CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

M.Sc. Geology

Session - 2020-22

Department of Geology

Programme Outcomes of M. Sc. Geology Programme

M.Sc. geology programme renders insight on the Earth Systems Sciences and its relationship with other branches of science leading to development of basic observational skill to become prominent geoscientist. Students will develop their critical thinking skills, application to solve the geological problems using scientific methods. Training under this program will enhance the ability of the students to acquire, analyze, recommend and communicate their ideas, scientific data and interpretation to the users. The programme equips them for competing in different National and International level examinations. This programme provides ample opportunities to the students to become a professional geologist in reputed industries and government agencies. It also motivates students to build their careers as researchers/academicians at universities or scientific organizations of National and International repute.

Course Structure of the Programme

Semester-I

Course Code	Course Title	Course Type	Credit Hours			Credit
			L	T	P	Cr
EGS.506	Mineralogy and Crystallography	*Core*	4	0	0	4
EGS.507	Paleontology	*Core*	4	0	0	4
EGS.508	Sedimentology	*Core*	2	0	0	2
EGS.509	Mineralogy and Crystallography (Practical)	*Core*	0	0	4	2
EGS.510	Paleontology and Sedimentology (Practical)	*Core*	0	0	4	2
Select any one from the following Discipline Elective course/MOOC						
EGS.511	Geomorphology and Geotectonics	Discipline Elective	4	0	0	4
EGS.512	Environmental Geology and Natural Hazards	Discipline Elective	4	0	0	4
EGS.513	Natural Resource and Watershed Management	Discipline Elective	4	0	0	4
Compulsory Foundation Course						
CST.501	Computer application (Theory)*#	Compulsory Foundation	2	0	0	2
STA.503	Statistics for Science * #	Compulsory Foundation	2	0	0	2
Interdisciplinary course						
	Interdisciplinary course #	IDC	2	0	0	2
		Total Credit Hours	**20**	**0**	**8**	**24**
Interdisciplinary course offered by the Department						
EGS 534	Introduction to Disaster Management	Interdisciplinary	2	0	0	**2**

Semester-II

Course Code	Course Title	Course Type	Credit Hours			Credit
			L	T	P	Cr
EGS.521	Geochemistry and Isotope Geology	*Core*	4	0	0	4
EGS.522	Igneous and Metamorphic Petrology	*Core*	4	0	0	4
EGS.523	Structural Geology	*Core*	4	0	0	4

EGS.524	Igneous and Metamorphic Petrology (Practical)	*Core*	0	0	4	2
EGS.525	Structural Geology (Practical)	*Core*	0	0	4	2
EGS.526	Field training – I †	Skill Based	0	0	0	2
EGS.542	Seminar	Skill Based	0	0	0	1
Select any one from the following Discipline Elective course /MOOC						
EGS.527	Oceanography and Climatology $	Discipline Elective	4	0	0	4
EGS.528	Mineral Exploration and Petroleum Geology	Discipline Elective	4	0	0	4
	Interdisciplinary course#	IDC	2	0	0	2
	Total Credit Hours		**18**	**0**	**10**	**25**

Interdisciplinary course offered by the Department						
EGS 534	Introduction to Disaster Management	Interdisciplinary	2	0	0	**2**

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

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

† Fieldwork will be conducted any time during the semester as per the suitable time. During any unavoidable circumstance, if the field work is not conducted in the allocated semester, then the fieldwork and its credits will be shifted to the subsequent semesters as per the requirement. Evaluation of this course will be based on the field activity, daily field report, final report submission and presentation.

$ Based on the availability of infrastructural facility and faculty any one of the course will be offered to the batch.

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			Credit
			L	T	P	Cr
EGS.551	Engineering Geology and Geophysics	*Core*	4	0	0	4
EGS.552	Hydrogeology, Remote Sensing and GIS	*Core*	4	0	0	4
EGS.553	Hydrogeology, Remote Sensing and GIS (Practical)	*Core*	0	0	4	2
EGS.555	Research Methodology	Compulsory Foundation	4	0	0	4
EGS.543	Seminar	Skill Based	0	0	0	1
EGS.599	Project work	Skill Based	0	0	12	6
	Value added Course	VAC	1	0	0	1
Total Credit Hours			**13**	**0**	**16**	**22**
Value Added Course offered by the Department						
EGS.503	Introduction to Field accessories for Geoscience	Value added course	1	0	0	1

Semester-IV

Course Code	Course Title	Course Type	Credit Hours			Credit
			L	T	P	Cr
EGS.571	Principle of Stratigraphy and Indian Stratigraphy	*Core*	4	0	0	4
EGS.572	Ore Geology	*Core*	4	0	0	4
EGS.573	Ore geology and Exploration (Practical)	*Core*	0	0	4	2
EGS.574	Field training – II ††	*Core*	0	0	0	2
EGS.575	Comprehensive Geosciences	DEC	2	0	0	2
EGS.576	Quantitative Geosciences	*DEC*	2	0	0	2
EGS.599	Project work	Skill Based	0	0	12	6
	Value added course	VAC	1	0	0	1
Total Credit Hours			**13**	**0**	**18**	**23**
Grand total credit Hours /Credit for all semester (I+II+III+IV)			**64**	**0**	**52**	**94**

Value Added Course offered by the Department

EGS.504	Introduction to geological Mapping	Value added course	1	0	0	1

†† Fieldwork will be conducted any time during the semester as per the suitable time window. Evaluation of this course will be based on the field activity, daily field report, final report submission and presentation during the 4th semester.

*DEC - Discipline enrichment course

L: Lectures, **T:** Tutorial, **P:** Practical, **Cr:** Credit (Two Practical credit hours = One credit)

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: Based on Subjective Type Test [25 Marks]
C. End Semester Subjective Test [25Marks]
D. End-Term Exam: Based on Objective Type Tests [25 Marks]

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

Semester – I

Course Code: EGS. 506

L	T	P	Credits
4	0	0	4

Course Title: Mineralogy and Crystallography

Total Hours: 60

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

- Apprise how the internal structure of minerals affects the external structure and physical properties of mineral and crystals.
- Compare the mineralogical concepts of polymorphism, solid solution and exsolution.
- Interpret the basic properties and chemistry of common rock-forming minerals.
- Solve the difficulties of mineral identification and mineralogical by applying polarizing microscope, x-ray diffraction, electron microprobe.

Course Contents

UNIT I **Hours 14**

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 **Hours 15**

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 **Hours 13**

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 **Hours 18**

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) 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, Tools used: PPT, Video, Animation, Whatsapp, Software Tool: Mineralogical interactive software, crystal maker, XRD data analysis tool, website: Mindat, Web minerals.

Suggested Readings:

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

Course Code: EGS-507
Course Title: Paleontology

L	T	P	Credits
4	0	0	4

Total Hours: 60

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

- Identify certain fossils fauna.
- Experiment with the technique of fossil extraction and taxonomy.
- Elaborate the origin and evolutionary history of various fossils in time and space and its application in hydrocarbon exploration.
- Formulate the paleoclimatic, paleoenvironmental and paleobiogeographic history of the earth.

Course Contents

UNIT I **Hours 15**

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, echinoids, gastropods and cephalopods general morphology and Indian occurrence.

UNIT II **Hours 15**

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 **Hours 15**

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 **Hours 15**

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, Problem solving, assignment, Group discussion, Tools used: PPT, Video, Animation.

Suggested Readings:

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

Course Code: EGS-508
Course Title: Sedimentology

L	T	P	Credits
2	0	0	2

Total Hours: 30

Learning Outcomes:

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

- Categorize the various sedimentary rocks and their mode of genesis in different depositional environment.
- Interpret the processes responsible for the deposition of the sediment and formation of sedimentary textures and structures.
- Construct the depositional environment of certain sedimentary rock based on recognition of facies associations, lithology, textures and structures.
- Formulate the sedimentary basin forming processes and its environmental and economic significance.

Course Contents

UNIT I **Hours 8**

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 **Hours 7**

Petrographic characteristic and classification of conglomerate, sandstones, limestones and argillaceous rocks, mudrocks. 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 **Hours 8**

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, phosphatic and ferruginous rocks. Heavy minerals and their importance in determination of provenance.

UNIT IV **Hours 7**

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, ICT, Video, and Animation, softwares: google class, piazza, padlet.

Suggested Readings:

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

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

L	T	P	Credits
0	0	4	2

Total Hours: 60

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

- Demonstrate the different minerals in hand specimen and under petrological microscope.
- Interpret the crystal parameter and to identify the mineral phase.
- Compare the different crystals system in hand specimen and under petrological microscope.
- Solve mineralogical and crystallographic problems using XRD data.
- Formulate empirical formula of the mineralogical phases and the impurities present in the minerals.

Course Contents

UNIT I **Hours 32**

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 **Hours28**

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

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

Evaluation Criteria: Total Marks – 100,
End semester exam (50 marks), Continues assessment (30marks), Lab record (10marks), Viva (10marks).

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

L	T	P	Credits
0	0	4	2

Total Hours: 60

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

- Classify the various sedimentary rocks and fossils.
- Analyze certain fossils and rock samples for paleoenvironment and paleoclimatic interpretation.
- Apply the sample preparation methods, separation of fossils and rocks, cataloguing of samples at research and industrial applications.
- Correlate the multidisciplinary nature of modern palaeontology with lithostaratigraphy, paleaoenvironment and paleobigeography.
- Reconstruct paleoenvironmental and ecological set up based on sedimentological and faunal records.

Course Contents

UNIT I **Hours 32**

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 **Hours 28**

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

Evaluation Criteria: Total Marks – 100,
End semester exam (50 marks), Continues assessment (30 marks), Lab record (10 marks), Viva (10 marks).

Discipline Elective course
Course Code: EGS.511
Course Title: Geomorphology and Geotectonic

L	T	P	Credits
4	0	0	4

Total Hours: 60

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

- Demonstrate the principal theories and models for landscape evolution.
- Assess the mode of formation, age and history of landforms in India.
- Distinguish landforms and their processes of formation in different climate zones and tectonic regimes.
- Develop relevant solution for elucidate geomorphologic problems.

Course Contents

UNIT I **Hours 14**

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 **Hours 16**

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 **Hours 15**

Definition and scope of tectonic geomorphology.Landscapeevolution.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 **Hours 15**

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, Problem solving, Seminar, assignment, Group discussion, Tools used, ICT, PPT, Video, Animation.

Suggested Readings:

1. Thornbury, W. D., 2004.*Principles of Geomorphology*, CBS publisher & distributer private Ltd.
2. Philip Kearey, Keith A. K., Frederick J. V., 2009. *Global Tectonics*, Wiley-Blackwell.
3. Richard John Huggett, 2007. *Fundamental of Geomorphology*, Taylor & Francis.
4. Angela L. Coe (edt), 2010. *Geological Field Techniques*, by Wiley-Blackwell.
5. Richard J. L, Peter B., and John W. B., 2011. *Basic Geological Mapping (Geological Field Guide),* Wiley-Blackwell; ISBN-13: 978-0470686348
6. Michael A. Summerfield (Editor), 2000. *Geomorphology and Global Tectonics*, Wiley,ISBN: 978-0-471-97193-1,
7. P. McL. D. Duff., 1993. *Holmes' Principles of Physical Geology*, Chapman and Hall, London.
8. R. J. Allison, 2002. *Applied Geomorphology: Theory and Practice*, Wiley.

9. Douglas W. B., and Robert S. A., 2011.*Tectonic Geomorphology*, Wiley-Blackwell; ISBN-13: 978-1444338867
10. Robert S. A., and Suzanne P. A., 2010.*Geomorphology: The Mechanics and Chemistry of Landscapes*, Cambridge University Press.
11. Paul R. B, and David R. M., 2013.*Key Concepts in Geomorphology*, W. H. Freeman.
12. Sharma, H. S., 1991. *Indian Geomorphology*, Concept Publishing Co. New Delhi.
13. Mahapatra, G. B., 2008. *Text book of Physical Geology*, CBS Publishers & Distributors Private Ltd.
14. Condie, K. C., 1997. *Plate Tectonics and Crustal Evolution*, Butterworth-Heinemann.

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

L	T	P	Credits
4	0	0	4

Total Hours: 60

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

- Discuss the role of geologic processes in assessment of natural hazards
- Formulate the occurrence and formation of earth resources and significant environmental effects caused by their extraction, processing, and use;
- Predict the major sources of water, soil, and sediment pollution and methods for their management;
- Evaluate the causes and effects of global climate change.
- Justify the how to mitigate the effects of natural hazard.

Course Contents

UNIT I **Hours 15**

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 **Hours 15**

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 **Hours 15**

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 **Hours 15**

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

L	T	P	Credits
4	0	0	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

- appraise the types of natural resources available and their relation with geology
- invent new ideas to conserve, manage and develop the Earth's natural resources available
- discuss exploration of water resource through watershed management and exploration methods
- evaluate the validity and limitations of scientific theories and claims about the environment.
- appraise the interactions among physical, biological, chemical, and human components of the environment.

Course Contents

UNIT I **Hours 15**

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 **Hours 15**

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 **Hours 15**

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 **Hours 15**

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. David A., 2013. *Environmental economics and natural resource management,* Routledge.
2. Gurdev Singh and Vinod Ahuja, 1992.*Land resource management*, Oxford & IBH Pub. Co.
3. Kathy Wilson Peacock, 2008. *Natural resources and sustainable developments*, Facts on file Inc.
4. Daniel R. L., 2009.*Sustainable natural resource management for scientists and engineers*, Cambridge University press
5. Jaidev Somesh, 2010. *Natural resources in 21st century*, ABD Publisher.
6. Panday, S.N. and Misra, S.P. (Eds.), 2008.*Essential Environmental Studies*, CRC Press.
7. Murthy, K.S. 1998.*Watershed Management in India*, Wiley Eastern Ltd. / New Age International Ltd.
8. Tideman, E.M., 1996.*Watershed Management: Guidelines for Indian Conditions*, Omega, New Delhi.
9. Verghese, B.G., 1990.*Water of Hope: Integrated Water Resource Development and Regional Co-operation within the Himalayan-Ganga-Brhamaputra-Barak Basin*, Oxford-IBH.

L	T	P	Credits
2	0	0	2

Course Code: CST: 501
Course Title: Computer applications (Theory)

Total Hours: 30

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

- Describe parts of computer hardware and software.
- Discuss networking and internet concepts.

- Use word processing software, presentation software, spreadsheet software and latex.

Course Contents

UNIT I **Hours 8**

Computer Fundamentals: Introduction to Computer, Input devices, Output Devices, Memory (Primary and Secondary), Concept of Hardware and Software, C.P.U., System bus, Motherboard, Ports and Interfaces, Expansion Cards, Ribbon Cables, Memory Chips, Processors, Software: Types of Software, Operating System, User Interface of popular Operating System, Introduction to programming language, Types of Computer.

UNIT II **Hours 8**

Computer Network: Introduction to Computer Network, Types of Network: LAN, WAN and MAN, Topologies of Network, Internet concept, WWW.

Word Processing: Text creation and Manipulation; Table handling; Spell check, Hyper-linking, Creating Table of Contents and table of figures, Creating and tracking comments, language setting and thesaurus, Header and Footer, Mail Merge, Different views, Creating equations, Page setting, Printing, Shortcut keys.

UNIT III **Hours 7**

Presentation Tool: Creating Presentations, Presentation views, working on Slide Transition, Making Notes Pages and Handouts, Drawing and Working with Objects, Using Animations, Running and Controlling a Slide Show, Printing Presentations, and Shortcut keys.

Spread Sheet: Entering and editing data in cell, Basic formulas and functions, deleting or inserting cells, deleting or inserting rows and columns, printing of Spread Sheet, Shortcut keys.

UNIT IV **Hours 7**

Use of Computers in Education and Research: Data analysis tools, e-Library, Search engines related to research, Research paper editing tools like Latex.

Transactional Modes: Lecture, Blended Learning, Collaborative Learning, Peer Learning/Teaching

Suggested Readings:

1. Sinha, P.K. (2017). Computer Fundamentals. New Delhi: BPB Publications.
2. Goel, A., Ray and(S. K. 2012) Computers: Basics and Applications. New Delhi: Pearson Education India.
3. Microsoft Office Professional 2013 Step by Step https://ptgmedia.pearsoncmg.com/images/9780735669413/samplepages/97807356694 13.pdf

Course Code: STA. 503
Course Title: Statistics for Sciences

L	T	P	Credits
2	0	0	2

Total Hours: 30

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

Course Contents

UNIT I **Hours 8**

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 **Hours 8**

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 **Hours 7**

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

UNIT IV **Hours 7**

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

5. Meyer, P. L., 1975. *Introductory Probability and Statistical Applications*, Oxford & IBH Pub.

Semester II

Course Code: EGS. 521
Course Title: Geochemistry and Isotope Geology

L	T	P	Credits
4	0	0	4

Total Hours-60

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

- Appraise behaviors of elements in the formation of primary and secondary rocks
- Formulate basics of isotope systematics and radioactive decay.
- Design the geochemical aspects for assessment of elements in and on Earth.
- Discuss the principles and applications of radiogenic isotope systematics to study geological processes and date rock-forming events.
- Adapt the principles and applications of stable isotope systematics.

Course Contents

Unit 1 **Hours 14**

Geochemistry

Introduction of geochemistry and cosmo-chemistry. 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 **Hours 15**

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

Unit III **Hours 18**

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-Pbisochron, U-Pb mineral dating and application.

Unit IV **Hours13**

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, Lecture cum demonstration, Project Method, Seminar, Co-operative learning, Focused group discussion, Team teaching, Mobile teaching, Collaborative learning, E- tutoring, Problem solving, Case analysis, Self-learning, Case based study, Experimentation.

Suggested readings:

1. Gunter Faure, 1998. *Principles and applications of Geochemistry*, Prentice Hall.
2. John V. Walther, 2010. *Essentials of Geochemistry*, Jones and Bartlett Publication.
3. Claude Allegre, 2008. *Isotope Geology*, Cambridge University Press.
4. Dickin, A.P., 2005. *Radiogenic Isotope Geology*. Cambridge University Press.
5. JochenHoefs, 2015.*Stable Isotope Geochemistry*, Springer International Publishing.
6. Gunter Faure, 1986. *Principles of Isotope Geology*, Wiley.
7. Gunter Faure and Teresa M. M, 2004.*Isotopes: Principles and Applications*, Wiley.
8. Francis Albarede, 2003. *Geochemistry, An introduction*, Cambridge University Press.
9. William M. W., 2013. *Geochemistry*, Wiley-Blackwell.
10. McSween Jr. H. Y., Richardson, S. M., and Uhle, M. E., 2003.*Geochemistry:Pathways and Processes*, Columbia University Press,
11. Mason, B. and Moore, C.B., 1991. *Introduction to Geochemistry*, Wiley Eastern.
12. Krauskopf, K. B., 1967. *Introduction to Geochemistry*, McGraw Hill.

Course Code: EGS. 522
Course title: Igneous and Metamorphic Petrology

L	T	P	Credits
4	0	0	4

Total Hours-60

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

- Evaluate 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.
- Assess certain igneous and metamorphic rocks on the basis of their mineralogical and textural characteristics.
- Interpret phase diagrams relevant to igneous systems and petrogenic grids relevant to metamorphic systems on the basis of mineral assemblages recorded in the rock.
- Discuss the chemistry of certain igneous/metamorphic rocks and predict their environment(s) of formation.

Course Contents

Unit I **Hours 14**

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, Albite Anorthite, Orthoclase-Anorthite) and ternary silicate systems (Orthoclase-Albite-Silica, Diopsite-Albite Anorthite, 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 **Hours 16**

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 **Hours15**

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 **Hours15**

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, Seminar, Group discussion, Cooperative learning, Blended learning, Flipped learning, Focused group discussion, Team teaching, Field visit, Brain storming, Mobile teaching, E- tutoring, Problem solving., Self-learning, Case based study, etc.

Suggested readings:

1. Winter, J.D., 2001.*An introduction to Igneous and Metamorphic Petrology*, Prentice Hall.
2. Philpotts, A.R. 1994. *Principles of Igneous and Metamorphic Petrology*, Prentice Hall.
3. Cox, K.G., Bell, J.D. and Pankhurst, R.J., 1993.*The Interpretation of Igneous Rocks*, Champman & Hall, London.
4. Turner, F. J., and Verhoogen, J., 1987.*Igneous and Metamorphic Petrology*, CBS.
5. Myron G., 2002. Igneous and Metamorphic Petrology, Blackwell Science.
6. Faure, G., 2001. *Origin of Igneous Rocks – The Isotopic Evidence*, Springer.
7. Hall A., 1997. *Igneous Petrology*, Longman.
8. Le Maitre, R.W., 2002. Igneous Rocks: A Classification and Glossary of Terms, Cambridge University Press.
9. McBirney, 1994.*Igneous Petrology*, CBS Publishers, Delhi.
10. Sood, M. K., 1982. *Modern Igneous Petrology*, Wiley-Interscience Publ., New York.
11. Srivastava Rajesh, K., Chandra, R. and Balkema, A. A., 1997.*Magmatism in Relation to Diverse Tectonic Settings*, Oxford University Press.
12. Bucher, K. and Martin, F., 2002.*Petrogenesis of Metamorphic Rocks*, Springer – Verlag.

13. Yardley, B.W.D., 1989. *An introduction to Metamorphic Petrology*, Longman Scientific & Technical, New York.
14. Spear, F. S. 1993.*Mineralogical Phase Equillibria and pressure – temperature – time Paths*, Mineralogical Society of America.
15. Powell, R. 1978. *Equilibrium thermodynamics in Petrology: An Introduction*, Harper & Row Publishers, London.
16. Bose, M.K., 1997. *Igneous Petrology*, World Press, Kolkata.

Course Code: EGS. 523
Course Title: Structural Geology

L	T	P	Credits
4	0	0	4

Total hours: 60

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

- Determine the geological structures of deformed continental regimes.
- Reconstruct the regional tectonic set up based on microstructural and petrofabric data.
- Design the relative timing of formation of structures, the kinematics of deformation and the progressive deformation histories at various tectonic regimes.
- Appraisal of structural geology in the mining and resource exploration environment.

Course Contents

Unit I **Hours15**

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 **Hours15**

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 **Hours15**

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 **Hours15**

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, Blended learning, Flipped learning, Focused group discussion, Team teaching, Field visit, Brain storming, Mobile teaching, Collaborative learning, E- tutoring, Problem solving.

Suggested readings:

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

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

L	T	P	Credits
0	0	4	2

Total Hours: 60

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.

- Inspect key textural/micro structural features of igneous and metamorphic rocks in hand specimen as well as under the microscope.
- 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.

Course Contents

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. LeMaitre, R. W., 2002. I*gneous Rocks: A Classification and Glossary of Terms*, Cambridge University Press.
2. Winter, J.D., 2001.*An introduction to Igneous and Metamorphic Petrology*, Prentice Hall.
3. Philpotts, A. R., 1994. *Principles of Igneous and Metamorphic Petrology*, Prentice Hall.
4. Cox, K.G., Bell, J.D., and Pankhurst, R.J., 1993.*The Interpretation of Igneous Rocks*, Champman & Hall, London.
5. Myron G., 2002. Igneous and Metamorphic Petrology, Blackwell Science.
6. Faure, G., 2001. *Origin of Igneous Rocks – The Isotopic Evidence*, Springer.
7. Hall A., 1997. *Igneous Petrology*, Longman.
8. Le Maitre, R.W., 2002. Igneous Rocks: A Classification and Glossary of Terms, Cambridge University Press.

Evaluation Criteria: Total Marks – 100,
End semester exam (50 marks), Continues assessment (30 marks), Lab record (10 marks), Viva (10marks).

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

L	T	P	Credits
0	0	4	2

Total hours: 60

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

- Solve the geometric and stereonet problems related to structural geology.
- Interpret various maps and identify the geological structures of deformed continental regimes with microstructural analysis.
- Apply an understanding of structural geology in the mining and resource exploration environment.

Course Contents

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. Stephen Marshak and Gautam Mitra.1988.Basic Methods of Structural Geology, Prentice Hall.
2. Ghosh, S.K., 1993. *Structural Geology: Fundamental and Modern Developments*, Pergamon Press.
3. Ramsay, J.G. and Huber, M. I., 1987. *Techniques of Modern Structural Geology. Vol. II. Folds and Fractures*, Academic Press.
4. Ramsay, J. G. and Huber, M. I., 1983.*Techniques of Modern Structural Geology. Vol. I. Strain Analysis*, Academic Press.
5. Donal M. Ragan, 2009. *Structural Geology: An Introduction to Geometrical Techniques,* Cambridge University Press.
6. Structural analysis of Metamorphic Tectonites by Turner, F.J. & Weiss, L.E. 1963, McGraw Hill.

Evaluation Criteria: Total Marks – 100,
End semester exam (50 marks), Continues assessment (30 marks), Lab record (10marks), Viva (10 marks).

Course Code: EGS 526
Course Title: Field training - I

L	T	P	Credits
0	0	2	1

Total hours: 30

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

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

Geological field training

Fieldwork will be conducted any time during the semester as per the suitable time. During any unavoidable circumstance, if the field work is not conducted in the allocated semester, then the fieldwork and its credits will be shifted to the subsequent semesters as per the requirement. Geological field training and fieldwork will be carried out as per the guideline of the University at proper sites for a period of 10 days. During the fieldwork, the students will be exposed to map reading, identification of lithology, structure, landforms, fossils, field mapping, sampling, data collections for lithology and structure, ore and economic geology. Evaluation of this course will be based on the field activity, daily field report, final report submission and presentation.

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

Suggested readings:

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

Evaluation Criteria: Full Marks – 100

Field activity (10 marks), Evaluation of field dairy during every day of fieldwork and final submission (20 marks), Final field report (40 marks), Presentation (30 marks) – Presentation will be evaluated using rubrics: Speak Clearly (4 marks), Posture and

Eye contact (4 marks), Content (4 marks), Preparation (4 marks), stay in topic (4 marks); Response to questions (10 marks).

Course Code: EGS.542
Course Title: Seminar

L	T	P	Credits
0	0	0	1

Total hours: 15

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.
Presentation is evaluated using rubrics: Speak Clearly (8 marks), Posture and Eye contact (8 marks), Content (8 marks), Preparation (8 marks), stay in topic (8 marks); Response to questions (20 marks);
Report evaluation is based on literature review and background knowledge (20 marks), Organization of content, formatting and references (10 marks) and Discussion (10 marks)

Discipline Elective: Select any one

Course Code: EGS. 527
Course Title: Oceanography and Climatology

L	T	P	Credits
4	0	0	4

Total hours: 60

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
- Determine the history and development of meteorology, oceanography (including marine biogeochemistry) and climate
- adapt modern field instrumentation, theory, programming and/or advanced analysis on geophysical problems

- Evaluate and assess data quality and different information sources in geophysics
- Formulate, process and implement strategies for data and theoretical analysis.

Course Contents

Unit I: Oceanography **Hours15**

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 **Hours15**

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 **Hours13**

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 **Hours17**

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

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

L	T	P	Credits
4	0	0	4

Total hours: 60

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

- evaluate ore deposit types, including genesis and exploration requirements;
- designing understanding on petroleum geology, exploration techniques, and resource evaluation;
- explain their concept-oriented approaches in the analysis of geological data;
- assess and apply geochemical exploration methods and geochemical data presentation/analysis;
- discuss the role of geology in mine design and operation.
- evaluate the range of surface and underground mining techniques

Course Contents

Unit I **Hours 15**

Mineral Economics : Distribution of mineralresources 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 **Hours15**

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 **Hours15**

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 **Hours15**

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.

Suggested readings:

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

9. Moon C. J., Whateley, M. K. G., and Evans, A. M., 2005. *Introduction to Mineral Exploration*, Blackwell Science.
10. Dobrin, M. B., and Savit C. H., 1988. *Introduction to geophysical prospecting*, McGraw-Hill Inc.
11. Kearey, P., Brooks M. and Hill, I., 2002. *An Introduction to Geophysical Exploration*, Wiley-Blackwell.

Interdisciplinary Course offered by the department

L	T	P	Credits
2	0	0	2

Course Code: EGS. 534
Course Title: Introduction to Disaster Management

Total hours: 30

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

- Discuss the concept of disaster risk management
- Elaborate the both the Natural and Artificial disaster and their management techniques
- Design concept on management and mitigation of disaster management
- Choose appropriate scientific approaches in understanding causes of natural hazards

Course Contents

Unit I **Hours 7**

Disaster Management: definition, scope, Objectives and Approaches;

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

Unit II **Hours 8**

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

Unit III **Hours 8**

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

Unit IV **Hours 7**

- 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.

Transactional Modes: Lecture, Lecture cum demonstration, Project Method, Inquiry training, Seminar, Group discussion, Blended learning, Flipped learning, Focused group discussion, Mobile teaching, Collaborative learning, Case based study,

Suggested reading:

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.
4. Bryant E., 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: Engineering Geology and Geophysics

L	T	P	Credits
4	0	0	4

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.
- Classifysoils 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.

Course Contents

Unit I **Hours15**

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 **Hours15**

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 **Hours15**

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 **Hours15**

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, 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. Bell, F.G., 1992. *Fundamentals of Engineering Geology*, Aditya Books Pvt. Ltd. Indian Edn.
2. Krynine, D.H. and Judd, W.R., 1998.*Principles of Engineering Geology*, CBS Edition. Delhi.
3. Bermett, M.R., and Doyle, P., 1999.*Environmental Geology*, John Wiley & Sons, N. York.

4. Lowrie, W., 1997.*Fundamental of Geophysics*, Cambridge Univ. Press. London.
5. Fowler, 2005.*The Solid Earth: An Introduction to Global Geophysics*, Cambridge University Press.
6. Telford, W.M., Geldart, L.P. and Sheriff, R.E., 1990.Applied Geophysics, Cambridge University Press.
7. Jaeger J., Cook N. G. and Zimmerman R., 2007. *Fundamentals of Rocks Mechanics*, Wiley-Blackwell
8. Reddy, D.V., 1995.*Engineering Geology for Civil Engineers*, IBH Publishing Co. Pvt. Ltd.
9. Peter Shearer, 1999.*Introduction to Seismology*, Cambridge University Press, Cambridge.
10. Alan E. Mussett, M. Aftab Khan, 2000.*Looking Into the Earth: An Introduction to Geological Geophysics*, Cambridge University Press.

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

L	T	P	Credits
4	0	0	4

Total hours: 60

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

- appraise the role of groundwater in hydrological cycle, groundwater flow pattern in different terrains.
- estimate quantity and to assess quality aspects of groundwater for better management, characterizations of aquifers in terms of yield, categorization of groundwater for different uses.
- Formulate the evolution of water chemistry through hydrogeochemical processes across different terrains.
- Develop utilization of satellite data in various applications such as geology, hydrogeology, climatatology, forestry, town planning etc.
- Maximize digital image processing technique of satellite data for various applications such as land use/land cover, digital elevation model(DEM).

Course Contents

Unit I **Hours 15**

Hydrosphere and Groundwater flow: Hydrosphere; Hydrological Cycle Ground Water- origin, type and occurrence, Scope and importance of Groundwater**;** Principles of groundwater flow: Darcy's law and its validity, concept of permeameters, water table, peizometer. 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 **Hours 15**

Occurrence, distribution and quality of Groundwater: Vertical distribution of groundwater; Hydrologic properties of Rocks– Porosity, Hydraulic conductivity,

Aquifers – characteristics of unconfined and confined aquifers; behavior of sedimentary, crystalline and volcanic rocks as aquifers – factors controlling hydrologic, aquifer properties and yield of wells in different rock types; Assessment of groundwater quality using hydrochemical parameters: hydrochemical data presentation and data analysis, concept and evaluation of hydrochemical facies, use of environmental isotopes in groundwater studies.

Unit III **Hours 15**

Fundamentals of Remote Sensing and GIS: Energy-atmospheric interaction: electromagnetic spectrum; atmospheric windows; spectral reflectance. Platforms, sensors, satellite series: Types of platform; orbital characteristics; aerial photographys; sensor types; sensor systems; Indian Remote Sensing Satellite series programme; LANDSAT; IKONOS; Quick bird. Image processing and interpretation: digital image processing; elements of image interpretation; visual image interpretation. Basics of Geographic Information System: spatial data and non-spatial data; vector and raster data; coordinate system. GPS: GPS systems; receivers; advantages and limitations.

Unit IV **Hours 15**

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 - groundwater exploration, identification of rocks, mineral explorations, geological surveys; alteration zones mapping; geomorphology applications, volcanic eruptions, surfacial deposit / bedrock mapping; lithological mapping; structural mapping; environmental geology; geo-hazard mapping, Drone application in geoscience.

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

7. Joseph G., 2003. *Fundamentals of remote sensing*, Universities Press, Hyderabad.
8. Sabbins, Jr. F. F., 1986. *Remote Sensing: Principles and Interpretation*, WH Freeman & Co.
9. Pandey, S. N., 1987. *Principles and Applications of Photogeology*, Wiley Eastern, New Delhi.
10. Gupta, R.P., 1990. Remote Sensing Geology, Springer Verlag.
11. Karanth, K. R., 1987. *Groundwater Assessment Development and Management,* McGraw Hill Publishers
12. Freeze and Cherry, 1979.*Groundwater*, Prentice-Hall.

Course Code: EGS. 553
Course Title: Hydrogeology and Remote Sensing and GIS (Practical)

L	T	P	Credits
0	0	4	2

Total hours: 60

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

- Construct water table maps for evaluation of groundwater flow, recharge and discharge site identification.
- Maximize exploration of groundwater resource using hydrogeology, remote sensing & GIS integrated approach
- Assess the quality of groundwater for different uses and to propose development and management of groundwater resource
- Improve the use of digital imaging software in groundwater mapping, exploration and management
- Propose GIS related models in assessing quantity and quality aspects of groundwater resource.

Lab Exercise:

1. Water table contour mapping.
2. Interpretation of flow net: groundwater flow movement, delineation of recharge and discharge areas.
3. Calculation of hydraulic gradients.
4. Representation of hydrochemical data in Stiff plot and interpretation.
5. Representation of hydrochemical data in Schoeller diagram and interpretation
6. Representation of hydrochemical data in Box and Whisker plot and interpretation
7. Evaluation of hydrochemical facies in Trilinear diagram and interpretation
8. Analysis of hydrochemical facies in Durov diagram.
9. Identification of landforms on toposheets, aerial photographs and satellite images
10. Digital image processing and data interpretation using image processing software

Transactional Modes: Lecture cum demonstration, Problem solving using graphs, maps, using image processing and GIS softwares such as Erdas Imagine, ArcGIS.

Evaluation Criteria: Total Marks – 100, End semester exam (50 marks), Continues assessment (30 marks), Lab record (10 marks), Viva (10 marks).

Course Code: EGS. 555
Course Title: Research Methodology

L	T	P	Credits
4	0	0	4

Total hours: 60

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

- Choose and propose appropriate research methods according to their research aims and objectives
- aware the limitations of particular research methods
- justify knowledge of the selection of various instruments and sample preparation techniques for addressing specific research problem
- Develop skills in qualitative and quantitative data analysis and presentation
- design advanced critical thinking skills and enhanced writing skills

Course Contents

Unit I **Hours 15**

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 **Hours 15**

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 **Hours 15**

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 **Hours 15**

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, Team teaching, Brain storming, Mobile teaching, Collaborative learning, Problem solving, Self-learning, Case based study, Through SOLE (Self Organized Learning Environment).

Suggested readings:

1. Bruce, L. B. 2001.*Qualitative Research Methods for Social Sciences*, Allyn and Bacon, Boston.
2. John, W. C., 2011.*Research Design: Qualitative, Quantitative and Mixed Methods Approaches*, Sage Publications, Thousand Oaks.
3. Lester, James, D. and Lester Jr. J. D., 2007.*Principles of Writing Research Papers*, Longman, New York.
4. Potts, P. J., 1997.*Silicate rock analysis*
5. Reed, S. J. B., 1990.*Recent developments in geochemical microanalysis: Chemical Geology*, Volume.83, PP. 1-9.
6. Frank A. Settle, 1997.*Handbook of Instrumental Techniques for Analytical Chemistry*, Prentice Hall, Upper Saddle River, NJ.

Course Code: EGS. 543
Course Title: Seminar

L	T	P	Credits
0	0	0	1

Total hours: 15

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

Presentation is evaluated using rubrics: Speak Clearly (8 marks), Posture and Eye contact (8 marks), Content (8 marks), Preparation (8 marks), stay in topic (8 marks); Response to questions (20 marks);

Report evaluation is based on literature review and background knowledge (20 marks), Organization of content, formatting and references (10 marks) and Discussion (10 marks)

Course code: EGS 599
Course title: Project work

L	T	P	Credits
0	0	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

Evaluation Criteria: As Satisfactory / unsatisfactory
Supervisor shall assess students on 60 marks based continuous assessment of students' performance, the lab/field work and final report. Report evaluation is based on origin of the research problem, and literature review (15 marks), methodology adopted (15marks), result and discussion (20 marks), and organization of content, formatting and references (10 marks).
A committee of examiners shall conduct viva-voce, which would consist of the supervisor, faculty member(s) of the department, and Head of the Department/ nominee as per the University Rule. The committee shall evaluate for remaining 40marks based on the presentation and viva-voce.
Presentation is evaluated using rubrics: Speak Clearly (4 marks), Posture and Eye contact (4 marks), Content (4 marks), Preparation (4 marks), stay in topic (4 marks); and response to questions (20 marks).

Value added Course offered by the department

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

L	T	P	Credits
1	0	0	1

Total Hours: 15

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

- Aware the different field accessories in geosciences.
- Measure the equipment's confidently at field.

Course Contents

Unit I **Hours 3**

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

Unit II **Hours 4**

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

Unit III **Hours 4**

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 **Hours 4**

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

Semester IV

Course Code: EGS. 571

Course Title: Principle of Stratigraphy and Indian Stratigraphy

L	T	P	Credits
4	0	0	4

Total hours: 60

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

- Construct stratigraphic cross sections into a historical summary that expresses environmental states and changes.
- Design appropriate nomenclature.
- Adapt the baselevel concept in reasoning through the succession of paleogeographic changes during which a series of strata accumulated.
- Discuss multiple variables that contribute to the accumulation of strata (e.g., tectonic subsidence, sediment supply, sea level change) in deducing plausible scenarios.

- Make up reasoning to construct one or more hypotheses for the paleogeographic and environmental histories that produced a series of strata.
- Appraise 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).

Course Contents

Unit I **Hours 14**

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 **Hours16**

Archaean-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 **Hours16**

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 Gondwana Supergroup 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- Palaeogene boundary.

Unit IV **Hours 14**

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. Stratigraphy and tectonics of the Siwalik Formation. Quaternary relative sea level changes.

Transactional Modes: Lecture, Demonstration, Lecture cum demonstration, Project Method, Seminar, Group discussion, Co-operative learning, Flipped learning, Focused group discussion, Team teaching, Field visit, Mobile teaching, Collaborative learning, Case analysis, Case study, Case based study,

Suggested readings:

1. Sam Boggs, Jr., 2011.*Principles of sedimentology & stratigraphy*, Prentice Hall.
2. Ravindra Kumar, 1998.*Fundamentals of historical geology and stratigraphy of India,* New Age, ISBN-13: 978-0852267455.
3. Ramakrishnan, M. and Vaidyanathan R., 2008.*Geology of India Vol. 1 & 2*, Geological Society of India, Bangalore, ISBN No: 978-81-85867-98-4.
4. Naqvi, S.M. and Rogers, J.J.W., 1987.*Precambrian Geology of India*, Oxford University Press.
5. Krishnan, M.S., 1982.*Geology of India and Burma*, C.B.S. Publishers & Distributors, Delhi.
6. Gary Nichols, 2009.*Sedimentology and stratigraphy*, Wiley-Blackwell, ISBN: 978-1-4051-3592-4.
7. Bolli, H. M. and Saunders, J. B., 1977., *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)*, American Geophysical Union, Washington, D. C.
8. Danbar, C.O., and Rodgers, J., 1957.*Principles of Stratigraphy*, John Wiley & Sons.
9. Pascoe, E.H., 1968.*A Manual of the Geology of India & Burma (Volume I – IV),* Govt. of India Press, Delhi
10. Pomerol, C., 1982.*The Cenozoic Era? Tertiary and Quaternary*, Ellis Harwood Ltd., Halsted Press.
11. Schoch, R.M., 1989.*Stratigraphy: Principles and Methods*, Van Nostrand Reinhold, New York.
12. Doyle, P. and Bennett. M. R., 1996.*Unlocking the Stratigraphic Record*, John Willey

Course Code: EGS. 572
Course title: Ore Geology

L	T	P	Credits
4	0	0	4

Total hours: 60

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

- Evaluate ore minerals in hand specimen and under the microscope.
- Improve knowledge in wide range of mineral deposits, including recognizing the overall geometry, zonation and alteration patterns associated with specific classes of metallic mineral deposits
- Elaborate 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.
- assess the formation of ore bodies is important in the current debates about global resources

Course Contents

Unit I **Hours 15**

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 **Hours 15**

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 **Hours 15**

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 **Hours 15**

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, Focused group discussion, Team teaching, Mobile teaching, Collaborative learning, Problem solving, Case analysis, Self-learning, Case based study.

Suggested readings:

1. Robb, L., 2005.*Introduction to Ore-forming processes*, Blackwell Publ., Oxford.
2. Evans, A.M., 1992.*Ore geology and industrial minerals*, Blackwell Science.
3. Misra, K.C. 1999.*Understanding mineral deposits*, Kluwer Academic Publishers.
4. Sinha, R. K. and Sharma, N.L., 1970.*Mineral economics*, Oxford& IBH.
5. Jensen, M.L. and Bateman, A.M., 1981.*Economic mineral deposits*, John Wiley & Sons.
6. Stanton, R. L., 1972.*Ore Petrology*, McGraw Hill.
7. Guilbert, J. M. and Park, Jr. C. F., 1986.*The Geology of Ore Deposits*, Freeman.
8. Barnes, H. L., 1979. *Geochemistry of Hydrothermal Ore Deposits*, John Wiley:
9. Umeshwar Prasad, 2014. *Economic Geology: Economic Mineral Deposits (Second Edition),* CBS Publishers & Distributors Pvt. Ltd., New Delhi.

Course Code: EGS. 573
Course Title: Ore geology and Exploration (Practical)

L	T	P	Credits
0	0	4	2

Total hours: 60

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

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. Calculation of apparent resistivity of subsurface layers using Schlumberger and Wenner electrode configuration
8. Interpretation of seismic and gravity data for mineral exploration

Suggested readings:

1. Annels, A.E., 1992.*Mineral deposit evaluation*, Chapman and Hall, London.
2. Evans, A.M., 1992.*Ore geology and industrial minerals*, Blackwell Science.
3. Lowrie, W., 1997.*Fundamental of Geophysics*, Cambridge Univ. Press. London.
4. Fowler, 2005.*The Solid Earth: An Introduction to Global Geophysics*, Cambridge University Press.
5. Telford, W.M., Geldart, L.P. and Sheriff, R.E., 1990.Applied Geophysics, Cambridge University Press.

Evaluation Criteria- Full marks – 100,
End semester exam (50 marks), Continues assessment (30 marks), Lab record (10 marks), Viva (10 marks).

Course Code: EGS 574
Course Title: Field Training - II

L	T	P	Credits
0	0	0	2

Total hours: 30

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

Geological field training

Fieldwork will be conducted any time during the semester as per the suitable time. Geological field training and fieldwork will be carried out as per the guideline of the University at proper sites for a 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. Evaluation of this course will be based on the field activity, daily field report, final report submission and presentation during the 4th semester.

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

Evaluation Criteria: Full Marks – 100

Field activity (10 marks), Evaluation of field dairy during every day of fieldwork and final submission (20 marks), Final field report (40 marks), Presentation (30 marks) – Presentation will be evaluated using rubrics: Speak Clearly (4 marks), Posture and

Eye contact (4 marks), Content (4 marks), Preparation (4 marks), stay in topic (4 marks); Response to questions (10 marks).

Course Code: EGS. 575
Course title: Comprehensive Geosciences

L	T	P	Credits
2	0	0	2

Total hours: 30

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 lecture cum tutorial classes. Past question papers of national level exams like CSIR-JRF-NET/GATE will be discussed in the classes. In this course student will solve geological questions from all the courses studied during their M.Sc. program in time bound manner. Different case study will be discussed in the classes. Problems will cover all the aspects of geosciences.

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 mark 100
Assignment (10 marks), Surprise test (15 marks), Mid semester Test (25 marks), End semester (objective type) exam (50 marks)

Course Code: EGS. 576
Course Title: Quantitative Geosciences

L	T	P	Credits
2	0	0	2

Total hours: 30

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
- interpret geologic markers vis a vis climate change

Quantitative Geosciences:
This course will be conducted as lecture cum tutorial classes. Students will learn the approach and application of different statistical tool to interpret the data comprises of suitable geological problems. These includes application such as probability function, hypothesis testing, Annova, exponential smoothing, regression and correlations, cross correlation, sampling, moving average for time series data, Fourier transformation,

matrix, PCA analysis and Eigen value, intrapolation, Markov chain and Embedded Markov chain, segmenting sequences, splines and semi variograms. Besides this, student will also solve other quantitative problems (related to geochemistry, isotope geology, geophysics, hydrogeology and economic geology) of geosciences in time bound manner.

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).

Suggested readings:

1. Ma, Y. Z. (2019). Quantitative geosciences: data analytics, geostatistics, reservoir characterization and modeling. Springer International Publishing.
2. Marsal, D., & Merriam, D. F. (2014). *Statistics for geoscientists*. Elsevier.
3. Zou, H. (2007). *Quantitative geochemistry*. Imperial college press.
4. Davis, J. C., (2002). *Statistics and data analysis in geology*. Wiley.
5. Liboutry, L. (2000). *Quantitative geophysics and geology*. Springer Science & Business Media.
6. Whitten, H. T. (Ed.). (1975). *Quantitative studies in the geological sciences* (Vol. 142). Geological Society of America.

Evaluation Criteria- Full marks – 100,
Assignment (10 marks), Surprise test (15 marks), Mid semester Test (25 marks), End semester (objective type) exam (50 marks)

Course code: EGS 599
Course title: Project work

L	T	P	Credits
0	0	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

Evaluation Criteria: As Satisfactory / unsatisfactory
Supervisor shall assess students on 60 marks based continuous assessment of students' performance, the lab/field work and final report. Report evaluation is based on origin of the research problem, and literature review (15 marks), methodology

adopted (15 marks), result and discussion (20 marks), and organization of content, formatting and references (10 marks).
A committee of examiners shall conduct viva-voce, which would consist of the supervisor, faculty member(s) of the department, and Head of the Department/ nominee as per the University Rule. The committee shall evaluate for remaining 40 marks based on the presentation and viva-voce.
Presentation is evaluated using rubrics: Speak Clearly (4 marks), Posture and Eye contact (4 marks), Content (4 marks), Preparation (4 marks), stay in topic (4 marks); and response to questions (20 marks).

Value added Course offered by the department

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

L	T	P	Credits
1	0	0	1

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

- Evaluate the processes and practices of geological mapping.
- Assess the processes of sampling techniques.

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

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

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

Unit IV **Hours 4**
Sampling strategies for micro-palaeontological and biostratigraphic studies and recording of palaeontological information.

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

Suggested readings:

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