CENTRAL UNIVERSITY OF PUNJAB

M.Sc. Geology

Session - 2021-23

Department of Geology

School of Environment and Earth Sciences

Graduate Attributes

The graduates of this MSc Geology Programme will develop deep level of disciplinary knowledge and ability to apply/practice this knowledge in multidisciplinary or multi-professional context to tackle the future challenges. They will be able to acquire, analyze and interpret data generated from laboratory or field, and can decipher the result to the scientific community. Graduates shall be capable of expanding their knowledge boundary through research and training; and take lead in cross disciplinary studies. After completion of this programmes, graduates will possess critical, creative and evidence-based thinking to solve local/regional/global problems; attain good communication skill and professionalism with ethical competency to work individually as well as in a team; will be capable enough to become an efficient entrepreneur and to take up leadership role. Additionally, they will be self-aware about the recent developments and emerging challenges; and to be a responsible global citizen. Graduates will be competent and technically adept geoscientists for building careers in research, teaching, government, industry, and non-governmental organizations.

Course Structure of the Programme

Semester-I

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
EGS.506	Mineralogy and Crystallography	*Core*	3	0	0	3
EGS.514	Sedimentology and Paleontology	*Core*	3	0	0	3
EGS.515	Structural Geology and Geotectonic	*Core*	3	0	0	3
EGS.516	Hydrogeology and Engineering Geology	*Core*	3	0	0	3
EGS.509	Mineralogy and Crystallography (Practical)	*Skill Based*	0	0	4	2
EGS.510	Paleontology and Sedimentology (Practical)	*Skill Based*	0	0	4	2
EGS.517	Structural Geology and Hydrogeology (Practical)	*Skill Based*	0	0	4	2
Select any one from the following Discipline Elective course[$]						
EGS.518	Geomorphology	Discipline Elective	3	0	0	3
EGS.519	Natural Resource Management		3	0	0	3
EGS.520	Watershed Management		3	0	0	3
GEO.566[†]	Glaciology		3	0	0	3
EVS.514[†]	Principles of Environmental Chemistry		3	0	0	3
Interdisciplinary course						
	Interdisciplinary course #	IDC	2	0	0	2
		Total	**17**	**0**	**12**	**23**
Interdisciplinary course offered by the Department						
EGS 534	Introduction to Disaster Management	IDC	2	0	0	2

Semester-II

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
EGS.521	Geochemistry and Isotope Geology	*Core*	3	0	0	3
EGS.522	Igneous and Metamorphic Petrology	*Core*	3	0	0	3
EGS.529	Principals of Geospatial	*Core*	3	0	0	3

	technology					
EGS.530	Geological Time and Stratigraphy	*Core*	3	0	0	3
EGS.531	Petrology and Geospatial technology (Practical)	*Skill Based*	0	0	4	2
Select any Two from the following Discipline Elective course[$]						
EGS.528	Mineral Exploration and Petroleum Geology	Discipline Elective	3	0	0	3
EGS.532	Oceanography		3	0	0	3
EGS.533	Paleobotany		3	0	0	3
EGS.535	Environmental Geology		3	0	0	3
EGS.536	Astro and Geobiology		3	0	0	3
EVS. 558[†]	Natural hazards and disaster management		3	0	0	3
GEO.507[†]	Climatology		3	0	0	3
Value Added Course (VAC)						
EGS.502	Geological Mapping	VAC	2	0	0	2
		Total	**20**	**0**	**4**	**22**

Semester-III

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	**T**	**P**	**Cr**
EGS.556	Solid Earth Geophysics	*Core*	3	0	0	3
EGS.572	Ore Geology	*Core*	3	0	0	3
EGS.555	Research Methodology	Compulsory Foundation	3	0	0	3
EGS.557	Analytical Techniques and Geo-statistics	Compulsory Foundation	3	0	0	3
EGS.575	Comprehensive Geoscience	*DEC*	0	2	0	2
EGS.526	Field Training	Skill Based	0	0	4	2
EGS.558	Entrepreneurship	Skill Based	1	0	0	1
EGS.600	Research Proposal	Skill Based	0	0	8	4
		Total	**13**	**2**	**12**	**21**

Semester-IV

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	**T**	**P**	**Cr**
EGS.600	Dissertation	Skill Based	0	0	40	20
		Total	**0**	**0**	**40**	**20**
Grand total Credit for all semester (I+II+III+IV)			**50**	**2**	**68**	**86**

Students may opt any Inter disciplinary course offered by other departments. Students are not allowed to take IDC course offered by the parent department.

$ Based on the availability of infrastructural facility and faculty, limited course(s) will be offered to the batch.

*DEC - Discipline enrichment course

†Course code starting with EVS and GEO belongs to the Department of Environmental Science and Technology, and Geography. Please refer their curriculum for details.

NB: MOOCs may be taken up 40% of the total credits (excluding dissertation credits). MOOC may be taken in lieu of any course but content of that course should match minimum 70%. However students need to consult with the Head of the department prior to the registration of the MOOC.

Students will have an option to carry out dissertation work in industry, national institutes or Universities in the top 100 NIRF ranking. Group dissertation may be opted, with a group consisting of a maximum of four students. These students may work using single approach or multidisciplinary approach. Research project can be taken up in collaboration with industry or in a group from within the discipline or across the discipline.

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

Evaluation Criteria for Theory Courses: Total Marks 100

A. Continuous/Internal Assessment: [25 Marks]
   [Internal assessment for different courses will be conducted using any two or more of the given methods: Surprise Tests, in-depth interview, unstructured interview, Jigsaw method, Think-Pair Share, Students Teams Achievement Division (STAD), portfolios, case based evaluation, video based evaluation, Kahoot, Padlet, Directed paraphrasing, Approximate analogies, one sentence summary, Pro and con grid, student generated questions, case analysis, simulated problem solving, media assisted evaluation, Application cards, Minute paper, open book techniques, classroom assignments, homework assignments, term paper]

B. Mid Semester Test: Based on Subjective Type Test [25 Marks]

C. End Semester (50 Marks): Subjective Test -70% [35 marks], Objective-30 % [15 marks]

Evaluation Criteria for practical/DEC/ Entrepreneurship/ Dissertation/Field training courses are given in the detailed syllabus.

Semester-I

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
EGS.506	Mineralogy and Crystallography	*Core*	3	0	0	3
EGS.514	Sedimentology and Paleontology	*Core*	3	0	0	3
EGS.515	Structural Geology and Geotectonic	*Core*	3	0	0	3
EGS.516	Hydrogeology and Engineering Geology	*Core*	3	0	0	3
EGS.509	Mineralogy and Crystallography (Practical)	*Skill Based*	0	0	4	2
EGS.510	Paleontology and Sedimentology (Practical)	*Skill Based*	0	0	4	2
EGS.517	Structural Geology and Hydrogeology (Practical)	*Skill Based*	0	0	4	2
Select any one from the following Discipline Elective course[$]						
EGS.518	Geomorphology	Discipline Elective	3	0	0	3
EGS.519	Natural Resource Management		3	0	0	3
EGS.520	Watershed Management		3	0	0	3
GEO.566[†]	Glaciology		3	0	0	3
EVS.514[†]	Principles of Environmental Chemistry		3	0	0	3
Interdisciplinary course						
	Interdisciplinary course #	IDC	2	0	0	2
		Total	**17**	**0**	**12**	**23**
Interdisciplinary course offered by the Department						
EGS 534	Introduction to Disaster Management	IDC	2	0	0	2

Course Code: EGS. 506

Course Title: Mineralogy and Crystallography

L	T	P	Credits
3	0	0	3

Total Hours: 45

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

- Apprise how the internal structure of minerals affect the external structure and physical properties of minerals 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 assemblage by applying polarizing microscope, x-ray diffraction and electron microprobe.

Course Contents

UNIT I **Hours 10**

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. Rules of substitution, introduction to phase diagram and solid solution series.

Hands on exercise of mineral specimens, Use of stick-ball model to check bonding and packing.

UNIT II **Hours 11**

Crystallography: Crystal systems, introduction to symmetry, derivation of 32 classes of symmetry.2D and 3D lattice, 14 Bravais lattice; introduction to space group. Study of stereogram and stereographic projections. Crystal defects, twinning and twin laws: common types of twins and their examples in minerals. Introduction to X-ray crystallography, and Bragg's equation.

Hands on exercise of crystal models, drawing of stereographic projections, Powder XRD data analysis.

UNIT III **Hours 12**

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.

Use of petrological microscope and analyzing each parameters.

UNIT IV **Hours 12**

A detailed study of the important silicates (listed below) 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, aluminosilicategroup (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

Mini project and student presentation on different silicate and non-silicate minerals, Group discussion

Transactional Modes: Lecture, Demonstration, Tutorial, Problem solving, 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., 2020. *Mineralogy and Optical Mineralogy*, Mineralogical, Society of America, ISBN 978-1-946850-02-7.
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.
12. Ram S. Sharma and Anurag Sharma, 2013. Crystallography and Mineralogy - Concepts and Methods, Geological society of India, Bengaluru.

Web Resources: http://webmineral.com/
https://www.mindat.org/
http://www.jsu.edu/depart/geography/mhill/earthsci/mineralID /virtualminlab.html
https://sketchfab.com/tags/minerals
http://www.minsocam.org/

Course Code: EGS.514
Course Title: Sedimentology and Paleontology

L	T	P	Credits
3	0	0	3

Total Hours: 45

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

- 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.
- 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 10**

Important sedimentary 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. Hands on exercise of and practices on sedimentary rock petrography and separation of heavy minerals, assignment.

UNIT II **Hours 11**

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.

Tectonic and sedimentation; Review of concept of geosynclines and plate-margins, major types of basins and distribution of environments and litho-facies within basins, evolution of basins with time. Sedimentary basins of India and their economic importance. Exercises on sedimentary facies identification, mapping the sedimentary basins of India, student seminar, group discussion.

UNIT III **Hours 13**

Life through age; species concept and speciation. 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. Exercises and brainstorming session on the evolution of life, demarcating the vertebrate fossils of India through ages and their global comparison, assignments.

UNIT IV **Hours 12**

Use of paleontological data in stratigraphy, biostratigraphy, paleoecology, evolution, paleoclimate and sea level changes; Principle of paleobiogeography.

Micropaleontology: Classification and uses of micro fossils. Detailed study of microfossils such as diatoms, Foraminifera, Radiolaria, Conodonta, Ostracoda and Charophyta. 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. Hand on exercise on the application of fossils of different sections and their correlation with other correlatable sections, student seminar.

Transactional Modes: Lecture, Demonstration, Tutorial, Problem solving, Seminar, assignment, Group discussion, Tools used: PPT, ICT, Video, and Animation, software's: Google class, piazza, padlet.

Suggested Readings:

1. Sam Boggs, Jr., 2016. *Principles of sedimentology and stratigraphy*, Prentice Hall, 5th Edition.
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.
12. Clarkson, E. N. K., 2017. *Invertebrate Palaeontology and Evolution*, Wiley-Blackwell, 5th Edition.
13. Michael Benton, 2014. *Vertebrate Palaeontology*, Wiley-Blackwell, 4th Edition.
14. Howard A. Armstrong, Martin D. Brasier, 2013. *Microfossils*, Blackwell Publishing Ltd., 2nd Edition.
15. Michael Foote, Arnold I. Miller, 2006. *Principles of Paleontology*, W. H. Freeman.
16. Jones, R. W. 2002. *Applied Palaeontology*, Natural History Museum, London.
17. Shrock, N., 2005.*Principles of Invertebrate Paleontology*, CBS Publisher & distributer Private Ltd.
18. Henry Wood, 2004. *Paleontology Invertebrate*, CBS Publication & distributer Private Ltd.
19. Donald R. Prothero, 2013. *Bringing Fossils to Life: An Introduction to Palaeobiology*, McGraw-Hill Higher Education, 3rd edition.
20. Sen Gupta, B. K., 2003. *Modern foraminifera*, Springer Netherlands

Web Resources:

https://www.gsi.gov.in/webcenter/portal/OCBIS/pageQuickLinks/pageTIPetrology?_afrLoop=21149458763392180&_adf.ctrl-state=zil7ujw74_67#!%40%40%3F_afrLoop%3D21149458763392180%26_adf.ctrl-state%3Dzil7ujw74_71
https://serc.carleton.edu/research_education/paleontology/general.html
https://www.palaeontologyonline.com/?doing_wp_cron=1621058580.7671799659729003906250
https://www.priweb.org/blog-post/learn-at-home
https://www.nationalgeographic.org/encyclopedia/paleontology/
https://naturalhistory.si.edu/education/teaching-resources/paleontology
https://www.ucl.ac.uk/GeolSci/micropal/welcome.html
https://www.sciencedaily.com/news/fossils_ruins/paleontology/

Course Code: EGS.515

L	T	P	Credits
3	0	0	3

Course Title: Structural Geology and Geotectonic

Total Hours: 45

Learning Outcomes:

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.
- 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 10**

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. Hands on exercises on the stress and strain analysis of deformed rocks, assignment and group discussion.

UNIT II **Hours 15**

Mechanics of folding, fold development and distribution of strains in folds. Buckling of single layer, multilayer and anisotropic materials. Analysis and interpretation of superimposed folding. Mechanics and geometric aspects of thrust, normal and strike-slip faults, and associated structural features. Planar and linear fabrics (Foliation and Lineation) in deformed rocks: description, classification, genesis and significance. Brittle and ductile shear zones, Geometry and products of shear zones, Mylonites and Cataclasites. Assignment, student Seminar, group discussion on rock deformation patterns at different regimes.

UNIT III **Hours 10**

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. 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. Hand on exercises on the application of beta and pie diagrams, preparation of cross sections of complex structures.

UNIT IV **Hours 10**

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 epiorogeny. Seismic belts of the earth. Seismicity and plate movements. Geodynamic Evolution of Himalaya. Geodynamics of the Indian plate. Student seminar, group discussion on global geodynamics and orogeny.

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. Marl and P. Billings, 2016. *Structural Geology*, Phi Learning, 3rd edition.
2. Robert J. Twiss and Eldridge M. Moores, 2006.*Structural Geology*, W. H. Freeman publisher.
3. Haakon Fossen, 2016. *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 Gautam Mitra, 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., 2014. *Structural Geology: Fundamental and Modern Developments*, Kidlington: Elsevier Science.
11. Condie, K. C., 1997. *Plate Tectonics and Crustal Evolution*, Butterworth-Heinemann.
12. Alan E. Mussett, M. Aftab Khan, 2000. *Looking Into the Earth: An Introduction to Geological Geophysics*, Cambridge University Press.

Web Resources:
https://www.gsi.gov.in/webcenter/portal/OCBIS/pageQuickLinks/pageTIStructuralGeology?_afrLoop=21149378600749056&_adf.ctrlstate=zil7ujw74_38#!%40%40%3F_afrLoop%3D21149378600749056%26_adf.ctrl-state%3Dzil7ujw74_42
http://www.geo.cornell.edu/geology/classes/RWA/GS_326/
https://serc.carleton.edu/NAGTWorkshops/structure/index.html
https://onlinecourses.nptel.ac.in/noc21_ce37/preview
https://ocw.mit.edu/courses/earth-atmospheric-and-planetary-sciences/12-113-structural-geology-fall-2005/
https://uh.edu/~jbutler/anon/anoncoursestructure.html

Course Code: EGS.516

L	T	P	Credits
3	0	0	3

Course Title: Hydrogeology and Engineering Geology

Total hours: 45

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.
- Formulate the evolution of water chemistry through hydro-geochemical processes across different terrains.
- Understand the engineering properties of rock and soil materials, engineering geological investigations.
- Understand the importance of engineering geology related to technical issues during construction, and conduct basic engineering geological assessments and analyzes.

Course Contents

Unit I **Hours 11**

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 permeameter, water table and piezometer. 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. Design a model on hydrologic cycle and concept of Darcy's law.

Unit II **Hours 12**

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. Group discussion on local major aquifer types and groundwater occurrence.

Unit III **Hours11**

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. Slope stability, geological factors affecting the stability of a facility on and in the soil. Physical characters of building stones. Metal and concrete aggregates. Group discussion on the popular engineering projects and highlight the salient points.

Unit IV **Hours11**

Geological consideration for evaluation of dams, reservoir sites, highways. 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. Brain storming on the impacts of engineering projects to the environments and their importance to highlight the salient points, student seminar.

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. 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. Karanth, K. R., 1987. *Groundwater Assessment Development and Management,* McGraw Hill Publishers
5. Freeze and Cherry, 1979.*Groundwater*, Prentice-Hall.
6. Bell, F.G., 1992. *Fundamentals of Engineering Geology*, Aditya Books Pvt. Ltd.

Indian Edn.
7. Krynine, D.H. and Judd, W.R., 1998.*Principles of Engineering Geology*, CBS Edition. Delhi.
8. Jaeger J., Cook N. G. and Zimmerman R., 2007. *Fundamentals of Rocks Mechanics*, Wiley-Blackwell
9. Reddy, D.V., 1995.*Engineering Geology for Civil Engineers*, IBH Publishing Co. Pvt. Ltd.

Web Resources:

https://iah.org/education/
https://www.routledge.com/Hydrogeology
https://www.youtube.com/watch?v=G7CnE5NBxZs
https://geologyscience.com/applied-geology/hydrogeology/

L	T	P	Credits
0	0	4	2

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

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

- Identification of rock-forming minerals in hand specimens.
- Identification of crystal model using symmetry elements,
- Use of Goniometer to measure interfacial angle of crystals and calculation of axial ratio.
- Representation of symmetry elements of crystals belonging to 32 classes of symmetry using stereonet.
- Analysis of XRD spectrum.
- 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.

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

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.

Web Resources:

http://www.jsu.edu/depart/geography/mhill/earthsci/mineralID/virtualminlab.html
https://sketchfab.com/tags/minerals
http://www.minsocam.org/
http://webmineral.com/
https://www.mindat.org/

Course Code: EGS.510
Course Title: Sedimentology and Paleontology (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

Following practical exercise will be conducted in the lab and some exercise may have multiple components.

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

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

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

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*, Graham 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.

Web Resources:

https://serc.carleton.edu/research_education/paleontology/general.html
https://www.palaeontologyonline.com/?doing_wp_cron=1621058580.7671799659729003906250
https://www.priweb.org/blog-post/learn-at-home
https://www.nationalgeographic.org/encyclopedia/paleontology/
https://naturalhistory.si.edu/education/teaching-resources/paleontology
https://www.ucl.ac.uk/GeolSci/micropal/welcome.html
https://www.sciencedaily.com/news/fossils_ruins/paleontology/

Course Code: EGS.517
Course Title: Structural Geology and Hydrogeology (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:

- 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.

- 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

Course Contents

Following practical exercise will be conducted in the lab and some exercise may have multiple components.

- 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.
- 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.
- Water table contour mapping.
- Interpretation of flow net: groundwater flow movement, delineation of recharge and discharge areas.
- Calculation of hydraulic gradients.
- Representation of hydrochemical data in Stiff plot and interpretation.
- Representation of hydrochemical data in Schoeller diagram and interpretation.
- Representation of hydrochemical data in Box and Whisker plot and interpretation.
- Evaluation of hydrochemical facies in Trilinear diagram and interpretation. Analysis of hydrochemical facies in Durov diagram.

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

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

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.
7. Todd D.K., 2007. *Groundwater Hydrology*, John Wiley and Sons
8. Gupta, S. K., 2011. *Modern Hydrology and Sustainable Water Development*, Wiley-Blackwell.
9. Raghunath, H.M., 1985. *Groundwater*, Wiley Eastern Ltd.
10. Karanth, K. R., 1987. *Groundwater Assessment Development and Management*, McGraw Hill Publishers
11. Freeze and Cherry, 1979.*Groundwater*, Prentice-Hall.

Web Resources:

https://serc.carleton.edu/NAGTWorkshops/structure/index.html
https://onlinecourses.nptel.ac.in/noc21_ce37/preview
https://ocw.mit.edu/courses/earth-atmospheric-and-planetary-sciences/12-113-structural-geology-fall-2005/
https://uh.edu/~jbutler/anon/anoncoursestructure.html
https://iah.org/education/
https://www.routledge.com/Hydrogeology
https://www.youtube.com/watch?v=G7CnE5NBxZs
https://geologyscience.com/applied-geology/hydrogeology/

Discipline Elective course

Course Code: EGS.518
Course Title: Geomorphology

L	T	P	Credits
3	0	0	3

Total Hours: 45

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 11**

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. Design a note on the concept of origin, evolution of landform, historical development, scope etc.

UNIT II **Hours 12**

Geomorphic processes and landforms-fluvial, glacial, aeolian, coastal and karst. River forms and processes-stream flow, stage-discharge relationship; hydrographs and flood frequency analysis, Environmental change-causes, effects on processes and landforms. Brain storming on geomorphic processes for landform development, landforms under different environments etc.

UNIT III **Hours 12**

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

UNIT IV **Hours 10**

Physiographic division of India, Submarine relief, Quaternary geomorphology, Eustatic sea-level change and impact of coastal geomorphology, recent advancement in geomorphological research, extra-terrestrial geomorphology: special emphasize on Mars landscape. Student seminar on recent advancement in geomorphological studies.

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.

Web Resources:

https://www.geomorphology.org.uk/
https://www.nature.com/subjects/geomorphology
https://www.usgs.gov/centers/umid-water/science/fluvial-geomorphology
https://onlinecourses.nptel.ac.in/noc20_ce28/preview

Course Code: EGS.519
Course Title: Natural Resource Management

L	T	P	Credits
3	0	0	3

Total Hours: 45

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
- 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 11**

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. Develop a sustainable model on natural resources of India. Presentation on forest resources of India.

UNIT II **Hours 12**

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. Design a concept model on water resources, drought, flood issues of India, restoration etc.

UNIT III **Hours 12**

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. Group discussion on organic farming, green manuring etc. to highlight the salient points;

UNIT IV **Hours 10**

Mineral resource: Type of mineral resources, reserve, policy and management. Rock and other building materials. Ocean resources, International territorial policy and geopolitics. Mineral resource management using Geo-spatial technologies. SDG goals. Group discussion on ocean resources of India. Student seminar.

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.

Web Resources:

https://www.icar.org.in/content/natural_resource_management_division
https://www.india.gov.in/topics/environment-forest/natural-resources
https://www.youtube.com/watch?v=ZFD13WoyUGw

Course Code: EGS.520
Course Title: Watershed Management

L	T	P	Credits
3	0	0	3

Total Hours: 45

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

- 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 11**

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. Group discussion on watershed management policies in India, to highlight the salient points.

UNIT II **Hours 12**

Rivers and Lakes in India; hydrological cycle; Water Conservation and management techniques; Wetland – definition, classification, functions, ecological importance and conservation. Concept of small dams, waste disposal practices and management; rainwater harvesting; concept of Micro Watershed Management; Watershed Management using Geo-spatial technologies. Prepare a note on watershed management plan of India, followed by student presentation on that note.

UNIT III **Hours 11**

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. Group discussion on water legislation and implementations and its presentation.

UNIT IV **Hours 11**

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. Mini project and student presentation on mechanism of Indian monsoon system and climatic regimes.

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

Suggested Readings:

1. Murthy, K.S. 1998. *Watershed Management in India*, Wiley Eastern Ltd. / New Age International Ltd.
2. Tideman, E.M., 1996. *Watershed Management: Guidelines for Indian Conditions*, Omega, New Delhi.
3. Verghese, B.G., 1990. *Water of Hope: Integrated Water Resource Development and Regional Co-operation within the Himalayan-Ganga-Brhamaputra-Barak Basin*, Oxford-IBH
4. Kathy Wilson Peacock, 2008. *Natural resources and sustainable developments*, Facts on file Inc.
5. Daniel R. L., 2009. *Sustainable natural resource management for scientists and engineers*, Cambridge University press
6. Panday, S.N. and Misra, S.P. (Eds.), 2008. *Essential Environmental Studies*, CRC Press.

Web Resources:

https://www.newworldencyclopedia.org/entry/Climate_of_India
https://www.weatheronline.co.uk/reports/climate/India.htm
https://www.india.gov.in/
https://bhuvan.nrsc.gov.in/bhuvan_links.php

Interdisciplinary Course (IDC) offered by the department

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

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:

- 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

Group Discussion and brainstorming session on disaster and hazards.

Unit II **Hours 8**

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

Student seminar, discussion and brainstorming session.

Unit III **Hours 8**

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

Student presentation and group discussion on the case study on Indian disasters, and their mitigation and preparedness techniques.

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.

Student Seminar and brainstorming session of disaster management system of India.

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

Suggested reading:

1. Srivastava, A.K. 2021. Text book of disaster management. Scientific Publishers.
2. Coppola, D. 2015. Introduction to International Disaster Management.

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

Web Resource:

http://www.onlinenidm.gov.in/
https://ndma.gov.in/
https://ndmindia.mha.gov.in/#
https://www.mha.gov.in/division_of_mha/disaster-management-division
https://www.undp.org/
https://library.wmo.int

Semester-II

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
EGS.521	Geochemistry and Isotope Geology	*Core*	3	0	0	3
EGS.522	Igneous and Metamorphic Petrology	*Core*	3	0	0	3
EGS.529	Principals of Geospatial technology	*Core*	3	0	0	3
EGS.530	Geological Time and Stratigraphy	*Core*	3	0	0	3
EGS.531	Petrology and Geospatial technology (Practical)	*Skill Based*	0	0	4	2
Select any Two from the following Discipline Elective course[$]						
EGS.528	Mineral Exploration and Petroleum Geology	Discipline Elective	3	0	0	3
EGS.532	Oceanography		3	0	0	3
EGS.533	Paleobotany		3	0	0	3
EGS.535	Environmental Geology		3	0	0	3
EGS.536	Astro and Geobiology		3	0	0	3
EVS.558[†]	Natural hazards and disaster management		3	0	0	3
GEO.507[†]	Climatology		3	0	0	3
Value Added Course (VAC)						
EGS.502	Geological Mapping	VAC	2	0	0	2
		Total	**20**	**0**	**4**	**22**

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

L	T	P	Credits
3	0	0	3

Total Hours: 45

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 11**

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

Unit II **Hours 10**

Geochemical classification of elements. 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. Chemical weathering of minerals and rocks. Take home exercise, peer learning and plotting of Eh-pH diagram for stability of different species/complex of elements.

Unit III **Hours 12**

Isotope Geology: Introduction and physics of the nucleus; radioactive decay; the law of radioactive decay; principles of mass spectrometry; K-Ar method: principles, methods and applications; Ar-Ar method: principles, method and advantages: Rb-Sr method: principles, Rb-Sr isochron and limitations. Sm-Nd Method: decay scheme, evolution of Nd with time, Nd model ages and application of Nd to petrogenesis; U-Th-Pb Method: decay schemes, U-Pb isochron, U-Pb mineral dating and application. Hands on exercise during class and take home exercise, assignment, student seminar.

Unit IV **Hours12**

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. Assignment, student seminar and group discussion.

Transactional Modes: Lecture, 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. Jochen Hoefs, 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. Mc Sween 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.

Web Resources:
https://www.uvm.edu › GEOL 195 - Geochemistry
http://www.geo.cornell.edu/geology/classes/Geo656/656notes03.html
https://wwwrcamnl.wr.usgs.gov/isoig/isopubs/itchch2.html
https://www.southalabama.edu/geology/haywick/GY112/ppt/112-pp8a.pdf
https://ocw.mit.edu/courses/earth-atmospheric-and-planetary-sciences/12-742-marine-chemistry-fall-2006/lecture-notes/lecture_2_notes.pdf

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

L	T	P	Credits
3	0	0	3

Total Hours-45

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 12**

Magma: nature and evolution; Magmatic processes: Partial melting, fractional

crystallization, assimilation, liquid immiscibility factors affecting magma and evolution, melting of mantle. 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.
Assignment, Take home exercise, mini projects.

Unit II **Hours 11**

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. Group discussion and take home exercise.

Unit III **Hours11**

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 .
Assignment, take home exercise and student presentation.

Unit IV **Hours11**

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. Student seminar, assignment and mini projects.

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.

Web Resources:

https://www.southalabama.edu/geography/allison/gy303/GY303Lectures.html
http://www1.mans.edu.eg/FacSciM/english/courses/geology/Dr_Mahrous/Abu%20El-Enen%20Metamorphic%20Petrology%20Course/Metamorphic%20Petrology%20-%20Lecture%20I.ppt
http://academic.sun.ac.za/natural/geology/undergraduate/modules/G214_course_notes_e.htm
https://serc.carleton.edu/resources/22102.html
http://eps.mcgill.ca/~courses/c212/Igneous14/IgPetClass/IntoPet212-14.pptx
http://www.geosciences.fau.edu/Resources/CourseWebPages/Spring2012/GLY4310_S12/index.4310_S10.htm
https://ocw.mak.ac.ug/courses/earth-atmospheric-and-planetary-sciences/12-479-trace-element-geochemistry-spring-2013/lecture-notes/
http://www.tulane.edu/~sanelson/eens212/

Course Code: EGS.529
Course Title: Principles of Geospatial technology

L	T	P	Credits
3	0	0	3

Total hours: 45

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

- Identify geospatial tools- remote sensing, GIS and GPS
- Develop utilization of satellite data in various applications such as geology, hydrogeology, climatology, 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: Fundamental Concepts of Remote Sensing Hours12

History of Remote Sensing, Spectrum, Spectral Quantities, Theories of EMR; Theory of EMR: Laws of Radiation; Concept of Blackbody radiation; Electromagnetic Spectrum; Scattering, Absorption, Refraction, Path Radiance Reflection, Transmission, Absorption; Energy-Earth Interaction, Atmospheric Windows, Spectral Signatures of Surface Features; RS Satellites- Polar sun-synchronous, geo-stationary; Platforms: Types and their orbital characteristics; Sensors types: active and passive; Sensors systems: whiskbroom and push broom; Principles and geometry of scanners and CCD arrays; Satellite RS data products or series: Optical, Microwave and Hyperspectral. Assignment, Take home exercise, peer learning on atmospheric interaction.

Unit II Image Processing and Interpretation Hours11

Image: Meaning and Types (Analogue and Digital) and Characteristics; Resolution: Spatial, Spectral, Radiometric and Temporal; Basics of Image Processing; Elements of Image Interpretation; Visual Interpretation; Ground Truth Collection; Hyperspectral remote sensing; SAR and UAV. Assignment on visual interpretation on various aerial photographs and satellite images.

Unit III Fundamental concept of GIS and GNSS Hours11

Concept and definition of GIS, History and development of GIS technology, Applications of GIS in various sectors; Geographic information database management system: data types (map, attributes, image data) and structure; Spatial and non-spatial data; Projection and Geo-referencing; Spatial analysis: overlay, buffer and proximity, network analysis; Introduction to GNSS; Concepts and type. Digitization of various features from base maps/satellite data using GIS based software.

Unit IV Applications of Geospatial Technology Hours11

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 applications in geoscience. Assignment on digital image processing using Erdas Imagine software.

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. Singh, C. K. (2018). *Geospatial Applications for Natural Resources Management,* CRC Press.
2. Shellito, B. (2017). *Geospatial Technologies*, 4th edition, W. H. Freeman Publisher.
3. Shamsi, U. M. (2012). *GIS applications for Water, Wastewater, and Stormwater systems,* CRC Press.
4. Bhatt, B. (2011). *Remote Sensing and GIS,* New Delhi: Oxford university press.
5. Skidmore, A. (2010). *Environmental Modelling with GIS and Remote Sensing*, New Delhi, Crc Press.
6. Abbasi, T. (2010). *Remote Sensing, GIS and Wetland management*, Discovery publishing house.
7. Lillisand, T. M., Keifer, R. W. (2007). *Remote Sensing and Image Interpretation,* USA: John Willey and Sons.
8. Joseph, G. (2003). *Fundamentals of Remote Sensing,* Hyderabad: Universities Press.
9. Chang, K. (2002). *Introduction to Geographic Information Systems,* USA: Tata McGraw-Hill.
10. Barrett, E. C. and Curtis, L. F. (1999). *Introduction to Environmental Remote Sensing,* USA: Chapman and Hall Publishers.
11. Curran, P. J. (1988). *Principles of Remote Sensing,* ELBS: Harlow Longman Scientific and Technical.

Web Resources:

https://bhuvan.nrsc.gov.in/bhuvan_links.php
https://landsat.gsfc.nasa.gov/data
https://www.esri.com/en-us/home

Course Code: EGS.530
Course Title: Geological Time and Stratigraphy

L	T	P	Credits
3	0	0	3

Total hours: 45

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 base level 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: **Hours10**

Principle of Stratigraphy: Geological time scale and History, 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. Discussion and practical exercises on the preparation of lithologs and their correlations.

Unit II **Hours13**

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

formations, assignment.

Unit III **Hours12**

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.

Gondwana 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. Assignment, student presentation and brainstorming sessions.

Unit IV **Hours10**

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. Take home exercise and brainstorming sessions, student seminar and group discussion.

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. Ravindra Kumar, 2018.*Fundamentals of historical geology and stratigraphy of India*, New Age, ISBN-13 : 978-0852267455
2. Sam Boggs, Jr., 2016.*Principles of sedimentology & stratigraphy*, Prentice Hall.
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. Pascoe, E.H., 1968.*A Manual of the Geology of India & Burma (Volume I – IV)*, Govt. of India Press, Delhi
9. Pomerol, C., 1982.*The Cenozoic Era? Tertiary and Quaternary*, Ellis Harwood Ltd., Halsted Press.
10. Schoch, R.M., 1989.*Stratigraphy: Principles and Methods*, Van Nostrand Reinhold, New York.
11. Doyle, P. and Bennett. M.R., 1996.*Unlocking the Stratigraphic Record*, John Willey.

Web Resources:
http://www.sepmstrata.org/page.aspx?pageid=15
https://www.gsi.gov.in/webcenter/portal/OCBIS/pageQuickLinks/pageEducationalVideos?_afrLoop=21139666199665056&_adf.ctrlstate=1brfb70tng_1#!%40%40%3F_afrLoop%3D21139666199665056%26_adf.ctrl-state%3D1brfb70tng_5

Course Code: EGS.531
Course Title: Petrology and Geospatial technology (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 and 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.
- Design various experiments for familiarization with satellite images, mapping and layout.
- Apply remote sensing and GIS software for image interpretation
- Develop the analytical skills for pre-processing, image classification and post-processing

Course Contents

Unit I **Hours 30**

Following exercise will be conducted in the lab.

- Megascopic and microscopic study of different igneous rocks.

- Calculation of CIPW Norms.
- Preparation of classificatory and variation diagrams and their interpretation.
- 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.

Unit II **Hours 30**

- **Satellite data mining:** downloading and familiarization of satellite imagery, reading metadata and basic characteristics of images.
- **Preprocessing:** geometric and radiometric correction, FCC generation, mosaicking, subletting and atmospheric correction
- **Image classification and interpretation:** visual interpretation, digital image processing (supervised, unsupervised and hybrid classification)
- **Post processing and accuracy assessment:** mixed pixel correction, error matrix, user accuracy, producer accuracy, overall accuracy, kappa indices.
- **GIS database mining:** point, polygon and line features capture, editing and manipulation, topology building, joining attribute table with spatial data.
- **Vector analysis**: proximity and overlay analysis, network analysis, geostatistical analysis.
- **Mapping and layout**: map template design, map layout design based on scale, export and publishing.
- **GPS mapping:** GCP collection, tracking and mapping.

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.
9. Kennedy, M. (2013). *Introducing geographic information systems with ArcGIS: A workbook approach to learning GIS,* Wiley & Sons Publications.
10. Chatwal, G. R., Anand, S. K. (2013). *Instrumental Methods of Chemical Analysis,* New Delhi: Himalaya Publishing House.
11. American Public Health Association (APHA) (2012). *Standard method for examination of water and wastewater*, 22nd edn. APHA, Washington.
12. Kennedy, M. (2010). *The Global positioning system and ArcGIS*. Crc Press.
13. Yadav, M. S. (2008). *Instrumental methods of chemical analysis*, New Delhi: Campus Books International.
14. Skoag, D. A., Holler, F. J., Crouch, S. R. (2007). *Principles of Instrumental Analysis,* CENGAGE Learning.
15. Rajvaidya, N., Markandey, D. (2005). *Environmental Analysis and Instrumentation*, APH Publisher.

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

https://www.southalabama.edu/geography/allison/gy303/GY303Lectures.html
http://academic.sun.ac.za/natural/geology/undergraduate/modules/G214_course_notes_e.htm
https://serc.carleton.edu/resources/22102.html
http://eps.mcgill.ca/~courses/c212/Igneous14/IgPetClass/IntoPet212-14.pptx
https://ocw.mak.ac.ug/courses/earth-atmospheric-and-planetary-sciences/12-479-trace-element-geochemistry-spring-2013/lecture-notes/
http://www.tulane.edu/~sanelson/eens212/
https://bhuvan.nrsc.gov.in/bhuvan_links.php
https://landsat.gsfc.nasa.gov/data
https://www.esri.com/en-us/home

Discipline Elective: Select any Two

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

L	T	P	Credits
3	0	0	3

Total hours: 45

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 10**

Distribution of mineral resources in India; Classification, rank and grading of coal; coal resources of India; Gas hydrates and coal bed methane. Introduction to mineral exploration, stages of exploration, type of explorations. Assignment, Take home exercise, peer learning.

Unit II **Hours12**

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. Assignment, take home exercise, group discussion.

Unit III **Hours12**

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. Case study by different group followed by discussion and assignment.

Unit-IV **Hours11**

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. Student seminar and brainstorming.

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.

Web Resources:

https://pubs.usgs.gov/of/1995/ofr-95-0831/CHAP3.pdf
https://www.osti.gov/servlets/purl/895050
http://faculty.washington.edu/dersh/Files/Geophysics2006.pdf
https://eclass.uoa.gr/modules/document/file.php/GEOL312/Geophysical%20methods/Forte_L1_Introduction%20to%20geophysical%20methods.pdf
https://www.gsi.ie/en-ie/programmes-and-projects/minerals/activities/mineral-exploration/Pages/Geophysical-Methods.aspx#:~:text=Seismic%20surveys% 20are%20an%20extremely, exploration%20being%20one% 20of%20them.

Course Code: EGS. 532
Course Title: Oceanography

L	T	P	Credits
3	0	0	3

Total hours: 45

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

- Explain and discuss oceanographic phenomena for both laymen and experts
- Determine the history and development of oceanography including marine biogeochemistry
- Formulate, process and implement strategies for data and theoretical analysis.

Course Contents

Unit I: **Hours 11**

Origin, evolution of ocean basins and their environmental response; Topographic features of the ocean floor; continental margin provinces, ocean basin provinces; coral reefs. Classification of marine sediments, sediment budget, transport and its accumulation in the ocean; sedimentation processes on continental shelves - physical processes, sediment response; deep-sea sediments. Assignment, Take home exercise, peer learning on oceanic topography.

Unit II **Hours 12**

Wave dynamics, deep water waves, shallow water waves; Ocean circulation: forces driving currents; surface currents, effects of surface currents on climate; thermohaline circulation - thermohaline circulation patterns, global heat connection and atmospheric Circulation. Wind induced vertical circulation - equatorial upwelling, coastal upwelling, downwelling; Coastal upwelling - its physical, chemical, biological characteristics, Tides - equilibrium theory of tides, dynamical theory of tides, tidal currents in coastal areas, observation and prediction of tides. Exercise on mechanics of atmospheric and oceanic circulation.

Unit III: **Hours 11**

Seawater chemistry: salinity - components, sources and processes controlling the composition of sea water; dissolved gases - Nitrogen, Oxygen, Carbon dioxide; Density structure of ocean; inputs of organic carbon, concept of food chain; primary production, measuring productivity, factors limiting productivity, Role of light, temperature, nutrients, physiological adaptations; Marine resources: Petroleum and Natural Gas, sand and gravel, magnesium and magnesium compounds, salts, manganese and phosphate nodules, metallic sulfides and muds. Group discussion on marine resources and exploration.

Unit IV **Hours 11**

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. Introduction to Marine exploration methods, petroleum potential of sea-

bed provinces beyond the continental slope; 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. Assignment on bathymetry, structure and EEZ of Indian ocean.

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. Kale, V. S. and Gupta, A., 2001.*Introduction to geomorphology*, Orient Longman, Bangalore.
5. Singh, S., 2011.*Physical geography*, Prayag Pustak Bhavan, Allahabad.
6. Strahler, A.N. and Strahler, 1996.*An introduction to physical geography*, John Wiley & Sons, UK.
7. S. Davis, R.A. Jr. 1972.*Principles of Oceanography*, Addison - Wesley Publishing Company.
8. Roonwal, G.S., 1986. *The Indian Ocean: Exploitable mineral and petroleum Resources*, Narosa Publishing House.
9. Francis P. Shepard, 1977. Geological Oceanography: Evolution of coasts, continental margins & the deep-sea floor, Pan Publication.
10. Bhatt J.J., 1978. *Oceanography – Exploring the planet Ocean*, D. van Nostrand Company.

Web Resources:

https://www.nationalgeographic.org/
https://www.nio.org/
https://science.nasa.gov/earth-science/focus-areas/oceanography

Course Code: EGS.533
Course Title: Palaeobotany

L	T	P	Credits
3	0	0	3

Total hours: 45

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

- understand the development of palaeobotany
- adapt modern field technique to apply palynology to understand the

palaeobotany and understand the paleoclimate

- Formulate, process and implement strategies for data and theoretical analysis.

Course Contents

Unit I: Hours10

Introduction to Paleobotany**:** Formation of Plant Fossils; Modes of preservation of fossils and taphonomic considerations; Types of microfossils. Theories on origin of life; the prebiotic environments; antiquity of life; first prokaryotes and evolution of eukaryotes; geological records and ecological significance of algae (stromatolites, diatoms, dinoflagellates), fungi (endomycorrhiza, epiphyllous fungi), bryophytes and early ferns (Palaeozoic). Student seminar and brainstorming session.

Unit II Hours11

Environmental changes before terrestrialization, fossil evidences for land adaptation, evolution of land plants- evidences, earliest trees in the fossil record. Preovules, hydrasperman reproduction; evolution of closed carpel- evidences from the ovulate fructifications of Glossopteridales, Corystospermales, Caytoniales, Bennettitales and Pentoxylales. Enigma of angiosperm origin- fossil leaves, flowers and pollen grains as evidences; nature and distribution of earliest angiosperms; reasons for late arrival; first grasses. Assignment, seminar and group discussion.

Unit III: Hours11

Introduction to palynology- Branches of palynology; Spore, pre-pollen and pollen morphology; Sample collection, Sample processing, Lab procedures and hands on exercise to separate the pollen from sediments; Evolution of aperture types; Palaeopalynology of Bengal Basin peat and Indian lower Gondwana coal; Non-pollen palynomorphs. Assignment, take home exercise, peer learning.

Unit IV Hours13

Fundamentals of palaeofloristics, palaeogeography, palaeoecology, paleoceanography and palaeoclimatology; Ancient DNA and other fossil biomolecules, stable isotopes, tree ring, speleothem and their potential in evolutionary and palaeoclimatological research, Fossil fuels-origin and depositional environment, role of microfossils in oil exploration, phytoliths in reconstruction of palaeovegetation and palaeoclimate. Use of microfossils in interpretation of sea floor tectonisim. Important plant fossils and microfossils in Indian stratigraphy. Assignment, Take home exercise, peer learning, seminar and group discussion.

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

Suggested readings:

1. Prothero D. R. 2013. Bringing Fossil to Life – An Introduction to Paleontology"

Columbia University Press. 3rd edition.
2. Bhattacharyya, K., M. R. Majumdar, S. G. Bhattacharyya. 2011. A Textbook of Palynology. New Central Book Agency (P) Ltd
3. Taylor, T.N., E.L. Taylor and M. Krings. 2009. Palaeobotany- The Biology and Evolution of Fossil Plants. Elsevier.
4. Alfred Traverse, 2008. Paleopalynology. Springer, 3rd Edition.
5. Willis, K.J., and J.C. McElwain. 2002. The Evolution of Plants. Oxford University Press, New York.
6. Jones, T.P. and Rowe, N.P. 1999. Fossil Plants and Spores: modern techniques. The Geological Society, London.
7. Cleal, C.J. and Thomas, B.A. 1999. Plant Fossils. The History of Land Vegetation. Woodbridge, Boydell Press, Woodbridge, VA. 128p.
8. Stewart, W.N. and Rothwell, G.W. 1993. Paleobotany and the Evolution of Plants. Cambridge University Press; 2nd edition
9. Agashe, S.N. and Andrews, H.N. 1997. Paleobotony: Plants of the Past, Their Evolution, Paleoenvironment and Application in Exploration of Fossil Fuels.Science Publishers, U.S.

Web Resources:
https://sites.google.com/site/paleoplant/home
http://lifeofplant.blogspot.com/2011/03/paleobotany.html
http://www1.biologie.uni-hamburg.de/b-online/kerp/links.html
http://www.equisetites.de/palbot/teach/palbotteach.html
https://www.floridamuseum.ufl.edu/paleobotany/resources/links/

Course Code: EGS.535
Course Title: Environmental Geology

L	T	P	Credits
3	0	0	3

Total Hours: 45

Learning Outcomes: Upon successful completion of this course, the student will be able to:
- Discuss the role of geologic processes in assessment of environment
- 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.

Course Contents

UNIT I **Hours 10**

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. Take home exercise and brain storming session on importance of environmental geology.

UNIT II **Hours 12**

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. Assignment and group discussion on environmental pollution.

UNIT III **Hours 12**

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. Preparation of assessment reports, assignments and brain storming session on types of disasters and its management.

UNIT IV **Hours 11**

Risk Assessment and Preparedness for Natural Hazards; Hazard zonation maps; Recent Environmental Issue and possible solutions: Global warming, Sea level rise, Acid rain, Ozone layer depletion. Acid Mine drainage (AMD), Groundwater contamination, Water stress and water scarcity, River interlinking conflict in India, Soil Erosion, Deforestation. Assignment and brain storming session on disaster risk management.

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.

Web Resources:

https://ndma.gov.in/
https://www.iwapublishing.com/news/disaster-management
https://nidm.gov.in/
https://www.who.int/

Course Code: EGS. 536
Course Title: Astro and Geobiology

L	T	P	Credits
3	0	0	3

Total hours: 45

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

- Evaluate the deep connection of life to the cosmos.
- Discuss the mode of formation and evolution of Earth and its key physical, chemical and biological processes for understanding the origin and evolution of life.
- Justify how life survives in extreme environments and the search for extraterrestrial life in our solar system and elsewhere by certain agencies.
- Discuss the chemical physical process involving the origin and evolution of life and its link with the extraterrestrial processes.

Course Content

Unit I **Hours 10**

Stellar evolution and the origin of the chemical elements; ejection into the interstellar medium; timescales for creation and dispersal of carbon and other key elements; interstellar clouds and astrobiologically relevant interstellar chemistry. Exercises and brainstorming session and group discussion.

Unit II **Hours 10**

Concept of habitable zones. Key biological molecules (amino acids, proteins, nucleic acids, etc); classification of life (kingdoms; domains); basic structure of prokaryotic and eukaryotic cells; genetic code. Pre-biological chemical evolution and the origin of

life: Urey-Miller-type experiments; importance of oxidation state of early Earth for organic molecule yields; probable importance of RNA; the RNA world and alternatives; panspermia. Student seminar and group discussion.

Unit III **Hours 12**

Epoch of heavy bombardment and the `impact frustration' of the origin of life Geobiology/geomicrobiology and its applications, Theories on origin of life. Life in extremes Hardy bacteria, chemo-lithotrophs, hydrothermal vents. Life before oxygen, Concept of biomineralization, characteristics of biominerals, biologically induced and biologically controlled biomineralisation processes. Assignments and take home exercise.

Unit IV **Hours 13**

Stromalotites; micro-fossils; and stable isotope ratios as evidence for the early appearance of life on Earth; discussion of astrobiological implications. Summary of major evolutionary innovations since early appearance of life; evolution of eukaryotic cells - evidence for endosymbiosis; Cambrian explosion; essential time frame for major evolutionary innovations; astrobiological implications. The search for life Mars and Europa, Past and future missions. Student Seminar and group discussion.

Transactional Modes: Lecture, Project Method, Inquiry training, Seminar, Group discussion, Blended learning, Flipped learning, Focused group discussion, Team teaching, Brain storming, Mobile teaching, Collaborative learning, Case based study.

Suggested readings:

1. Andrew May, 2019. Astrobiology: The Search for Life Elsewhere in the Universe. Icon Books Ltd. Planetary Astrobiology (Space Science Series)
2. David C. Catling, 2014. Astrobiology: A Very Short Introduction. Oxford University Press. ISBN-13: 978-0199586455.
3. Donald R. Prothero, 2013. *Bringing Fossils to Life: An Introduction to Palaeobiology*, McGraw-Hill Higher Education, 3rd edition.
4. Jack J. Lisauer & Imke de Pater, 2013. Fundamental Planetary Science: Physics, Chemistry and Habitability. Cambridge University Press. ISBN-13: 978-0521618557.
5. Woodruff Sullivan & John Baross. 2007. Planets & Life'.Cambridge University Press. IISBN 978-0-521-82421-7.
6. J. Bennett & S. Shostak.2011. Life in the Universe. Pearson Education Inc. ISBN-13: 978-0321687678. 3d edition.
7. Kevin W. Plaxco & Michael Gross 2011. Astrobiology. The Johns Hopkins University Press. ISBN-13: 978- 1421400969.2nd edition.
8. Caleb A. Scharf. 2008. "Extrasolar Planets and Astrobiology". University Science Books. ISBN-10 1891389556 / ISBN-13 978-1891389559.
9. J. Seckbach, J. ChelaFlores, T. Owen & F. Raulin. 2004. "Life in the Universe: From the Miller Experiment to the Search for Life on other Worlds". Kluwer Academic

Publishers. ISBN 1-4020-3093-2.
10. Horst Rauchfuss 2008. Chemical Evolution and the Origin of Life. Springer Verlag. ISBN 978- 3-540-78822-5 hardcover.
11. Hornbeck G. & Baumstark-Khan C. 2001. Astrobiology: The Quest for the Conditions of Life. Springer-Verlag. ISBN 3- 540-42101-7

Web Resources:

https://distantearths.com/best-astrobiology-exoplanet-books/
https://astrobiology.nasa.gov/careers-employment-courses/
http://www.astrobio.net/
http://www.astrobiology.com/
http://www.newscientist.com/section/space

Value Added Course

Course Code: EGS.502
Course Title: Geological Mapping

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

- Aware the different field accessories in geosciences.
- Measure the equipment's confidently at field.
- Evaluate the processes and practices of geological mapping.
- Assess the processes of sampling techniques.

Course Contents

Unit I **Hours 7**

Field Geology: Introduction to toposheets, Scale definition; small scale and large-scale maps; reading various components of a toposheet. Geological map-definition, various components of a geological map including scale, legend, structures etc. Studies of outcrop pattern, topographic law and rules of 'V'. Take home exercise aassignment and group discussion.

Unit II **Hours 7**

Instruments used in geological field studies; techniques and use of geological tools during field work-use of clinometer compass, Brunton compass, GPS, altimeter. Attitude measurements; measurement of true thickness and distance, section measurement techniques and significance. Hands on exercise on the application of geological tools and section measurement and group discussion.

Unit III **Hours 8**

Geological mapping procedures: Geological mapping of igneous terrains, geological mapping of sedimentary terrains. Geological mapping of metamorphic terrains and recording of structural information, preparation of Geological Cross-section. Hands on exercise on the geological mapping and cross-section preparations, assignments and group discussion.

Unit IV **Hours 8**

Techniques for sample collection: Sampling and oriented sampling, its significance; sampling for isotopic, geochronological and geochemical studies and its significance. Sampling strategies for micro-palaeontological and biostratigraphic studies and recording of palaeontological information. Hand on exercise on the sampling processes for certain geological analysis, assignments and group discussion.

Transactional Modes: Lecture, practical Demonstration, Video demostrations, Lecture cum demonstration, ICT methods, web resource, Brain storming session.

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.

Web Resource:

https://surveyofindia.gov.in/
https://www.usgs.gov/core-science-systems/national-cooperative-geologic-mapping-program
https://www.usgs.gov/products/maps/geologic-maps
http://www.geosci.usyd.edu.au/users/prey/FieldTrips/BrokenHillOlary/Mapping.html
https://www.gsi.ie/en-ie/programmes-and projects/minerals/activities/mineral-exploration/Pages/Geological-Mapping.aspx

Semester III

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
EGS.556	Solid Earth Geophysics	*Core*	3	0	0	3
EGS.572	Ore Geology	*Core*	3	0	0	3
EGS.555	Research Methodology	Compulsory Foundation	3	0	0	3
EGS.557	Analytical Techniques and Geo-statistics	Compulsory Foundation	3	0	0	3
EGS.575	Comprehensive Geoscience	*DEC*	0	2	0	2
EGS.526	Field Training	Skill Based	0	0	4	2
EGS.558	Entrepreneurship	Skill Based	1	0	0	1
EGS.600	Research Proposal	Skill Based	0	0	8	4
		Total	**13**	**2**	**12**	**21**

Course Code: EGS.556
Course Title: Solid Earth Geophysics

L	T	P	Credits
3	0	0	3

Total hours: 45

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

- 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.
- Develop the ability to perform geophysical data analysis, interpretation and to use seismological data for understanding the earth sub surface.

Course Contents

Unit I **Hours11**

Introduction to geophysics; shape and size of earth; gravitational field of the earth; variation of gravity on the earth surface; principles of gravity methods and instrument used; gravity field surveys; corrections applied to gravity data; The Bouguer anomaly; regional and residual anomalies; gravity anomaly maps and their interpretation. Relative motion of plates, Stability of triple junction. Assignment, take home exercise, group discussion

Unit II **Hours11**

Geomagnetic field of the earth; magnetic properties of rocks; principles of magnetic methods; Variation of gravitational and magnetic fields over earth's surface, Densities and magnetic susceptibilities of rocks and minerals. Instruments of magnetic surveying; Field procedure in conducting gravity and magnetic surveys and data reductions; aeromagnetic surveys; profiling and sounding. Problem solving after each methods, take home exercise.

Unit III **Hours12**

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. Conventional and modern (CDP) methods of acquisition of seismic reflection data. Applications of Seismic methods to oil exploration, groundwater exploration and engineering problems. Assignment, take home exercise, lab based exercise.

Unit IV **Hours11**

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.

Brief outline of various well logging techniques: self-potential and resistivity logs, radioactive logs, induction logs, caliper logs, sonic logs, borehole video; well logging applications in petroleum, groundwater and mineral exploration. Assignment, take student seminar and mini project.

Transactional Modes: Lecture, Lecture cum demonstration, Project Method, Seminar, Group discussion, Team teaching, Brain storming, Mobile teaching, Collaborative learning, Case analysis, Case study, Case based study, Through SOLE (Self Organized Learning Environment).

Suggested readings:

1. Lowrie, W., 1997. *Fundamental of Geophysics*, Cambridge Univ. Press. London.
2. Fowler, 2005.*The Solid Earth: An Introduction to Global Geophysics*, Cambridge University Press.
3. Telford, W.M., Geldart, L.P. and Sheriff, R.E., 1990.Applied Geophysics, Cambridge University Press.
4. Peter Shearer, 1999.*Introduction to Seismology*, Cambridge University Press, Cambridge.
5. Alan E. Mussett, M. Aftab Khan, 2000.*Looking in to the Earth: An Introduction to Geological Geophysics*, Cambridge University Press.

6. Lillie, R.J., 1998. Whole Earth Geophysics: An Introductory Book for Geologists and Geophysicists, Pearson Education.
7. Parasnis, D. S., 1986. Principles of Applied Geophysics, Chapman and Hall.
8. Dobrin, M.B. and Savit, C.H., 2014. Introduction to Geophysical Prospecting, Mcgrawhill Exclusive.
9. Gadallah, Mamdouh R. and Fischer, R.L., 2009. Exploration Geophysics, Springer-Verlag Berlin Heidelberg.
10. Albert Tarantola, 2005. Inverse Problem Theory and Model Parameter Estimation. SIAM
11. Thorne Lay and Terry Wallace, 1995. Modern Global Seismology, Academic Press.

Web Resources:
https://www.ucl.ac.uk/EarthSci/people/lidunka/GEOL2014/Revised%20Course/OVERVIEW.htm
https://www.bu.edu/pasi/files/2011/01/MarcSpiegelman1-06-1330.pdf
https://www.irsm.cas.cz/ext/ethiopia/resources/lecture_notes.pdf
http://www-gpsg.mit.edu/12.201_12.501/
https://ocw.mit.edu/courses/earth-atmospheric-and-planetary-sciences/12-201-essentials-of-geophysics-fall-2004/lecture-notes/

Course Code: EGS.572
Course title: Ore Geology

L	T	P	Credits
3	0	0	3

Total hours: 45

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 11**

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. Assignment, take home exercise, seminar

Unit II **Hours 12**

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. Hands on exercise and group discussion.

Unit III **Hours 12**

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. Student seminar, assignment and take home exercise.

Unit IV **Hours 10**

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. Assignment, take home exercise, seminar

Transactional Modes: Lecture, 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.

Web Resources:

https://www.southalabama.edu/geology/haywick/GY111/111-8.pdf
http://earthsci.org/mineral/mindep/class_dep/class_dep.html
https://pubs.usgs.gov/bul/0225/report.pdf
https://www.mlsu.ac.in/econtents/1911_Mineral%20Deposits%20in%20India.pdf
https://gsi.gov.in/webcenter/portal/OCBIS/pagePublications/pageViewGSIPublication?_adf.ctrl-state=w5w97un87_5&_afrLoop=21339913384895836#!

Course Code: EGS. 555
Course Title: Research Methodology

L	T	P	Credits
3	0	0	3

Total hours: 45

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 11**

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. Assignment, take home exercise on identifying research gap from different selected topic, discussion.

Unit II **Hours 11**

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. Assignments and exercise on developing bibliography, referencing.

Unit III **Hours 12**

Pre-field preparations, Field mapping and documentation, Procedure of sampling, Introduction to field mapping and section measurement, Recent advancement on analytical techniques, field gears, data sciences and AI in the field of Earth Sciences. Assignment, take home exercise and student seminar.

Unit IV **Hours 11**

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. Assignment, take home exercise and student seminar.

Transactional Modes: Lecture, Lecture cum demonstration, Project Method, Seminar, Group discussion, Co-operative learning, Blended learning, Flipped learning, Team teaching, Brain storming, Mobile teaching, Collaborative learning, Self-learning, 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. Blaxter, L.; Hughes, C. and Tight, M. (1996): How to Research. Open University Press, Buckingham.
4. Paltridge, B., Starfield, S. (2019). *Thesis and Dissertation Writing In a Second Language,* Routledge Publisher.
5. Hofmann, A. H. (2019). *Scientific Writing and Communication: Papers, Proposals, and Presentations,* Oxford Univ Pr; 4th edition, USA.
6. Kothari, C. R., Garg, G. (2019). *Research Methodology: Methods And Techniques,* New Age International Publishers; Fourth edition, India.
7. Prathapan, K. (2019). *Research Methodology for Scientific Research*,

Dreamtech Press, India
8. Kothari, C. R. (2008). *Research methodology(s)*. New Age International, New Delhi.
9. Lester, James, D. and Lester Jr. J. D., 2007. *Principles of Writing Research Papers*, Longman, New York.
10. Potts, P. J., 1997. *Silicate rock analysis*
11. Reed, S. J. B., 1990. *Recent developments in geochemical microanalysis: Chemical Geology*, Volume.83, PP. 1-9.
12. Frank A. Settle, 1997. *Handbook of Instrumental Techniques for Analytical Chemistry*, Prentice Hall, Upper Saddle River, NJ.

Web Resources:

https://prog.lmu.edu.ng/colleges_CMS/document/books/EIE%20510%20LECTURE%20NOTES%20first.pdf
https://iare.ac.in/sites/default/files/MTECH-CAD.CAM-R18-RM-IP-NOTES.pdf
http://14.139.185.6/website/SDE/sde578.pdf
https://www.modares.ac.ir/uploads/Agr.Oth.Lib.17.pdf
https://fac.ksu.edu.sa/sites/default/files/introduction-to-research-and-research-methods.pdf

Course Code: EGS. 557
Course Title: Analytical techniques and geostatistics

L	T	P	Credits
3	0	0	3

Total hours: 45

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

- Explain principle, instrumentation and application of instruments
- Distinguish steps and working principle of electrochemical, and spectrometric
- Describe the types, principle and applications of chromatographic techniques
- solve quantitative problems of geosciences

Course Contents

Unit I **Hours 11**

Electrochemical methods: pH meter, Conductivity meter, TDS meter, DO meter, Salinity meter used in field/in-situ. Voltammetry method-Anode stripping voltammetry.

Spectrometric Methods for elemental analysis: U.V. spectrophotometer, Flame photometry, Atomic absorption spectrophotometry (AAS), Microwave-plasma Atomic Emission Spectroscopy (MP-AES); Inductive Coupled Plasma-Atomic

Emission Spectroscopy (ICP-AES) and optical emission Spectroscopy (ICP-OES). Hands on exercise, assignment and student seminar.

Unit II **Hours 12**

Introduction to working principles, concepts, sample preparation, applications and limitations of X-ray Diffractions (XRD), Scanning Electron Microscope (SEM), X-ray fluorescence (XRF), Energy-dispersive X-ray spectroscopy (EDS, EDX, or XEDS), Electron Probe Micro Analyzer (EPMA), Proton Induced X-ray Emission (PIXE). Assignment, take home exercise and student seminar.

Unit III **Hours 11**

Principle and applications of Chromatography techniques; Inductive Coupled Plasma Mass Spectroscopy (ICP-MS): Quadruple and magnetic sector; Multi collector Mass spectrometer like TIMS, MC-ICP-MS, LA-MC-ICP-MS; Optical simulation Luminescence (OSL) dating techniques; Accelerator mass spectrometer; other supporting analytical methods like: Thermo gravimetric Analysis (TGA, DTA), Total Organic Carbon analyzer, Particle size analyzer, Magnetic separator. Assignment, take home exercise, seminar

Unit IV **Hours 11**

Application of different statistical tool to interpret the geological data such as sampling, descriptive statistics, central tendency of data, probability function, hypothesis testing, Anova, 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, segmenting sequences, splines and semi variograms. Introduction to Mathematical modelling. Assignment, take home exercise and student seminar

Transactional Modes: Lecture, 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. Potts, P. J., 1997. *Silicate rock analysis*

a. Reed, S. J. B., 1990. *Recent developments in geochemical microanalysis: Chemical Geology*, Volume.83, PP. 1-9.

b. Frank A. Settle, 1997. *Handbook of Instrumental Techniques for Analytical Chemistry*, Prentice Hall, Upper Saddle River, NJ.

4. Hussain, C. H., Kecili, R (2020). *Modern Environmental Analysis Techniques for Pollutants*, Elsevier Book, ISBN: 9780128169346.
5. Ahluwalia V. K. (2015). *Instrument Methods of chemical analysis,*Ane Books Pvt. Ltd.
6. Holler F. J., Crouch, S. R. (2014). *Skoog& West's Fundamental of Analytical Chemistry,* 9th edition, CENGAGE learning.
7. Chatwal, G. R., Anand, S. K. (2013). *Instrumental Methods of Chemical Analysis,* Himalaya Publishing House, New Delhi
8. Patnaik, P. (2010). *Handbook of environmental analysis,* CRC Press, USA
9. Rouessac, F., Roussac, A. (2008). *Chemical analysis: modern instrumentation and techniques*, Wiley, England.
10. Skoag, D. A., Holler, F. J., Crouch, S. R. (2007). *Principles of Instrumental Analysis,* CENGAGE Learning.
11. Skoog D. A., Holler, F. L., Crouch, S. R. (2007). *Principles of instrumental analysis,* USA: Thomson Brooks/Cole Publishers.
12. Rajvaidya, N., Markandey, D. (2005). *Environmental Analysis and Instrumentation*, APH Publisher.
13. Eaton, A. D., Clesceri, L. S., Rice, E. W., Greenberg, A. E. (2005). *Standard methods for examination of water and wastewater,* 21st Edition.American Public Health Association, American Water Worker Association, Water Environment Federation, USA.
14. Wiersma, G. (2004). *Environmental monitoring,* CRC Press, UK.
15. Svehla, G. (1996). *Vogel's qualitative inorganic analysis, 7th Edition,* Prentice Hall, USA
16. Shukla, S. K., Srivastava, P. R. (1992). *Methodology for environmental monitoring and assessment,* New Delhi: Commonwealth Publishers.
17. Ewing, G. W. (1985). *Instrumental methods of chemical analysis, 5th edition,* USA: McGraw Hill Publications
18. Harris, D. C. (1948). *Exploring Chemical Analysis,* 3rd edition. W. H Freeman & Company.

Web Resources:

https://pubs.acs.org/doi/10.1021/acsnano.9b05157
https://serc.carleton.edu/research_education/geochemsheets/techniques/XRF.html
http://www.ecs.umass.edu/eve/facilities/equipment/ICPMS/ICPMS%20quick%20guide.pdf
https://www.eag.com/techniques/spectroscopy/particle-induced-x-ray-emission-pixe/
https://serc.carleton.edu/research_education/geochemsheets/techniques/TIMS.html
https://web.njit.edu/~gilhc/EE495/TIMS.htm
https://www.thermofisher.com/blog/microscopy/edx-analysis-with-sem-how-does-it-work/

https://serc.carleton.edu/research_education/geochemsheets/techniques/MCICPMS.html
https://serc.carleton.edu/research_education/geochemsheets/browse.html#xray

Course Code: EGS.575
Course title: Comprehensive Geosciences

L	T	P	Credits
0	2	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, Group discussion, Focused group discussion, Team teaching, Brain storming, Collaborative learning, Problem solving, Case analysis, Self-learning, Through SOLE (Self Organized Learning Environment).

Evaluation Criteria- Full mark 100; Objective type test for both Mid semester Test (50 marks) and End semester exam (50 marks).

Course Code: EGS 526
Course Title: Field Training

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

- 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.

- Assess how to prepare geological map, geological cross section.

Geological field training:
Field training will be conducted in small groups / whole class during the semester or in the semester break between I and II and III as per the suitable time. Geological field training cum fieldwork will be carried out as per the guideline of the University at selected 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, fossils, 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 end semester exam. Prior to filed work, literature review on the selected/proposed field area will be carried out by the students and basic information's will be provided to students.
Due to any unavoidable circumstance, if the field work is not conducted in the allocated semester or before, then the students will be assigned with seminar, report writing and partial lab work/mathematical modelling work to fulfill the credit requirement and a separate evaluation criteria will be used for assessment.

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

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 (3 marks), Content (4 marks), Preparation (5 marks), stay in topic (4 marks); Response to questions (10 marks).

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.

Additional material will be provided to the students prior to the field visit based on the locality/geological sites selected for that year.

Course Code: EGS. 558
Course Title: Entrepreneurship

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

- Understand the basic concepts of entrepreneur, entrepreneurship and its importance.
- Aware of the issues, challenges and opportunities in entrepreneurship.
- Develop capabilities of preparing proposals for starting small businesses.
- Know the availability of various institutional supports for making a new start-up.

Course Contents

Unit I **Hours 4**

Introduction to entrepreneur and entrepreneurship; Characteristics of an entrepreneur; Characteristics of entrepreneurship; entrepreneurial traits and skills; innovation and entrepreneurship; Types of entrepreneurial ventures; enterprise and society in Indian context; Importance of women entrepreneurship. Group discussion and student seminar.

Unit II **Hours 4**

Promotion of a venture – Why to start a small business; How to start a small business; opportunity analysis, external environmental analysis, legal requirements for establishing a new unit, raising of funds, and establishing the venture - Project report preparation – format for a preliminary project report, format for a detailed/final project report. Brain storming session and case study.

Unit III **Hours 4**

Scope and opportunities in the field for mineral exploration, ground water exploration, geotechnical solution and geo-consultant. Basic requirements for establishing small business. Group discussion and student seminar.

Unit IV **Hours 3**

Case studies and live interaction with the young and dynamic Geo-entrepreneur. Possible avenue for developing Geo-entrepreneur. Requirement and demand on geo-consultancy. Mini projects, student seminars and proposal on development and scope of possible Geo-entrepreneur.

Transactional Modes: Lecture, Project Method, Inquiry training, Seminar, Group discussion, Co-operative learning, Blended learning, Flipped learning,

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

Suggested readings:

1. Arora, Renu (2008). *Entrepreneurship and Small Business*, DhanpatRai& Sons Publications.
2. Chandra, Prasaaan (2018). *Project Preparation, Appraisal, Implementation*, Tata Mc-Graw Hills.
3. Desai, Vasant (2019). *Management of a Small Scale Industry*, Himalaya Publishing House.
4. Jain, P. C. (2015). *Handbook of New Entrepreneurs*, Oxford University Press.
5. Srivastava, S. B. (2009). *A Practical Guide to Industrial Entrepreneurs*, Sultan Chand & Sons.

Evaluation Criteria- Full mark 50; Objective type Mid semester Test (25 marks) and subjective End semester exam (25 marks).

Course code: EGS.600
Course title: Research Proposal

L	T	P	Credits
0	0	8	4

Total Hours: 120

Learning Outcome:

After completion of the course, students will be able to

- Identify the research gap
- Potential literature review
- Develop hypothesis to solve the problem
- Make their own research proposal

Content:

Each candidate required to submit a dissertation proposal / synopsis of research work carried out towards the fulfillment of his/her M.Sc. dissertation. 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) Proposed laboratory investigation (if any) carried out by the candidate,
(e) Expected Outcome

Evaluation Criteria: The evaluation of dissertation proposal in the third semester will carry 50% weightage by supervisor and 50% by HoD and senior-

most faculty of the department. The evaluation of dissertation in the fourth semester will be as follows: 50% weightage for continuous evaluation by the supervisor which includes regularity in work, mid-term evaluation, report of dissertation, presentation, and final viva-voce; 50% weightage based on average assessment scores by an external expert, HoD and senior-most faculty of the department. Distribution of marks will be based on report of dissertation (30%), presentation (10%), and final viva-voce (10%). The final viva-voce will be through offline or online mode.

Evaluator	Marks	Evaluation
Supervisor	50	Dissertation proposal and presentation
HoD and senior-most faculty of the department	50	Dissertation proposal and presentation

Semester IV

Course Code	Course Title	Course Type	Credit Hours			Credit
			L	T	P	Cr
EGS.600	Dissertation	Skill Based	0	0	40	20
		Total	**0**	**0**	**40**	**20**

Course code: EGS.600
Course title: Dissertation

L	T	P	Credits
0	0	40	20

Total Hours: 600

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

- Formulate a research problem and identify
- Know the limitations and expected outcome
- Synthesis and interpret the field and lab data
- Draw the Inference from the result
- Decipher the future direction of research from the result
- Take up research for solving local/regional/global challenges

Content:
Each candidate required to submit a dissertation based on his/her research work carried out towards the fulfillment of his/her M.Sc. dissertation.
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: The evaluation of dissertation proposal in the third semester will carry 50% weightage by supervisor and 50% by HoD and senior-most faculty of the department. The evaluation of dissertation in the fourth semester will be as follows: 50% weightage for continuous evaluation by the supervisor which includes regularity in work, mid-term evaluation, report of dissertation, presentation, and final viva-voce; 50% weightage based on average assessment scores by an external expert, HoD and senior-most faculty of the department. Distribution of marks will be based on report of dissertation (30%), presentation (10%), and final viva-voce (10%). The final viva-voce will be through offline or online mode. Similar evaluation pattern will be used for internship where supervisor will award 50% marks and external co-supervisor, HoD and senior-most faculty will award 50% marks. The work load of one contact hour per student will be calculated for dissertation in fourth semester.

Evaluator	**Marks**	**Evaluation**
Supervisor	50	Continuous assessment (regularity in work, mid-term evaluation) dissertation report, presentation, final viva-voce
External expert, HoD and senior-most faculty of the department	50	Dissertation report (30), presentation (10), final viva-voce (10)