



Bachelor of Science (Honours) Geology under CBCS

PATNA UNIVERSITY, PATNA

Programme Code:

Programme Outcomes

At the completion of the programme, students will attain the ability to:

- PO1:** Develop understanding of Earth/Geological Sciences.
- PO2:** Apply the knowledge of allied disciplines in understanding geological science
- PO3:** Develop insightful understanding of Environment with emphasis on sustainable development.

Programme Specific Outcomes

At the completion of the programme, students will attain the ability to:

- PSO1:** develop an understanding of dynamics of Earth and its interior, geomorphological processes that shapes earth
- PSO2:** impart knowledge of genesis of various rocks and earth's energy resources including metals non-metals, hydrocarbons etc
- PSO3:** carry out field work and work as a team, communicate and learn project management.

Course Structure

Semester – I

| Sl. No. | Name of the Course | Type of Course | L-T-P | Credit | Marks |
|--------------------------|---------------------------------------|----------------|-------|--------|-------|
| 1 | Fundamentals of the Earth System (Th) | CC-1 (Th) | 4-1-0 | 4 | 100 |
| 2 | Fundamentals of Earth System (P) | CC-1 (P) | 0-0-6 | 2 | 100 |
| 3 | Mineralogy and Crystallography (Th) | CC-2 (Th) | 4-1-0 | 4 | 100 |
| 4 | Mineralogy and Crystallography (P) | CC-2 (P) | 0-0-6 | 2 | 100 |
| 5 | English Communication/MIL | AECC- 1 | 2-1-0 | 2 | 100 |
| 6 | Generic Elective- 1 (Th) | GE- 1 (Th) | 4-1-0 | 4 | 100 |
| 7 | Generic Elective- 1 (P) | GE- 1 (P) | 0-0-6 | 2 | 100 |
| Total credit - 20 | | | | | |

Semester – II

| Sl. No. | Name of the Course | Type of Course | L-T-P | Credit | Marks |
|--------------------------|---------------------------------------|----------------|-------|--------|-------|
| 1 | Mineralogy and Optical Mineralogy(Th) | CC-3 (Th) | 4-1-0 | 4 | 100 |
| 2 | Mineralogy and Optical Mineralogy (P) | CC-3 (P) | 0-0-6 | 2 | 100 |
| 3 | Structural Geology (Th) | CC-4 (Th) | 4-1-0 | 4 | 100 |
| 4 | Structural Geology (P) | CC-4 (P) | 0-0-6 | 2 | 100 |
| 5 | Environmental Science | AECC- 2 | 2-1-0 | 2 | 100 |
| 6 | Generic Elective- 2 (Th) | GE- 2 (Th) | 4-1-0 | 4 | 100 |
| 7 | Generic Elective- 2 (P) | GE- 2 (P) | 0-0-6 | 2 | 100 |
| Total credit - 20 | | | | | |

Semester – III

| Sl. No. | Name of the Course | Type of Course | L-T-P | Credit | Marks |
|--------------------------|-----------------------------|----------------|-------|--------|-------|
| 1 | Geomorphology (Th) | CC-5 (Th) | 4-1-0 | 4 | 100 |
| 2 | Geomorphology (P) | CC-5 (P) | 0-0-4 | 2 | 100 |
| 3 | Igneous Petrology (Th) | CC-6 (Th) | 4-1-0 | 4 | 100 |
| 4 | Igneous Petrology (P) | CC-6 (P) | 0-0-4 | 2 | 100 |
| 5 | Metamorphic Petrology (Th) | CC-7 (Th) | 4-1-0 | 4 | 100 |
| 6 | Metamorphic Petrology (P) | CC-7 (P) | 0-0-4 | 2 | 100 |
| 7 | Skill Enhancement Course- 1 | SEC- 1 | 2-1-0 | 2 | 100 |
| 8 | Generic Elective- 3 (Th) | GE- 3 (Th) | 4-1-0 | 4 | 100 |
| 9 | Generic Elective- 3 (P) | GE- 3 (P) | 0-0-4 | 2 | 100 |
| Total credit - 26 | | | | | |

Semester – IV

| Sl. No. | Name of the Course | Type of Course | L-T-P | Credit | Marks |
|--------------------------|-----------------------------|----------------|-------|--------|-------|
| 1 | Sedimentology (Th) | CC-8 (Th) | 4-1-0 | 4 | 100 |
| 2 | Sedimentology (P) | CC-8 (P) | 0-0-4 | 2 | 100 |
| 3 | Stratigraphy (Th) | CC-9 (Th) | 4-1-0 | 4 | 100 |
| 4 | Stratigraphy (P) | CC-9 (P) | 0-0-4 | 2 | 100 |
| 5 | Palaeontology (Th) | CC-10 (Th) | 4-1-0 | 4 | 100 |
| 6 | Palaeontology (P) | CC-10 (P) | 0-0-4 | 2 | 100 |
| 7 | Skill Enhancement Course- 2 | SEC- 2 | 2-1-0 | 2 | 100 |
| 8 | Generic Elective- 4 (Th) | GE- 4 (Th) | 4-1-0 | 4 | 100 |
| 9 | Generic Elective- 4 (P) | GE- 4 (P) | 0-0-4 | 2 | 100 |
| Total credit - 26 | | | | | |

Semester – V

| Sl. No. | Name of the Course | Type of Course | L-T-P | Credit | Marks |
|--------------------------|--------------------------------------|----------------|-------|--------|-------|
| 1 | Hydrogeology (Th) | CC-11 (Th) | 4-1-0 | 4 | 100 |
| 2 | Hydrogeology (P) | CC-11 (P) | 0-0-4 | 2 | 100 |
| 3 | Economic Geology (Th) | CC-12 (Th) | 4-1-0 | 4 | 100 |
| 4 | Economic Geology (P) | CC-12 (P) | 0-0-4 | 2 | 100 |
| 5 | Discipline Specific Elective- 1 (Th) | DSE- 1 (Th) | 4-1-0 | 4 | 100 |
| 6 | Discipline Specific Elective- 1 (P) | DSE- 1 (P) | 0-0-4 | 2 | 100 |
| 7 | Discipline Specific Elective- 2 (Th) | DSE- 2 (Th) | 4-1-0 | 4 | 100 |
| 8 | Discipline Specific Elective- 2 (P) | DSE- 2 (P) | 0-0-4 | 2 | 100 |
| Total credit - 24 | | | | | |

Semester – VI

| Sl. No. | Name of the Course | Type of Course | L-T-P | Credit | Marks |
|--------------------------|--|----------------|-------|--------|-------|
| 1 | Global Tectonics and Geodynamics (Th) | CC-13 (Th) | 4-1-0 | 4 | 100 |
| 2 | Global Tectonics and Geodynamics (P) | CC-13 (P) | 0-0-4 | 2 | 100 |
| 3 | Engineering Geology and Mineral Resources (Th) | CC-14 (Th) | 4-1-0 | 4 | 100 |
| 4 | Engineering Geology and Mineral Resources (P) | CC-14 (P) | 0-0-4 | 2 | 100 |
| 5 | Discipline Specific Elective- 3 (Th) | DSE- 3 (Th) | 4-1-0 | 4 | 100 |
| 6 | Discipline Specific Elective- 3 (P) | DSE- 3 (P) | 0-0-4 | 2 | 100 |
| 7 | Discipline Specific Elective- 4 (Project/Dissertation) | DSE- 4 | 0-0-6 | 6 | 100 |
| Total credit - 24 | | | | | |

Total Credits – 140***L/T/P: number of classes per week**

DSE/GE may either carry 6 credit, i.e., Theory (4 credit) + Practical (2 credit) format

Or

Consolidated (6 credit) for Theory only

Discipline Specific Elective Course (DSE):

| Course name | L-T-P |
|---|-------|
| 1. Remote Sensing & GIS | 4-1-4 |
| 2. Earth and Climate | 5-1-0 |
| 3. Urban Geology | 5-1-0 |
| 4. Fuel Geology | 4-1-4 |
| 5. Environmental Geology and Geogenic Disaster | 5-1-0 |
| 6. Introduction to Geophysics, Mining & Exploration Geology | 5-1-0 |
| 7. River Science | 5-1-0 |
| 8. Oceanography | 5-1-0 |
| 9. Elements of Geochemistry | 5-1-0 |

Generic Elective (GE):

| For Geology Students | | For Other Students | |
|----------------------|-------|--|-------|
| Course name | L-T-P | Course name | L-T-P |
| 1. Physics | | 1. Fundamentals of the Earth System | 4-1-6 |
| 2. Chemistry | | 2. Geomorphology and Geotectonics | 5-1-0 |
| 3. Botany | | 3. Mineralogy | 4-1-6 |
| 4. Zoology | | 4. Structural Geology | 4-1-6 |
| 5. Mathematics | | 5. Remote Sensing & GIS | 4-1-4 |
| 6. Statistics | | 6. Environmental Geology and Geogenic Disaster | 5-1-0 |
| | | 7. Petrology | 4-1-4 |
| | | 8. Economic Geology & Hydrogeology | 4-1-4 |
| | | 9. Stratigraphy & Palaeontology | 4-1-4 |

Skill Enhancement courses (SEC):

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SEMESTER – I
CC1 : FUNDAMENTALS OF THE EARTH SYSTEM

Course Outcomes

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

- CO1:** Gain comprehensive understanding of the Earth as a planetary body.
CO2: Explain about the plate tectonics, earthquake & volcano.
CO3: Analyze Earth's surface process.

| CC1 : FUNDAMENTALS OF THE EARTH SYSTEM (Credit: 4) | | |
|---|---|------------------------|
| Unit | Topics to be covered | No. of Lectures |
| 1 | <ul style="list-style-type: none"> • Aim, application and various branches of Geology • Solar system; Brief idea about Meteorites • Origin of the Earth • Earth- important physical parameters | 10 |
| 2 | <ul style="list-style-type: none"> • Age of the Earth • Geological time scale • Brief idea of the-<i>Atmosphere, Hydrosphere, Lithosphere, Biosphere</i> | 10 |
| 3 | <ul style="list-style-type: none"> • Elementary idea about the Plate tectonics. • Earthquakes- causes and types • Internal structure of the Earth • Volcano- types and causes. | 12 |
| 4 | <ul style="list-style-type: none"> • Surface processes: Weathering – <i>physical, chemical, biological</i>; Erosion • Brief idea of evolution of various landforms – <i>Glacial, Fluvial, Karst, Eolian</i> • Introduction to Historical Geology • Concept of Stratification; Fossils and Fossilization | 16 |
| TOTAL | | 48 |

Suggested Reading :

1. Holmes, A.: Principles of Physical Geology.
2. Longwell and Flint : Introduction to Physical Geology
3. Dutta, A.K. : An Introduction to Physical Geology
4. Singh, S. : Physical Geography
5. Singh, Praveen : Textbook of Engineering and General Geology
6. Siddarth, K. : Earth's Dynamic Surface
7. Duff, P. M. D., & Duff, D. (Eds.). (1993). Holmes' principles of physical geology. Taylor & Francis
8. Emiliani, C. (1992). Planet earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
9. Gross, M. G. (1977). Oceanography: A view of the earth

| CC1 : FUNDAMENTALS OF THE EARTH SYSTEM (Practical) (2 credit) | |
|--|--|
| Practical | |
| <ul style="list-style-type: none"> • Study of topographic maps • Contour maps • Study of Seismic zones of India • Geological Time Scale/ Hydrogeological Cycle | |

CC2 : MINERALOGY AND CRYSTALLOGRAPHY

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Gain basic knowledge of minerals & their properties
CO2: Comprehend different non-silicate minerals
CO3: Define various Crystal Structure.

| CC2 : MINERALOGY AND CRYSTALLOGRAPHY (Credit: 4) | | |
|---|---|------------------------|
| Unit | Topics to be covered | No. of Lectures |
| 1 | <ul style="list-style-type: none"> • Minerals definition; Rock forming minerals & Ore minerals. • Brief idea of <i>Ionic radii, Ionic substitution & Co-ordination number</i> • Isomorphism, Polymorphism, Pseudomorphism • Physical properties of the minerals: <i>Form, Color, Streak, Lustre, Cleavage, Fracture, Hardness, Specific gravity, Tenacity, Magnetic properties, Electrical properties</i> | 14 |
| 2 | <ul style="list-style-type: none"> • Chemical classification of minerals – <i>native element, sulphides, oxides and hydroxides, halites, carbonate, sulphates, phosphate</i> • Structural classification of silicates. | 10 |
| 3 | <ul style="list-style-type: none"> • Introduction to Crystal and their Characters- <i>Crystal form, Face, Edge, Solid angle, Interfacial angle, Crystallographic axis and angles, Bravais lattice</i> • Introduction to crystal parameters and symmetry elements • Laws of Crystallography | 14 |
| 4 | <ul style="list-style-type: none"> • Fundamental idea of crystal systems. • Detailed study of the following crystal systems: <i>Isometric, Tetragonal, Hexagonal</i> | 10 |
| TOTAL | | 48 |

Suggested Reading :

1. Berry and Mason, (1961). Mineralogy. W. H. Freeman & Co.
2. Dana, E.S. and Foo, W.E., (2002). A Textbook of Mineralogy
3. Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.
4. Flint, Y., (1975). Essentials of crystallography, Mir Publishers.
5. Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
6. Philips, F.C., (1963). An introduction to crystallography. Wiley, New York.
7. Perkin D. (2010) Mineralogy. Pearson
8. Ram S. Sharma and Anurag Sharma (2013) Crystallography and Mineralogy – Concepts and Methods. Text Book Series, Geological Society of India,. Bangalore
9. Read, H. H., (1968) Rutley's Element of Mineralogy. Thomas Murby and Co.

| CC2 : MINERALOGY AND CRYSTALLOGRAPHY (Practical) (Practical: 2 credits) |
|---|
| <p>Practical</p> <ul style="list-style-type: none"> ➤ Clinographic Projection of : Isometric System – Cube, Octahedron, Rhombdodecahedron, and Tetrahedron (+ve and –ve) Tetragonal System – 1st and 2nd order Prism with Basal pinacoids, 1st and 2nd order Pyramids, Zircon, Vesuvianite ➤ Study of the following minerals: |

- Calcite, Gypsum, Talc, Fluorite, Apatite, Topaz, Corundum, Baryte, Kyanite, Haematite, Galena, Bauxite, Psilomelane, Garnet, Nepheline, Beryl, Andalusite, Sillimanite, Tourmaline, Magnetite, Pyrite, Chromite, Pyrolusite.

SEMESTER- II

CC3 : MINERALOGY AND OPTICAL MINERALOGY

Course Outcomes

After the completion of the course, the student will be able to:

CO1: Comprehend basics of Optics and its behavior within minerals

CO2: Gain knowledge and classification of silicate mineral groups

| CC3 : MINERALOGY AND OPTICAL MINERALOGY (Credit: 4) | | |
|---|---|------------------------|
| Unit | Topics to be covered | No. of Lectures |
| 1 | <ul style="list-style-type: none"> • Elementary concepts of Light, Propagation of light through minerals • Polarization • Double refraction | 6 |
| 2 | <ul style="list-style-type: none"> • Petrological Microscope and its function • Construction of Nicol prism • Optical accessories and its uses | 12 |
| 3 | <ul style="list-style-type: none"> • Isotropism and Anisotropism • Important optical properties: <i>Refractive index, Pleochroism, Pleochroic haloes, Extinction and extinction angle, Birefringence, Interference colours, Optical indicatrix</i> | 12 |
| 4 | <ul style="list-style-type: none"> • Detailed study of the following rock forming mineral groups with reference to their Structure, Composition, Classification, Physical and Optical properties, Paragenesis: <i>Olivine, Pyroxene, Amphibole, Mica, Feldspar, Silica polymorphs</i> • Detailed study of the following minerals <i>Hornblende, Tremolite, Actinolite, Hypersthene, Augite, Quartz, Orthoclase, Microcline, Muscovite, Biotite,</i> | 18 |
| | TOTAL | 48 |

Suggested Reading :

1. *Berry and Mason, (1961). Mineralogy. W. H. Freeman & Co.*
2. *Dana, E.S. and Foo, W.E., (2002). A Textbook of Mineralogy*
3. *Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.*
4. *Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.*
5. *Kerr, B. F. (1995). Optical Mineralogy. McGraw-Hill, New York.*
6. *Perkin D. (2010) Mineralogy. Pearson*
7. *Read, H. H., (1968) Rutley's Element of Mineralogy. Thomas Murby and Co.*
8. *Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.*

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| CC3 : MINERALOGY AND OPTICAL MINERALOGY (Practical) (Practical: 2 credits) |
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Practical :

- Megascopic studies of the following minerals :
Quartz, Orthoclase, Microcline, Plagioclase, Muscovite, Biotite, Hornblende, Tremolite, Actinolite, Diopside, Augite, Enstatite, Olivine,
- Microscopic study of common rock forming minerals.
Quartz, Microcline, Plagioclase, Muscovite, Biotite, Hornblende, Augite, Diopside, Olivine

CC4 : STRUCTURAL GEOLOGY**Course Outcomes**

After the completion of the course, the student will be able to:

- CO1:** Gain knowledge of factors responsible for generating structural features of rocks.
CO2: Analyse strain ellipse & ellipsoid.
CO3: Understand the concept & mechanism of folds, faults, Joints & Unconformity.

| CC4 : STRUCTURAL GEOLOGY (Credit: 4) | | |
|---|---|------------------------|
| Unit | Topics to be covered | No. of Lectures |
| 1 | <ul style="list-style-type: none"> • Elementary concepts of structural geology • Idea of Stress and Strain • Ductile vs. Brittle deformation • Lineation, Foliation, Cleavage. | 12 |
| 2 | <ul style="list-style-type: none"> • Attitude of beds, Dip and Strike • Outliers and inliers • Outcrops and outcrop patterns • Clinometer and Brunton compass and its Uses • Joint - definition and types | 12 |
| 3 | <ul style="list-style-type: none"> • Fold – definition and its classification • Causes and mechanism of Folding • Recognition and significance of Fold | 10 |
| 4 | <ul style="list-style-type: none"> • Fault – definition and its classification • Mechanism of Fault • Recognition and significance of Fault • Unconformity- definition and types • Recognition and geological significance of Unconformity | 14 |
| | TOTAL | 48 |

Suggested Reading :

1. Billings, M. P. (1987) *Structural Geology, 4th edition, Prentice-Hall*
2. Davis, G. R. (1984) *Structural Geology of Rocks and Region. John Wiley*
3. Hills, E.S., (1963) *Elements of Structural Geology. Farrold and sons, London.*
4. Lahee F. H. (1962) *Field Geology. McGraw Hill*
5. Park, R. G. (2004) *Foundations of Structural Geology. Chapman & Hall.*
6. Pollard, D. D. (2005) *Fundamental of Structural Geology. Cambridge University Press.*
7. Ragan, D. M. (2009) *Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)*
8. Ramsay, J.G. (1967) *Folding and fracturing of rocks. Mcgraw-Hill, New York*

CC4 : STRUCTURAL GEOLOGY (Practical)
(Practical: 2 credits)

Practical :

- Study of geological maps
- Drawing of geological section and description of their geological history.
- Plotting of Dip & Strike on the stereo-net.

SEMESTER – III
CC5 : GEOMORPHOLOGY

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Explain and classify different Landforms.
CO2: Outline the geomorphology of Indian subcontinents.

| CC5 : GEOMORPHOLOGY (Credit: 4) | | |
|--|---|------------------------|
| Unit | Topics to be covered | No. of Lectures |
| 1 | <ul style="list-style-type: none"> • Definition, Scope and Fundamental concepts of Geomorphology • Endogenic geomorphic processes; Diastrophism • Exogenic geomorphic processes; Weathering, mass wasting, Erosion | 12 |
| 2 | <ul style="list-style-type: none"> • Geomorphic cycle and their interpretations • Brief study of the following <i>Causes of Rejuvenation, Penneplanation, Relief of ocean floor</i> • Drainage patterns and their significance | 12 |
| 3 | <ul style="list-style-type: none"> • Geological work of natural agencies: <ul style="list-style-type: none"> - Wind action and Aeolian landforms - Underground water and Karst topography • Glacial processes and landforms • Fluvial processes and landforms | 12 |
| 4 | <ul style="list-style-type: none"> • Geomorphic features of India <i>Extra Peninsular, Peninsular, Indo-Gangetic plain</i> • Brief study of the Physiography and geomorphology of Bihar | 12 |
| | TOTAL | 48 |

Suggested Reading :

1. Chorley, R. J., (1984) *Geomorphology*. Methuen.
2. M.A. Summerfield (1991) *Global Geomorphology*. Wiley & Sons.
3. Robert S. Anderson and Suzanne P. Anderson (2010): *Geomorphology - The Mechanics and Chemistry of Landscapes*. Cambridge University Press.
4. Selby, M. J., (1996) *Earths Changing Surface*. Oxford University Press, UK
5. Thornbury, W. D., (1997) *Principles of Geomorphology*, Wiley eastern Limited, New Delhi
6. Verma, V. K., (1986) *Geomorphology Earth Surface processes and form*. McGraw Hill.

CC5 : GEOMORPHOLOGY (Practical)
(Practical: 2 credits)

Practical

- Physiographic division & drainage system on outline map of India
- Physiographic division & drainage system on outline map of Bihar.
- Basic exercise on Drainage Pattern.
- Basics of morphometry.

CC6 : IGNEOUS PETROLOGY**Course Outcomes**

After the completion of the course, the student will be able to:

- CO1:** Understand the concept of different rock types
CO2: Know factors and processes of magma generation
CO3: Comprehend various classification of igneous rocks
CO4: Explain the factors responsible for diversity of igneous rocks.
CO5: Understand preliminary idea of phase-equilibria.

| CC6 : IGNEOUS PETROLOGY (Credit: 4) | | |
|--|---|------------------------|
| Unit | Topics to be covered | No. of Lectures |
| 1 | <ul style="list-style-type: none"> • Introduction to Petrology-distinguishing features of three types of rocks. • Magma – Definition, Composition, primary magma • Bowen’s Reaction series: Discontinuous and Continuous series | 8 |
| 2 | <ul style="list-style-type: none"> • Form, Structure and Texture of Igneous rock • Generation and crystallization of Magma • Plate tectonics and Magmatism | 10 |
| 3 | <ul style="list-style-type: none"> • Different schemes of classification of Igneous rock. • Processes of Diversification of Igneous rocks: <i>Fractional crystallization, Gravitational segregation, Thermo-gravitational diffusion, Filter pressing, Liquid immiscibility, Assimilation & Magma mixing</i> | 10 |
| 4 | <ul style="list-style-type: none"> • Introduction to Phase rule; Study of the following Phase diagrams: - <i>Binary: An-Di, Ab-An; Ternary: Ab-An-Di</i> • Petrographic description of the following rock types : <i>Granite, Rhyolite, Syenite, Nepheline-syenite, Monzonite, Diorite, Anorthosite, Gabbro, Basalt, Peridotite, Pyroxenite, Dunite, Trachyte and Andesite.</i> | 20 |
| TOTAL | | 48 |

Suggested Reading :

1. Huang : Petrology
2. Nockolds, Chinner and Kinoshita: Petrology for students
3. Harker : Petrology for students
4. Blatt, Ehler: Petrology (Igneous, Sedimentary and Metamorphic)
5. Hall : Igneous Petrology
6. Hyndman, W.D. : Petrology of Igneous and Metamorphic Rocks
7. Turner and Verhoogen : Igneous and Metamorphic Petrology
8. Hatch and Wells : Petrology of the Igneous Rocks
9. Philpotts : Principles of Igneous and Metamorphic Petrology
10. Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.

11. Winter, J. D. (2014). *Principles of igneous and metamorphic petrology*. Pearson.
12. Rollinson, H. R. (2014). *Using geochemical data: evaluation, presentation, interpretation*. Routledge.
13. Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw-Hill Science Engineering.
14. McBirney, A. R. (1984). *Igneous Petrology*. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press),
15. Myron G. Best (2001). *Igneous and Metamorphic Petrology*,
16. K. G. Cox, J. D. Bell. (1979). *The Interpretation of Igneous Rocks*. Springer/Chapman & Hall.
17. Bose M.K. (1997). *Igneous Petrology*.
18. G W Tyrrell. (1926). *Principles of Petrology*. Springer

| CC6 : IGNEOUS PETROLOGY (Practical) (Practical: 2 credits) | |
|--|--|
| Practical : | |
| <ul style="list-style-type: none"> ➤ Megascopic study of the following rocks: <i>Granite, Syenite, Pegmatite Diorite, Gabbro, Basalt, Rhyolite, Dunite, Trachyte, Obsidian, Pumice, Peridotite, Pyroxenite, Anorthosite, Norite</i> ➤ Microscopic study of the following rocks: <i>Granite, Syenite, Nepheline–syenite, Granodiorite, Diorite, Gabbro Dolerite, Basalt, Peridotite, Anorthosite.</i> ➤ <i>Classification of Igneous rocks by plotting of analyzed data on various sheets.</i> | |

CC7 : METAMORPHIC PETROLOGY

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Explain various agents of Metamorphism and types of metamorphic rocks
CO2: Outline the basic features of rocks and able to classify different metamorphic rock
CO3: Understand preliminary idea of inter-relationship between plate tectonics and metamorphism
CO4: Gain knowledge of basic ideas of metamorphism and different type of metamorphic rock

| CC7 : METAMORPHIC PETROLOGY (Credit: 4) | | |
|--|---|------------------------|
| Unit | Topics to be covered | No. of Lectures |
| 1 | <ul style="list-style-type: none"> • Aims and scope of Metamorphic Petrology • Concept of Metamorphism: <i>Diagenesis, Anataxis, Palingenesis</i> • Concept of Metamorphic Grade, Zones, Isograds, Index minerals | 10 |
| 2 | <ul style="list-style-type: none"> • Agents of metamorphism • Types of Metamorphism • Preliminary ideas of - <i>metamorphic differentiation, Prograde, Retrograde, and Poly-metamorphism, paired metamorphic belts</i> | 10 |
| 3 | <ul style="list-style-type: none"> • Texture of metamorphic rocks • Structure of metamorphic rocks • Classification of metamorphic rocks | 12 |
| 4 | <ul style="list-style-type: none"> • Metamorphic Facies and Facies series | 16 |

| | | |
|--|--|----|
| | <ul style="list-style-type: none"> • Plate tectonics and metamorphism • Petrography of the following metamorphic rocks : <i>Slate, Phyllite, Schists, Gneisses, Amphibolites, Granulite, Marble, Quartzite, Hornfels, Charnockite, Khondalite, Eclogite, Skarns.</i> | |
| | TOTAL | 48 |

Suggested Reading :

1. Tyrell, G.W. : *Principles of Petrology*
2. Huang : *Petrology*
3. Nockolds, Chinner and Kinox: *Petrology for students*
4. Harker : *Petrology for students*
5. Blatt, Ehler: *Petrology (Igneous, Sedimentary and Metamorphic)*
6. Best, M.G. : *Igneous and Metamorphic Petrology*
7. Hyndman, W.D. : *Petrology of Igneous and Metamorphic Rocks*
8. Turner and Verhoogen : *Igneous and Metamorphic Petrology*
9. Philpotts, A., & Ague, J. (2009). *Principles of igneous and metamorphic petrology*. Cambridge University Press.
10. Winter, J. D. (2014). *Principles of igneous and metamorphic petrology*. Pearson.
11. Rollinson, H. R. (2014). *Using geochemical data: evaluation, presentation, interpretation*. Routledge.
12. Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw-Hill Science Engineering.
13. Yardley, B. W., & Yardley, B. W. D. (1989). *An introduction to metamorphic petrology*. Longman Earth Science Series

| |
|--|
| CC7 : METAMORPHIC PETROLOGY (Practical) (Practical: 2 credits) |
| <p>Practical</p> <ul style="list-style-type: none"> ➤ Megascopic study of the following rocks: <i>Slate, Phyllite Schist, Gneisses, Marble, Charnockite, Amphibolite, Khondalite</i> ➤ Microscopic study of the following rocks: <i>Schists, Gneisses, Amphibolite, Charnockite</i> |

SEMESTER – IV
CC8 : SEDIMENTOLOGY

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Explain the different processes responsible for the formation of sedimentary rocks.
- CO2:** Outline the basic features of sedimentary rocks and classify them.
- CO3:** Identify the fundamental differences between various sedimentary environments and their significance in geological studies.

| CC8 : SEDIMENTOLOGY (Credit: 4) | | |
|--|--|-----------------|
| Unit | Topics to be covered | No. of Lectures |
| 1 | <ul style="list-style-type: none"> • Processes of formation of Sedimentary rocks. • Lithification and Diagenesis. • Provenance & Heavy minerals | 11 |

| | | |
|---|--|----|
| 2 | <ul style="list-style-type: none"> Elementary idea of Sedimentary Environments: <i>Physical parameters and Chemical parameters</i> Classification of sedimentary rocks | 11 |
| 3 | <ul style="list-style-type: none"> Texture of Sedimentary Rocks Elementary ideas of Grain Size, Particle Shape and Fabric. Clastic and Non-clastic rocks | 12 |
| 4 | <ul style="list-style-type: none"> Structures of Sedimentary Rocks: <i>Primary, Secondary, Biogenic</i> Petrographic study of the following rocks:- <i>Conglomerate, Breccia, Sandstone – Arkose, Greywacke, Orthoquartzite, Limestone, Dolomite, Shale.</i> | 14 |
| | TOTAL | 48 |

Suggested Reading :

- Allen, J.R.L., (1985). *Principles of Physical Sedimentology*. George Allen and Unwin, London.
- Blatt, H., Middleton, G., and Murray, R., (1980). *Origin of Sedimentary rocks*. Princeton Hall.
- Boggs, S.: *Petrology of Sedimentary Rocks*, Cambridge University Press.
- Collinson, J. D. & Thompson, D. B. (1988) *Sedimentary structures*, Unwin- Hyman, London.
- Folk, R. L., (1974). *Petrology of Sedimentary Rock*. Hemphill Publishing Company, Austin, Texas
- Harker : *Petrology for students*
- Huang : *Petrology*
- Nichols, G. (2009) *Sedimentology and Stratigraphy Second Edition*. Wiley Blackwell
- Nockolds, Chinner and Kinnox: *Petrology for students*
- Pettijohn, F. J., (1984) *Sedimentary rocks*, Harper & Bros.
- Prothero, D. R., & Schwab, F. (2004). *Sedimentary geology*. Macmillan.
- Sengupta, S. M., (2007). *Introduction to Sedimentology*, CBS Publishers and Distributor, New Delhi.
- Tyrell, G.W. : *Principles of Petrology*
- Tucker, M. E. (2006) *Sedimentary Petrology*, Blackwell Publishing.

CC8 : SEDIMENTOLOGY (Practical) (Practical: 2 credits)

Practical

- Megascopic study of the following rocks:
Conglomerate, Breccia, Sandstones – Orthoquartzite, Arkose, Greywacke, Limestone, Dolomite, Shale.
- Microscopic study of the following rocks:
Sandstone, Orthoquartzite, Arkose, Greywacke.

CC9 : STRATIGRAPHY

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** apply principles of stratigraphy in various geological studies.
CO2: give a brief idea of geology of India including major cratons and basins of India.
CO3: present a comprehensive idea of Geological evolution of Indian continent.

CC9 : STRATIGRAPHY (Credit: 4)

| Unit | Topics to be covered | No. of Lectures |
|--------------|--|-----------------|
| 1 | <ul style="list-style-type: none"> Principles of Stratigraphy Methods of Stratigraphic correlation Brief idea about <i>Lithostratigraphy, Biostratigraphy and Chronostratigraphy</i> Brief study of – <i>cratons and mobile belts</i> | 12 |
| 2 | <ul style="list-style-type: none"> Brief account of the stratigraphy with special reference to classification, distribution, lithology, fossil content (if any) and economic significance of <ul style="list-style-type: none"> Archaean of <i>Dharwar and Singhbhum</i> Proterozoic basins: <i>Cuddapah and Vindhyan</i> | 14 |
| 3 | <ul style="list-style-type: none"> Brief account of the stratigraphy of the following with special reference to classification, distribution, lithology, fossils, and economic significance. <ul style="list-style-type: none"> <i>Gondwana Supergroup, Jurassic of Kutch, Cretaceous of South India</i> | 11 |
| 4 | <ul style="list-style-type: none"> Brief account of the stratigraphy of the following with special reference to classification, distribution, lithology, fossil content and economic significance <ul style="list-style-type: none"> <i>Tertiary of Assam, Siwalik group</i> Brief idea of important stratigraphic boundaries in India | 11 |
| TOTAL | | 48 |

Suggested Reading :

1. Krishnan, M. S. (1982) *Geology of India and Burma*, CBS Publishers, Delhi
2. Doyle, P. & Bennett, M. R. (1996) *Unlocking the Stratigraphic Record*. John Wiley
3. Ramakrishnan, M. & Vaidyanadhan, R. (2008) *Geology of India Volumes 1 & 2, Geological society of India, Bangalore.*
4. Ravindrakumar (2018). *Fundamentals of Historical Geology and Stratigraphy of India*, Newage Publication
5. Valdiya, K. S. (2010) *The making of India*, Macmillan India Pvt. Ltd
6. Wadia, D., (1973). *Geology of India*. McGraw Hill

| CC9 : STRATIGRAPHY (Practical) (Practical: 2 credits) |
|---|
| <p>Practical :</p> <ul style="list-style-type: none"> ➤ Distribution of Stratigraphic formation on the outline map of India. <ul style="list-style-type: none"> - <i>Dharwar, Singhbhum, Cudappah, Vindhyan, Gondwana</i> ➤ Study of stratigraphic rocks of <ul style="list-style-type: none"> - <i>Khondalite, Charnockite, Singhbhum Granite, Kolhan conglomerate, BHJ, BHQ, Vindhyan Sandstone, Rohtas Limestone, Porcellanite, Rajgir Quartzite, Rajgir Phyllites, Talchir sandstone, Barakar sandstone, Rajmahal Traps, Talchir Shale</i> |

CC10 : PALAEOLOGY

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Identify and differentiate various types of fossils.
- CO2:** Explain the different theories regarding evolution of life and mass extinctions.
- CO3:** Understand the importance of fossils in studying past life.

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| CC10 : PALAEOLOGY |
|--------------------------|

| (Credit: 4) | | |
|--------------------|--|------------------------|
| Unit | Topics to be covered | No. of Lectures |
| 1 | <ul style="list-style-type: none"> • Definition and Types of Fossil • Modes of preservation of fossils • Ichnofossils; Index fossil Uses of Fossils | 12 |
| 2 | <ul style="list-style-type: none"> • Theories of organic evolution • Life through geologic ages • Mass Extinctions | 12 |
| 3 | <ul style="list-style-type: none"> • Classification, Morphology and Geological history: <i>Gastropoda, Bivalvia, Cephalopoda, Brachiopoda, Trilobita</i> | 14 |
| 4 | <ul style="list-style-type: none"> • Significance of Gondwana flora • Extinction of Siwalik mammals Microfossils and their significance | 10 |
| | TOTAL | 48 |

Suggested Reading :

1. Cowen, R., (2000). *History of Life. Blackwell Science.*
2. Doyle, P.: *Understanding Fossils: An Introduction to Invertebrate Palaeontology.*
3. Raup, D. M., Stanley, S. M., Freeman, W. H. (1971) *Principles of Paleontology*
4. Clarkson, E. N. K. (2012) *Invertebrate paleontology and evolution 4th Edition by Blackwell Publishing.*
5. Benton, M. (2009). *Vertebrate paleontology. John Wiley & Sons.*
6. Shukla, A. C., & Misra, S. P. (1975). *Essentials of paleobotany. Vikas Publisher*
7. Armstrong, H. A., & Brasier, M.D. (2005) *Microfossils. Blackwell Publishing.*
8. Woods, Henry : *Invertebrate Palaeontology*

| CC10 :PALAEONTOLOGY (Practical) (Practical: 2 credits) | |
|---|--|
| Practical : | |
| <ul style="list-style-type: none"> ➤ Identification of fossils and their geological age: <i>invertebrate, vertebrate, plant fossils</i> ➤ Drawing of fossils based on morphological features. | |

SEMESTER – V
CC11 : HYDROGEOLOGY
Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Explain the fundamentals of hydrogeology.
CO2: Define the movement and distribution of groundwater.
CO3: Differentiate between various types of hydrostratigraphic units.
CO4: Define physio-chemical nature of groundwater

| CC11 : HYDROGEOLOGY (Credit: 4) | | |
|--|--|------------------------|
| Unit | Topics to be covered | No. of Lectures |
| 1 | <ul style="list-style-type: none"> • Hydrogeology: concepts, scope and its societal relevance | 10 |

| | | |
|---|--|----|
| | <ul style="list-style-type: none"> Hydrologic cycle: <i>precipitation, evapo-transpiration, infiltration, run-off and subsurface movement of water</i> Hydrogeological properties of water-bearing formation: <i>Porosity, Permeability</i> | |
| 2 | <ul style="list-style-type: none"> Origin and types of Groundwater: <i>Juvenile water, Connate water, Meteoric water, Vadose water</i> Vertical distribution of subsurface water; Zone of aeration and zone of saturation Water table and Piezometric surface | 10 |
| 3 | <ul style="list-style-type: none"> Types of Aquifer: <i>Unconfined, Confined and Leaky aquifers.</i> Springs and their Types Artificial recharge of groundwater | 14 |
| 4 | <ul style="list-style-type: none"> Physical and chemical properties of water and water quality Elementary idea of Groundwater flow; Darcy's law Groundwater resources of Bihar | 14 |
| | TOTAL | 48 |

Suggested Reading :

1. Davis, S. N. and De Weist, R.J.M. 1966. *Hydrogeology*, John Wiley & Sons Inc., N.Y.
2. Hudak, P. F., (1999). *Principle of Hydrogeology*, Lewis Publishers
3. Freeze, R. A., and Cherry, J.A. (1979). *Groundwater*, Prentice Hall
4. Karanth K.R., 1987, *Groundwater: Assessment, Development and management*, Tata McGrawHill Pub. Co. Ltd.
5. Raghunath, H. M., (1987). *Groundwater*, New Age International
6. Todd, D. K. 2006. *Groundwater hydrology*, 2nd Ed., John Wiley & Sons, N.Y.

| | |
|---|--|
| CC11 : HYDROGEOLOGY (Practical) (Practical: 2 credits) | |
| Practical : | |
| <ul style="list-style-type: none"> Hydrogeological properties of Rocks <ul style="list-style-type: none"> - Granite, Basalt, Rhyolite - Sandstone, Limestone, Shale - Gneiss, Schist, Quartzite Study and drawing of hydrogeological provinces of Bihar | |

CC12 : ECONOMIC GEOLOGY

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Identify and distinguish various ore minerals and their deposits.
CO2: Present a comprehensive idea about genesis and distribution of major ore minerals and associated host rocks.
CO3: Describe the various exploration methods for mineral deposits

| CC12 : ECONOMIC GEOLOGY (Credit: 4) | | |
|--|---|-----------------|
| Unit | Topics to be covered | No. of Lectures |
| 1 | <ul style="list-style-type: none"> Introduction to Ore, Ore mineral, gangue, Ore tenor, Cut-off grade. Forms and structure of ore deposits. Classification of Ore deposits | 10 |

| | | |
|--------------|---|----|
| 2 | <ul style="list-style-type: none"> Processes of formation of mineral deposits with special reference to: <i>Magmatic Concentration, Hydrothermal processes, Supergene Sulphide enrichment</i> | 14 |
| 3 | <ul style="list-style-type: none"> Processes of formation of mineral deposits with special reference to: <i>Residual deposits, Placer deposits.</i> Metallogenic epochs and provinces | 12 |
| 4 | <ul style="list-style-type: none"> Brief idea of relationship between Plate Tectonics and Mineral deposits. Prospecting and exploration methods - <i>Geological, Geophysical, Geochemical</i> | 12 |
| TOTAL | | 48 |

Suggested Reading :

1. Jenson and Bateman: *Economic Mineral Deposits*
2. Prasad, U.: *Economic Geology*
3. Brown, C. and Dey, A.K.: *Indian Mineral Wealth*
4. Sinha and Sharma: *Mineral Economics*
5. Tarlings: *Economic Geology and Geotectonics*
6. Riley, Charles M.: *Our Mineral Resources*
7. Bagchi, Sengupta and Rao: *Elements of Prospecting and Exploration*
8. Kesler, Stephen E.: *Mineral Resources, Economics and the Environment*
9. Guilbert, J.M. and Park Jr., C.F. (1986) *The Geology of Ore deposits. Freeman & Co.*
10. Evans, A.M. (1993) *Ore Geology and Industrial minerals. Wiley*
11. Laurence Robb. (2005) *Introduction to ore forming processes. Wiley.*
12. Gokhale, K.V.G.K. and Rao, T.C. (1978) *Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.*
13. Deb, S. (1980) *Industrial minerals and rocks of India. Allied Publishers.*
14. Sarkar, S.C. and Gupta, A. (2014) *Crustal Evolution and Metallogeny in India. Cambridge Publications*

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|---|--|
| CC12 : ECONOMIC GEOLOGY (Practical) (Practical: 2 credits) | |
| Practical : | |
| <ul style="list-style-type: none"> ➤ Megascopic study of important ore and economic minerals. <i>Talc, Graphite, Gypsum, Calcite, Fluorite, Apatite, Topaz, Corundum, Beryl, Barite, Kyanite, Sillimanite, Hematite, Magnetite, Chromite, Chalcopyrite, Malachite, Azurite, Bauxite, Galena, Pyrite, , Ilmenite, Rutile, Monazite, Garnet, Asbestos, Diamond, Fire clay, and China clay.</i> | |
| Distribution of economic minerals on the outline map of India. | |

SEMESTER – VI
CC13 : GLOBAL TECTONICS AND GEODYNAMICS

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Understand the various theories of geo-tectonics.
CO2: Explain the tectonic framework of the earth.

| CC13 : GLOBAL TECTONICS AND GEODYNAMICS (Th) (Credit: 4) | | |
|---|---|-----------------|
| Unit | Topics to be covered | No. of Lectures |
| 1 | <ul style="list-style-type: none"> Concept of Diastrophism, Orogeny and Epirogeny Isostasy: Airy's and Pratt's Hypothesis | 10 |

| | | |
|--------------|---|----|
| 2 | <ul style="list-style-type: none"> Continental Drift : Wegner's Hypothesis Evidences of Continental Drift Concept of sea floor spreading | 12 |
| 3 | <ul style="list-style-type: none"> Brief idea of the following: <i>Paleomagnetism, Palaeoclimate, Polar wandering, Island arcs, Rift Valley</i> Mountains – Types, character and origin | 14 |
| 4 | <ul style="list-style-type: none"> Concept of Plate tectonics. Types of Plate boundary: Convergent , Divergent and Conservative boundaries Structure and evolution of Himalayas | 12 |
| TOTAL | | 48 |

Suggested Reading :

1. Badgley, P. C., (1965). *Structural and Tectonic Principles*, Harper & Row.
2. Belousov, V.V., (1980). *Geotectonics*, Springer-Verlag Berlin Heinemann
3. Condie. Kent. C., *Plate Tectonics and Crustal Evolution*, Pergamon Press
4. Gass I.G., *Understanding the Earth*. Artemis Press (Pvt.) Ltd. U.K.
5. Moores, E. M. and Twiss, R. J., (1995). *Tectonics*, W. H. Freeman
6. Singh, S. : *Physical Geography*
7. Steers, J.A. : *The Unstable Earth*
8. Valdiya, K.S., (1984). *Aspects of Tectonics*, Tata McGrath Hills.
9. Wiley : *Dynamic Earth*

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| CC13 : GLOBAL TECTONICS AND GEODYNAMICS (Practical) (Practical: 2 credits) |
| Practical <ul style="list-style-type: none"> ➤ Tectonic maps of India ➤ Study of different plate boundaries on world map ➤ Study of Paleogeographic maps |

CC14 : ENGINEERING GEOLOGY AND MINERAL RESOURCES

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Carry out the sampling for exploration and exploitation purpose of mineral deposits.
- CO2:** Define physio-mechanical properties of rocks.
- CO3:** Define the role of geology in the planning and construction of civil structures..
- CO4:** Understand and describe the Genesis and distribution of major ore minerals and associated host rocks
- CO5:** identify the major economic minerals.

| CC14 : ENGINEERING GEOLOGY AND MINERAL RESOURCES (Credit: 4) | | |
|---|---|-----------------|
| Unit | Topics to be covered | No. of Lectures |
| 1 | <ul style="list-style-type: none"> Sampling: Principle, Methods, Size and Quantity Pits, Trenches, Bore-holes and Logging Geology and mineral resources of Bihar | 10 |
| 2 | <ul style="list-style-type: none"> Engineering properties of Rocks | 14 |

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|---|---|----|
| | <ul style="list-style-type: none"> Role of Geology in planning and Construction of Engineering Projects: <i>Dam site selection, Tunnels, Bridge and Road alignment</i> | |
| 3 | <ul style="list-style-type: none"> Detailed study of the following economic mineral deposits of India: <i>Iron, Manganese, Base-metals, Coal and Petroleum, Atomic minerals</i> | 10 |
| 4 | <ul style="list-style-type: none"> A brief study of the physical properties, chemical composition, mode of occurrence, uses and distribution of following economic minerals in India: <i>Galena, Chromite, Ilmenite, Rutile, Monazite, Barite, Garnet, Beryl, Graphite, Talc, Gypsum, Calcite, Fluorite, Apatite, Feldspar, Quartz, Topaz, Corundum, Diamond, Kyanite, Sillimanite, Asbestos, Fire clay, and China clay.</i> | 14 |
| | TOTAL | 48 |

Suggested Reading :

- Bell, F.G., (2006). *Basic Environmental and Engineering Geology* Whittles Publishing.
- Bell, F.G., (2007). *Engineering Geology*, Butterworth-Heineman
- Brown, C. and Dey, A.K. : *Indian Mineral Wealth*
- Deb, S. (1980) *Industrial minerals and rocks of India*. Allied Publishers.
- Gokhale, K.V.G.K. and Rao, T.C. (1978) *Ore deposits of India their distribution and processing*, Tata-McGraw Hill, New Delhi.
- Goodman, R.E., 1993. *Engineering Geology: Rock in Engineering constructions*. John Wiley & Sons, N.Y.
- Johnson, R.B. and De Graf, J.V. 1988. *Principles of Engineering Geology*, John Wiley.
- Kesler, Stephen E. : *Mineral Resources, Economics and the Environment*
- Krynin, D.P. and Judd W.R. 1957. *Principles of Engineering Geology and Geotechnique*, McGraw Hill (CBS Publ).
- Prasad, U. : *Economic Geology*
- Ramakrishnan, M. &Vaidyanadhan, R. (2008) *Geology of India Volumes 1 & 2, Geological society of India, Bangalore.*
- Riley, Charles M. : *Our Mineral Resources*
- Sinha and Sharma : *Mineral Economics*
- Wadia : *Minerals of India*
- Waltham, T., 2009. *Foundations of Engineering Geology (3rd Edn.)* Taylor & Francis.

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| CC14 : ENGINEERING GEOLOGY AND MINERAL RESOURCES (Practical) (Practical: 2 credits) |
| Practical <ul style="list-style-type: none"> ➤ Structural problems relating to dip and strike & thickness of beds, three-point problems. ➤ Megascopic study of important ore and economic minerals. ➤ Distribution of Economic deposits on the map of India & World |

Discipline Specific Elective (DSE)

DSE1 : REMOTE SENSING & GIS

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Understand the basics of aerial photography and its application in Geology
CO2: Explain the principles, applications of Remote Sensing and Geographic Information System.

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| DSE1 : REMOTE SENSING & GIS |
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| (Credit: 4) | | |
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| Unit | Topics to be covered | No. of Lectures |
| 1 | <ul style="list-style-type: none"> • Introduction to aerial photographs; Advantages & Interpretation • Types of aerial photographs and classification • Scale of aerial photographs • Principles of stereoscopic viewing | 12 |
| 2 | <ul style="list-style-type: none"> • Basic concepts in remote sensing, electromagnetic spectrum • EMR interaction with atmosphere and earth surface • Atmospheric windows, atmospheric effects on remotely sensed data | 10 |
| 3 | <ul style="list-style-type: none"> • Types of satellites and images. • Sensors and their characteristics, Sensor platforms. • Spatial, spectral and temporal resolution • Introduction to Digital Image Processing • Indian Remote Sensing satellites | 14 |
| 4 | <ul style="list-style-type: none"> • Introduction to GIS, Components of GIS, Hardware and software requirements • Data input, Data output and visualization, Raster and vector data • Geo-referencing, Map projections GPS and its applications | 12 |
| TOTAL | | 48 |

Suggested Reading :

1. Demers, M.N., 1997. *Fundamentals of Geographic Information System*, John Wiley & sons. Inc.
2. Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001. *GPS: Theory & Practice*, Springer Wien New York.
3. Jensen, J.R., 1996. *Introductory Digital Image Processing: A Remote Sensing Perspective*, Springer-Verlag.
4. Lillesand, T. M. & Kiefer, R.W., 2007. *Remote Sensing and Image Interpretation*, Wiley.
5. Richards, J.A. and Jia, X., 1999. *Remote Sensing Digital Image Analysis*, Springer-Verlag

| DSE1 : REMOTE SENSING & GIS (Practical) (2 credits) | |
|---|--|
| Practical : | |
| <ul style="list-style-type: none"> ➤ Toposheet reading, Contours, spot heights ➤ Scale conversion: RF, linear, Verbal ➤ Stereoscopic study of Aerial photographs | |

DSE2 : ENVIRONMENTAL GEOLOGY AND GEOGENIC DISASTER

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Understand the structure and functions of ecosystem. Natural and anthropogenic factors affecting Environment.
- CO2:** Explain natural disasters and its mitigation

| DSE2 : ENVIRONMENTAL GEOLOGY AND GEOGENIC DISASTER (Credit: 6) | | |
|---|--|------------------------|
| Unit | Topics to be covered | No. of Lectures |
| 1 | <ul style="list-style-type: none"> • Introduction to Environmental geology • Interaction between Human activities and the natural environment • Pollution: Point, line and area source of Pollution | 12 |

| | | |
|---|--|-----------|
| | <ul style="list-style-type: none"> Water Quality Parameters and BIS standards | |
| 2 | <ul style="list-style-type: none"> Organic & Inorganic Pollutants Heavy Metal Pollution Remedial measures of pollution | 10 |
| 3 | <ul style="list-style-type: none"> Earthquakes: Causes, Effects and Mitigation Magnitude and Intensity of Earthquakes Seismic Hazard Zoning Map Volcanoes and Volcanic hazards | 12 |
| 4 | <ul style="list-style-type: none"> Floods: Interaction between rivers and its flood plain Flood plain mapping and zoning Landslides –Causes, Types and Mitigation | 14 |
| 5 | <ul style="list-style-type: none"> Cyclones- Monitoring Droughts – Meteorological, Agriculture and Hydrological types Climate change | 12 |
| | TOTAL | 60 |

Suggested Reading :

- Bell, F.G., 1999. *Geological Hazards*, Routledge, London.
- Bryant, E., 1985. *Natural Hazards*, Cambridge University Press.
- Keller, E. A., (1987). *Environmental Geology*, Shales E. Merrill Publishing Co., Columbus, Ohio.
- Liu, B. C., (1981). *Earthquake Risk and Damage*, Westview.
- Montgomery, C., (1984). *Environmental Geology*, John Wiley and Sons, London.
- Sharma, J. P., *Environmental Studies*, Laxmi Publications (P) Ltd., New Delhi.
- Smith, K., 1992. *Environmental Hazards*. Routledge, London.
- Subramaniam, V., 2001. *Textbook in Environmental Science*, Narosa International
- Valdiya, K. S., (1987). *Environmental Geology- Indian context*. Tata Mcgraw Hill, New Delhi

DSE3 : FUEL GEOLOGY

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Understand the basic of coal, its types, formation and qualitative analysis.
CO2: Explain of coal deposits and its geographical distribution in India.
CO3: Understand the geological processes of oil and gas formation, movement, entrapment and its deposits in india.

| DSE3 : FUEL GEOLOGY (Credit: 4) | | |
|--|--|------------------------|
| Unit | Topics to be covered | No. of Lectures |
| 1 | <ul style="list-style-type: none"> Definition and origin of Coal Classification of coal Fundamentals of Coal Petrology: lithotypes, microlithotypes and macerals in coal Proximate and Ultimate analysis | 14 |
| 2 | <ul style="list-style-type: none"> Coal carbonization Coal Bed Methane (CBM) Distribution of Gondwana & Tertiary coal | 10 |
| 3 | <ul style="list-style-type: none"> Chemical composition and physical properties of crudes in | 12 |

| | | |
|---|--|----|
| | nature <ul style="list-style-type: none"> • Origin of petroleum Migration & Accumulation of Petroleum | |
| 4 | <ul style="list-style-type: none"> • Basic ideas of Reservoir rocks & traps. • Cap rocks- definition and general properties. • Petroliferous basins of India. | 12 |
| | TOTAL | 48 |

Suggested Reading :

1. Bastia, R., & Radhakrishna, M. (2012). *Basin evolution and petroleum prospectivity of the continental margins of India (Vol. 59)*. Newnes
2. Bjorlykke, K., (1989). *Sedimentology and petroleum geology*. Springer-Verlag.
3. Chandra D. (2007). *Chandra's Text book on applied coal petrology*. Jijnasa Publishing House.
4. Colin R. Ward (Edited), *Coal Geology and Technology*.
5. F.K. North, *Petroleum Geology*, (Publishers- Allen and Unwiry.)
6. North, F.K., 1985, *Petroleum Geology*, Allen and Unain.
7. Shelly R.C. (2014). *Elements of Petroleum geology: Third Edition, Academic Press*
8. Singh, M.P. (Ed.) 1998 - *Coal and Organic Petrology*. Publ. Corp. New Delhi.
9. Tissot B.P. and Welge, D. ll., 1986, *Petroleum Formation Occurrence Springer Verla*
10. Wilcon and Wells , *Coal, Coke and Coal chemical*

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| DSE3 : FUEL GEOLOGY (Practical) (Practical: 2 credits) |
| Practical : <ol style="list-style-type: none"> 1. Identification of coal samples. 2. Distribution of various fuel / hydrocarbon resources on outline map of India, Study of geological maps, Isopach maps and sections of important oilfields of India, |

DSE4 : EARTH AND CLIMATE

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Explain global climate system and controlling factors.
- CO2:** Understand atmosphere, atmospheric circulation, concept and mechanism of Indian monsoon.
- CO3:** Develop an integrated perspective on climate change and its effect

| DSE4 : EARTH AND CLIMATE (Credit: 6) | | |
|---|---|--------------|
| Unit | Topics to be covered | No. of hours |
| 1 | <ul style="list-style-type: none"> • Components of the climate system • Climate controlling factors • Earth's heat budget. | 8 |
| 2 | <ul style="list-style-type: none"> • Layering of atmosphere and atmospheric Circulation • Atmosphere and ocean interaction and its effect on climate • Global oceanic conveyor belt and its control on earth's climate | 16 |
| 3 | <ul style="list-style-type: none"> • Mechanism of monsoon • Factors associated with monsoonal intensity • Effects of monsoon | 10 |
| 4 | <ul style="list-style-type: none"> • Response of biosphere to Earth's climate • Climate Change: natural vs. anthropogenic effects • Brief introduction to archives of climate change | 14 |

| | | |
|---|--|----|
| 5 | <ul style="list-style-type: none"> • Milankovitch cycles and variability in the climate • Pleistocene Glacial-Interglacial cycles • Marine isotope stages | 12 |
| | TOTAL | 60 |

Suggested Reading :

1. Rudiman, W.F., (2001). *Earth's climate: past and future. Edition 2, Freeman Publisher.*
2. Rohli, R. V., and Vega, A. J., (2007). *Climatology. Jones and Barlett*
3. Lutgens, F., Tarbuck, E., and Tasa, D., (2009). *The Atmosphere: An Introduction to Meteorology. Pearson Publisher*
4. Aguado, E., and Burt, J., (2009). *Understanding weather*

DSE5 : OCEANOGRAPHY

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Understand the ocean topography and global ocean circulation
CO2: Explain atmosphere-ocean interaction and Indian monsoon system.
CO3: Understand extensive marine resources and factors affecting marine life.

| DSE5 : OCEANOGRAPHY (Credit: 6) | | |
|--|--|---------------------|
| Unit | Topics to be covered | No. of hours |
| 1 | <ul style="list-style-type: none"> • Definitions & Scope of Oceanography • Bottom relief of Ocean floor; Hypsographic curve - <i>continental shelf, slope, rise and abyssal plains, submarine canyons</i> • Introduction to Ocean Stratification/Layers | 12 |
| 2 | <ul style="list-style-type: none"> • Source & Nature of Marine deposits • Classification of Marine Sediments • Methods to study Marine Sediments • Laws of the Sea | 12 |
| 3 | <ul style="list-style-type: none"> • Structure and chemical composition of the Atmosphere • Atmosphere - Ocean Interaction • Concept of Coriolis Effect • India Monsoon System | 12 |
| 4 | <ul style="list-style-type: none"> • Physical and chemical properties of sea water and their spatial variations. • Residence times of elements in sea water. • Concept of Thermohaline circulation and Oceanic Conveyor Belt • El Niño and La Niña | 12 |
| 5 | <ul style="list-style-type: none"> • Primary productivity in the Oceans • Environmental Factors for Marine Life – Physical and Biological factors • Communities of Oceans – Pelagic and Benthic Communities | 12 |
| | TOTAL | 60 |

Suggested Reading :

1. Garrison, Tom, 2011. *Essentials of Oceanography, Brooks/Cole; International edition.*
2. Thomas D. & Bowers D., 2012. *Introducing Oceanography (Introducing Earth and Environmental Sciences); Dunedin Academic Press.*
3. Ruddiman, W.F., 2008, *Earth's Climate Past and Future, WH Freeman & Co.*
4. Bender, M., 2013, *Paleoclimate, Princeton Premiers in Climate.*
5. Kenneth, J., 1982, *Marine Geology and Geophysics.*
6. Wright J. and Colling A., 1995, *Seawater: its composition, properties and behaviors, The Open University.*

DSE6 : RIVER SCIENCE

Course Outcomes

After the completion of the course, the student will be able to:

CO1: dynamic characters of a river understand system.

CO2: Explain the evolution fluvial morphology and stream management.

| DSE6 : RIVER SCIENCE (Credit: 6) | | |
|-------------------------------------|---|--------------|
| Unit | Topics to be covered | No. of hours |
| 1 | <ul style="list-style-type: none">Physical properties of water, sediment and channel flowRiver discharge, River hydrographs (UH, IUH, SUH, GIUH) and its application in hydrological analysis.Flood frequency analysis | 12 |
| 2 | <ul style="list-style-type: none">Sediment load and sediment yieldSediment transport processes in riversErosion and sedimentation processes in channel. | 12 |
| 3 | <ul style="list-style-type: none">Quantitative analysis of network organization- morphometryRole of drainage network in flux transferEvolution of drainage network in geological time scale. | 12 |
| 4 | <ul style="list-style-type: none">Patterns of alluvial rivers - braided, meandering and anabranching channels,Dynamics of alluvial riversDifferent classification approaches in fluvial geomorphology and its applications. | 12 |
| 5 | <ul style="list-style-type: none">River response to climate, tectonics and human disturbanceBedrock channel processes and evolution of fluvial landscapes.Integrated approach to stream management | 12 |
| | TOTAL | 60 |

Suggested Reading :

1. Bryirely and Fryirs (2005) *Geomorphology and river management*. Blackwell Pub.
2. Davies, T. (2008) *Fundamentals of hydrology*. Routledge Publications.
3. Julien, P. Y. (2002) *River Mechanics*. Cambridge University Press Knighton, D. (1998) *Fluvial forms and processes: A new perspective*. Arnold Pubs.
4. Richards. K. (2004) *Rivers: Forms and processes in alluvial channels*. Balckburn Press.
5. Robert, A. (2003) *River Processes: An introduction to fluvial dynamics*. Arnold Publications.
6. Tinkler, K. J., Wohl, E. E. (eds.) 1998. *Rivers over rock*. American Geophysical Union Monogrpah, Washington, DC.
7. Vanoni, V. A. (2006) *Sedimentation Engineering*. ASCE Manual, Published by American Society of Civil Engineering

DSE7 : INTRODUCTION TO GEOPHYSICS, MINING & EXPLORATION GEOLOGY

Course Outcomes

After the completion of the course, the student will be able to:

CO1: Understand different components of geophysics and its applications in mining.

CO2: Explain different geophysical exploration methods and estimation of natural reserve and resources

| DSE7 : INTRODUCTION TO GEOPHYSICS, MINING & EXPLORATION GEOLOGY (Th) (Credit: 6) | | |
|---|--|---------------------|
| Unit | Topics to be covered | No. of hours |
| 1 | <ul style="list-style-type: none"> • Inter-relationship between geology and geophysics • Preliminary ideas of the geophysical anomalies • Different types of survey, Scales of survey; Profiling and Sounding techniques | 10 |
| 2 | <ul style="list-style-type: none"> • Brief idea of the principles and applications of different types of geophysical methods: <i>gravity, magnetic, electrical and seismic</i> | 14 |
| 3 | <ul style="list-style-type: none"> • Resource & reserve • Mineral resources in industries • A brief overview of classification of mineral deposits | 10 |
| 4 | <ul style="list-style-type: none"> • Principles of Prospecting and exploration • Sampling, subsurface sampling including pitting, trenching and drilling • Geochemical exploration. | 12 |
| 5 | <ul style="list-style-type: none"> • Principles of reserve estimation, density and bulk density • Factors affecting reliability of reserve estimation • Reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks) • Regular and irregular grid patterns, statistics and error estimation | 14 |
| TOTAL | | 60 |

Suggested Reading :

1. *Outlines of Geophysical Prospecting- A manual for geologists* by Ramachandra Rao, M. B., Prasaranga, University of Mysore, Mysore, 1975.
2. *Exploration Geophysics- An Outline* by Bhimasarikaram V.L.S., Association of Exploration Geophysicists, Osmania University, Hyderabad, 1990.
3. Dobrin, M.B. (1984) *An introduction to Geophysical Prospecting*. McGraw-Hill, New Delhi.
4. Telford, W.M., Geldart, L.P., & Sheriff, R.E. (1990). *Applied geophysics (Vol.1)*. Cambridge university press.
5. Lowrie, W. (2007). *Fundamentals of geophysics*. Cambridge University Press.
6. Clark, G.B. 1967. *Elements of Mining*. 3rd Ed. John Wiley & Sons.
7. Arogyaswami, R.P.N. 1996 *Courses in Mining Geology*. 4th Ed. Oxford- IBH.
8. Moon, C.J., Whateley, M.K.G., Evans, A.M., 2006, *Introduction to Mineral Exploration*, Blackwell Publishing.

DSE8 : ELEMENTS OF GEOCHEMISTRY

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Explain the key concepts of geochemistry.
CO2: Understand the interrelation between different spheres of geochemistry.
CO3: Explain various applications of geochemistry.

| DSE8 : ELEMENTS OF GEOCHEMISTRY (Credit: 6) | | |
|--|---|---------------------|
| Unit | Topics to be covered | No. of hours |
| 1 | <ul style="list-style-type: none"> • The Periodic Table: Introduction to properties of elements, • Nucleosynthesis: <i>Cosmic, Stellar, Explosive</i> • Cosmic abundance of element; Oddo-Harkin's Principle | 10 |

| | | |
|---|---|----|
| 2 | <ul style="list-style-type: none"> • Geochemical classification of elements: <i>Atmophile, Lithophile, Chalcophile, Siderophile</i> • Partition Coefficient: <i>Compatible & Incompatible Elements</i> • Geochemical Cycle | 14 |
| 3 | <ul style="list-style-type: none"> • Meteorites & its Composition • Composition of the Earth's Crust: <i>Continental & Oceanic</i> • Composition of the Earth's Mantle & Core | 10 |
| 4 | <ul style="list-style-type: none"> • Aqueous Geochemistry: Basic concepts, Ionic & Redox potential, pH • Basics of Isotope Geology • Radiogenic & Stable isotopes | 12 |
| 5 | <ul style="list-style-type: none"> • Fundamentals of Environmental Geochemistry • Composition of the Atmosphere • Composition of the Biosphere | 14 |
| | TOTAL | 60 |

Suggested Reading :

1. Mason, B. (1986). *Principles of Geochemistry. 3rd Edition, Wiley, New York.*
2. Rollinson, H. (2007). *Using geochemical data - evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific and Technical.*
3. Walther, J. V. (2009). *Essentials of geochemistry. Jones and Bartlett Publishers.*
4. Albarede, F. (2003). *Geochemistry: an introduction. Cambridge University Press.*
5. Faure, Gunter and Teresa M. Mensing (2004). *Isotopes Principles and Applications. Wiley India Pvt. Ltd*

DSE9 : URBAN GEOLOGY

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Explain the role of geological phenomenon in urban life.
- CO2:** Correlate water and soil contamination due to urbanization and natural hazards control in urban center.

| DSE9 : URBAN GEOLOGY (Credit: 6) | | |
|---|--|---------------------|
| Unit | Topics to be covered | No. of hours |
| 1 | <ul style="list-style-type: none"> • Role of Geology in Urban life. • Geological feature and mapping for subsurface in Metropolitan areas. • Geotechnical site characterization | 12 |
| 2 | <ul style="list-style-type: none"> • Soil: Definition, Types ; Soil Horizon • Chemistry of Soil • Effect of pollutants on Agriculture | 10 |
| 3 | <ul style="list-style-type: none"> • Geological problems in construction of underground structures in urban areas • Underground Constructions in Urban areas : Rail and Road | 12 |
| 4 | <ul style="list-style-type: none"> • Sources of contamination of water in Urban Areas • Standards of water: drinking and irrigation purpose • Waste water Treatment | 12 |
| 5 | <ul style="list-style-type: none"> • GIS – Introduction & Application in Urban development • Seismic Hazards: Micro-zonation of hazard based on engineering, geological features • Precaution from Seismic Hazard in Urban Planning | 14 |
| | TOTAL | 60 |

Suggested Reading :

1. Huggenberger, P. and Eptin, J. 2011. *Urban Geology: Process-Oriented Concepts for Adaptive and Integrated Resource Management*. Springer
2. Lollino, G. et al. (Ed.), *Engineering Geology for Society and Territory*. Springer

**DSE10 : FIELD WORK / TRAINING / DISSERTATION / PROJECT / INTERNSHIP
(Credit: 6)**

GE1 : FUNDAMENTALS OF THE EARTH SYSTEM

**Credit: Theory (4) Practical (2)
Same as CC – 1**

GE2 : GEOMORPHOLOGY AND GEOTECTONICS**Course Outcomes**

After the completion of the course, the student will be able to:

- CO1:** Explain and classify different landforms.
CO2: Understand the evolution of the continents and Ocean basins
CO3: Explain tectonic evolution with geologic time.

| GE2 : GEOMORPHOLOGY AND GEOTECTONICS (Credit: 4) | | |
|---|--|---------------------|
| Unit | Topics to be covered | No. of hours |
| 1 | <ul style="list-style-type: none"> • Basic principles of Geomorphology • Endogenic geomorphic processes; Diastrophism • Exogenic geomorphic processes; Weathering, mass wasting, Erosion | 12 |
| 2 | <ul style="list-style-type: none"> • Geomorphic cycles • Brief study of the following: <i>Causes of Rejuvenation, Peneplanation, Relief of ocean floor</i> | 12 |
| 3 | <ul style="list-style-type: none"> • Geological work of: <i>river, wind, glacier</i> • Drainage patterns and their significance | 12 |
| 4 | <ul style="list-style-type: none"> • Elementary idea of continental drift, sea floor spreading • Basic concepts of Plate tectonics; Plate margins • Mountains – Types, character and origin | 12 |
| TOTAL | | 48 |

Suggested Reading :

1. Belousov, V.V., (1980). *Geotectonics*, Springer-Verlag Berlin Heinemann
2. Chorley, R. J., (1984) *Geomorphology*. Methuen.
3. Gass I.G., *Understanding the Earth*. Artemis Press (Pvt.) Ltd. U.K.

4. M.A. Summerfield (1991) *Global Geomorphology*. Wiley & Sons.
5. Moores, E. M. and Twiss, R. J., (1995). *Tectonics*, W. H. Freeman
6. Robert S. Anderson and Suzanne P. Anderson (2010): *Geomorphology - The Mechanics and Chemistry of Landscapes*. Cambridge University Press.
7. Singh, S. : *Physical Geography*
8. Selby, M. J., (1996) *Earths Changing Surface*. Oxford University Press, UK
9. Thornbury, W. D., (1997) *Principles of Geomorphology*, Wiley eastern Limited, New Delhi
10. Valdiya, K.S., (1984). *Aspects of Tectonics*, Tata McGrath Hills
11. Verma, V. K., (1986) *Geomorphology Earth Surface processes and form*. McGraw Hill.
12. Wiley : *Dynamic Earth*

| GE2 : GEOMORPHOLOGY AND GEOTECTONICS (Practical) (Practical: 2 credits) | |
|--|--|
| Practical : | |
| 1. Physiographic division & drainage system on outline map of Bihar. Study of different plate boundaries on world map | |

GE3 : MINERALOGY

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Gain comprehensive ideas about silicates and their classification
CO2: Explain different properties of minerals
CO3: Understand various crystals structure & crystal system

| GE3 : MINERALOGY (Credit: 4) | | |
|---|---|---------------------|
| Unit | Topics to be covered | No. of hours |
| 1 | <ul style="list-style-type: none"> • Minerals – Definition and physical properties – <i>forms, colour, streak, luster, cleavage, fracture, hardness, specific gravity etc.</i> • Moh’s scale of hardness • Isomorphism and Polymorphism | 10 |
| 2 | <ul style="list-style-type: none"> • Crystal – Definition, faces, edges & solid angles, crystallographic axis, crystallographic planes, crystal notations • Symmetry elements: <i>axis-, plane- and center of symmetry</i> • Laws of crystallography • Contact goniometer and its use • Introduction to the crystal system; Study of the normal class of the following crystal systems: <i>Isometric system, Tetragonal system, Orthorhombic system.</i> | 14 |
| 3 | <ul style="list-style-type: none"> • Propagation of light through minerals; Nicol prism • Petrological Microscope and its function • Study of important optical properties – <i>Relief, Pleochroism, Interference colour, Double refraction and Extinction</i> | 12 |
| 4 | <ul style="list-style-type: none"> • Structural Classification of silicates. • Mineralogy of important group of rock forming minerals with reference to <i>composition, structure, physical and optical properties</i> – Pyroxene, Amphibole, Feldspar, Silica polymorph. | 12 |
| TOTAL | | 48 |

Suggested Reading :

1. *Berry and Mason, (1961). Mineralogy. W. H. Freeman & Co.*
2. *Dana, E.S. and Foo, W.E., (2002). A Textbook of Mineralogy*
3. *Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.*
4. *Flint, Y., (1975). Essentials of crystallography, Mir Publishers.*
5. *Kerr, B. F. (1995). Optical Mineralogy. McGraw-Hill, New York*
6. *Philips, F.C., (1963). An introduction to crystallography. Wiley, New York.*
7. *Perkin D. (2010) Mineralogy. Pearson*
8. *Ram S. Sharma and Anurag Sharma (2013) Crystallography and Mineralogy – Concepts and Methods. Text Book Series, Geological Society of India, Bangalore*
9. *Read, H. H., (1968) Rutley's Element of Mineralogy. Thomas Murby and Co.*
10. *Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.*

| |
|--|
| GE3 : MINERALOGY (Practical) (Practical: 2 credits) |
|--|

Practical :

1. *Crystal drawing of the following forms: Cube, Octahedron, Rhombdodecahedron, Zircon*
2. *Study of Physical properties of the following minerals : Quartz, Orthoclase, Microcline, Feldspar, Muscovite, Biotite, Hornblende, Tremolite, Actinolite, Olivine, Calcite, Gypsum, Talc, Fluorite, Apatite, Topaz, Corundum, Baryte, Kyanite, Tourmaline, Garnet, Magnetite, Hematite, Chalcopyrite, Pyrite, Bauxite, Chromite, Pyrolusite, Psilomelane.*
3. *Microscopic Study of the common rock forming minerals.*

GE4 : STRUCTURAL GEOLOGY**Credit: Theory (4) Practical (2)****Same as CC - 4****GE5 : REMOTE SENSING & GIS****Credit: Theory (4) Practical (2)****Same as DSE - 1****GE6 : ENVIRONMENTAL GEOLOGY AND GEOGENIC DISASTER****Credit: Theory (6)****Same as DSE - 5**

GE7 : PETROLOGY

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Understand the concept of different rock types.
CO2: Explain factors and processes of magma generation.
CO3: Understand various classification of igneous rocks.
CO4: Explain ideas of metamorphism and different type of metamorphic rock.

| GE7 : PETROLOGY (Credit: 4) | | |
|--|--|---------------------|
| Unit | Topics to be covered | No. of hours |
| 1 | <ul style="list-style-type: none"> • Introduction to Petrology- distinguishing features of three types of rocks. • Magma – Definition, Types and Composition • Bowen’s Reaction Principle | 8 |
| 2 | <ul style="list-style-type: none"> • Form, Structure and Texture of Igneous rock • IUGS classification of Igneous rock. • Petrographic description of the following rock types : <i>Granite, Rhyolite, Syenite, Diorite, Gabbro, Basalt, Granodiorite, Dolerite</i> | 12 |
| 3 | <ul style="list-style-type: none"> • Definition and formation of Sedimentary Rocks • Texture and structure of Sedimentary rocks • Classification of Sedimentary rocks • Petrographic study of the following rocks:- <i>Conglomerate, Sandstone, Limestone, Breccia, Shale.</i> | 14 |
| 4 | <ul style="list-style-type: none"> • Metamorphism – definition, agents and types • Texture and Structure of Metamorphic rocks • Classification of Metamorphic rocks • Petrography of the following metamorphic rocks : <i>Slate, Phyllite, Schists, Gneisses, Amphibolite, Granulite, Marble, Quartzite, Charnockite</i> | 14 |
| TOTAL | | 48 |

Suggested Reading :

1. Allen, J.R.L., (1985). *Principles of Physical Sedimentology*. George Allen and Unwin, London
- Blatt, Ehler: *Petrology (Igneous, Sedimentary and Metamorphic)*
2. Blatt, Ehler: *Petrology (Igneous, Sedimentary and Metamorphic)*
3. Boggs, S.: *Petrology of Sedimentary Rocks*, Cambridge University Press.
4. Bose M.K. (1997). *Igneous Petrology Huang : Petrology*
5. Harker : *Petrology for students*
6. McBirney, A. R. (1984). *Igneous Petrology*. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press),
7. Myron G. Best (2001). *Igneous and Metamorphic Petrology*,
8. Nockolds, Chinner and Kinnox: *Petrology for students*
9. Pettijohn, F. J., (1984) *Sedimentary rocks*, Harper & Bros Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw-Hill Science Engineering.
10. Sengupta, S. M., (2007). *Introduction to Sedimentology*, CBS Publishers and Distributor, New Delhi Tyrell, G.W. : *Principles of Petrology*
11. Winter, J. D. (2014). *Principles of igneous and metamorphic petrology*. Pearson.

GE7 : PETROLOGY (Practical)
(Practical: 2 credits)

Practical :

- Megascopic study of the following rocks:
 - Granite, Rhyolite, Diorite, Gabbro, Basalt, Granodiorite, Dolerite, Conglomerate, Breccia, Sandstones, Greywacke, Limestone, Dolomite, Shale., Slate, Phyllite, Schist, Gneisses, Marble, Charnockite, Amphibolite
- Microscopic study of the following rocks:
 - Granite, Diorite, Gabbro, Basalt, Granodiorite, Dolerite, Syenite, Sandstone, Orthoquartzite, Arkose, Greywacke, Limestone, Schists, Gneisses, Amphibolite, Charnockite,

GE8 : ECONOMIC GEOLOGY AND HYDROGEOLOGY

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Understand classification of mineral deposits and their processes of formation.
CO2: Gain a comprehensive idea about genesis and distribution of major ore minerals and associated host rocks.
CO3: Explain basic concepts of hydrogeology
CO4: Appreciate properties of water bearing geological formation

| GE8 : ECONOMIC GEOLOGY AND HYDROGEOLOGY (Credit: 4) | | |
|--|---|---------------------|
| Unit | Topics to be covered | No. of hours |
| 1 | <ul style="list-style-type: none"> • Concept of Ore, Ore mineral, Gangue, Tenor of Ores. • Forms and structure of ore deposits. • Classification of Ore deposits | 10 |
| 2 | <ul style="list-style-type: none"> • An elementary idea of the processes of formation of mineral deposit with special reference to- <i>Magmatic concentrates, Supergene sulphide enrichments, Placer deposits</i> • Study of the properties and distribution of the following economic minerals: <ul style="list-style-type: none"> – Talc, Gypsum, Calcite, Fluorite, Apatite, Felspar, Quartz, Topaz, Corundum, Chromite, Beryl, Barite, Kyanite, Pyrolusite, Psilomelane, Mica, Hematite, Magnetite, Chalcopyrite, Bauxite, Graphite, Galena | 14 |
| 3 | <ul style="list-style-type: none"> • Hydrogeology: concepts, scope and its societal relevance • Hydrologic cycle: <i>precipitation, evapo-transpiration, infiltration, run-off and subsurface movement of water</i> • Hydrogeological properties of water-bearing formation: <i>Porosity, Permeability</i> | 14 |
| 4 | <ul style="list-style-type: none"> • Physical and chemical properties of water • Origin and types of Groundwater: <i>Juvenile water, Connate water, Meteoric water, Vadose water</i> • Groundwater resources of Bihar | 10 |
| | TOTAL | 48 |

Suggested Reading :

1. Brown, C. and Dey, A.K.: *Indian Mineral Wealth*
2. Davis, S. N. and De Weist, R.J.M. 1966. *Hydrogeology, John Wiley & Sons Inc., N.Y.*
3. Evans, A.M. (1993) *Ore Geology and Industrial minerals. Wiley*

4. *Jenson and Bateman: Economic Mineral Deposits*
5. *Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw Hill Pub. Co. Ltd.*
6. *Prasad, U.: Economic Geology*
7. *Raghunath: Hydrology*
8. *Riley, Charles M.: Our Mineral Resources*
9. *Sinha and Sharma: Mineral Economics*
10. *Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.*

| GE8 : ECONOMIC GEOLOGY AND HYDROGEOLOGY (Practical) (Practical: 2 credits) | |
|--|---|
| Practical : | |
| ➤ | Observation of the following economic minerals with reference to their physical properties : Talc, Gypsum, Calcite, Fluorite, Apatite, Topaz, Corundum, Beryl, Barite, Kyanite, Sillimanite, Hematite, Magnetite, Chromite, Chalcopyrite, Malachite, Azurite, Bauxite, Galena, Pyrite. |
| ➤ | Groundwater provinces on the map of India. |

GE9 : PALAEOONTOLOGY AND STRATIGRAPHY

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Unravel the geological events of the past.
CO2: Explain the order in which the rock formation formed
CO3: Understand the idea of Geological evolution of India.
CO4: Explain the evolution of life through study of fossils.

| GE9 : PALAEOONTOLOGY AND STRATIGRAPHY (Credit: 4) | | |
|---|--|--------------|
| Unit | Topics to be covered | No. of hours |
| 1 | <ul style="list-style-type: none"> • Definition and Types of Fossil • Condition of Fossilization and Modes of preservation of fossils • Uses of Fossils | 10 |
| 2 | <ul style="list-style-type: none"> • Classification, Morphology and Geological history: • <i>Gastropoda, Bivalvia, Cephalopoda, Brachiopoda, Trilobita</i> | 14 |
| 3 | <ul style="list-style-type: none"> • Definition, Principles of Stratigraphy • Methods of Stratigraphic correlation • Geological Time Scale • Brief idea about <i>Lithostratigraphy, Biostratigraphy and Chronostratigraphy</i> | 12 |
| 4 | <ul style="list-style-type: none"> • An outline of Indian stratigraphy with special reference to - <i>Archaean of Singhbhum, Proterozoic basin of Vindhyan, Gondwana Supergroup, Siwalik Group</i> | 12 |
| TOTAL | | 48 |

Suggested Reading :

1. *Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by Blackwell Publishing.*
2. *Doyle, P. & Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley*
3. *Krishnan, M. S. (1982) Geology of India and Burma, CBS Publishers, Delhi*
4. *Ramakrishnan, M. & Vaidyanadhan, R. (2008) Geology of India Volumes 1 & 2, Geological society of India, Bangalore.*

5. Raup, D. M., Stanley, S. M., Freeman, W. H. (1971) *Principles of Paleontology*
6. Shukla, A. C., & Misra, S. P. (1975). *Essentials of paleobotany*. Vikas Publisher
7. Valdiya, K. S. (2010) *The making of India*, Macmillan India Pvt. Ltd
8. Woods, Henry : *Invertebrate Palaeontology*

GE9 : PALAEONTOLOGY AND STRATIGRAPHY (Practical)
(Practical: 2 credits)

Practical :

- Distribution of Stratigraphic formation on the outline map of India.
 - Dharwar, Singhbhum, Cudappah, Vindhyan, Gondwana
- Study of stratigraphic rocks of
 - Khondalite, Singhbhum Granite, Kolhan conglomerate, BHJ, BHQ, Vindhyan Sandstone, Rohtas Limestone, Talchir sandstone, Barakar sandstone, Rajmahal Traps
- Identification of fossils and their geological age: invertebrate, vertebrate, plant fossils
- Drawing of fossils based on morphological features.