CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

M.Sc. Geology

Session - 2019-21

Department of Geography and Geology

SEMESTER-I

Course Code	Course Title	Course Type	Credit Hours			
			L	T	P	Total
CST.501	Computer application (Theory)* #	Compulsory Foundation	2	-	-	2
STA.503	Statistics for Science * #	Compulsory Foundation	2	-	-	2
EGS.506	Mineralogy and Crystallography	Core	4	-	-	4
EGS.507	Paleontology	Core	4	-	-	4
EGS.508	Sedimentology	Core	2	-	-	2
EGS.509	Mineralogy and Crystallography (Practical)	Core	-	-	4	4
EGS.510	Paleontology and Sedimentology (Practical)	Core	-	-	4	4
Select any one from the followings						
EGS.511	Geomorphology & Geotectonics	Discipline Elective	4	-	-	4
EGS.512	Environmental Geology and Natural Hazards	Discipline Elective	4	-	-	4
EGS.513	Natural Resource and Watershed Management	Discipline Elective	4	-	-	4
Interdisciplinary course						
IDC	Interdisciplinary course	IDC	2	-	-	2
Total Credit Hours			**20**	**-**	**8**	**28**

SEMESTER-II

Course Code	Course Title	Course Type	Credit Hours			
			L	T	P	Total
EGS.521	Geochemistry and Isotope Geology	Core	4	-	-	4
EGS.522	Igneous and Metamorphic Petrology	Core	4	-	-	4
EGS.523	Structural Geology	Core	4	-	-	4
EGS.524	Igneous and Metamorphic Petrology (Practical)	Core	-	-	4	4
EGS.525	Structural Geology (Practical)	Core	-	-	4	4
EGS.526	Field training – I †	Skill Based	-	-	2	2
EGS.542	Seminar	Skill Based	-	1	-	1
Select any one						
EGS.527	Oceanography and Climatology	Discipline Elective	4	-	-	4
EGS.528	Mineral Exploration and	Discipline	4	-	-	4

	Petroleum Geology	Elective				
EGS 534	Introduction to Disaster Management	IDC	2			2
Total Credit Hours			**18**	**1**	**10**	**29**

* University level courses (theory) will be offered by the Department of Computer Sciences and Technology, Mathematics and Statistics or Computational Science.

Student can choose suitable MOOC courses instead of CST.501 or STA.503 or IDC

† Fieldwork will be conducted in the beginning of 2nd semester. This fieldwork will be focused on the sedimentological and paleontological aspect. Evaluation of this course will be based on the field activity, daily field report, final report submission and presentation.

NB: Students are free to choose suitable MOOC courses in addition to the credit defined in the course structure.

SEMESTER-III

Course Code	Course Title	Course Type	Credit Hours			
			L	**T**	**P**	**Total**
EGS.551	Ore Geology	Core	4	-	-	4
EGS.552	Hydrogeology, Remote Sensing and GIS	Core	4	-	-	4
EGS.553	Ore Geology, Remote Sensing and GIS (Practical)	Core	-	-	4	4
EGS.554	Quantitative Geosciences	Discipline enrichment course	-	2	-	2
EGS.555	Research Methodology	Compulsory Foundation	4	-	-	4
EGS.503	Introduction to Field accessories for Geoscience	Value added course	-	1	-	1
EGS.543	Seminar	Skill Based	-	1	-	1
EGS.599	Project work	Skill Based	-	-	12	12
Total Credit Hours			**12**	**4**	**16**	**32**

SEMESTER-IV

Course Code	Course Title	Course Type	Credit Hours			
			L	T	P	Total
EGS.571	Principle of Stratigraphy and Indian Stratigraphy	Core	4	-	-	4
EGS.572	Engineering Geology and Geophysics	Core	4	-	-	4
EGS.573	Engineering Geology and Geophysics (Practical)	Core	-	-	4	4
EGS.574	Field training – II ††	Core	-	-	2	2
EGS.575	Comprehensive Geosciences	Discipline enrichment course	-	2	-	2
EGS.504	Introduction to geological Mapping	Value added course	-	1	-	1
EGS.599	Project work	Skill Based	-	-	12	12
Total Credit Hours			**8**	**3**	**18**	**29**
Grand total credit Hours for all semester (I+II+III+IV)			**58**	**8**	**52**	**118**
Total credit for all semester (I+II+III+IV) = 92			**58**	**8**	**26**	**92**

†† Fieldwork will be conducted in the beginning of 4th semester. This fieldwork will be focused on the lithological and structural mapping/ ore geology. Evaluation of this course will be based on the field activity, daily field report, final report submission and presentation during the 4th semester.

L: Lectures, **T:** Tutorial, **P:** Practical, NB: Two Practical credit hours = One credit

1. Mode of transaction: Lecture, Demonstration, Tutorial, Problem solving, Seminar, Group discussion, Field work,

A. Tools used: PPT, Video, Animation movie, Whatsapp,

B. Software Tool: Stellarium, Celestia, Mineralogical interactive software, crystal maker

2. Evaluation Criteria for Theory Courses: Total Marks 100

A. Continuous Assessment: [25 Marks]
   i. Surprise Test (minimum three) - (10 Marks)
   ii. Term paper (10 Marks)
   iii. Assignment(s) (5 Marks)
B. Mid Semester Test-1: Based on Subjective Type Test [25 Marks]
C. Mid Semester Test-2: Based on Subjective Type Test [25Marks]
D. End-Term Exam: Based on Objective Type Tests [25 Marks]

Evaluation Criteria for Practical/Seminar/field training courses are given in the syllabus

SEMESTER – I

Course Code: CST: 501
Course Title: Computer applications (Theory)
Total Hours: 30

L	T	P	Cr
2	-	-	2

Learning Outcomes: Upon successful completion of this course, the student will be able to:

- Use different operating system and their tools easily.
- Use word processing software, presentation software, spreadsheet software
- Understand networking and internet concepts.
- Use computers in every field like teaching, industry and research

UNIT I **7 Hours**

Introduction to computer and its block, understanding of basic computer hardware, Computer Configuration, Memory Hierarchy, Networking and data sharing, WWW, Software structure.

UNIT II **8 Hours**

Introduction to Word Processing and Microsoft Office, Introduction to MS Paint, Notepad and Word, Creating and Saving Documents, Text Formatting, Tables, Document Review Option, Mail Merge, Inserting Table of Contents, Reference Management.

UNIT III **7 Hours**

Microsoft Spreadsheet and its applications, Presentation applications, Internet browsers and Image processing applications

UNIT IV **8 Hours**

Application of Coral Draw, Sigma plot, Map info, Google terrain image in geology. Use of GW kit, GCD kit, Rock ware and NORM calculation using spread sheet.

Transactional Modes: Lecture, Demonstration, Tutorial and practice in the lab, Problem solving, Seminar, Group discussion, PPT, Video and Animation.

Suggested Readings:

1. Computer Fundamentals by Sinha, P.K., 2004, BPB Publications.
2. An Introduction to Database Systems by Date C. J., 2000, Addison-Wesley Longman, Massachusetts.
3. Information Technology: Inside and Outside by David Cyganski, John, A. OrrandR.F.Vaz, 2000, Prentice Hall, New Jersey.
4. Fundamentals of MS Office 2007 by Douglas, Gretchen and Mark Connell, 2007, Kendall Hunt Publication Company, Dubuque.

Course Code: STA. 503
Course Title: Statisticsfor Sciences
Total Hours: 30

L	T	P	Cr
2	-	-	2

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

- apply statistical methods for the interpretation and analysis of scientific data.
- do required statistical application in geological research

UNIT I **8 Hours**

Descriptive Statistics: Meaning, need and importance of statistics. Attributes and variables. Measurement and measurement scales. Collection and tabulation of data. Diagrammatic representation of frequency distribution: histogram, frequency polygon, frequency curve, gives, stem and leaf plot, pie chart

UNIT II **8 Hours**

Measures of central tendency, dispersion (including box and whisker plot), skewness and kurtosis. Data on two attributes, independence and association of attributes in 2x2 tables. Linear regression and correlation (Karl Pearson's and Spearman's) and residual plots.

UNIT III **7 Hours**

Random experiments, sample spaces (finite and infinite), events, algebra of events, three basic approaches to probability, combinatorial problems

UNIT IV **7 Hours**

Axiomatic approach to probability. Product sample spaces, conditional probability, Bayes' formula. Correlation and Regression analysis, rank correlation coefficients, curve fitting

Transactional Modes: Lecture, Tutorial, Problem solving with example, Group discussion, PPT, Video and Animation.

Suggested Readings:

1. Understanding Basic Statistics by Charles Henry Brase & Corrinne Pellillo Brase, 2013, 6th edition, Brooks/Cole, Cengage Learning, USA.
2. Introduction to mathematical statistics by Hogg, R.V. & Raise, A.T., 1978, Macmillan Pub. Co. Inc.
3. Applied General Statistics by Croxton, F.E. & Cowden, D.J., 1975, Prentice-Hall Inc.
4. Introduction to Mathematical Statistics by Hoel, P.G., 1997, John Wiley & Sons, Inc.
5. Introductory Probability and Statistical Applications by Meyer, P.L., 1975, Oxford & IBH Pub

Course Code: EGS. 506
Course Title: Mineralogy and Crystallography
Total Hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcomes: Upon successful completion of this course, the student will be able to:

- Understand how the internal structure of minerals affects the external structure and physical properties of a mineral (e.g. crystal symmetry, crystal habit)
- explain the mineralogical concepts of polymorphism, solid solution and exsolution
- explain which mineral identification method is appropriate for a mineralogical problem (e.g. polarizing microscope, x-ray diffraction, electron microprobe)
- recognize and describe the basic properties and chemistry of common rock-forming minerals
- explain the mineralogical variation in igneous, sedimentary and metamorphic rocks

UNIT I **14 Hours**

Mineralogy: Introduction to mineralogy, broad classification, properties of minerals & environments of formation. Crystal chemistry: chemistry of elements, bonding and packing in mineral, coordination number, chemical analysis of minerals, general and structural mineral formulae. Polymorphs/structural states, rules of substitution, introduction to phase diagram and solid solution series.

UNIT II **15 Hours**

Crystallography: Crystal systems, introduction to symmetry, derivation of 32 classes of symmetry.2D and 3D lattice, 14 Bravais lattice, introduction to space group. International system of crystallographic notation and study of stereogram. Different types of crystal projections – spherical and stereographic and their uses. Crystal defects, twinning and twin laws: common types of twins and their examples in minerals. Introduction to X-ray crystallography, and Bragg's equation. Powder method in X-ray crystallography

UNIT III **13 Hours**

Optical Mineralogy: Petrographical microscope; Introduction to optics, Isotropic and anisotropic minerals, optical crystallography of uniaxial and biaxial crystals, indicatrix, pleochroism, interference figures, crystal orientation, determination of optic sign ,2V and 2E.

UNIT IV **18 Hours**

A detailed study of the important silicates (listed below) and non-silicate mineral with reference to general and structural formulae, classification, atomic structure, polymorphs/structural states, solid solution and

experimental work on pressure-temperature stability of the minerals, modes of occurrence and alterations.

a) Nesosilicates/Orthosilicates: olivine group, garnet group, aluminosilicate group (kyanite, andalusite, sillimanite),humite group, zircon.
b) Sorosilicates: melilite, axinite and epidote group.
c) Cyclosilicates: beryl, tourmaline, cordierite, eudialyte
d) Inosilicates: pyroxene group, amphibole group and wollastonite
e) (e)Phyllosilicates: mica group,kaolinite-serpentine group, talc-pyrophyllite,chlorite, smectite.
f) Tectosilicates: silica group, feldspar group, zeolite and feldspathoid

Transactional Modes: Lecture, Demonstration, Tutorial, Problem solving, Seminar, Group discussion, Tools used: PPT, Video, Animation, Whatsapp, Software Tool: Mineralogical interactive software, crystal maker, XRD data analysis tool, website: Mindat, Web minerals.

Suggested Readings:

1. Mineralogy and Optical Mineralogy by Dyar M. D., Gunter M. E., Tasa D., 2008, Mineralogical, Society of America, ISBN 978-0-939950-81-2.
2. Mineralogy by Perkins Dexter, 2012, Pearson Education.
3. Dana`s Textbook of Mineralogy (With Extended Treatise on Crystallography and Physical Mineralogy), by William E. Ford, 2006, CBS Publishers & Distributors Pvt. Ltd., ISBN 10: 8123908091.
4. Optical Crystallography by Bloss, 1999, Mineralogical Society of America.
5. Crystallography and Crystal Chemistry by Bloss, 1994, Mineralogical Society of America.
6. Introduction to Mineralogy by William Nesse, 2011, Oxford University Press, ISBN: 9780199827381.
7. Introduction to Optical Mineralogy by William Nesse, 2012, Oxford University Press, ISBN: 9780199846276.
8. Minerals and Rocks-Exercises in Crystallography, Mineralogy and Hand Specimen Petrology by Cornelius Klein, 2007, Wiley publisher.
9. Mineralogy by Berry, L.G., Mason, B. and Dietrich, R.V., 2004, CBS Publishers, ISBN 10: 8123911483, ISBN 13: 9788123911489.
10. Introduction to the Rock-Forming Minerals by Deer W.A., Howie R.A. and Zussman J., 2013, Mineralogical Society of America.
11. Rutley's Elements of Mineralogy, by Gribble, 2005, CBS Publishers, ISBN-10: 8123909160.

Course Code: EGS-507
Course Title: Paleontology
Total Hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

- Understand the evolutionary history of various fossils in time and space.
- Learn how to extract, annotate (context recording), prepare, preserve and catalogue fossils; Recognize sedimentary deposits capable of preserving fossils;
- Understand and apply the principal elements of fossil excavation;
- Understand the multidisciplinary nature of modern palaeontology to correlate lithostaratigraphy, palaeogeography and paleaoenvironment of any studied area.

UNIT I **15 Hours**

Scope of paleontology; Origin and evolution of life through age; species concept and speciation. Techniques in palaeontology: mega fossils, microfossils, nano-fossils and ichno-fossils–mode of collection and illustration; binomial nomenclature, Mass extinctions and their causes.
Study of Invertebrate paleontology with special reference to functional morphology: trilobites, brachiopods, gastropods and cephalopods general morphology and Indian occurrence.

UNIT II **15 Hours**

Micropaleontology: Classification and uses of micro fossils. Detailed study of microfossils such as diatoms, Foraminifera, Radiolaria, Conodonta, Ostracoda and Charophyta. Plant fossils: Gondwana flora and their significance.

UNIT III **15 Hours**

Vertebrate palaeontology: General characters, classification, evolution of Fishes including Agnaths, Placoderms, Chondrichythis and Osteichthyes. General characters, age of Amphibians, Reptiles and Mammals. General characters, classification, evolution, age and extinction of Dinosaurs. General characters, classification and evolution of Horse, Elephant and Man. Vertebrate fossil records of Siwaliks. A brief study on the Mesozoic reptiles of India.

UNIT IV **15 Hours**

Use of paleontological data in stratigraphy, biostratigraphy, paleoecology, evolution, paleoclimate and sea level changes; Principle of paleobiogeography.
Use of microfossils in interpretation of sea floor tectonism. Application of micropaleontology in hydrocarbon exploration; oxygen and carbon stable isotopes studies of microfossils and their use in bathymetric measurement and paleoclimate interpretation

Transactional Modes: Lecture, Demonstration, Tutorial, Problem solving, Seminar, assignment, Group discussion, Tools used: PPT, Video, Animation.

Suggested Readings:

1. Invertebrate Palaeontology& Evolution by Clarkson, E. N.K., 1998, Wiley-Blackwell.
2. Vertebrate Palaeontology, by Michael Benton, 2004, Wiley-Blackwell.
3. Microfossils, by Howard A. Armstrong, Martin D. Brasier, 2004, Blackwell Publishing Ltd.
4. Principles of Paleontology by Michael Foote, Arnold I. Miller, 2006, W. H. Freeman.
5. Applied Palaeontology by Jones, R.W. 2002, Natural History Museum, London.
6. Principles of Invertebrate Paleontology by Shrock, N., 2005, CBS Publisher & distributer Private Ltd.
7. Paleontology Invertebrate by Henry Wood, 2004, CBS Publication & distributer Private Ltd.
8. Bringing Fossils to Life: An Introduction to Palaeobiology, by Donald R. Prothero, 2003, McGraw-Hill Higher Education.
9. Modern foraminifera by Sen Gupta, B.K. 2003, Springer Netherlands

Course Code: EGS-508
Course Title: Sedimentology
Total Hours: 30

L	T	P	Cr
2	-	-	2

Learning Outcomes:

Upon successful completion of this course, the student will be able to:

- Classify the various sedimentary rocks and explain their mode of genesis in different depositional environment.
- Interpret the processes responsible for the deposition of the sediment from the nature of the sediment and sedimentary structures present within the sedimentary rock;
- Understand the depositional environment of a sedimentary rock package based on recognition of facies associations; and
- Recognize and explain the methodology of carrying out scientific research in the field of sedimentary geology.

UNIT I **8 Hours**

Origin of terrigenous clastic and non-clastic grains; weathering and its products; Grain size, textural parameters and their significance. Textural and compositional maturity. Major carbonate minerals; carbonate grains of biological origin. Simple fluid flow concepts, fluid flow mechanics and formation of sedimentary bed, sediment transport.

UNIT II **7 Hours**

Petrographic characteristic and classification of conglomerate, sandstones, limestones and argillaceous rocks, mud rocks. Concept of facies and methods of their analysis and interpretation of depositional environments. Processes and characteristics of Aeolian, fluvial, barrier-beach, tidal-flats and deep sea environments

UNIT III **8 Hours**

Important bed forms and sedimentary structures– their genesis and stratigraphic significance. Application of sedimentary structures in palaeocurrent analysis; Diagenesis – Physical and chemical processes. Evidences of diagensis in sandstones, mudrocks and carbonate rocks. Evaporites, siliceous, phosphetic and ferruginous rocks. Heavy minerals and their importance in determination of provenance

UNIT IV **7 Hours**

Tectonic and sedimentation; Review of concept of geosynclines and plate-margins, major types of basins and distribution of environments and lithofacies within basins, evolution of basins with time. Sedimentary basins of India and their economic importance.

Transactional Modes: Lecture, Demonstration, Tutorial, Problem solving, Seminar, assignment, Group discussion, **Tools used:** PPT, Video, Animation.

Suggested Readings:

1. Principles of sedimentology & stratigraphy by Sam Boggs, Jr., 2011, Prentice Hall.
2. Sedimentary Geology, by Donald R. Prothero and Fred Schwab; 2013, W. H. Freeman.
3. Carbonate Sedimentology by Tucker, M.E. and Wright, V.P., 1991, Wiley Publisher.
4. Sedimentary Environments: Processes, Facies and Stratigraphy by Reading, H.G., 1996, Wiley-Blackwell.
5. Sedimentology and stratigraphy by Gary Nichols, 2009, Wiley-Blackwell, ISBN: 978-1-4051-3592-4.
6. Atlas of Sedimentary Rocks Under the Microscope by Adams, A. E.,MacKenzie, W. S., Guilford, C., 1984, Prentice Hall.
7. Sedimentary Rocks in the Field: A Practical Guide (Geological Field Guide), by Maurice E. Tucker, 2011, Wiley-Blackwell.
8. Principles of Sedimentary Basin Analysis by Miall, A.D., 2000, Springer-Verlag.
9. Sedimentary Basins by Einsele, G., 1992. Springer Verlag.
10. Depositional Sedimentary Environments by Reineck, H.E. and Singh, I.B., 1980, Springer-Verlag.
11. Introduction to Sedimentology by Sengupta, S., 1997, Oxford-IBH.

Course Code: EGS 509
Course Title: Mineralogy and Crystallography (Practical)
Total Hours: 60

L	T	P	Cr
-	-	4	2

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

- Identify the different minerals in hand specimen and under petrological microscope
- Identify the different crystals in hand specimen and under petrological microscope
- Use XRD data to interpret the crystal parameter and to identify the mineral phase.
- Use XRF data to find out empirical formula of the mineral and understand the impurities present in the minerals.

UNIT I **32 Hours**

Mineralogy and crystallography: Identification of rock-forming minerals in hand specimens. Introduction to crystal models, Goniometer and its use in measuring interfacial angle of crystals and calculation of axial ratio. Representation of symmetry elements of crystals belonging to 32 classes of symmetry and study of their stereograms. Analysis of XRD spectrum.

UNIT II **28 Hours**

Optical Mineralogy: Scheme of pleochroism and absorption of a given mineral in thin section. Determination of extinction angle, Determination of order of interference colours. Determination of length fast and length-slow characters of minerals. Study of interference figures of uniaxial and biaxial crystals, determination of optic signs. Identification of rock forming minerals using optical properties.

Transactional Modes: Demonstration, practical with real specimens, Problem solving, Group discussion, Tools used: PPT, Video, Animation, Software Tool: Mineralogical interactive software, crystal maker, website: Mindat, Web minerals.

Suggested Readings:

1. Minerals and Rocks-Exercises in Crystallography, Mineralogy and Hand Specimen Petrology by Cornelius Klein, 2007, Wiley.
2. Mineralogy by Perkins Dexter, 2012, Pearson Education.
3. Dana`s Textbook of Mineralogy (With Extended Treatise on Crystallography and Physical Mineralogy), by William E. Ford, 2006, CBS Publishers & Distributors Pvt. Ltd.
4. Mineralogy and Optical Mineralogy by Dyar MD, Gunter ME, Tasa D, 2008, Mineralogical, Society of America.

5. Optical Crystallography, by Bloss, 1999, Mineralogical Society of America.
6. Crystallography and Crystal Chemistry by Bloss, 1994, Mineralogical Society of America.
7. Introduction to Mineralogy by William Nesse, 2011, Oxford University Press.
8. Introduction to Optical Mineralogy by William Nesse, 2012, Oxford University Press.
9. Mineralogy by Berry, L.G., Mason, B. and Dietrich, R.V., 2004, CBS Publishers.
10. Introduction to the Rock-Forming Minerals by W.A. Deer, R.A. Howie and J. Zussman, 2013, Mineralogical Society of America.

Evaluation Criteria: Total Marks – 100,
End semester exam (70%), Lab record (15%), Viva (15%)

Course Code: EGS 510
Course Title: Paleontology and Sedimentology (Practical)
Total Hours: 60

L	T	P	Cr
-	-	4	2

Learning Outcomes: Upon successful completion of this course, the student will be able to:

- Learn how to extract, annotate (context recording), prepare, preserve and catalogue fossils;
- Understand the multidisciplinary nature of modern palaeontology to correlate lithostaratigraphy, palaeogeography and paleaoenvironment of any studied area.
- Classify the various sedimentary rocks and explain their mode of genesis in different depositional environment.
- Interpret the processes responsible for the deposition of the sediment from the nature of the sediment and sedimentary structures present within the sedimentary rock.

UNIT I **32 Hours**

Study of clastic and non-clastic rocks in hand specimens. Microscopic examination of important rock-types. Grain-size analysis by sieving method: plotting of size-distribution data as frequency and cumulative curves; Computation of statistical parameters and interpretation. Heavy mineral separation; their Microscopic characters, graphic representation and interpretation. Assemblages of sedimentary structures and their palaeo-environmental significance. Palaeo-current analysis. Study of vertical profile sections of some selected sedimentary environment.

UNIT II **28 Hours**

Study of morphology of brachiopods, bivalves and gastropods, cephalopods, echinoids. Separation, processing, wet sieve analyses, preparation of slides of microfossils (demonstration only).Morphology and morphological descriptions of planktonic & benthonic foraminifera, ostracods. Morphology of radiolaria, diatoms, pollen and spores. Construction of range charts.

Transactional Modes: Demonstration, practical with real specimens, Problem solving, Group discussion, Tools used: PPT, Video, Animation, Software Tool: Sedilog, Gradistat, Photoshop.

Suggested Readings:

1. Atlas of Sedimentary Rocks Under the Microscope by A. E. Adams, W. S. MacKenzie, C. Guilford, 1984, Prentice Hall.
2. Principles of Invertebrate Paleontology by N. Shrock, 2005, CBS publication.
3. A Practical approach to Sedimentology by Roy C. Lindholm, 1987, Allen and Unwin, London.
4. Microfossils by M.D. Braiser, 1980, George Allen and Unwin.
5. Elements of Micropaleontology by Bignot, G., 1985, Grahm and Trottman, London.
6. Introduction to Marine Micropaleontology, by Haq and Boersma, 1978, Elsevier.
7. Systematics & Fossil Record-Documenting Evolutionary Patterns by Smith, A.B., 1994, Blackwell publisher.
8. Micropaleontology in Petroleum exploration by R.W. Jones, 1996, Clarendon Press Oxford.
9. Paleontology Invertebrate by Henry Wood, 2004, CBS Publication.
10. Introduction to Sedimentology by Sengupta, S., 1997, Oxford-IBH.

Evaluation Criteria: Total Marks – 100,
End semester exam (70%), Lab record (15%), Viva (15%)

Course Code: EGS.511
Course Title: Geomorphology and Geotectonic
Total Hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcomes: Upon successful completion of this course, the student will be able to:

- explain principal terms, definitions and theories (e.g. conceptual approaches in geomorphology)
- describe landforms and land forming processes in different climate zones and tectonic regimes
- explain different theories and models for landscape evolution
- discuss the development of micro to mega scale landforms and their lifespans

- assess the mode of formation, age and history for landforms in India.
- plan and carry out a geomorphological field investigation (including observation, interpretation and report)
- search and find relevant information to elucidate geomorphological problems

UNIT I **14 Hours**

Development in geomorphology, Historical and process geomorphology, the geomorphic systems, geomorphic materials and process: weathering, sediment production, pedogenesis, mass movement, erosion, transportation and deposition, landforms in relation to climate, rock type, structure and tectonics.

UNIT II **16 Hours**

Geomorphic processes and landforms-fluvial, glacial, aeolian, coastal and karst. River forms and processes-stream flow, stage-discharge relationship; hydrographs and flood frequency analysis, Submarine relief, Environmental change-causes, effects on processes and landforms. Extra-terrestrial geomorphology.

UNIT III **15 Hours**

Definition and scope of tectonic geomorphology. Landscape evolution. Concept of Form-Process relationship in landscape evolution. Geomorphology and topographic analysis including DEM, topographical maps, map reading, geomorphic mapping, slope analysis and drainage basin analysis, applications of geomorphology in mineral prospecting, civil engineering, hydrology and environmental studies.

UNIT IV **15 Hours**

Major tectonic features of the oceanic and continental crust. Seafloor spreading and plate tectonics. Island arcs, Oceanic islands and volcanic arcs. Continental drift-geological and geophysical evidence, mechanics, objections, present status. Gravity and magnetic anomalies at mid-oceanic ridges, deep sea trenches, continental shield areas and mountain chains. Isostasy, orogeny and epeirogeny. Seismic belts of the earth. Seismicity and plate movements. Geodynamic Evolution of Himalaya. Geodynamics of the Indian plate.

Transactional Modes: Lecture, Demonstration, Tutorial, Problem solving, Seminar, assignment, Group discussion, Tools used: PPT, Video, Animation, topo-sheet and maps.

Suggested Readings:

1. Principles of Geomorphology by W.D. Thornbury, 2004, CBS publisher & distributer private Ltd.
2. Global Tectonics by Philip Kearey, Keith A. Klepeis, Frederick J. Vine, 2009, Wiley-Blackwell.

3. Fundamental of Geomorphology by Richard John Huggett, 2007, Taylor & Francis.
4. Geological Field Techniques by Angela L. Coe (edt), 2010, Wiley-Blackwell.
5. Basic Geological Mapping (Geological Field Guide), by Richard J. Lisle, Peter Brabham, John W. Barnes, Wiley-Blackwell; 2011, ISBN-13: 978-0470686348
6. Geomorphology and Global Tectonics, Michael A. Summerfield (Editor), 2000, Wiley,ISBN: 978-0-471-97193-1,
7. Principles of Physical Geology by Holmes, and edited by P. McL. D. Duff., 1993, Chapman and Hall, London.
8. Applied Geomorphology: Theory and Practice, by R. J. Allison, 2002, Wiley.
9. Tectonic Geomorphology by Douglas W. Burbank, Robert S. Anderson, Wiley-Blackwell; 2011, ISBN-13: 978-1444338867
10. Geomorphology: The Mechanics and Chemistry of Landscapes by Robert S. Anderson, Suzanne P. Anderson, 2010, Cambridge University Press.
11. Key Concepts in Geomorphology by Paul R. Bierman, David R. Montgomery, 2013, W. H. Freeman.
12. Indian Geomorphology by H.S. Sharma, 1991, Concept Publishing Co. New Delhi.
13. Text book of Physical Geology by G.B. Mahapatra, 2008, CBS Publishers & Distributors Private Ltd.
14. Plate Tectonics and Crustal Evolution by Condie, Kent. C., 1997, Butterworth-Heinemann.

Course Code: EGS-512
Course Title: Environmental Geology and Natural Hazards
Total Hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcomes: Upon successful completion of this course, the student will be able to:

- describe the scientific method as applied in the earth sciences;
- explain the hydrologic cycle and theory of plate tectonics as related to natural hazards and earth resources;
- describe common earth materials and their relationship to environmental hazards;
- explain how earth processes create hazards to life and property;
- describe the occurrence and formation of earth resources and significant environmental effects caused by their extraction, processing, and use;
- describe the major sources of water, soil, and sediment pollution and methods for their management;
- explain the causes and effects of global climate change.

UNIT I **15 Hours**

Introduction to Environmental Geology: Fundamental concepts of environmental geosciences, its scope and necessity; Definition, structure, composition and general characteristics of lithosphere, hydrosphere, atmosphere and biosphere; Concept of ecology, ecosystem, its structure and functions, types of ecosystem; Biogeochemical cycles of carbon, nitrogen, phosphorus and sulfur; Physiography, drainage, climate, soils and natural resources of India.

UNIT II **15 Hours**

Environmental issues: Water pollution : types of water pollution, groundwater pollution sources, pathways and mechanism, attenuation processes, case histories of natural (arsenic and fluoride poisoning) and man-made water pollution; water logging, causes, effects and remedial measures, aquifers; declining groundwater tables, subsidence and compaction of aquifers ; Soil pollution- sources, causes and effects; Soil pollution control measures; Air pollution : definition, terminology, sources and classification of air pollutants; effects of air pollution- acid rain, green house effects and ozone layer depletion; Air pollution control and management.

UNIT III **15 Hours**

Introduction to Disasters: Introduction to natural and manmade disasters; Dimensions of natural and anthropogenic disasters; Floods –nature and frequency of flooding, flood hazards, urbanization and flooding, flood hydrographs, Dams barrages and river diversions; Landslides; Coastal hazards – tropical cyclone, coastal erosion, sea level changes, coastal zone management; Earth quakes - Seismic waves, quake resistant buildings and dams; Tsunamis; Volcanoes; Wild fires; Oil spills; Urban hazards and disasters.

UNIT IV **15 Hours**

Risk Assessment and Preparedness: Pre-Disaster Management activities; Hazard and vulnerability analysis; Hazard zonation maps : preparation and utilization; capability assessment; emergency / contingency planning and post-disaster management activities; Development planning, planning environment, types of plans, MBO, SWOT analysis; Mitigation strategy : Relief measures, community health, casualty management Role of Government, Non-Governmental and media agencies, Reconstruction and Rehabilitation; Awareness through print and electronic media, involving youth in field observations

Transactional Modes: Lecture, Demonstration, Tutorial, Problem solving, Seminar, assignment, Group discussion, **Tools used:** PPT, Video, Animation, toposheet and maps.

Suggested Readings:

1. Environmental Geology by Barbar W. Murk et al., 1996, John Wiley & Sons, New York.
2. Introduction to Environmental Geology by Edward A. Keller, 2011, Pearson Education publisher.
3. Environmental Geology by K. S. Valdiya, 2013, McGraw-Hill Education (India)
4. Disaster Management and Preparedness by Collins Larry R. and Schneid Thomas D., 2000, Taylor and Francis.
5. Earth Science and the Environment by Graham Thompson and Jon Turk, 2007, Thomson and Brooks/cole.
6. Disaster Management by Goel S.L. and Kumar Ram, 2001, Deep and Deep Publications.
7. Living with Risk: A global review of disaster reduction initiatives, 2004 Vision, United Nations.
8. India Disasters Report: Towards a Policy Initiatives by Parasuraman S., 2004, Oxford University Press.

L	T	P	Cr
4	-	-	4

Course Code: EGS-513
Course Title: Natural Resource and Watershed Management
Total Hours: 60

Learning Outcomes: Upon successful completion of this course, the student will be able to integrate and apply technical knowledge in the following key areas

- Geology & Climate - rock materials and processes of the lithosphere, plate tectonics; deformational histories, and past climates;
- Soils & Water - morphology, ecology, chemistry, physics, and health;
- Geography & Geospatial Technology - human cultural impacts, resource utilization trends and spatial patterns, geographic information systems and modeling;
- Resource Management - effects of land management activities on, and restoration and rehabilitation of, soil and water resources.
- To evaluate the validity and limitations of scientific theories and claims about the environment.
- Understand the interactions among physical, biological, chemical, and human components of the environment.

UNIT I **15 Hours**

Natural resources: Definition; Resource and Reserve; Classification of natural resources; natural resource degradation and conservation; Environmental impacts of resource depletion. Forest Resources: Forest cover of India and world; forest types, functions of forest – production and protection; Conservation of forests; forestry programmes – social forestry, farm forestry,

urban forestry, community forestry; deforestation; Exploitation of forest resources; Afforestation; Desertification; Forest policy.

UNIT II **15 Hours**

Water Resources: Surface, ground water, marine and brackish water resources - assessment and utilization; Rivers and Lakes in India; hydrological cycle; Ground water depletion; Water logging and salinity; Water Conservation and management techniques; Rain water harvesting; Watershed management; Eutrophication; Restoration of Lakes; River cleaning, River action plans - Ganga and Yamuna action plan, Interlinking of rivers; conflicts over water.

Land resources: Land degradation due to mining, exploration, industrialization, irrigation and natural disasters; Soil Erosion, Loss of soil fertility, Restoration of soil Fertility, Soil Conservation Methods; restoration of degraded land; Wasteland reclamation, Organic farming, green manuring, Wetland – definition, classification, functions, ecological importance and conservation.

UNIT III **15 Hours**

Concept of watershed, introduction to watershed management, different stakeholders and their relative importance, watershed management policies and decision making, problems, approach and components. Structure and relief, physiographic divisions, drainage systems and watersheds. Concept of small dams waste disposal practices and management; rainwater harvesting; Wetland and concept of Micro Watershed Management; Watershed Management using Geo-spatial technologies.

UNIT IV **15 Hours**

Community participation, private sector participation, Institutional issues, Socio-economy, Integrated development; Watershed Management in India, Water legislation and implementations, policies and decision making. Community participation, Private sector participation, Case studies. Storm water management, design of drainage system, flood routing through channels and reservoir, flood control and reservoir operation, case studies on flood damage. Drought assessment and classification, drought analysis techniques, drought mitigation planning. Perspective on recycle and reuse, Waste water reclamation.

Transactional Modes: Lecture, Demonstration, Tutorial, Problem solving, Seminar, assignment, Group discussion, **Tools used:** PPT, Video, Animation.

Suggested Readings:

1. Environmental economics and natural resource management by Anderson, David A., 2013, Routledge.
2. Land resource management by Gurdev Singh and Vinod Ahuja, 1992, Oxford & IBH Pub. Co.
3. Natural resources and sustainable developments by Kathy Wilson Peacock, 2008, Facts on file Inc.

4. Sustainable natural resource management for scientists and engineers by Lynch, Daniel R., 2009, Cambridge University press
5. Natural resources in 21st century by Jaidev Somesh, 2010, ABD Publisher
6. Essential Environmental Studies by Panday, S.N. and Misra, S.P. (Eds.), 2008, CRC Press.
7. Watershed Management in India by Murthy, K.S. 1998.Wiley Eastern Ltd. / New Age International Ltd.
8. Watershed Management: Guidelines for Indian Conditions by Tideman, E.M., 1996, Omega, New Delhi.
9. Water of Hope: Integrated Water Resource Development and Regional Co-operation within the Himalayan-Ganga-Brhamaputra-Barak Basin by Verghese, B.G., 1990, Oxford-IBH.

SEMESTER II

Course Code: EGS. 521
Course Title: Geochemistry and Isotope Geology
Total Hours - 60

L	T	P	Cr
4	-	-	4

Learning Outcome: Upon successful completion of this course, the student will be able to

- Understand the behaviors of elements in the formation of primary and secondary rocks
- Learn the basics of isotope systematics and radioactive decay.
- Learn the relevance of geochemistry to understanding the distribution of elements in and on Earth.
- Learn the principles and applications of radiogenic isotope systematics to study geological processes and date rock-forming events.
- Get acquainted with the principles and applications of stable isotope systematics.

Unit 1 **14 Hours**

Geochemistry
Introduction of geochemistry and cosmochemistry. Abundance of elements in the solar system and chemical composition and properties of Earth's layers. Atmosphere: its layers, chemical composition and evolution of atmosphere. Meteorites, classification, mineralogy, origin, significance and phenomena of fall.

Unit II **15 Hours**

Geochemical classification of elements. Periodic table with special reference to rare earth elements and transition elements. Principles of ionic substitution in minerals; Rules of ionic substitution, coupled substitution; Distribution coefficient: Capture admission and camouflage, Geochemical classification of elements; Behaviour of major and trace including rare earth elements during magmatic crystallization. Geochemistry of uranium and lithium. Elemental mobility in surface environment. Concept of geochemical-biogeochemical cycling: Minor cycle and major cycle. Eh-pH diagram; Principle of chemical mass balance and rock- cycle; Chemical weathering of minerals and rocks

Unit III **18 Hours**

Isotope Geology

Introduction and physics of the nucleus; radioactive decay; the law of radioactive decay; review of mineral structure; principles of mass spectrometry; K-Ar method: principles, methods and applications; Ar-Ar method: principles, method and advantages: Rb-Sr method: principles, Rb-Sr isochron and limitations. Sm-Nd Method: decay scheme, evolution of Nd with time, Nd model ages and application of Nd to petrogenesis; U-Th-Pb Method: decay schemes, U-Pb isochron, U-Pb mineral dating and application.

Unit IV **13 Hours**

Stable isotopes and their fractionation; ratio Mass Spectrometry; principles of oxygen, carbon and sulphur isotope geochemistry and their application in Geology. Application of Cosmogenic radionuclides in the geosciences. Principles and application of Fission Track and Radiocarbon methods of dating.

Transactional Modes: Lecture, Demonstration, Lecture cum demonstration, Project Method, Inquiry training, Seminar, Group discussion, Co-operative learning, Blended learning, Flipped learning, Focused group discussion, Team teaching, Field visit, Brain storming, Mobile teaching, Collaborative learning, E- tutoring, Problem solving, Case analysis, Case study, Self-learning, Case based study, Through SOLE (Self Organized Learning Environment), Experimentation.

Suggested readings:

1. Principles and applications of Geochemistry by Gunter Faure, 1998, Prentice Hall.
2. Essentials of Geochemistry by John V. Walther, 2010, Jones and Bartlett Publication.
3. Isotope Geology by Claude Allegre, 2008, Cambridge University Press.
4. Radiogenic Isotope Geology by Dickin, A.P., 2005, Cambridge University Press.
5. Stable Isotope Geochemistry by JochenHoefs, 2015, Springer International Publishing.
6. Principles of Isotope Geology by Gunter Faure, 1986, Wiley.
7. Isotopes: Principles and Applications by Gunter Faure and Teresa M. Mensing, 2004, Wiley

8. Geochemistry, An introduction by Francis Albarede, 2003, Cambridge University Press.
9. Geochemistry by William M. White; 2013, Wiley-Blackwell.
10. Geochemistry: Pathways and Processes by H.Y. McSween Jr., S.M. Richardson and M.E. Uhle, 2003, Columbia University Press,
11. Introduction to Geochemistry byMason, B. and Moore, C.B., 1991, Wiley Eastern.
12. Introduction to Geochemistry by Krauskopf, K. B., 1967, McGraw Hill.

Course Code: EGS. 522
Course title: Igneous and Metamorphic Petrology
Total Hours - 60

L	T	P	Cr
4	-	-	4

Learning Outcome: Upon successful completion of this course, the student will be able to

- Identify the common rock forming minerals of igneous and metamorphic rocks in both hand specimen and thin-section.
- Identify key textural/micro structural features of igneous and metamorphic rocks and appreciate the significance of such features with regard to geological processes that have operated.
- Assign a name to an igneous or metamorphic rock on the basis of its mineralogical and textural characteristics, and appreciate the environment(s) of formation.
- Practical experience of rock and mineral identification in hand specimen and in thin-section using a transmitted light microscope.
- interpret phase diagrams relevant to igneous systems and petrogenic grids relevant to metamorphic systems on the basis of mineral assemblages recorded in the rock.
- make detailed and annotated petrographic sketches from thin-section observation and to summarize the salient features and relate the chemistry of the system and environment of formation.

Unit I **14 Hours**

Magma: nature of magma, Magma generation in the mantle, their nature and evolution; Magmatic processes: Partial melting, fractional crystallization, assimilation, liquid immiscibility factors affecting magma and evolution, melting of mantle. Generation of magmas in different tectonic environments. The phase equilibrium of unary, binary and ternary systems and its relation to magma genesis and crystallization in the recent experimental works. Study of phase equilibria in binary (Diopside-Anorthite, Forsterite- Silica, Leucite-Silica, AlbiteAnorthite, Orthoclase-Anorthite) and ternary silicate systems (Orthoclase-Albite-Silica, Diopsite-AlbiteAnorthite, Diopside-Forsterite-Silica, Fayalite-Leucite-Silica) in the light of modern experimental works. Interpretation of igneous textures in terms of rate of nucleation and crystal growth.

Unit II **16 Hours**

IUGS classification of the Igneous rocks. CIPW Norm. total alkali-silica (TAS) classification of volcanic igneous rocks Petrology and petrogenesis of ultramafic, basaltic, granitic, alkaline igneous rocks including ophiolite, carbonatite, nephelinite-ijolilte, lammproits, and layered igneous rocks with Indian examples. Plume magmatism and hot spots. Mantle metasomatism. Mantle heterogeneities. Partial melting (batch and fractional melting), crystal fractionation, contamination (AFC process) and dynamic melting.

Unit III **15 Hours**

Mineralogical phase rule for closed and open systems. Nature of metamorphic reactions, concept and classification of metamorphic facies, Graphical representation of minerals in ACF, AKF, AFM and A'F'M' diagrams; Time relation between phases of deformation and metamorphic crystallization. Introduction to ultrahigh temperature and ultrahigh pressure metamorphism, description of each facies of low–Pressure, medium to high–pressure and very high pressure with special reference to characteristic minerals, subdivision into zones/sub-facies, Metamorphism of shale, mafic and calcareous rocks Mineral assemblages, Metamorphic reactions and pressure–temperature conditions of metamorphism .

Unit IV **15 Hours**

Isograds and reaction isograds, Schrienemakers rule and construction of petrogenetic grids, Metamorphic differentiation, anatexis and origin of migmatites in the light of experimental studies, Regional metamorphism and paired metamorphic belts with reference to the theory of plate tectonics, Geothermobarometry Pressure – temperature – time paths.

Transactional Modes: Lecture, Demonstration, Lecture cum demonstration, Project Method, Inquiry training, Seminar, Group discussion, Cooperative learning, Blended learning, Flipped learning, Focused group discussion, Team teaching, Field visit, Brain storming, Mobile teaching, Collaborative learning, E- tutoring, Problem solving., Self-learning, Case based study, etc.

Suggested readings:

1. An introduction to Igneous and Metamorphic Petrology by Winter, J.D., 2001, Prentice Hall.
2. Principles of Igneous and Metamorphic Petrology by Philpotts, A.R. 1994, Prentice Hall.
3. The Interpretation of Igneous Rocks by Cox, K.G., Bell, J.D. and Pankhurst, R.J., 1993, Champman& Hall, London.
4. Igneous and Metamorphic Petrology by Turner, F. J., and Verhoogen, J., 1987, CBS.
5. Igneous and Metamorphic Petrology by Best, Myron G., 2002. Blackwell Science.
6. Origin of Igneous Rocks – The Isotopic Evidence by Faure, G., 2001, Springer.
7. Igneous Petrology by Hall A., 1997, Longman.

8. Igneous Rocks: A Classification and Glossary of Terms by Le Maitre, R.W., 2002, Cambridge University Press.
9. Igneous Petrology by McBirney, 1994, CBS Publishers, Delhi.
10. Modern Igneous Petrology by Sood, M. K., 1982, Wiley-Interscience Publ., New York.
11. Magmatism in Relation to Diverse Tectonic Settings by Srivastava Rajesh, K., Chandra, R. and Balkema, A.A., 1997, Oxford University Press.
12. Petrogenesis of Metamorphic Rocks by Bucher, K. and Martin, F., 2002, Springer – Verlag.
13. An introduction to Metamorphic Petrology by Yardley, B.W.D., 1989, Longman Scientific & Technical, New York.
14. Mineralogical Phase Equillibria and pressure – temperature – time Paths by Spear, F. S. 1993, Mineralogical Society of America.
15. Equilibrium thermodynamics in Petrology: An Introduction by Powell, R. 1978, Harper & Row Publishers, London.
16. Igneous Petrology by Bose, M.K., 1997, World Press, Kolkata.

Course Code: EGS. 523
Course Title: Structural Geology
Total hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcome: Upon successful completion of this course, the student will be able to

- Interpret the geological structure of deformed continental regimes, and microstructural analysis.
- Interpret the relative timing of formation of structures, the kinematics of deformation, and the progressive deformation histories in these regimes.
- Apply an understanding of structural geology in the mining and resource exploration environment

Unit I **15 Hours**

Stress and analysis of stress in two and three dimension. Plane stress analysis and Mohr stress circle, and its relationship with faulting and fracture mechanics. Mechanical principle, properties of rocks and their controlling factors. Theory of rock failure: brittle failure – shear and tensile failures. Role of fluid pressure and effective pressure in brittle failure.

Strain analysis– finite and infinitesimal, homogeneous and inhomogeneous strains. Strain and deformation paths. Determination of strain in naturally deformed rocks.

Unit II **15 Hours**

Description and geometric classification of folds. Mechanics of folding. Fold development and distribution of strains in folds. Brittle and ductile shear zones, Geometry and products of shear zones, Mylonites and Cataclasites; buckling of single layer, multilayer and anisotropic materials. Analysis and interpretation of superimposed folding.

Unit III **15 Hours**

Planar and linear fabrics (Foliation and Lineation) in deformed rocks: description, classification, genesis and significance. Basic idea about petrofabrics and use of Universal stage. Stereographic and equal area projections for representing different types of fabrics, π and β diagrams. Non-diastrophic structures: significance in the study and analysis of deformed rocks.

Unit IV **15 Hours**

Description and classification of faults and joints. Mechanics of faulting and jointing, and stress conditions for thrust, normal and strike-slip faults. Mechanics and geometric aspects of thrust, normal and strike-slip faults, and associated structural features. Thin-skinned and thick-skinned deformations; Decollement. Geometrical analysis of simple and complex structures on macroscopic scale. Identification of top and bottom of the strata/rock.

Transactional Modes: Lecture, Demonstration, Lecture cum demonstration, Project Method, Inquiry training, Seminar, Group discussion, Co operative learning, Blended learning, Flipped learning, Focused group discussion, Team teaching, Field visit, Brain storming, Mobile teaching, Collaborative learning, E- tutoring, Problem solving.

Suggested readings:

1. Structural Geology by Marland P. Billings, 2000, Phi Learning.
2. Structural Geology by Robert J. Twiss, Eldridge M. Moores, 2006, W. H. Freeman publisher.
3. Structural Geology by Haakon Fossen, 2010, Cambridge University Press.
4. Structural Geology: An Introduction to Geometrical Techniques by Donal M. Ragan, 2009, Cambridge University Press.
5. Techniques of Modern Structural Geology. Vol. I. Strain Analysis by Ramsay, J.G. and Huber, M.I., 1983, Academic Press.
6. Techniques of Modern Structural Geology. Vol. II. Folds and Fractures by Ramsay, J.G. and Huber, M.I., 1987, Academic Press.
7. Folding and fracturing of rocks by Ramsay, J.G., 1967, McGraw Hill.
8. Basic Methods of Structural Geology by Stephen Marshak and GautamMitra.1988, Prentice Hall.
9. An outline of Structural Geology by Hobbs, B.E., Means, W.D. and Williams, P.F., 1976, John Wiley and Sons. New York.
10. Structural Geology: Fundamental and Modern Developments by Ghosh, S.K., 1993, Pergamon Press.

Course Code: EGS. 524
Course Title: Igneous and Metamorphic Petrology (Practical)
Total Hours: 60

L	T	P	Cr
-	-	4	2

Learning Outcome: Upon successful completion of this course, the student will be able to

- Identify the common rock forming minerals of igneous and metamorphic rocks in both hand specimen and thin-section.

- Identify key textural/micro structural features of igneous and metamorphic rocks and appreciate the significance of such features with regard to geological processes that have operated.
- Assign a name to an igneous or metamorphic rock on the basis of its mineralogical and textural characteristics, and appreciate the environment(s) of formation.
- Practical experience of rock and mineral identification in hand specimen and in thin-section using a transmitted light microscope.

Unit I

Rock analyses (rapid method of silicate analysis). Determination of Loss on Ignition (LOI) of rock samples. Preparation of classificatory and variation diagrams and their interpretation. Study of non-silicate minerals and elements. Megascopic and microscopic study of different igneous rocks. Calculation of CIPW Norms.

Unit II

A detailed study of textures in Rock Sections with reference to time relations between the phases of deformation and recrystallization of minerals, Calculation of ACF, AKF and AFM values from chemical and structural formulation of minerals and their graphical representation. Study of Metamorphic Rocks in hand specimens and thin sections belonging to different facies with emphasis on texture/structure, mineral composition, parent rock, metamorphic facies / subfacies.

Transactional Modes: Demonstration, Group discussion, Problem solving, Case analysis, Case study, Self-learning, Case based study, Through SOLE (Self Organized Learning Environment), Experimentation.

Suggested readings:

1. Igneous Rocks: A Classification and Glossary of Terms by LeMaitre, R.W., 2002, Cambridge University Press.
2. An introduction to Igneous and Metamorphic Petrology by Winter, J.D., 2001, Prentice Hall.
3. Principles of Igneous and Metamorphic Petrology by Philpotts, A.R. 1994, Prentice Hall.
4. The Interpretation of Igneous Rocks by Cox, K.G., Bell, J.D. and Pankhurst, R.J., 1993, Champman& Hall, London.

Course Code: EGS. 525
Course Title: Structural Geology (Practical)
Total hours: 60

L	T	P	Cr
-	-	4	2

Learning Outcome: Upon successful completion of this course, the student will be able to

- Recognize map and interpret the geological structure of deformed continental regimes, and microstructural analysis.
- Apply an understanding of structural geology in the mining and resource exploration environment

Unit I

Preparation and interpretation of Geological maps and sections. Structural problems based on orthographic and stereographic projections, concerning economic deposit. Recording and plotting of the structural data on base map.

Unit II

Study of the hand specimen of deformed structures, Strain estimation from the data already collected from the field. Study of dip-isogons from the fold profiles.

Transactional Modes: Demonstration, Group discussion, Problem solving, Case analysis, Case study, Self-learning, Case based study, Through SOLE (Self Organized Learning Environment), Experimentation.

Suggested readings:

1. Basic Methods of Structural Geology by Stephen Marshak and Gautam Mitra. 1988, Prentice Hall.
2. Structural Geology: Fundamental and Modern Developments by Ghosh, S.K., 1993, Pergamon Press.
3. Techniques of Modern Structural Geology. Vol. II. Folds and Fractures by Ramsay, J.G. and Huber, M.I., 1987, Academic Press.

Evaluation Criteria: Total Marks – 100,
End semester exam (70%), Lab record (15%), Viva (15%)

Course Code: EGS 526
Course Title: Field training - I
Total hours: 30

L	T	P	Cr
-	-	2	1

Learning Outcome: Upon successful completion of this course, the student will be able to

- Apply theoretical knowledge at ground observation in field and to learn essential observational and practical skills.
- Identifying rocks and interpreting the physical (including tectonic) processes that may have been involved in their formation.
- Identify different rock type, different deformational structures, such as fold, fault, lithology and depositional features etc. in the field.
- Learn how to get adopt in the fieldwork environment in certain professional and scientific organizations.

Geological field training

Geological field training and fieldwork will be carried out as per the guideline of the University at proper sites for a minimum period of 10 days. During the fieldwork, the students will be exposed to identification of lithology, structure, landforms, fossils, field mapping, sampling, data collections for lithology and structure, ore and economic geology.

Transactional Modes: Demonstration, Inquiry training, Group discussion, Co operative learning, Blended learning, Focused group discussion, Team teaching, Field visit, Brain storming, Problem solving, Case analysis, Self-learning, Case based study, Through SOLE (Self Organized Learning Environment).

Suggested readings:

1. Geological field techniques by Angela L. C. 2010, Blackwell Publishing Ltd.
2. Basic Geological Mapping (Geological Field Guide) by Lisle, R. J., Brabham, P. and Barnes, J. W., 5th edition, 2011, Wiley-Blackwell.
3. Guide to Field Geology by Mathur, S.M., 2001, PHI Learning Private Limited-New Delhi.
4. Field geology (Illustrated) by Maley, T.S., 1994, Mineral Land Publications.
5. Field geology by Lahee, F. H., 6th edition, 1961, McGraw-Hill.

Evaluation Criteria: Full Marks – 100
Field activity (10%), Evaluation of field dairy during every day of field work and final submission (20%), Final field report (40%), Presentation (30%) – Presentation will be evaluated as style (5%), content (5%), understanding (10%) and question & answer (10%).

Course Code: EGS. 542
Course Title: Seminar
Total hours: 15

L	T	P	Cr
-	1	-	1

Course Objective:

- To enhance the presentation skill and of the student.
- To introduce how the scientific research paper, any subject matter organized for presentation and how it will attract attention of audience.

Learning Outcome: Student will learn how to present their thought/idea/ scientific findings in a skillful way. How to participate in the discussion and question /answer session during presentation?

Seminar:

Students will be assigned with a topic, research article, book chapter or any subject related topic to prepare a report and presentation. Scheduled seminars will be conducted in the department in the presence of experts.

Transactional Modes: Project Method, Inquiry training, Seminar, Group discussion, Problem solving, Case analysis, Case study, Self-learning, Through SOLE (Self Organized Learning Environment), Experimentation.

Evaluation Criteria- Full marks 100.
It will be evaluated based on Literature strength, Organization of content, report evaluation**,** presentation, discussion and question answer.

Discipline Elective: Select any one

Course Code: EGS. 527
Course Title: Oceanography and Climatology
Total hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcome: Upon successful completion of this course, the student will be able to

- explain and discuss meteorological, oceanographic and climate phenomena for both laymen and experts
- comprehension of the history, development and terminology of the fields of meteorology, oceanography (including marine biogeochemistry) and climate
- understand of the key components of meteorology, oceanography and climate, and has in-depth knowledge in a specialised subject
- apply modern field instrumentation, theory, programming and/or advanced analysis on geophysical problems
- Evaluate and discuss data quality and different information sources in geophysics
- Formulate, discuss and implement strategies for data and theoretical analysis.

Unit I: Oceanography **15 Hours**

Origin, evolution of ocean basins and their environmental response; Topographic features of the ocean floor; Classification of marinesediments, sedimentation processes; Wave dynamics; Ocean circulation Gyres: forces driving currents; thermohaline circulation; equatorial upwelling, coastal upwelling, downwelling; Waker circulation El Nino, La Nina, seasons and monsoons Ocenic Conveyer belt Circulation. Tides - equilibrium theory of tides, dynamical theory of tides, tidal currents in coastal areas, observation and prediction of tides.

Unit II **15 Hours**

Seawater chemistry: salinity - components, sources and processes controlling the composition of sea water; Density structure of ocean; inputs of organic carbon, concept of food chain; primary production, measuring productivity, factors limiting productivity,Marine resources: Origin and evolution of the Indian Ocean, structure and physiography of the Indian Ocean, bathymetry and bottom characteristics, sediment distribution on the Indian Ocean floor. Petroleum occurrences and exploration activity around the margins of the Indian Ocean. India's Exclusive Economic Zone (EEZ); marine minerals in the EEZ of India.

Unit III: Climatology **13 Hours**

Fundamentals of meteorology, Scales of meteorology, Parameters of meteorology- pressure, wind, temperature, humidity, radiation; Radiations: Radiation laws, short wave and long wave radiations; Albedo; Emissivity; Radiation Budget of Earth; Application of meteorological principles to transport and diffusion of pollutants, Topographic effects.

Unit IV **Hours 17**

The boundary layer; Inversion; Local microclimate; Greenhouse effect; Radiation balance; Precipitation; Atmospheric movements; Distribution of radiation; Rotation of earth- Coriolis acceleration, angular momentum; General meridional circulations: Hadley cells; Middle latitudes; Circulation of water and energy in atmosphere; Weather, and Climate in India; El Nino, La Nina; Climatic classification schemes; Climate change-Emissions and Global warming, impact on sea level in south Asian region; Environmental disruptions and their implications.

Transactional Modes: Lecture, Demonstration, Lecture cum demonstration, Project Method, Inquiry training, Seminar, Group discussion, Blended learning, Flipped learning, Focused group discussion, Team teaching, Field visit, Brain storming, Mobile teaching, Collaborative learning, Case based study, Through SOLE (Self Organized Learning Environment).

Suggested readings:

1. Oceanography-An invitation to Marine Science by Garrison T., 1996, Wadsworth Publishing Company
2. Oceanography - A view of the Earth by Gross, M.G., 1972, Prentice-Hall.
3. Introductory Oceanography by Thurman, B.Y., 1978, Charles E. Merill Publishing Company.
4. Climatology, by Lal, D. S., 2011, Sharda Pustak Bhavan.
5. General climatology by Critchfield, H. J., 2009, PHI Learning, New Delhi.
6. Introduction to geomorphology by Kale, V. S. and Gupta, A., 2001, Orient Longman, Bangalore.
7. Physical geography by Singh, S., 2011, Prayag Pustak Bhavan, Allahabad.
8. An introduction to physical geography by Strahler, A.N. and Strahler, 1996, John Wiley & Sons, UK.
9. Principles of Oceanography by S. Davis, R.A. Jr. 1972, Addison - Wesley Publishing Company.
10. The Indian Ocean: Exploitable mineral and petroleum Resources by Roonwal, G.S., 1986,Narosa Publishing House.
11. Geological Oceanography: Evolution of coasts, continental margins & the deep-sea floor by Francis P. Shepard, 1977, Pan Publication.
12. Oceanography – Exploring the planet Ocean by Bhatt J.J., 1978, D. van Nostrand Company.

Course Code: EGS. 528
Course Title: Mineral Exploration and Petroleum Geology Mineral
Total hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcome: Upon successful completion of this course, the student will be able to

- Understand the ore deposit types, including genesis and exploration requirements;
- Get a thorough understanding of petroleum geology, exploration techniques, and resource evaluation;
- Enhance their concept-oriented approaches in the analysis of geological data;
- Understand and apply geochemical exploration methods and geochemical data presentation/analysis;
- Know the role of geology in mine design and operation.
- Know the range of surface and underground mining techniques

Unit I **15 Hours**

Mineral Economics : Distribution of mineral resources in India; Magmatic, hydrothermal and surface processes of ore formation; Active ore-forming systems; Geological setting, characteristics, and genesis of ferrous, base and noble metals. Origin, migration and entrapment of petroleum; properties of source and reservoir rocks; structural, stratigraphic and combination traps; Petroliferous basins of India; Classification, rank and grading of coal; coal resources of India; Gas hydrates and coal bed methane.

Unit II **15 Hours**

Mineral Exploration Methods: Geological, geophysical, geochemical and geobotanical methods of surface and sub-surface exploration on different scales; Sampling, assaying and evaluation of mineral deposits; Estimation of grade and reserve of ores; methods of mineral deposit studies including ore microscopy, fluid inclusions and isotopic systematic; ores and metamorphism: cause and effect relationship; Methods of petroleum exploration.

Unit-III **15 Hours**

Occurrence and Source rocks: Classification and composition of Petroleum; Physical properties of petroleum; Occurrence of petroleum; Nature of source rock, composition of biomass; Kerogene: Composition and types; Reservoir rocks, pore space and fluids; Reservoir Traps; Origin, migration and accumulation of petroleum. Basin Analysis.

Unit-IV **15 Hours**

Indian Oil Fields- Prospecting and Drilling: Oil bearing basins of India and the world; India's position as regards to petroleum and natural gas future prospects; Geophysical prospecting for petroleum; Drilling, logging and subsurface correlation. Importance of micropaleontology in the field of petroleum exploration.

Transactional Modes: Lecture, Demonstration, Lecture cum demonstration, Project Method, Inquiry training, Seminar, Group discussion, Blended learning, Flipped learning, Focused group discussion, Team teaching, Field visit, Brain storming, Mobile teaching, Collaborative learning, Case based study, Through SOLE (Self Organized Learning Environment).

Suggested readings:

1. Geology of Petroleum by Leverson, 2006, CBS.
2. Elements of Petroleum Geology by Selley, R.C., 1997, Atlantic publishers & distribution Pvt. Ltd, Delhi.
3. Geology of Petroleum by Emmons, W. H., 2015, Sagwan press.
4. Introduction to geophysical prospecting by Dobrin, M. B. and Savit, C. H., 1988, McGraw-Hill Inc.
5. An Introduction to Geophysical Exploration by Kearey, P., Brooks, M. and Hill, I., 2002, Wiley-Blackwell.
6. Principles of Applied Geophysics by Parasnis, D. S., 1986, Chapman and Hall.
7. Geochemistry in mineral exploration by Hawkes, H. E., Webb J. S., In eds., Croneis, C., 2012, Literary Licensing, LLC.
8. Mineral Exploration: Principles and Application by Haldar, S. K. 2013, Elsevier.
9. Introduction to Mineral Exploration by Moon C. J., Whateley, M. K. G. and Evans, A.M., 2005, Blackwell Science.
10. Introduction to geophysical prospecting by Dobrin, M. B. and Savit C. H., 1988, McGraw-Hill Inc.
11. An Introduction to Geophysical Exploration by Kearey, P., Brooks M. and Hill, I., 2002, Wiley-Blackwell.
12. Geochemistry in mineral exploration by Hawkes, H. E., Webb J. S., In eds., Croneis, C., 2012, Literary Licensing, LLC.

Interdisciplinary Course offered by the department

Course Code: EGS. 534
Course Title: Introduction to Disaster Management
Total hours: 30

L	T	P	Cr
2	-	-	2

Learning Outcome: The main objectives of this course are to make aware of both the Natural and Artificial disaster, their management techniques and familiarize the students with the foundations and the recent trends in disaster management.

Course Contents

Unit I **7 Hours**

Disaster Management: definition, scope, Objectives and Approaches;

- Elements of Disaster Management
- Concept of hazard, risk, vulnerability and disaster

Unit II **8 Hours**

- Classification of disasters- natural disasters and human induced disasters;
- Disasters in India- earthquake, landslide, flood, cyclone, industrial disasters, etc.

Unit III **8 Hours**

- Disaster mitigation: Concept, importance, tools, strategies with reference to specific disasters;
- Disaster preparedness: Concept, nature, measures, disaster preparedness plan.

Unit IV **7 Hours**

- Role and responsibility of Central, State, District and Local Administration, Armed Forces, NGOs, media, etc.;
- Disaster relief; Reconstruction planning; A brief introduction to the mechanism of disaster management in India.

Suggested readings:

1. Ahmad, A. (2010): *Disaster Management: Through the New Millennium*, Anmol Publications, New Delhi.
2. Ahmed, Shaik Iftikhar (2008). *Disaster Management in the Wake of a Flood*, Twenty First Century Publications, Patiala.
3. Bilham, R. (2009). The seismic future of cities. Bulletin of Earthquake Engineering, 7, pp. 839-887.
4. Bryant Edwards (2005). Natural Hazards, Cambridge University Press, U.K.
5. Bureau of Indian Standards (2002). Indian Standards: Criteria for Earthquake Resistant Design of Structures, Part I, Fifth Revision.
6. Burton, I., Kates, R.W. and White, G.F. (1993). *Environment as Hazard*, 2nd edition, Guilford Press, New York.

SEMESTER III

Course Code: EGS.551
Course Title: Ore Geology
Total hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcome: Upon successful completion of this course, the student will be able to

- Recognize common ore minerals in hand samples and under the microscope
- Get familiarize with a wide range of mineral deposits, including recognizing the overall geometry, zonation and alteration patterns associated with specific classes of metallic mineral deposits
- Relate overall geometry, zonation and alteration patterns of rock associations to specific classes of metallic mineral deposits.

- Evaluate different processes of element enrichment by fluids and melts to from ore bodies.
- Understand the formation of ore bodies is important in the current debates about global resources.

Unit I **15 Hours**

Modern concept of ore genesis; mode of occurrence of ore bodies – morphology and relationship of host rock and migration, wall-rock alteration. Structural, physicochemical and stratigraphic controls of ore localization. Paragenesis, paragenetic sequence and zoning in metallic ore deposits. Spatial and temporal distribution of ore deposits – a global perspective. Earth's evolutionary history and evolutionary trends in ore deposits. Ore deposits in relation to plate tectonics.

Unit II **15 Hours**

Mineralogy, classification and genesis of petrological ore associations: Ortho-magmatic ores of ultramafic-mafic association, ores of felsic-silicic igneous rocks: ores related to submarine volcanism, biochemical, chemical and clastic sedimentation; placers and residual concentration deposits. Ores of metamorphic affiliations. Hydrothermal ore deposits. Principle of Fluid inclusions in ore: assumptions, limitations and applications. Geothermo-barometry and isotope studies in ore geology.

Unit III **15 Hours**

Study of ore minerals related to the following metals such as such Fe, Mn, Cr, Cu, Pb, Zn, Al, Mg, Au, Sn and W with special reference to their mineralogy, genesis, uses in important industries and their distribution in India. Strategic, critical and essential minerals. Importance of minerals in national economy and mineral policy. Mineral concessional rules of India. Law of the Sea.

Unit IV **15 Hours**

Fundamentals of coal petrology, peat, lignite, bituminous and anthracite coal. Microscopic constituents of coal. Indian coal deposits. Origin, migration and entrapment of natural hydrocarbons. Characters of source and reservoir rocks. Structural, stratigraphic and mixed traps. Techniques of exploration. Geographical and geological distributions of onshore and offshore petroliferous basins of India. Methods of petroleum exploration. Surface and subsurface exploration, gas hydrate and coal bed methane. Nuclear and Non-conventional source of energy.

Transactional Modes: Lecture, Demonstration, Lecture cum demonstration, Project Method, Inquiry training, Seminar, Group discussion, Co operative learning, Blended learning, Flipped learning, Focused group discussion, Team teaching, Mobile teaching, Collaborative learning, Problem solving, Case analysis, Self-learning, Case based study, Through SOLE (Self Organized Learning Environment).

Suggested readings:

1. Introduction to Ore-forming processes by Robb, L., 2005, Blackwell Publ., Oxford.
2. Ore geology and industrial minerals by Evans, A.M., 1992, Blackwell Science.

3. Understanding mineral deposits by Misra, K.C. 1999, Kluwer Academic Publishers.
4. Mineral economics by Sinha, R. K. and Sharma, N.L., 1970, Oxford & IBH.
5. Economic mineral deposits by Jensen, M.L. and Bateman, A.M., 1981, John Wiley & Sons.
6. Ore Petrology by Stanton, R. L., 1972, McGraw Hill.
7. The Geology of Ore Deposits by Guilbert, J. M. and Park, Jr. C. F., 1986, Freeman.
8. Geochemistry of Hydrothermal Ore Deposits by Barnes, H.L., 1979, John Wiley:
9. Economic Geology: Economic Mineral Deposits (Second Edition) by Umeshwar Prasad, 2014, CBS Publishers & Distributors Pvt. Ltd., New Delhi.

Course Code: EGS 552
Course title: Hydrogeology, Remote Sensing and GIS
Total hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcome: Upon successful completion of this course, the student will be able to

- Find/obtain GIS/RS datasets, download them, and prep them for use in GIS or remote sensing analysis.
- Interpret metadata; explore and interpret datasets lacking metadata.
- Troubleshoot issues with projections and coordinate systems.
- Figure things out on their own, find answers to their own questions, and use help menus, books, online forums, and other help resources effectively. Students should be doggedly persistent and self-sufficient.
- Collect data independently in the field and integrated it with a GIS.
- Design and carry out or manage a GIS-based or remote sensing-based independent project.
- Gain knowledge on the hydrological cycle, the water balance, hydrological processes.
- Identify hydrological problems relevant for other subject areas within civil and environmental engineering.

Unit I **15 Hours**

Hydrosphere and Groundwater flow: Hydrosphere; Hydrological Cycle Ground Water- origin, type and occurrence, Scope and importance of Groundwater**;** Factors that affect occurrence of groundwater - Climate, topography, geology; Principles of groundwater flow: concept of groundwater potential, validity of Darcy's law for laminar and turbulent flow – Tracing of groundwater movement with flow nets; Pumping tests – principles – types of pumping tests, procedures, concept of well hydraulics, determination of aquifer properties and well characteristics by simple graphical methods– significance of transmissivity and storativity data.

Unit II **15 Hours**

Occurrence and distribution of Groundwater: Vertical distribution of groundwater; Hydrologic properties of Rocks– Porosity, Hydraulic conductivity, Derivation of Darcy's law; Aquifers – characteristics of unconfined and confined aquifers; Aquifer properties – Concepts of Transmissivity and Storativity; behavior of sedimentary, crystalline and volcanic rocks as aquifers – factors controlling hydrologic, aquifer properties and yield of wells in different rock types; Impact of drought and groundwater overexploitation on aquifers; groundwater pollution.

Unit III **15 Hours**

Fundamentals of Remote Sensing; Types of platform; Types of Sensors; Data collection, Aerial Photography, Visual Image Interpretation, Digital image processing, Introduction to Global Positioning System (GPS); Types of Satellites; Different satellite exploration programs and their characteristics: LANDSAT, METEOSAT, MODIS, SPOT and IRS Satellite Series. Google Earth; Bhuvan; GPS; GAGAN. Elements of GIS; Map Projection; Data structures in GIS, GIS softwares; Vector and Raster based analysis; Overlays operations; Network Analysis; Spatial analysis.

Unit IV **15 Hours**

Applications of Remote Sensing and GIS in Geology: Thermal Infra-red remote sensing in geological studies; microwave remote sensing for geological applications; Applications of remote sensing - identification of rocks, mineral explorations, geological surveys; alteration zones mapping; geomorphology applications, volcanic eruptions, surfacial deposit / bedrock mapping; lithological mapping; structural mapping; sand and gravel (aggregate) exploration/ exploitation; hydrocarbon exploration; environmental geology; geobotany; sedimentation mapping and monitoring; event mapping and monitoring; geo-hazard mapping.

Transactional Modes: Lecture, Demonstration, Lecture cum demonstration, Project Method, Inquiry training, Seminar, Group discussion, Co operative learning, Blended learning, Flipped learning, Focused group discussion, Team teaching, Field visit, Brain storming, Mobile teaching, Collaborative learning, Problem solving, Self-learning, Case based study, Through SOLE (Self Organized Learning Environment).

Suggested readings:

1. Groundwater Hydrology by Todd D.K., 2007, John Wiley and Sons
2. Modern Hydrology and Sustainable Water Development by Gupta, S. K., 2011, Wiley-Blackwell.
3. Groundwater by Raghunath, H.M. 1985, Wiley Eastern Ltd.
4. Remote sensing and image interpretation by Lillisand, T. M. and Keifer, R. W., 2007, John Willey and Sons, USA
5. Introduction to geographic information systems by Chang, Kang-taung, 2002, Tata McGraw-Hill, USA.
6. Introduction to environmental remote sensing by Barrett, E. C. and Curtis L. F., 1999, Chapman and Hall Publishers, USA.
7. Fundamentals of remote sensing by Joseph G., 2003, Universities Press,

Hyderabad.
8. Remote Sensing: Principles and Interpretation by Sabbins, Jr. F.F. 1986, WH Freeman & Co.
9. Principles and Applications of Photogeology by Pandey, S.N., 1987, Wiley Eastern, New Delhi.
10. Remote Sensing Geology, by Gupta, R.P., 1990, Springer Verlag.
11. Groundwater Assessment Development and Management by Karanth, K.R.,1987, McGraw Hill Publishers
12. Groundwater by Freeze and Cherry, 1979, Prentice-Hall.

Course Code: EGS. 553
Course Title: Ore geology, and Remote Sensing and GIS (Practical)
Total hours: 60

L	T	P	Cr
-	-	4	2

Learning Outcome: Upon successful completion of this course, the student will be able to

- Recognize common ore minerals in hand samples and under the microscope
- Get familiarize with a wide range of mineral deposits, including recognizing the overall geometry, zonation and alteration patterns associated with specific classes of metallic mineral deposits
- find/obtain GIS/RS datasets, download them, and prep them for use in GIS or remote sensing analysis.
- interpret metadata; explore and interpret datasets lacking metadata.

Lab Exercise:

1. Megascopic study of Indian metallic ores and industrial minerals in hand specimens.
2. Study of optical properties and identification of important ore minerals under ore-microscope.
3. Preparation of maps showing distribution of metallic minerals in India and also classical world mineral deposits.
4. Preparation of maps showing distribution industrial minerals in India and also classical world mineral deposits.
5. Estimation of grade, tonnage of ore deposits.
6. Interpretation of borehole logs.
7. Determination of photo scale.
8. Determination of height of objects, dip of bed, slope and thickness of beds by Parallax bar.
9. Study of landforms and interpretation of lithology and structure from aerial photographs and satellite images
10. Identification of landforms on toposheets, aerial photographs and satellite images

Transactional Modes: Lecture cum demonstration, Problem solving, Through SOLE (Self Organized Learning Environment), Experimentation.

Suggested readings:

1. Mineral deposit evaluation by A.E. Annels, 1992, Chapman and Hall, London.
2. Ore geology and industrial minerals by Evans, A.M. 1992, Blackwell Science.
3. Remote sensing and image interpretation by Lillisand, T. M. and Keifer, R. W., 2007, John Willey and Sons, USA.

Evaluation Criteria: Total Marks – 100, End semester exam (70%),
Lab record (15%), Viva (15%)

Course Code: EGS. 554
Course Title: Quantitative Geosciences
Total hours: 30

L	T	P	Cr
-	2	-	2

Learning Outcome: Upon successful completion of this course, the student will be able to

- solve quantitative problems of geosciences
- prepare themselves for various national level competitive exams

Quantitative Geosciences:
This course will be conducted as tutorial classes. In this course student will solve quantitative problems of geosciences in time bound manner. Various numerical problems of geosciences will be discussed and solved in the classes. Problems will cover all the aspects of geosciences. Past question papers of national level exams will be discussed in the classes.
Transactional Modes: Project Method, Inquiry training, Seminar, Group discussion, Focused group discussion, Team teaching, Brain storming, Collaborative learning, Problem solving, Case analysis, Case study, Self-learning, Through SOLE (Self Organized Learning Environment).

Evaluation Criteria- Full marks – 100,
End semester exam (70%), Assignment based evaluation (15%), Surprise test (15%)

Course Code: EGS. 555
Course Title: Research Methodology
Total hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcome: Upon successful completion of this course, the student will be able to

- choose methods appropriate to research aims and objectives
- Understand the limitations of particular research methods

- Acquire knowledge of the selection of various instruments and sample preparation for addressing specific research problem.
- Develop skills in qualitative and quantitative data analysis and presentation
- Develop advanced critical thinking skills and enhanced writing skills

Unit I **15 Hours**

Concept and definition of Research: academic research, basic and fundamental research, applied research, theoretical, conventional and experimental research. Concepts and needs of research hypothesis. Research proposal and concepts; developing research proposal in the field of geosciences; research approach and identifying gap areas from literature review; problem formulation and statement of research objective.

Unit II **15 Hours**

Literature survey and review, use of digital library, online resource; necessity of review of literatures.Problem formulation and statement of research objective; Developing of bibliography.Concepts on plagiarism, ISSN and ISBN numbers, impact factors and citation index of research articles and assessing the quality of research articles.

Unit III **15 Hours**

Pre-field preparations, Field mapping and documentation, Procedure of sampling, Introduction to field mapping and section measurement, Introduction to working principles, concepts, sample preparation, applications and limitations of X-ray Diffractions (XRD), Scanning Electron Microscope (SEM), ICP MS, X-ray fluorescence (XRF),Energy-dispersive X-ray spectroscopy (EDS, EDX, or XEDS), Mass spectrometer, OSL and Fission Track Dating.

Unit IV **15 Hours**

Types of data: primary and secondary data, Source and authenticity of secondary data, Introduction on the techniques of data representation, documentation and representation tools, basic presentation structures, writing a scientific paper, abstract and summary writing and organizing thesis, project reports; Integrative approach in geology.

Transactional Modes: Lecture, Demonstration, Lecture cum demonstration, Project Method, Inquiry training, Seminar, Group discussion, Co-operative learning, Blended learning, Flipped learning, Focused group discussion, Team teaching, Field visit, Collaborative learning, E- tutoring, Self-learning, Case based study, Through SOLE (Self Organized Learning Environment),

Suggested readings:

1. Qualitative Research Methods for Social Sciences by Bruce, L. B. 2001, Allyn and Bacon, Boston.
2. Research Design: Qualitative, Quantitative and Mixed Methods Approaches by John, W. C., 2011, Sage Publications, Thousand Oaks.

3. Principles of Writing Research Papers by Lester, James, D. and Lester Jr. J. D., 2007, Longman, New York.
4. Silicate rock analysis by P. J. Potts, 1997.
5. Recent developments in geochemical microanalysis: Chemical Geology by Reed, S. J. B., 1990, Volume. 83, PP. 1-9.
6. Handbook of Instrumental Techniques for Analytical Chemistry by Frank A. Settle, 1997, Prentice Hall, Upper Saddle River, NJ.

Course Code: EGS 503
Course Title: Introduction to field accessories in geosciences
Total Hours: 15

L	T	P	Cr
1	-	-	1

Learning Outcome: Upon successful completion of this course, the student will be able to

- Understand the different field accessories in geosciences.
- Handle the equipments confidently at field.

Unit I **3 Hours**

Field Geology: Introduction to toposheets, Scale definition; small scale and large-scale maps; reading various components of a toposheet.

Unit II **4 Hours**

Geological map-definition, various components of a geological map including scale, legend, structures and, etc. Studies of outcrop pattern, topographic law and rules of 'V'.

Unit III **4 Hours**

Instruments used in geological field studies; techniques and use of geological tools during field work-use of clinometer compass, Brunton compass, GPS, altimeter.

Unit IV **4 Hours**

Attitude measurements; measurement of true thickness and distance, section measurement techniques and significance.

Transactional Modes: Lecture, Demonstration, Lecture cum demonstration, Field visit, Brain storming.

Suggested readings:

1. Geological field techniques by Angela L. C. 2010, Blackwell Publishing Ltd.
2. Basic Geological Mapping (Geological Field Guide) by Lisle, R. J., Brabham, P. and Barnes, J. W., 5th edition, 2011, Wiley-Blackwell.
3. Guide to Field Geology by Mathur, S.M., 2001, PHI Learning Private Limited-New Delhi.
4. Field geology (Illustrated) by Maley, T.S., 1994, Mineral Land Publications.
5. Field geology by Lahee, F. H., 6th edition, 1961, McGraw-Hill.

Course Code: EGS. 543
Course Title: Seminar
Total hours: 15

L	T	P	Cr
-	1	-	1

Learning Outcome: Student will learn how to present their thought/idea/ scientific findings in a skillful way. How to participate in the discussion and question /answer session during presentation?

Seminar: Students will be assigned with a topic, research article, book chapter or any subject/project/dissertation related topic to prepare a report and presentation. Scheduled seminars will be conducted in the department in the presence of experts.

Evaluation Criteria- Full mark 100
It will be evaluated based on Literature strength, Organization of content, report evaluation**,** presentation, discussion and question answer.

Course code: EGS 599
Course title: Project work

L	T	P	Cr
-	-	12	6

Each candidate required to submit a dissertation/ project report based on his/her research work carried out towards the fulfillment of his/her M.Sc. dissertation/ Project work.
It will have following components:

a) Origin of the research problem and literature review
b) Objective of the research work
c) Methodology of the work, field observations (if any) and data recorded by the candidate,
d) Details of laboratory investigation (if any) carried out by the candidate,
e) Synthesis of results and interpretation
f) Concluding remarks and future direction

Total Marks: As Satisfactory
The teacher who supervised the respective student will award the 60 % of the marks. A board of examiners will conduct viva-voce, and would consist of the supervisor, faculty member(s) of the department, and other faculty members appointed by the competent authority. The committee will award the rest 40% of the marks including those of presentation and viva-voce. A candidate who does not submit the project report or fails to get pass marks in it will appear again in viva-voce examination of the same class M.Sc. II year in a subsequent year as per university rule.

SEMESTER IV

Course Code: EGS. 571
Course Title: Principle of Stratigraphy and Indian Stratigraphy
Total hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcome: Upon successful completion of this course, the student will be able to

- Transforms a stratigraphic cross section into a historical summary that expresses environmental states and changes.
- Correctly applies terminology.
- Employs the base level concept in reasoning through the succession of paleogeographic changes during which a series of strata accumulated.
- Manipulates multiple variables that contribute to the accumulation of strata (e.g., tectonic subsidence, sediment supply, sea level change) in deducing plausible scenarios.
- Utilizes reasoning to construct one or more hypotheses for the paleogeographic and environmental histories that produced a series of strata.
- Applies an understanding of stratigraphic sequence mapping and interpretation to a variety of data types typical to surface geological and subsurface geological analysis (ie, outcrop, well log, seismic).
- Deduces from knowledge of a modern depositional environment the positions and times in a base level cycle that are prone to generation of unconformities and condensed intervals, and applies this insight to interpretation of ancient strata.

Unit I **14 Hours**

Principle of Stratigraphy: History and development of stratigraphy; stratigraphic procedures (surface and subsurface), concept of lithofacies and biofacies; stratigraphic correlation (litho, bio- and chronostratigraphic correlation). Study of standard stratigraphic code (lithostratigraphic, biostratigraphic and chronostratigraphic); Concepts of magneto stratigraphy, chemo stratigraphy, event stratigraphy, and sequence stratigraphy.

Unit II **16 Hours**

Archaeans-Precambrian stratigraphy of India: Precambrian stratigraphic framework of India; Classification, structure and tectonics of the Dharwar craton; Ancient supracrustal (Sargur Type); Gold bearing schist belts of Eastern Karnataka (Kolar Type); Younger schist belts (Dharwar Type); Gneiss complex, granulites, charnockites; Structure, tectonics and stratigraphy of the OMG, OMTG, Iron Ore Group (Singbhum Craton); Stratigraphy of the Sukma, Bengpal, and Bailadila series from Central India; Ancient granites, viz. Singbhum, Chitradurga, etc.; Archaeans of the Extra Peninsular region; Archaean-Proterozoic boundary; Stratigraphy, geology, tectonics and evolution of the following Proterozoic basins/Purana formations in India - Delhi-Aravalli Supergroup, Singbhum Group, Sausar-Sakoli Groups,

Vindhyans, Cuddapah, Pranhita-Godavari, Bhima, Kaladgi.

Unit III **16 Hours**

Palaeozoic stratigraphy: Igneous activities and palaeogeography during the Palaeozoic Era. Stratigraphy, facies, and fossil contents of the Palaeozoic rock formations of Peninsular and extra-peninsular India. Permian-Triassic boundary.

Gondawana stratigraphy: Concepts, classification, fauna, flora and age limits of GondwanaSupergroup and related palaeogeography, palaeoclimate, depositional characteristics and igneous activity.

Mesozoic stratigraphy: Classification, depositional characteristics, fauna and flora, age limits, correlation of Triassic, Jurassic and Cretaceous systems in principal basins of Peninsular and extra-peninsular India. Stratigraphy of the Deccan volcanic province; Cretaceous-Tertiary boundary.

Unit IV **14 Hours**

Cenozoic stratigraphy: Classification, depositional characteristics, fauna and flora of the Palaeogene and Neogene systems in their type localities and their equivalents in India. Epoch boundaries of the Cenozoic in India. Quaternaries of Peninsular India; Neogene-Quaternary boundary. Statigraphy and tectonics of the Siwalik. Quaternary relative sea level changes.

Transactional Modes: Lecture, Demonstration, Lecture cum demonstration, Project Method, Seminar, Group discussion, Co operative learning, Blended learning, Flipped learning, Focused group discussion, Team teaching, Field visit, Brain storming, Mobile teaching, Collaborative learning, Case analysis, Case study, Case based study, Through SOLE (Self Organized Learning Environment).

Suggested readings:

1. Principles of sedimentology & stratigraphy by Sam Boggs, Jr., 2011, Prentice Hall.
2. Fundamentals of historical geology and stratigraphy of India by Ravindra Kumar, 1998, New Age, ISBN-13: 978-0852267455.
3. Geology of India by Ramakrishnan, M. and Vaidyanathan R., 2008, Vol. 1 & 2, Geological Society of India, Bangalore, ISBN No: 978-81-85867-98-4.
4. Precambrian Geology of India by Naqvi, S.M. and Rogers, J.J.W., 1987, Oxford University Press.
5. Geology of India and Burma by Krishnan, M.S., 1982, C.B.S. Publishers & Distributors, Delhi.
6. Sedimentology and stratigraphy by Gary Nichols, 2009, Wiley-Blackwell, ISBN: 978-1-4051-3592-4.
7. Introduction to stratigraphy and paleontology, in Indian ocean geology and biostratigraphy (eds. J.R. Heirtzler, H.M. Bolli, T.A. Davies, J.B. Saunders and J.G. Sclater), by Bolli, H. M. and Saunders, J. B., 1977, American Geophysical Union, Washington, D. C.
8. Principles of Stratigraphy by Danbar, C.O. and Rodgers, J., 1957, John Wiley & Sons.
9. A Manual of the Geology of India & Burma (Volume I – IV) by Pascoe, E.H.,

1968, Govt. of India Press, Delhi
10. The Cenozoic Era? Tertiary and Quaternary by Pomerol, C., 1982, Ellis Harwood Ltd., Halsted Press.
11. Stratigraphy: Principles and Methods by Schoch, R.M., 1989, Van Nostrand Reinhold, New York.
12. Unlocking the Stratigraphic Record by Doyle, P. and Bennett. M.R., 1996, John Willey.

Course Code: EGS. 572
Course title: Engineering and Geophysics
Total hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcome: Upon successful completion of this course, the student will be able to

- Understand the engineering properties of rock and soil materials, engineering geological investigations, slope stability, geological factors affecting the stability of a facility on and in the soil, engineering, stability and protection of underground facilities, etc.
- Classify soils and rocks, use of air photos and geological maps, engineering geological problems related to design and stability.
- Understand the importance of engineering geology related to technical issues during construction, and conduct basic engineering geological assessments and analyzes.
- Develop the ability to perform geophysical data analysis, interpretation and to use seismological data for understanding the earth sub surface.

Unit I **15 Hours**

Role of engineering geology in civil constructions. Various stages of engineering geological investigation for civil engineering projects. Soil mechanics – three phases of soil, consistency limits, particle size distribution, soil classification, consolidation and compaction, and shear strength of soil. Engineering properties of rocks; rock discontinuities. Physical characters of building stones. Metal and concrete aggregates.

Unit II **15 Hours**

Geological consideration for evaluation of dams, reservoir sites, highways, etc. Dam foundation rock problems. Geotechnical evaluation of tunnel alignments and transportation routes, method of tunneling; classification of ground for tunneling purposes; various types of support. Introduction to various types of mining methods and its planning.

Unit III **15 Hours**

Introduction to geophysics; characteristics of planet and planetary motions, shape and size of earth; Relative motion of plates, Stability of triple junction, gravitational and magnetic field of the earth, principles of gravity methods and instrument used, corrections applied to gravity data; principles of magnetic methods; instruments of

magnetic surveying, Field procedure in conducting magnetic surveys and data reductions.

Unit IV **15 Hours**

Seismic methods: principles and instruments used; seismic velocity and interpretation of seismic data; Seismic refraction and reflection methods. Geometry of refraction and reflection paths in a layered earth. Seismic noise; Reflection and refraction field methods. Electrical methods: basic principles and various types of electrode configuration; Electrical resistivity method, self-potential and resistively surveying; field procedures and interpretation of field data. Applications of electrical and electromagnetic methods in solving geological problems.

Transactional Modes: Lecture, Demonstration, Lecture cum demonstration, Project Method, Seminar, Group discussion, Co operative learning, Blended learning, Flipped learning, Focused group discussion, Team teaching, Field visit, Brain storming, Mobile teaching, Collaborative learning, Case analysis, Case study, Case based study, Through SOLE (Self Organized Learning Environment).

Suggested readings:

1. Fundamentals of Engineering Geology by Bell, F.G., 1992, Aditya Books Pvt. Ltd. Indian Edn.
2. Principles of Engineering Geology by Krynine, D.H. and Judd, W.R., 1998, CBS Edition. Delhi.
3. Environmental Geology by Bermett, M.R. and Doyle, P., 1999, John Wiley & Sons, N. York.
4. Fundamental of Geophysics by Lowrie, W., 1997, Cambridge Univ. Press. London.
5. The Solid Earth: An Introduction to Global Geophysics by CMR Fowler, 2005, Cambridge University Press.
6. Applied Geophysics by Telford, W.M., Geldart, L.P. and Sheriff, R.E., 1990, Cambridge University Press.
7. Fundamentals of Rocks Mechanics by Jaeger J., Cook N. G. and Zimmerman R., 2007, Wiley-Blackwell
8. Engineering Geology for Civil Engineers by Reddy, D.V., 1995, IBH Publishing Co. Pvt. Ltd.
9. Introduction to Seismology, by Peter Shearer, 1999, Cambridge University Press, Cambridge.
10. Looking Into the Earth: An Introduction to Geological Geophysics by Alan E. Mussett, M. Aftab Khan, 2000, Cambridge University Press.

L	T	P	Cr
-	-	4	2

Course Code: EGS. 573
Course Title: Engineering geology and Geophysics (Practical)
Total hours: 60

Learning Outcome: Upon successful completion of this course, the student will be able to

- Understand the engineering properties of rock and soil materials, engineering geological investigations, slope stability, geological factors affecting the stability of a facility on and in the soil, engineering, stability and protection of underground facilities, etc.
- Classify soils and rocks, use of air photos and geological maps, engineering geological problems related to design and stability.
- Develop the ability to perform geophysical data analysis, interpretation and to use seismological data for understanding the earth sub surface.

Lab Exercise:

1) Earthquake epicentral location from travel time data *(graphical).*
2) Fault plane solution of an earthquake from teleseismic records.
3) Seismic wave propagation *(graphical)* problems.
4) Interpretation of seismic and resistivity data for exploration and structural purpose.
5) Study of gravity data maps and their interpretation.
6) Study of properties of common rocks with reference to their utility in engineering projects.
7) Study of maps and models of important engineering structures as dam sites and tunnels.
8) Interpretation of geological maps for landslide problems.
9) Various problems of soil and rock mechanical properties.
10) Calculation of various geo-engineering aspects.

Suggested readings:

1. Introduction to Seismology by Peter Shearer, 1999, Cambridge University Press.
2. Inverse Problem Theory and Model Parameter Estimation by Albert Tarantola, 2005, SIAM.
3. The Solid Earth: An Introduction to Global Geophysics by CMR Fowler, 2005, Cambridge University Press.
4. Fundamentals of Engineering Geology by Bell, F.G., 1992, Aditya Books Pvt. Ltd. Indian Edn.
5. Principles of Engineering Geology by Krynine, D.H. & Judd, W.R., 1998, CBS Edition, Delhi.

Course Code: EGS 574
Course Title: Field Training - II
Total hours: 30

L	T	P	Cr
-	-	2	1

Learning Outcome: Upon successful completion of this course, the student will be able to

- Apply theoretical knowledge at ground observation in field and to learn essential observational and practical skills.

- Identifying rocks and interpreting the physical (including tectonic) processes that may have been involved in their formation.
- Identify different rock type, different deformational structures, such as fold, fault, lithology and depositional features etc. in the field.
- Learn how to get adopt in the fieldwork environment in certain professional and scientific organizations.
- Learn how to prepare geological map, geological cross section.

Geological field training

Geological field training and fieldwork will be carried out as per the guideline of the University at proper sites for a minimum period of 10 days. During the fieldwork, students will do the geological mapping of an areas (depend on the prospective mining or continental elevated region); will learn different rock type, different deformational structures, such as fold, fault, lithology and depositional features; will visit mining/drilling sites; sample and fossils collections if available in the area.

Transactional Modes: Demonstration, Inquiry training, Group discussion, Cooperative learning, Blended learning, Focused group discussion, Team teaching, Field visit, Brain storming, Problem solving, Case analysis, Self-learning, Case based study, Through SOLE (Self Organized Learning Environment).

Suggested readings:

1. Geological field techniques by Angela L. C. 2010, Blackwell Publishing Ltd.
2. Basic Geological Mapping (Geological Field Guide) by Lisle, R. J., Brabham, P. and Barnes, J. W., 2011, Wiley-Blackwell.
3. Guide to Field Geology by Mathur, S.M., 2001, PHI Learning Private Limited-New Delhi.
4. Field geology (Illustrated) by Maley, T.S., 1994, Mineral Land Publications.
5. Field geology by Lahee, F. H., 1961, McGraw-Hill.

Evaluation Criteria: Full Marks – 100

1. Field activity (10%), Evaluation of field dairy during every day of field work and final submission (20%), Final field report (40%), Presentation (30%) – Presentation will be evaluated as style (5%), content (5%), understanding (10%) and question & answer (10%).

Course Code: EGS. 575
Course title: Comprehensive Geosciences
Total hours: 30

L	T	P	Cr
-	2	-	2

Learning Outcome: Upon successful completion of this course, the student will be able to

- solve quantitative problems of geosciences
- prepare themselves for various national level competitive exams

Comprehensive Geosciences:
This course will be conducted as tutorial classes. In this course student will solve geological questions from all the courses studied during his/her M.Sc. program in time bound manner. Different case study will be discussed in the classes. Problems will cover all the aspects of geosciences. Past question papers of national level exams will be discussed in the classes.

Evaluation Criteria- Full mark 100
End semester exam (70%), Assignment based evaluation (15%), Surprise test (15%)

L	T	P	Cr
-	1	-	1

Course Code: EGS 504
Course Title: Introduction to geological Mapping
Total hours: 15

Learning Outcome: Upon successful completion of this course, the student will be able to

- Understand the processes and practices of geological mapping.
- Understanding the processes of sampling techniques.

Unit I **3 Hours**
Geological mapping procedures: Geological mapping of igneous terrains, geological mapping of sedimentary terrains.

Unit II **4 Hours**
Geological mapping of metamorphic terrains and recording of structural information, preparation of Geological Cross-section.

Unit III **4 Hours**
Techniques for sample collection: Sampling and oriented sampling, its significance; sampling for isotopic, geochronological and geochemical studies and its significance.

Unit IV **4 Hours**
Sampling strategies for micropalaeontological and biostratigraphic studies and recording of palaeontological informations.

Transactional Modes: Lecture, Demonstration, Lecture cum demonstration, Field visit, Brain storming.

Suggested readings:

1. Geological field techniques by Angela L. C. 2010, Blackwell Publishing Ltd.
2. Basic Geological Mapping (Geological Field Guide) by Lisle, R. J., Brabham, P. and Barnes, J. W., 5th edition, 2011, Wiley-Blackwell.
3. Guide to Field Geology by Mathur, S.M., 2001, PHI Learning Private Limited-New Delhi.
4. Field geology (Illustrated) by Maley, T.S., 1994, Mineral Land Publications.
5. Field geology by Lahee, F. H., 6th edition, 1961, McGraw-Hill.

Course code: EGS 599
Course title: Project work

L	T	P	Cr
-	-	12	6

Each candidate required to submit a dissertation/ project report based on his/her research work carried out towards the fulfillment of his/her M.Sc. dissertation/ Project work.

It will have following components:

a. Origin of the research problem and literature review
b. Objective of the research work
c. Methodology of the work, field observations (if any) and data recorded by the candidate,
d. Details of laboratory investigation (if any) carried out by the candidate,
e. Synthesis of results and interpretation
f. Concluding remarks and future direction

Total Marks: As Satisfactory

The teacher who supervised the respective student will award the 60 % of the marks. A board of examiners will conduct viva-voce, and would consist of the supervisor, faculty member(s) of the department, and other faculty members appointed by the competent authority. The committee will award the rest 40% of the marks including those of presentation and viva-voce. A candidate who does not submit the project report or fails to get pass marks in it will appear again in viva-voce examination of the same class M.Sc. II year in a subsequent year as per university rule.