge University Press.
7. Lowrie, W. (1997). *Fundamentals of Geophysics (*2nd ed.). London, UK: Cambridge University press.
8. Singh, M.P. (1998). Coal and Organic Petrology. New Delhi, India:Hindustan.
9. Spry, A. (1969). Metamorphic Textures. UK, Pergamon Press.
10. Turner, F.J. (1998). Metamorphic Petrology, New York, NY: McGraw Hill.
11. Wilson, M. (1989). *Igneous Petrogenesis*, London, UK: Unwin Hyman.
12. Yardley, B.W.D. (1990). *An Introduction to Metamorphic Petrology*. London, UK: ELBS, Longman.


**Suggested e-learning materials:**

1. Magnetic North, Geomagnetic and Magnetic Poles http://wdc.kugi.kyoto-u.ac.jp/igrf/index.html
2. World Magnetic Model Calculator

   http://www.geomag.bgs.ac.uk /data_service/models_compass/igrf.html

3. Introduction to metamorphism

http://www.geol.ucsb.edu/faculty/hacker/geo102C/lectures/part2.html

4. Phase Equilibrium

https://serc.carleton.edu/research_ education /equilibria/index.html

5. International Commission on stratigraphy

http://www.stratigraphy.org/

6. International Chronostratigraphic Chart

http://www.stratigraphy.org /index.php/ics-chart-timescale

7. Textures of rocks and economic minerals

https://epgp.inflibnet.ac.in/ ahl.php?csrno=448

8. Textures of igneous rocks

https://swayam.gov.in/course/3948-petrology

# Third Semester

## GEOL 516 Hydrogeology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Explain the distribution and movement of groundwater in the soil and rocks of the Earth's crust.
- Describe hydrological cycle and related parameters.
- Determine the physical and chemical parameters to assess groundwater quality.
- Evaluate the major geological factors controlling groundwater exploration.

**Course Content:**

**Section A**

Introduction and scope of hydrogeology. Groundwater: origin and age of groundwater. Hydrological cycle, Vertical distribution of groundwater. Water table, Porosity, Permeability, Zone of saturation: specific yield and retention.

**Section B**

Aquifers: Characteristics and types. Darcy's law, hydraulic conductivity. Well hydraulics: Confined and Unconfined. Groundwater modeling: Types and steps in development of groundwater model.

**Section C**

Water Sampling. Groundwater quality. Saline water intrusion: Groundwater regimes in India. Groundwater exploration (Geological and Geophysical methods). Artificial recharge of groundwater. Rain water harvesting.

**Recommended Books:**

1. Arul, P. (2000). *A textbook of groundwater*. Virudachalam, India: Dhanam.
2. Karanth, K.R. (1989). *Hydrogeology*. New Delhi, India: Tata McGraw Hill.
3. Nagabhushaniah, H. S. (2001). *Groundwater in Hydrosphere*. New Delhi, India: CBS.
4. Raghunath, H. M. (2014). *Groundwater* (3rd ed.). New Delhi, India: New Age International.
5. Todd, D. K., & Mays, L. W. (2004) *Groundwater Hydrology* (3rd ed.). New Delhi, India: Wiley India.

**Suggested e-learning materials:**

1. Introduction to hydrogeology
   https://epgp.inflibnet.ac.in/ahl.php?csrno=448
2. Ground water hydrology
   https://nptel.ac.in/courses/105105106/

## GEOL 522 Palaeontology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Describe the characteristics and preservation of fossils.
- Explain the evolution of life and their environment forms from fossil records.
- Explain the morphology of microfossils and their application in determining palaeoclimate, sea level change.
- Elucidate the geology of oil and gas reservoirs and their location.

**Course Content:**

**Section A**

Introduction and scope of Palaeontology. Concepts of taphonomy and biostratinomy. Principles of palaeoecology. Theories of origin of life. Principles of biogeography. Patterns and causes of Extinction. Concept and mechanism of speciation.

**Section B**

Modes of preservation of fossils. Collection, preservation and preparation of fossils. Fossil record and geological time scale. Evolution of Man, Horse and Elephant. Siwalik vertebrate fauna and Gondwana flora. Trace fossils.

**Section C**

Definition and scope of micro-palaeontology. Techniques in micro-palaeontology. Morphotaxonomy of Foraminifera, Ostracodes, Conodonts, Radiolaria and diatoms. Importance of microfossils in stratigraphy, determination of palaeo environments and sea level changes in the geological past and the role of micro-palaeontology in oil exploration.

**Recommended Books:**

1. Armstrong, H. A., & Braiser, M. D. (2005). *Microfossil* (2nd ed.). Oxford, UK: Blackwell.

2. Bignot, B. (1985). *Elements of Microplaeontology*. London, UK: Graham and Trotman.

3. Clarkson, E. N. K. (1998). *Invertebrate Palaeontology and Evolution* (4th ed.). Singapore:Wiley-Blackwell.

4. Cushman, J. A. (1948). *The Foramanifera, their classification and use* (4th ed.). Cambridge, UK: Harvard University Press.

5. Glaessner, M. F. (1945). *Principles of Micropalaeontology*. Melbourne, Australia: Melbourne University Press.

6. Jain, P. C., & Anantharaman, M. S. (2005). *Palaeontology: Evolution and Animal Distribution* (6th ed.). New Delhi, India: Vishal.

7. Moore, R. C, Lalicker, C.G. & Fisher, A.G. (1997). *Invertebrate fossils*. New Delhi, India: CBS.

8. Prothero, D. R. (2003). *Bringing Fossil to Life-An Introduction to Palaeontology* (3rd ed.). New York, NY: Columbia University Press.

9. Raup, D. M., & Stanley, S. M. (1985). *Principles of Palaeontology* (2nd ed.). New Delhi, India: CBS.

10. Shrock, R. R., & Twenhofel, W. H. (2005). *Principles of Invertebrate Paleontology* (2nd ed.). New York, NY: CBS.

**Suggested e-learning materials:**

1. Fossils morphology
   https://www.palaeontologyonline.com/

2. Origin of life and evolution
   https://nptel.ac.in/courses/122103039/module2/lec6/4.html

3. Taphonomy
   https://www.encyclopedia.com/science-and-technology/biology-and-genetics/biology-general/taphonomy

## GEOL 523 Remote Sensing and GIS in Geology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Explain the principles of platforms and sensor characteristics, satellite orbits and data characteristics.
- Elucidate principles and applications of advance techniques including multispectral, hyperspectral, thermal-infrared, microwave remote sensing.
- Describe the concepts and components of GIS and GPS.
- Describe the applications of Geographical Information System in various fields of geology.

**Course Content:**

**Section A**

Remote Sensing (RS): Principle and scope. Electromagnetic radiation– types and sources, Black body radiation. Absorption bands and Atmospheric windows. Remote Sensing Sensor: types and their resolution. General Orbital characteristics of satellites. Sensor characteristics of remote sensing satellites: LANDSAT, IRS series (LISS and AWiFS), ASTER, Quickbird. Indian Planetary Missions.

**Section B**

Multispectral, Hyperspectral, Thermal Infrared, Microwave remote sensing: Introduction, Principle and applications in geology. Global Positioning System (GPS): Introduction and application in geology. Fundamentals of Digital Image Processing (DIP): Image rectification, Image enhancement and Image classification.

**Section C**

Principles and application of Geographic Information System (GIS). Components of GIS. Map projections-Types and properties. Raster and vector data models. Digital Elevation Model (DEM) and its applications in Geology.

**Recommended Books:**

1. Bonham-Carter, G. F. (1994). *Geographic Information System for Geoscientists: Modelling with GIS*. London, UK: Oxford Pergamon Press.

2. Clarbe, C. K. (1997). *Getting started with Geographic Information System*. New York, NY: Prentice Hall.

3. Demers, M.N. (1997). *Fundamentals of Geographic Information System*. New York, NY: John Wiley & Sons.

4. Drury, S.A. (1987). *Image Interpretation in Geology*. London, UK: Allen and Unwin.

5. George, J. (2005). *Fundamentals of Remote Sensing*. Hyderabad, India:Universities Press.

6. Gupta, R. P. (2003). *Remote Sensing Geology*. Berlin, Germany: Springer–Verlag.

7. Jain, A.K. (1989). *Fundamentals of digital image processing*. New Delhi, India: Prentice Hall.

8. Jensen, J.R. (1996). *Introductory Digital Image Processing: A Remote Sensing Perspective*. Berlin, Germany: Springer-Verlag.

9. Lillesand, T. M., & Kiefer, R.W. (2007). *Remote Sensing and Image Interpretation*. New York, NY: John Wiley.

10. Pandey, S.N. (1987). *Principles and Application of Photogeology*. New Delhi, India:Wiley Eastern.

11. Prost, G.L. (1994). *Remote Sensing for Geologists: A guide to Image Interpretation*. London, UK: CRC Press.

12. Reddy, M.A. (2002). *Text book of Remote Sensing and Geographic Information System*. Hyderabad, India: B.S.

13. Sabbins, F.F. (1985). *Remote Sensing-Principles and applications*. New York, NY: Freeman.

14. Siegal, B.S., & Gillespie, A.R. (1980). *Remote Sensing in Geology*. New York, NY: John Wiley.

**Suggested e-learning materials:**

1. Introduction to GIS

   http://www.gisresources.com/iirs-e-learning-certificate-programmes-remote-sensing-geoinformation-sciences/

2. Remote Sensing Basics

   https://www.iirs.gov.in/EDUSAT

3. Introduction to GIS and hydrogeology https://epgp.inflibnet.ac.in/ahl.php?csrno=448

## GEOL 515L Geology Lab-III with Field Work

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **12** | **6** |

**Learning Outcomes:**

After the completion of this course, students will be able to:

- Describe the morphological characters of invertebrates and vertebrate fossils.
- Identify microfossils and their separation from matrix through microscope.
- Assessment of water quality and determination of aquifer properties.
- Process and analyze remote sensing data.

**Course Content:**

**Remote Sensing and GIS in Geology**

1. Procurement of satellite data.
2. Creating a standard FCC from satellite imagery.
3. Creating spectral profiles using satellite imagery and its interpretation.
4. Identification of landforms on topographic maps and satellite imagery.
5. Registration of satellite data with a toposheet of the area
6. Generating contrast stretched images.
7. Classification of images based on supervised and unsupervised and accuracy assessment.
8. Creation of DEM and draping of satellite imagery.
9. Generating slope map, aspect map and drainage network map

**Hydrogeology**

1. Delineation of hydrological boundaries on water table contour maps
2. Determination of porosity of rocks.

3. Determination of permeability of rocks.
4. Estimation of specific retention and specific yield.
5. Calculation of storage coefficient and transmissivity.
6. Physical analysis of water (pH, EC and TDS).
7. Chemical analysis of water (Anions and cations).
8. Determination of relative hardness of water.

**Palaeontology**

1. Study of morphological characters of some important Invertebrates fossils belonging to Brachiopoda, Gastropoda, Ammonoidea, Echinoidea and Corals.
2. Techniques of separation of Microfossils from matrix.
3. Study of larger benthic foraminifera.
4. Morphological study of microfossils.

**Geological Field Work**

*** Note**: Scientific calculators are permitted during examination.

**Recommended Books:**

1. Bignot, B. (1985). *Elements of Microplaeontology*. London, UK: Grahm and Trottman.
2. Braiser, M. D. (1980). *Microfossils*. London, UK: Geogrge Allen and Unwin.
3. Clarkson, E. N. K. (1998). *Invertebrate Palaeontology and Evolution*. Singapore: Wiley-Blackwell
4. Cushman, J. A. (1940). *The Foramanifera, their classification and use*. Cambridge, UK: Harvard University Press.
5. Drury, S. A. (1987). *Image Interpretation in Geology*. London, UK: Allen and Unwin.

6. Glaessner, M. F. (1945). *Principles of Micropalaeontology*. Melbourne, Australia: Melbourne University Press.

7. Karanth, K.R. (1989). *Hydrogeology*. New Delhi, India: Tata McGraw Hill.

8. Nagabhushaniah, H. S. (2001). *Groundwater in Hydrosphere*. New Delhi, India: CBS.

9. Pandey, S. N. (1987). *Principles and Application of Photogeology*. New Delhi, India: Wiley Eastern.

10. Raghunath, H. M. (2014). *Groundwater*. New Delhi, India: New Age International.

11. Ray, R. G. (1969). *Aerial Photographs in Geologic Interpretations*. USGS Prof. Paper 373.

12. Sabbins, F. F. (1985). *Remote Sensing-Principles and applications*. New York, NY: Freeman.

13. Siegal, B.S., & Gillespie, A.R. (1980) Remote Sensing in Geology. New York, NY:John Wiley.

14. Todd, D. K., & Mays, L. W. (2004). *Groundwater Hydrology*. New Delhi, India: Wiley India.

**Suggested e-learning materials:**

1. Microfossils
   http://www.ga.gov.au/scientific-topics/disciplines/palaeontology

2. Fossils Morphology
   https://www.palaeontologyonline.com/

3. Introduction to GIS and hydrogeology
   https://epgp.inflibnet.ac.in/ahl.php?csrno=448

# Fourth Semester

## GEOL 525P Project

| Max. Marks : 100 | L | T | P | C |
|---|---|---|---|---|
| (CA: 40 + ESA: 60) | 0 | 0 | 48 | 24 |

**Learning Outcomes:**

After the completion of this course, students will be able to:

- Describe the recent development and advanced techniques in geology leading to practical implementation to solve complex research problems.
- Interact and work in academic, research and industrial environment.
- Use different interpretation skills and data processing techniques to solve real time research problems.
- Synthesize the outcomes in form of written manuscripts.'

# Discipline Electives

## GEOL 512 Environmental Geology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Explain the application of geologic information to the entire spectrum of interactions between people and physical environment.
- Describe and mitigate the exposure of natural hazards on humans.
- Elucidate several types of pollutions and their sources.
- Explain the vulnerability of natural hazards.

**Course Content:**

**Section A**

Fundamental concepts of Environmental Geology. Introduction to Natural hazards: Causes and Impact. Types of Hazards. Earthquakes, Tsunami, volcanoes, Landslides and Floods.

**Section B**

Natural Resources. Environmental aspects of natural resource development and Management: Water resources, Mineral resources and Fossil fuels.

**Section C**

Pollution, their sources and types. Air Pollution, Pollution of rivers, lakes and groundwater.

**Recommended Books:**

1. Bryant, E. (1985). *Natural hazards*. London, UK: Cambridge University Press.
2. Keller, E.A. (1978). *Environmental Geology*. New Jersey, NJ: Bell and Howell.
3. Montgomery, C.W. (2011). *Environmental Geology*. New York, NY: McGrawHill.

4. Reichard, J. S. (2011). *Environmental Geology*. New York, NY: McGrawHill.

5. Smith, K. (1992). *Environmental hazards*. London,UK: Routledge.

**Suggested e-learning materials:**

1. Environment science
   https://epgp.inflibnet.ac.in/ahl.php?csrno=448
   https://nptel.ac.in/courses/105105106/

## GEOL 519 Marine Geology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students will be able to:

- To introduce various aspects of marine geology including physical, chemical, biological, geological in particular and concepts of Palaeoceanography.
- Interpret the sedimentary process leading to deposition of sediments found in different water depths and marine settings.
- Explain the major ocean driving forces and significance of sea-level changes in the geological record.
- Recognize the role of proxy indicators for paleo oceanographic interpretation.

**Course Content:**

**Section A**

History of development of Marine Geology, Salinity and Density of Ocean Water, Residence times of elements in sea water. Water Masses, types their formation, Ocean Circulation, Coriolis Effect and Ekman spiral, convergence, divergence and upwelling, Currents of Indian, Pacific and Atlantic Ocean. El Nino, Thermohaline circulation and oceanic conveyor belt. Tides, Opening and closing of ocean gateways during Cenozoic.

**Section B**

Ocean Sediments: Meaning, classification based on size and source, Factors controlling the deposition and distribution of oceanic sediments.

Classification of the marine environment and marine organisms, Physio-chemical factors affecting marine life – light, temperature, salinity, pressure, nutrients, dissolved gases, adaptation and biological processes. Marine pollution: causes, effect and measures. Ocean resources: Gas hydrate, Manganese nodule, Phosphorite and Placer deposits.

**Section C**

Morphologic and tectonic domains of the ocean floor: Structure, composition and mechanism of the formation of oceanic crust, Hypsometric curves and Major relief features. Seawater- basalt interactions, Hydrothermal vents. Palaeoceanography – approaches to palaeoceanographic reconstructions; proxy indicators for palaeoceanographic interpretation. Joint Global Ocean Flux Study (JGOFS) and its applications in Palaeoceanography.

**Recommended Books:**


1. Davis, R. J. A. (1986). *Oceanography-An Introduction of the Marine Environment* (2nd ed.). Iowa, IA: Win C. Brown.
2. Garrison, T. (2009). *Essentials of Oceanography* (5th ed.). California, CA: Brooks/Cole Cengage Learning.
3. Erickson, J. (2003). *Marine Geology- Exploring the New Frontiers of the Ocean* (Revised ed.). New York, NY: Facts on File, Inc.
4. Lal, D. S. (2015). *Oceanography* (Revised ed.). Allahabad, India: Sharda Pustak Bhawan.
5. Pinet, P. R. (2016) *Invitation to Oceanography* (7th ed.). Massachusetts, MA: Jones and Bartlett.
6. Riley, J. P. and Chester, R. (1971). Introduction to Marine Chemistry. New York, NY: Academic Press.
7. Sidhartha, K. (1999) *Oceanography: Brief Introduction*. New Delhi, India: Kisalya.
8. Trujillo, A. P. and Thurman, H. V. (2014). *Essentials of Oceanography* (12th ed.). Pearson.


**Suggested e-learning materials:**

1. Elements of Ocean Engneering
   https://nptel.ac.in/courses/114105002/
2. Oceanography
   https://epgp.inflibnet.ac.in/ahl.php?csrno=10

3. Basalt — Seawater Interaction
https://link.springer.com/chapter/10.1007/978-1-4899-0402-7_11

4. Introduction to Observational Physical Oceanography
https://ocw.mit.edu/courses/earth-atmospheric-and-planetary-sciences/12-808-introduction-to-observational-physical-oceanography-fall-2004/

## GEOL 520 Mining and Engineering Geology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Recognize geochemical, geological, geophysical sampling method to locate ore bodies.
- Describe the suitable mining methods and time-plan to carry out mining activity on different sites.
- Explain the methods of ore processing and beneficiation.
- Consider the geological factors controlling the site selection for civil engineering projects.

**Course Content:**

**Section A**

Introduction: Definition, basic concepts and classification of mining methods. Detail study of surface mining methods: Open pit, Quarrying, Auger and placer Mining. Underground Mining Methods: Room and Pillar method, Sublevel stopping, cut and fill stopping, Square set stopping and Block Caving Methods.

**Section B**

Ore dressing and its importance. Basic ore dressing operations viz. crushing, grinding, sizing, screening and classification. Concentration process, Magnetic and electrostatic separation, Gravity concentration, Froth Floatation, Amalgamation and Agglomeration.

**Section C**

Engineering properties of rocks and physical characteristics of building stones, concretes and other aggregates. Geological and geotechnical investigations, types and problems of major civil engineering structures: dams and reservoirs, bridges, highways and tunnels. Mass movement with special emphasis on landslides and causes of hillslope instability. Seismic design of buildings.

**Recommended Books:**


1. Arogyaswamy, R. N. P. (1995). *Courses in Mining Geology* (4th ed.). New Delhi, India: Oxford and IBH.
2. Bell, F. G. (2009). *Fundamentals of engineering Geology*. Hyderabad, India: BS.
3. Clark, G. B. (1967). *Elements of Mining* (3rd ed.). New Delhi, India: John Wiley.
4. Gangopadhyay, S. (2013). *Engineering Geology*. New Delhi, India: Oxford University Press.
5. Gaudin, A. M. (1939). *Principles of Mineral Dressing*. Bombay, India: McGraw Hill.
6. Kesavulu, C. N. (2009). *Text Book of Engineering Geology* (2nd ed.). New Delhi, India: Trinity Press.
7. Krynine, D. P., & Judd W.R. (1957). *Principles of Engineering Geology and Geotechnique*. New York, NY: McGrawHill.
8. McKinstry, H. E. (1972). *Mining Geology*. New York, NY: Prentice-Hall Inc.
9. Prabin, S. (2014). *Engineering and General Geology*. New Delhi, India: S K Kataria & Sons.
10. Reddy, M.M.T. (2007). *A Text Book of Applied Engineering Geology*. New Delhi, India: New Age International.
11. Thomas, L. J. (1978). *An Introduction to Mining: exploration, feasibility, extraction, rock mechanics*. Sydney, Methuen of Australia.
12. Vallejo, L. G. D., & Ferrer, M. (2011). *Geological Engineering*. Netherland: CRC.

**Suggested e-learning materials:**

1. Prospecting for Economic Minerals-Drilling, Sampling, Assaying http://vidyamitra.inflibnet.ac.in/content/index/5a6f0e258007bef961f76b4f/SL
2. Stress and strain behavior of material https://nptel.ac.in/courses/105105106/20#
3. Dam https://epgp.inflibnet.ac.in/ahl.php?csrno=448

## GEOL 513 Fuel Geology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students will be able to:

- Explore coal deposits, their mode of occurrences, structures in coal seams and application of coal petrography.
- Describe the geology of petroleum reservoirs, prospective and their exploration techniques.
- Describe the source of radioactive minerals, chemistry, prospects and exploration techniques.
- Provide feasible solutions for radioactive waste management.

**Course Content:**

**Section A**

Definition, origin, types and rank of coal. Mode of occurrences and structures in coal seam. Coal petrography. Indian coal deposits. Introduction to Coal bed methane.

**Section B**

Origin, composition, migration and entrapment of natural hydrocarbons. Properties of source and reservoir rocks. Porosity: Types and classification and Permeability: Types. Reservoir traps: structural, stratigraphic and combination traps. Geographical and geological distributions of onshore and offshore petroliferous basins of India.

**Section C**

Mineralogy and geochemistry of radioactive minerals. Distribution of radioactive minerals in India. Sources and classification of radioactive waste. Radioactive waste management.

**Recommended Books:**


1. Acharyya, S. K. (2000). *Coal and Lignite Resources of India: An overview*. Bangalore, India: Geological Society of India.
2. Aswathanarayana, U. (1985). *Principles of Nuclear Geology*. New Delhi, India: Oxford Press.
3. Boyle, R .W. (1982). *Geochemical prospecting for Thorium and uranium deposits*. Amsterdam & New York, Elsevier.
4. Chandra, D., Singh, R. M., & Singh, M. P. (2000). *Textbook of coal (Indian context)*. Varanasi, India: Tara.
5. Dahlkamp, F. J. (1993). *Uranium Ore Deposits,* Berlin Heidelberg, Germany: *Springer-Verlag*.
6. Durance, E. M. (1986). *Radioactivity in Geology-principles and application*. Chichester, UK: Ellis Hoorwool.
7. Francis, W. (1961). *Coal*. London, UK: Edward Arnold.
8. Holson, G. D., & Tiratso E. N. (1985). *Introduction to Petroleum Geology*, Houston, TX: Gulf.
9. KDMIPE ONGC. (1986). *Petroliferous basins of India*: Dehradun, India: India Petroleum.
10. Krishnaswamy, S. (1979). *India's Mineral Resources*. New Delhi, India: Oxford IBH.
11. Levorsen, A. L. (1967). *Geology of Petroleum* (2nd ed.). San Francisco, CA: Freeman.
12. Selley, R. C. (1998). *Elements of Petroleum Geology*. San Diego, CA: Academic Press.
13. Singh, M. P. (1998). *Coal and Organic Petrology*. New Delhi, India: Hindustan.
14. Tissot, B. P., & Welte D.H. (1984). *Petroleum formation and occurrence* (2nd ed.). Berlin Heidelberg, Germany: Springer-Veralg.

**Suggested e-learning materials:**

1. Fossil fuels
   https://opentextbc.ca/geology/chapter/20-3-fossil-fuels/
2. Petroleum and CBM
   http://oilandgasgeology.com/

## GEOL 524 Geological Field Methods

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **4** | **0** | **0** | **4** |

**Learning Outcomes:**

After the completion of this course, students will be able to:

- Collect and record data using common geologic field methods
- To interpret the geological history of the region
- Analyze sediment and water samples for its textural and chemical characteristics
- Handle the surveying instruments such as Theodolite, and Total Station

**Course Content:**

**Section A**

Introduction to field geology, its aim and scope. Topographic Maps, Scale and orientation of topographic sheet, Topographic Map symbols. Description and Usage of Brunton and Clinometers compass, Haversack, Hammer, Chisel, Measuring tape and Field diary. Importance of Field Photographs and Sketches. Procedure for preparation of Geological and Geomorphic map and its interpretation. Introduction to Geodesy, Applications of GPS and GPS survey.

**Section B**

Recording and interpretation of Igneous, Sedimentary and Metamorphic rock features in Field. Method to construct the graphic sedimentary log. Procedure of collection of sediment samples for various analysis such as textural, geochemical analysis and mineral extraction. Method of

collection of rock samples for thin-sections, preservation of fossils and collection of water samples for geochemical analysis.

**Section C**

Surveying: Definition, principles, classification and techniques. Chain and Plane Table Survey. Theodolite (digital theodolite) and Total Station Surveying. Introduction to Dumpy and Auto level surveying. Uses of Total Station in Geological and Geomorphic Mapping.

**Recommended Books:**


1. Billings, M.P. (1972). *Structural Geology* (3rded.). New York, NY: Prentice Hall.
2. Lahee, F.H. (1961). *Field Geology (5 th* ed.). New york, NY: Mc Graw Hills
3. Robert, R.C (1962). *Manual of field geology*, New York, NY: John Wiley & sons
4. Mathur, S.M (2001). *Guide to field Geology,* New Delhi: PHI .
5. Hosmer, G.L. (1946). *Geodesy (2nd* ed), New York, NY: Wiley
6. Duggal, S. K. (2015). *Surveying* (4th ed.). New Delhi, India: McGraw Hill.
7. Rollinson, H (2015). *Using geochemical data: evaluation presentation, interpretation.* New York, NY


**Suggested e-learning materials:**

1. Principle of Survey
   https://nptel.ac.in/courses/105107122/
2. Digital land survey and Mapping
   https://nptel.ac.in/courses/105107158

## Reading Electives

## ENVS 512R Agroforestry

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(ESA: 100)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Describe agroforestry and agroforestry interventions.
- Assess the role of Agroforestry as a sustainable land-use activity.
- Describe nutrient cycling and role of agroforestry in soil and water conservation
- Describe various energy plantation methods.

**Course Content:**

Agroforestry - definition and scope. Tropical deforestation, rising demands of fuel wood, fodder and timber, social, ecological and economic reasons for agroforestry. Traditional agroforestry systems: shifting cultivation, taungya, homegardens. Recent trends in Silviculture and Energy plantations. Trees in agricultural fields and farm boundaries. Commercial crops under shade of planted trees as well as natural forests. Agroforestry for wasteland development and temperate agroforestry practices. Nutrient cycling and role of agroforestry in soil and water conservation, Nitrogen fixation, improvement in soil physico-chemical properties. Soil organic matter status and soil organic matter, Soil fertility considerations in agroforestry nutrient needs of trees and crops**.**

**Recommended Books :**

1. Chundawat, B. S.,& Gautam, S. K. (2016). *Textbook of Agroforestry*. New Delhi, India: Oxford & Ibh.
2. Jose, S. (2009). *Agroforestry for Ecosystem Services and Environmental Benefits (Advances in Agroforestry)*. Dordrecht, Netherlands: Springer
3. Mukherjee, A. (2016). *Agroforestry and Watershed Management: An Interlocked System.* New Delhi, India: Random.
4. Raj, A. J. (2017). *Agroforestry Theory and Practices*. Jodhpur, India: Scientific.

**Suggested e-learning materials:**

1. Introductory Agroforestry
   http://ecoursesonline.iasri.res.in/course/view.php?id=157
2. Forestry Technologies
   http://agritech.tnau.ac.in/forestry/agroforestry_index.html

## ENVS 513R Energy Resources and Conservation

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(ESA: 100)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Describe the non-conventional sources of energy.
- Explain concepts on energy utilization and conservation.
- Emphasize energy conservation strategies in residential, industrial and transportation sector.
- Describe National Energy Policy.

**Course Content:**

Introduction: Energy, work and power. Classification of energy resources, An overview of the current global and National Energy Scenario. Fossil Fuels: Sources, exploration of oil, coal, natural gas, shale; Exploitation of Fossil fuels and their Environmental consequences. Nuclear Energy: Nuclear fission and Fusion; Nuclear fuel cycle, Nuclear reactor and nuclear power, Renewable and Alternative Energy Sources, Solar energy, Solar power, Photovoltaic cells; Wind power; Geothermal energy; Ocean energy. Environmental consequences of biomass resource harnessing, Energy Conservation: National Energy Policy, Energy efficient appliances, BEE Label, Modes of Energy Conservation in residential, industrial and transportation sector.

**Recommended Books :**

1. Agarwal, S. K. (2003). *Nuclear Energy: Principles Practice and Prospects.* New Delhi, India: APH.

2. Chaturvedi, P. (1995). *Bio-Energy Resources.* New Delhi, India: Concept.

3. Dayal, M. (1997). *Renewable Energy: Environment and Development*. New Delhi, India: Konark.

4. Mahajan, V. S. (1991). *National Energy: policy, crisis and growth*. New Delhi, India: Ashish.

5. Markuszewski, R., & Blaustein, B. D. (1986). *Fossil fuels utilization. Environmental concerns*. Washington, DC: American Chemical Society.

6. Vandana, S. (2002). *Alternative Energy.* New Delhi, India: APH.

**Suggested e-learning materials:**

1. Biodiesel production
   https://nptel.ac.in/courses/102105058/52

2. Sustainability through Green Manufacturing Systems: An Applied Approach
   https://nptel.ac.in/courses/112104225/22

## ENVS 515R Man and Environment

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(ESA: 100)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Describe the complex interactions of humans and ecological systems in the natural world.
- Synthesize, and apply a wide range of scientific literature in the ecological and environmental science.
- Interpret a wide range of scientific literature in ecology and environmental science.
- Apply the information in the realms of environmental sciences and sustainability.

**Course Content:**

Human Population, its Growth and Distribution, Environmental Deterioration associated with population growth, Man Induced Environmental Changes, Types of Human Activities, Impact of Human Activities such as Deforestation, Mining and Industrialization. Environmental Awareness- Need and Role in Betterment of Environment Concept and Significance of Environmental Movements, Environmental Movements in India with special reference to The Bishnoi Movement, Chipko Movement, Appiko Movement, Narmada Bachao Andolan, Silent Valley Movement. Components of natural and built environment: Resources and human settlements, modifications in natural environment, causes and consequences.

**Recommended Books :**

1. Bal Anand, S. (2005). *An Introduction to Environmental Management*. Mumbai, India : Himalaya.
2. Chandana, R. (2008). *A Geography of population*. New Delhi, India: Kalyani.
3. Chopra, G. (2006). *Population Geography*. New Delhi, India: Commonwealth.
4. Chorley, R. J., Schumm, S. A., & Sugden, D. E. (1984). *Geomorphology*. London , UK : Methuen and Company Ltd.
5. Dayal, P. (1994). *A Text Book of Geomorphology*. New Delhi, India :Kalyani.
6. Rapoport, A. (2016). *Human aspects of urban form: towards a man—environment approach to urban form and design*. Oxford, UK : Elsevier Pergamon Press.

**Suggested e-learning materials:**

1. Environment and Ecology

   https://nptel.ac.in/courses/122102006/

2. Ecological Degradation and Environmental Protection
   https://nptel.ac.in/courses/109104045/35#

## ENVS 517R Water and Sustainable Development

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(ESA: 100)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Classify major causes of exploitation of water resources, particularly in the Indian and Asian context.
- Summarize rainwater harvesting and water conservation measures.
- Describe methods of Irrigation management.
- Describe importance of Wetlands and its conservation

**Course Content:**

Water and sustainable development. Water and human health – Access to safe drinking water and sanitation; public health issues. Water and food production – Role of irrigation in food security. Shifts in cropping patterns, Rain-fed agriculture, increasing use of groundwater. Environmental, economic and social implications of exploitation of ground water resources. Water and human amenities – Urban water supplies; exploitation, conservation and rainwater harvesting. Wetland, its use and abuse with Ramsar Convention. Urban floods, storm water drainage and integrated urban water management (IUWM). Irrigation management – canals and micro-irrigation.

**Recommended Books :**

1. Asawa, G. L. (2005). *Irrigation and Water Resources Engineering*, New Delhi, India: New Age.
2. Biswas, A. K., Jellau, M., & Stout, G. (1993). *Water for sustainable development in 21st century – A Global perspective*, Oxford, UK: Oxford University Press.
3. David, L. F. (2007). *Water Policy for Sustainable Development*. Baltimore, Maryland: Johns Hopkins University Press.
4. Jain, S. K., & Singh, V. P. (2003). *Water Resources Systems Planning and Management*. Amsterdam, Netherlands: Elsevier.

**Suggested e-learning materials:**

1. Water, Society and Sustainability

   https://onlinecourses.nptel.ac.in/noc18_hs36/preview

2. Irrigation Efficiencies - II and Irrigation Methods and their Suitability

   https://nptel.ac.in/courses/105102159/15

## GEOG 513R Environmental Challenges and Disaster Management

| Max. Marks : 100 | L | T | P | C |
|---|---|---|---|---|
| (ESA: 100) | 0 | 0 | 4 | 2 |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Explain approaches to study environmental development and crisis.
- Describe world energy crisis with its causes and suggested measures for improvement.
- Describe several environmental problems their causes, consequences and mitigation.
- Depict the major disasters and their management with the help of case studies.

**Course Content:**

**Environment:-**Definition and types of Environment; Environmental Development Crisis:-Introduction and its causes; Energy Crisis:- Concept, Causes and Remedies; Environmental issues associated with Green Revolution; Impact of Urbanization on Environment.

**Deforestation:-** Concept, Causes, Effects and Conservation; Desertification:- Concept, Causes, Impacts and Preventions; Water Scarcity:- Causes ; Methods of Rain Water Harvesting (special reference to Traditional Methods); Acid Rain:- Causes, Consequences and Mitigation Measures; Solid Waste:- Introduction, Types and Management.

**Disaster:-** Definition and Classification; Natural Disaster:- Nature and Types; Flood:- Causes, Impacts and Methods of Management; Earthquake:-

Introduction, Types, Causes, Effects and Mitigation; Case Studies:- Bhuj Earthquake-2001, Tsunami (Southern India)-2004 and Kedarnath Disaster-2013.

*** Note – Stencils are to be permitted during the examination.**

**Recommended Books:**

1. Gautam, A. (2010). *Environmental Geography*. Allahabad, India: Sharda Pustak Bhawan.
2. Ghosh, G. K. (2015). *Disaster Management*. New Delhi, India: A.P.H.
3. Singh, S. (2002). *Physical Geography*. Gorakhpur, India: Vasundhara.

**Suggested e-learning materials:**

1. Deforestation:- Concept, Causes, Effects https://www. livescience.com/27692-deforestation.html
2. Acid Rain:- Causes, Consequences and Mitigation Measures https://www.conserve-energy-future.com/causes-and-effects-of-acid-rain.php
3. Solid Waste:- Introduction, Types and Management https://www. indiawaterportal.org/topics/solid-waste

## GEOG 514R India: Socio-Political and Environmental Scenario

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(ESA: 100)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Understand the current issues related with boundaries, water sharing, agricultural disparities, food security in India.
- Describe problems in Agricultural Development.
- Discuss Gender Issues and Women Safety.

- Find the role of non – conventional energy resources for solving energy crisis.

**Course Content:**

Relation of India with neighbouring countries and border disputes with China and Pakistan. Drought problems, Interlinking of rivers as a solution of water crises and disputes of river water sharing with reference to Narmada, Krishna, Cauvery and Sutlej Yamuna Link (SYL). Problems and disparities in agricultural development, food security and farmer suicides in India. Energy crisis in India and its solution with the help of nuclear, solar, hydro and wind power. Gender issues and women safety, poverty and unemployment.

**Recommended Books :**


1. Deshpande, C. D. (1992*). India, A Regional Interpretation*. New Delhi, India: ICSSR & Northern Book Centre.
2. Gallaher, C. et al. (2012). *Key Concepts in Political Geography* (Reprint). New Delhi, India: Sage.
3. Hussain, A. (2007). *Political Geography.* New Delhi, India: Vishvabharti.
4. Singh, R. L. (Ed.).(1971). *India - A Regional Geography*. Varanasi, India: National Geographical Society.
5. Tirtha, R., & Gopal, K. (1996). *Emerging India.* Jaipur. India: Rawat.
6. बंसल, एस. सी. (2011). *भारत का भूगोल.* मेरठ, भारत : मीनाक्षी.


**Suggested e-learning materials:**

1. Interlinking of rivers
   https://www.geoecomar.ro/website/publicatii/Nr.192013/12_mehta_web_2013.pdf

2. Farmer suicides
   http://www.ipcinfo.org/fileadmin/user_upload/fsn/docs/Agriculture%20and%20rural%20development%20in%20India.pdf
3. Food Security
   https://dfpd.nic.in/LwB3AHIAaQB0AGUAcgBlAGEAZABkAGEAdABhAC8AUABvAHIAdABhAGwALwBNAGEAZwBhAHoAaQBuAGUALwBEAG8AYwB1AG0AZQBuAHQALwA=1_93_1_Original.pdf
4. Gender Issues in India
   https://www.indiacelebrating.com/social-issues/gender-inequality-in-india/

## GEOG 515R Rajasthan: Challenges and Prospects

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(ESA: 100)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Describe the major environmental, socio economic problems of Rajasthan.
- Explain desertification, Aravalli development, agriculture and tourism of Rajasthan.
- Analyze existing state and national policies in terms of socio economic conditions.
- Aware society regarding existing policies related to child marriage, Female feticide and other Social problems.

**Course Content:**

Major Canal Irrigation Project and Its impact; Desertification and Desert Development programmes; Identification of drought prone areas and mitigation, problem of mining and Aravalli Development Programme, Problems and measures of Agricultural development; Programmes for forest conservation; Poultry farming, Planning for livestock development; Role of Tourism in the economy.

Socio- economic issues and Government policies and programmes: child marriage, female feticide, female education, gender discrimination and caste; unemployment and poverty.

**Recommended Books :**


1. Singh, G. (2010). *Geography of India* (9th ed.). Delhi, India: Atma Ram.
2. शर्मा, आर. (2010). *राजस्थान का भूगोल.* उदयपुर, भारत: हिमाशुं.
3. शर्मा एच. एस., एवं शर्मा, एम. एल. (2015). *राजस्थान का भूगोल.* जयपुर, भारत: पचंशील.
4. सक्सैना, एच. (2014). *राजस्थान का भूगोल.* जयपुर, भारत : राजस्थान हिन्दी ग्रंथ अकादमी.


**Suggested e-learning materials:**

1. Indira Gandhi Canal
   https://www.rajras.in/index.php/indira-gandhi-canal/
2. Tourist spots in Rajasthan
   http://www.transindiatravels.com/rajasthan/tourist-places-to-visit-in-rajasthan/
3. Problem of Desertification
   http://www.cazri.res.in/annals/1993/1993JA-1.pdf.

## GEOG 517R Transforming India

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(ESA: 100)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Assess the ongoing governmental policies applicable to socio-economic and health sectors.
- Aware society about the injustice caused to women in terms of Triple Talaq.

- Explain current livelihood struggle in the society and the role of skill development in enhancing quality of life.
- Suggest the measures of improvement in the policies.

**Course Content:**

Transforming India into a digitally empowered society and development through digitalization, its effects and problems. Demonetization- a step to less cash to cash less economy. Indian youth as a change agent and quality of education for empowering Indian youth, Skill development and empowering youth, Population pressure in job sector and creating livelihood opportunities. Swachh Bharat Mission and Sanitation revolution for clean and healthy society, Ayushman Bharat Yojana- a step towards Health for all. Beti Bachao-Beti Padhao- a step for girl's development and Triple Talaq in India- an injustice for women or religious issue.

**Recommended Books :**

1. Ghosh, J., Chandrashekra, C. P., & Patnaik, P. (2017). *Demonetisation Decoded*. New York, NY: Routledge.
2. Panigrahi, R. L. (2005*). Population problems in India*. New Delhi, India: DPH.
3. Sinha, M., & Sinha, R. K.(Ed). (2008). *Swachh Bharat, A clean India*. New Delhi, India: Prabhat.

**Suggested e-learning materials:**

1. Transforming India
   http://transformingindia.in/
2. Digital India
   https://www.indianeconomy.net/splclassroom/what-is-digital-india/
3. Demonetization
   http://www.mbauniverse.com/group-discussion/topic/business-economy/demonetisation
4. Skill Development in India
   https://www.indiainfoline .com/article/article-latest/skill development-in-india-gaps-and-opportunities 118092700366_1.html
5. Swachh Bharat Mission

https://www.mapsofindia.com/my-india/society/swachh-bharat-abhiyan-making-india-clean-more

6. Betibachao and BetiPadhao

http://www.mbauniverse.com/group-discussion/topic/social-issues/beti-bachao-beti-padhao

## GEOL 514R Geo Tourism

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(ESA: 100)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Elucidate the criterion require for designating geotour sites.
- Explore the geological and geographical attributes of the geosites.
- Develop a geo-conservation plan for geotour sites.
- Evaluate the potential of geosites for revenue generation.

**Course Content:**

Definition and scope of Geotourism. Principles of Geotourism. Geoconservation Plans. Introduction to geodiversity and Geopark. UNESCO's Global Geopark development program. Overview of GSI monuments and geotour sites-Sendra Granite of Pali District Rajasthan, Lonar Lake of Buldana District Maharastra, Peninsular Gneiss at Lalbagh Bangalore Karnataka. Natural Arch in Tirumala hills Chitoor District, Barr Conglomerate, Pali District Rajasthan, Marine Gondwana Fossil Park, Fossil Wood Parks, Siwalik Fossil Park, Stromatolite Parks, Columnar Basalt, Pillow Lava, Pyroclastic Rocks, Nepheline Syenite, Welded Tuff, Charnockite, Great Boundary Fault, Eparchaean Unconformity, Tirumala hills. World's major geotour sites.

**Recommended Books :**

1. Chen, A. (2015). *The Principles of Geotourism.* Beijing, China: Springer-Verlag.

2. Dowling, R., & Newsome, D. (Eds.). (2018). *Handbook of Geotourism.* Gloucestershire, UK : Edward Elgar.

3. Dowling, R., & Newsome, D. (Eds.). (2005). *Geotourism*. Oxford, UK: Elsevier.

4. Newsome, D., & Dowling, R. (Eds.). (2010). *GEOTOURISM: The Tourism of Geology and Landscape*. Oxford, UK: Goodfellow.

**Suggested e-learning materials**

1. UNESCO geological heritage and geo-tourism in Peru
http://www.unesco.org/new/en/media-services/single view/news/unesco_geoparks_geological_heritage_and_geo_tourism_ in_peru/

2. Geotourism
https://link.springer.com/referenceworkentry/10.1007%2F978-3-319-01669-6_93-1

3. Geotourism in India
https://www.gsi.gov.in

## GEOL 517R Indian Mineral Deposits, Economics and Mining Ethics

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(ESA: 100)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Explain the distribution of mineral resources in India.
- Evaluate the mineral resources and reserves in Indian and global perspective.
- Familiarize with the concept of mineral legislation and policies.
- Delineate the different environmental issues associated with mining activities.

**Course Content:**

Introduction to types and distribution of various mineral deposits in India. Occurrences of important metallic, non-metallic/industrial and fuel mineral

deposits of India. Mineral economics and its major concept. Introduction for Global mineral resources. Conservation and substitution of minerals; changing pattern of mineral consumption, Growth of mineral industry and economy, Mineral industry and its adverse effect to the environment. Environmental baseline data needed for mine planning-Its acquisition and documentation during different stages of exploration. Nature and extent of environmental problems due to surface and underground mining. Legislation and control measures for mining. Mineral legislation in Indian context (The Mines and Minerals Regulation and Development Act, 1957). Reclamation and restoration of mined land.

**Recommended Books :**


1. Arogyaswamy, R. N. P. (1995). *Courses in Mining Geology* (4th ed.). New Delhi, India: Oxford and IBH.
2. Banerjee, D. K. (1998). *Mineral Resources of India* (2nd ed.). Kolkata, India: The World Press.
3. Chatterjee, K. K. (1993). *An Introduction to Mineral Economics* (2nd ed.). Bangalore, India: New Age International.
4. Sharma, N. L., & Ram, K. S. V. (1964). *Introduction to India's economic minerals*. Dhanbad, India: Dhanbad.
5. Sinha, R. K., & Sharma, N. L. (1988). *Mineral Economics* (4th ed.). New Delhi, India: Oxford & IBH pub. Co.


**Suggested e-learning materials:**

1. Mineral and energy resources
   http://ncert.nic.in/ncerts/l/legy207.pdf
2. Economic Minerals of India
   https://www.researchgate.net/publication/315831629_Economic_Minerals_of_India

## GEOL 518R Innovation and Entrepreneurship in Earth Sciences

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(ESA: 100)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Understand necessary steps to open a new venture.

- Gain an understanding of creating products or services, launching innovative projects and making R&D investments in a start-up context.
- Develop marketing strategies for tools and technical products used in earth sciences.
- Familiarize with the legal concepts and financial planning for a successful new venture.

**Course Content:**

An overview of Entrepreneurs and Entrepreneurship. Evolution and Growth of Earth Science. Entrepreneurship in India, Starting small business. Planning-Organization and Management. Basic layout of Proposal for seeking loan from financial institution, Legal requirements, Basic Financial Planning and problems. Case study of successful Earth Science Entrepreneurs in India Earth Science component in Government of India PSU (MECL, NHPC Mini Ratna, ONGC, NTPC, CIL Maharatna) and in MNC (Larsen and Toubro, Tata, Reliance, Vedanta, Dalmiya groups, Aditya Birla). Entrepreneurs Skills and Competencies. Earth Science technology for harnessing Innovation. Challenges of new startups, Marketing Strategies development, Tools and techniques for market Assessments, Methods and sources for market survey and Market Information. Presentation of Market Survey Report.

**Recommended Books :**

1. Clarysse, B. (2011). *The Smart Entrepreneur: How to Build for a Successful Business*. London, UK : Elliott & Thompson.
2. Sethi, A. (2016). *From Science to Startup: The Inside Track of Technology. Entrepreneurship*. Göttingen, Germany: Copernicus & Springer.
3. Westhead, P., & Wright, M.(2013). *Entrepreneurship. A very short introduction*. Oxford, UK: Oxford University Press.

**Suggested e-learning materials:**

1. Sustainability, Innovation and Entrepreneurship
   https://nptel.ac. in/courses/110107094/26
2. New Enterprises

https://ocw.mit.edu/courses/sloan-school-of-management/15-390-new-enterprises-spr

## GEOL 521R Natural Hazards and Disasters

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(ESA: 100)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Explain the key concepts, definitions, perspectives of all hazards and management.
- Describe prevention and mitigation of natural hazards.
- Depict the preparedness response and recovery management of natural disasters.
- Elucidate the sustainable development methods in disaster mitigation.

**Course Content:**

Introduction to Disasters and Hazards, Processes (Internal and External), Types of Hazards: causes and consequences, Prediction and Indicators of Natural Disasters, Socio-economic and Health impacts of Natural Disasters.

Natural Disasters – Earthquake: Processes, Magnitude, Intensity and Impact; Volcanism: Types, Risks and Impact; Tsunami and Cyclone: Types, Causes, processes and Impact; Floods: Introduction, Magnitude, Frequency, Zonation and Impact. Mass Wasting: Classification, causes and Impact, Disaster Management: Prevention, Preparedness and Mitigation, Planning and control of Natural Disaster, Case Studies: Nepal Earthquake, Kedarnath Disaster, Bhuj Earthquake 2001.

**Recommended Books :**

1. Bolt, B. A. (1988). *Earthquakes.* New York, NY: WH Freeman & Company.

2. Decker, R. W. & Decker, B. B. (2005). *Volcanoes* (4th ed.). New York, NY: WH Freeman & Company.

3. Dowrick, D. (2003). *Earthquake Risk Reduction Zone.* England, UK:John Wiley & Sons.

4. Gere, J. M., & Shah, H. C. (1984). *Terra Non Firme Understanding and Preparing for Earthquakes.* New York, NY: WH Freeman & Company.

5. IGNOU (2005). *Understanding Natural Disasters*. eGyanKosh, Noida, India: Shagun Offset Press.

6. Keller, E. A., &Devecchio, E. D. (2015). Natural Hazards (4th ed.). New York, NY: Pearson.

7. Keller, E.A. (1978). *Environmental Geology* (9th ed.). North Carolina, NC : Bell & Howell.

8. Montgomery, C.W. (2013). *Environmental Geology* (10th ed.). New York, NY : Mc-Graw-Hill.

9. Prakash, I. (1994). *Disaster Management*. Ghaziabad, India: Rastriya Prahari.

10. Sharma, V. K. (1995). *Disaster Management*. New Delhi, India: Indian Institute of Public Administration (*IIPA*).

11. Singh, S. (2015). *Environmental Geography*. Allahabad, India: Pravalika.

## Suggested e-learning materials:

1. Introduction to Natural hazards
   https://epgp.inflibnet.ac.in/ahl.php?csrno=17
   https://onlinecourses.nptel.ac.in/noc19_ce14/preview

2. Disasters and Hazards
   https://ndma.gov.in/en/

## GEOG 518R Health, Space and Ecology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(ESA: 100)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

After the completion of this course, students should be able to:

- Analyze and explain concepts of mortality, morbidity and health.
- Explain the distribution of major communicable and non-communicable diseases in India.
- Develop an understanding of the structure of health care services in India.
- Explain and analyze the Public and Private Initiatives in health-care provisions and also about Health Policies and Programmes running in India

**Course Content:**

Concept of mortality, morbidity and health; Colonial and Post- Colonial conception of health and medicine; Health as a commodity; Health and Quality of life; Linkage between health and ecology; Pattern of morbidity-world and India; Geographical aspect of distribution of major diseases in India- communicable (HIV/AIDS, Tuberculosis (TB) and non-communicable (Malaria, Cholera); Regional variation in prevalence of diseases; Sources of infection, modes of transmission; Structure of health care services in India; Health inequality; Problems of access and utilization; Public and Private Initiatives in health-care provisions; Health Policies and Programmes in Independent India.

**Recommended Books:**

1. Akhtar, R. (Ed). (2016). C*limate Change and Human Health Scenario in South and Southeast Asia.* New Delhi, India: Springer Nature.
2. Choudhary, B.K. (2008). *Tuberculosis in India: A Political Ecology Approach.* Riga: VDM Verlag.
3. Farmer, P. (1999). *Infection and Inequalities: the modern Plagues*. Berkeley: University of California Press.
4. Lankinen, S.K. (Ed). (1994). *Health and disease in Developing Countries*. London: Macmillan Education Ltd.

5. May, J. M. (1970). *The World Atlas of Diseases*. New Delhi, India: Nat Book Trust.
6. Naidoo, J., Wills, J. (2001). *Introduction to Health Studies*. NY: Pal grave.
7. Park, J. E., & Park, K. (2007). *Preventive and Social Medicine.* (19th ed.).Jabalpur, India: M/s Banarsi das.
8. Park, J. E., & Park, K. (2014). *Text Book of Community Health for Nurses*. Jabalpur, India: Ansari.
9. Phillips, D.R., Varhasset, Y. (Ed). (1994). *Health and Development*. London: Routledge.
10. सिंधई, जी. सी. (2010). *चिकित्साभूगोल* (द्वितीय सं.). गोरखपुर, भारतः वसुन्धरा.

**Suggested e-learning materials:**

1. Family Welfare programme in India
   http://planningcommission.nic.in/plans/mta/mta-9702/mta-ch17.pdf
2. Public and Private Initiatives in health-care provisions
   https://www.who.int/healthsystems/topics/financing/healthreport/P-P_HSUNo39.pdf
3. Geographical aspect of distribution of major diseases in India-communicable and non- communicable
   http://planningcommission.nic.in/aboutus/committee/wrkgrp12/health/WG_3_2non_communicable.pdf

## List of Alternative Online Reading Electives

**Students can opt alternative online courses for the following reading electives:**

| S. No. | Courses | Alternative online course | Agency/ Portal | Credit point(s) | New URL |
|---|---|---|---|---|---|
| 1 | ENVS 513R Energy Resources and Conservation | Non-Conventional Energy Resources | Indian Institute of Technology Madras, NPTEL | 2 | https://nptel.ac.in/courses/121/106/121106014/ |
| 2 | GEOL 517R Indian Mineral Deposits, Economics and Mining Ethics | Mineral Resources: Geology, Exploration, Economics and Environment | Indian Institute of Technology Roorkee, NPTEL | 2 | https://nptel.ac.in/courses/105/105/105105170/ |
| 3 | GEOL 521R Natural Hazards and Disaster | Natural Hazards Part 1 | Indian Institute of Technology Kanpur, NPTEL | 2 | https://nptel.ac.in/courses/105/104/105104183/ |