

CENTRAL UNIVERSITY OF PUNJAB



M.Sc. Geology

Batch 2023

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 the 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 these programmes, graduates will possess critical, creative and evidence-based thinking to solve local/regional/global problems; attain good communication skills 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.509	Mineralogy and Crystallography (Practical)	Skill Based	0	0	4	2
EGS.515	Structural Geology and Geotectonic	Core	3	0	0	3
EGS. 608	Structural Geology (Practical)	Skill Based	0	0	2	1
EGS. 521	Geochemistry and Isotope Geology	Core	3	0	0	3
EGS.530	Geological Time and Stratigraphy	Core	3	0	0	3
EGS.557	Analytical Techniques and Geo-statistics	Compulsory Foundation	3	0	0	3
	Tutorial	Remedial	0	2	0	0
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
EGS.606	Geomagnetism		3	0	0	3
GEO.566†	Glaciology		3	0	0	3
EVS.514†	Principles of Environmental Chemistry		3	0	0	3
Total			18	2	6	21

Semester-II

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
EGS.516	Hydrogeology and Engineering Geology	Core	3	0	0	3
EGS.522	Igneous and Metamorphic Petrology	Core	3	0	0	3
EGS.609	Petrology (I) and Hydrogeology (II) (Practical)	Skill Based	0	0	4	2
EGS.526	Field Training	Skill Based	0	0	2	1
EGS.556	Solid Earth Geophysics	Core	3	0	0	3
EGS.558	Entrepreneurship in Geosciences	Skill Based	2	0	0	2
	Tutorial	Remedial	0	2	0	0
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
EGS.537	Quaternary Geology		3	0	0	3
EVS.558†	Natural hazards and disaster management		3	0	0	3
GEO.507†	Climatology		3	0	0	3
Interdisciplinary course						
	Interdisciplinary course#	IDC	2	0	0	2
Total			19	2	6	22

Interdisciplinary course offered by the Department						
EGS.534	Introduction to Disaster Management	IDC	2	0	0	2
EGS.607	Introduction to Earth System Science	IDC	2	0	0	2

Semester-III

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
EGS.514	Sedimentology and Paleontology	Core	3	0	0	3
EGS.510	Sedimentology (I) and Paleontology(II) (Practical)	Skill Based	0	0	4	2
EGS.529	Principals of Geospatial technology	Core	3	0	0	3
EGS.555	Research Methodology	Compulsory Foundation	3	0	0	3
EGS.572	Ore Geology	Core	3	0	0	3
EGS. 610	Ore Geology (I) and Geospatial technology (II) (Practical)	Skill Based	0	0	4	2
EGS.600	Dissertation Part I	Skill Based	0	0	8	4
	Tutorial	Remedial	0	2	0	0
Value Added Course (VAC) (Any One)						
EGS.502	Geological Mapping	VAC	2	0	0	2
EGS.505	Environmental Magnetism	VAC	2	0	0	2
Total			14	2	16	22

Semester-IV

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
EGS.600	Dissertation Part II	Skill Based	0	0	40	20
Total			0	0	40	20
Grand total Credit for all semester (I+II+III+IV)			52	6	68	85

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

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.

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

→ Students may opt any internship/ academic or industrial training during semester break with approval from department. Above experiential learning/internship equivalent to 40–45 contact hours will be considered as

one credit (as per NCrf guidelines).

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.

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 Courses: Total Marks 100

- End semester exam (50 marks)
- Continues assessment (30 marks)
- Lab record (10 marks)
- Viva (10 marks)

Evaluation Criteria for practical/ 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.509	Mineralogy and Crystallography (Practical)	Skill Based	0	0	4	2
EGS.515	Structural Geology and Geotectonics	Core	3	0	0	3
EGS.608	Structural Geology (Practical)	Skill Based	0	0	2	1
EGS.521	Geochemistry and Isotope Geology	Core	3	0	0	3
EGS.530	Geological Time and Stratigraphy	Core	3	0	0	3
EGS.557	Analytical Techniques and Geo-statistics	Compulsory Foundation	3	0		3
	Tutorial	Remedial	0	2	0	0
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
EGS.606	Geomagnetism		3	0	0	3
GEO.566†	Glaciology		3	0	0	3
EVS.514†	Principles of Environmental Chemistry		3	0	0	3
Total			18	2	6	21

Course Code: EGS.506

L	T	P	Credits
3	0	0	3

Course Title: Mineralogy and Crystallography

Total Hours: 45

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

CLO1: Apprise how the internal structure of minerals affects the external structure and physical properties of minerals and crystals.

CLO2: Compare the mineralogical concepts of polymorphism, solid solution and exsolution.

CLO3: Interpret the basic properties and chemistry of common rock-forming minerals.

CLO4: Solve the difficulties of mineral identification and mineralogical assemblage by applying polarizing microscope, x-ray diffraction and electron microprobe.

Unit/ Hour	Contents	Mapping with CLO
I/10	<p>Mineralogy: Introduction to mineralogy, broad classification, properties of minerals & environments of formation. Crystal chemistry: bonding and packing in mineral, coordination number and Pauling's Rules, chemical analysis of minerals, general and structural mineral formulae. Rules of substitution, introduction to phase diagram and solid solution series.</p> <p>Learning Activities: Hands on exercise of mineral specimens, Use of stick-ball model to check bonding and packing.</p>	CLO1 CLO4
II/11	<p>Crystallography: Crystal Morphology, Crystal Symmetry, Crystallographic Axes, 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. Twinning, Polymorphism, Polytypism, Pseudomorphism, Crystal defects, twinning and twin laws: common types of twins and their examples in minerals. Introduction to X-ray crystallography, and Bragg's equation.</p> <p>Learning Activities: Hands on exercise of crystal models, drawing of stereographic projections, Powder XRD data analysis.</p>	CLO2 CLO4
III/12	<p>Optical Mineralogy: Petrological microscope; Introduction to optics, Isotropic and anisotropic minerals, Interference Phenomena, Compensation, and Optic Sign, optical crystallography of uniaxial and biaxial crystals, indicatrix, pleochroism, interference figures, crystal orientation, determination of optic sign, 2V and 2E.</p> <p>Learning Activities: Use of petrological microscope and analyzing each parameters.</p>	CLO4
IV/12	<p>A detailed study of the important silicates (listed below) mineral</p> <p>(a) Nesosilicates/Orthosilicates: olivine group, garnet group, aluminosilicate group, humite group, zircon.</p> <p>(b) Sorosilicates: melilite, axinite and epidote group.</p> <p>(c) Cyclosilicates: beryl, tourmaline, cordierite, eudialyte</p> <p>(d) Inosilicates: pyroxene group, amphibole group and wollastonite</p> <p>(e) Phyllosilicates: mica group, kaolinite-serpentine group, talc-pyrophyllite, chlorite, smectite.</p>	CLO2 CLO3 CLO4

	(f) Tectosilicates: silica group, feldspar group, zeolite and feldspathoid	
	Learning Activities: 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/mine_ralID/virtualminlab.html
<https://sketchfab.com/tags/minerals>
<http://www.minsocam.org/>

Course Code: EGS.509

L	T	P	Credits
0	0	4	2

Course Title: Mineralogy and Crystallography (Practical)

Total hours: 60

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

- CLO1: Demonstrate the different minerals in hand specimen and under petrological microscope.
- CLO2: Interpret the crystal parameter and to identify the mineral phase
- CLO3: Compare the different crystals system in hand specimen and under petrological microscope.
- CLO4: Solve mineralogical and crystallographic problems using XRD data.
- CLO5: Formulate empirical formula of the mineralogical phases and the impurities present in the minerals.

Unit/ Hour	Contents	Mapping with CLO
I/60	Identification of rock-forming minerals in hand specimens	CLO1
	Identification of crystal model using symmetry elements	CLO2
	Use of Goniometer to measure interfacial angle of crystals and calculation of axial ratio.	CLO3
	Representation of symmetry elements of crystals belonging to 32 classes of symmetry using stereonet	
	Scheme of pleochroism and absorption of a given mineral in thin section	CLO1 CLO3
	Determination of extinction angle, Determination of order of interference colours, 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	
	Analysis of powder XRD spectrum of minerals	CLO2 CLO4
	Empirical formula of the mineralogical phases and the impurities present in the minerals	CLO5

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.

Course Code: EGS.515

L	T	P	Credits
3	0	0	3

Course Title: Structural Geology and Geotectonic

Total Hours: 45

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

CLO1: Determine the geological structures of deformed continental regimes.

CLO2: Reconstruct the regional tectonic set up based on microstructural and petrofabric data.

CLO3: Design the relative timing of formation of structures, the kinematics of deformation and the progressive deformation histories at various tectonic regimes.

CLO4: Appraisal of structural geology in the mining and resource exploration environment.

CLO5: Distinguish landforms and their processes of formation in different climate zones and tectonic regimes.

CLO6: Develop relevant solution for elucidate geomorphologic problems.

Unit/ Hour	Contents	Mapping with CLO
I/10	Structural elements and measurements, 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. Strain analysis– finite and infinitesimal, homogeneous and inhomogeneous strains. Strain and deformation paths.	CLO1 CLO3

	<p>Learning Activities: Determination of strain in naturally deformed rocks. Hands on exercises on the stress and strain analysis of deformed rocks, assignment and group discussion.</p>	
II/15	<p>Mechanism of folding, Classification of folds, 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 Lamination) in deformed rocks: description, classification, genesis and significance. Brittle and ductile shear zones, Geometry and products of shear zones, Mylonites and Cataclasites.</p> <p>Learning Activities: Assignment, student Seminar, group discussion on rock deformation patterns at different regimes.</p>	CLO1 CLO2
III/10	<p>Stereographic and equal area projections for representing different types of fabrics, π and β diagrams. Thin-skinned and thick-skinned deformations; Decollement. Geometrical analysis of simple and complex structures on macroscopic scale.</p> <p>Learning Activities: Hand on exercises on the application of beta and pie diagrams, preparation of cross sections of complex structures.</p>	CLO2
IV/10	<p>Major tectonic features of the oceanic and continental crust. Seafloor spreading and plate tectonics. Island arcs, Oceanic islands and volcanic arcs. Origin of plumes and tectonic inference. Continental drift- geological and geophysical evidence, mechanics, objections, present status. Gravity and magnetic anomalies at mid-oceanic ridges, deep sea trenches, continental shield areas and mountain chains. Isostasy, orogeny and epeirogeny. Seismic belts of the earth. Seismicity and plate movements. Geodynamic Evolution of Himalaya through time. Geodynamics of the Indian plate.</p> <p>Learning Activities: Student seminar, group discussion on global geodynamics and orogeny.</p>	CLO4 CLO5 CLO6

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?_afLoop=21149378600749056&_adf.ctrlstate=zil7ujw74_38#!%40%40%3F_afLoop%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.htm>
[\(1233\) STRUCTURAL GEOLOGY \(Prof. Santanu Misra, IIT Kanpur\) - YouTube](#)

Course Code: EGS. 608

Course Title: Structural Geology
(Practical)

L	T	P	Credits
0	0	2	1

Total Hours: 30

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

CLO1: Solve the stratum contours, V-rule, geometric and borehole

problems related to the Structural geology.

CLO2: Solve various stereonet problems and construct stereographic projections of the field data.

CLO3: Interpret various maps and identify the geological structures of deformed continental regimes with microstructural analysis.

Unit/ Hour	Contents	Mapping with CLO
I/30	Study of stratum contours and their relation with the dip of the beds	CLO1
	Relation between true thickness and width of outcrop of a bed using 'V' rule	CLO1
	Graphical solution of structural problems using geometrical methods	CLO1
	Bore-hole problems (Three pin problems)	CLO1
	Structural problems based on orthographic and stereographic projections, concerning economic deposit	CLO2
	Preparation and interpretation of Geological maps and sections	CLO3
	Recording and plotting of the structural data on base map	CLO3

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.

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/>
 (1233) STRUCTURAL GEOLOGY (Prof. Santanu Misra, IIT Kanpur) - YouTube

Course Code: EGS. 521

Course Title: Geochemistry and Isotope Geology

L	T	P	Credits
3	0	0	3

Total Hours: 45

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

CLO1 Appraise behaviors of elements in the formation of primary and secondary rocks

CLO2 Formulate basics of isotope systematics and radioactive decay.

CLO3 Design the geochemical aspects for assessment of elements in and on Earth.

CLO4 Discuss the principles and applications of radiogenic isotope systematics to study geological processes and date rock-forming events.

CLO5 Adapt the principles and applications of stable isotope systematics.

Unit/ Hour	Contents	Mapping with CLO
I/11	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. Learning Activities: Assignments, Take home exercise, Group discussion.	CLO1 CLO2
II/10	Geochemical classification of elements. Chemical Bonds, Ionic Radii, and Crystals, Distribution coefficient; Behavior of major and trace including rare earth elements during magmatic crystallization, Oddo Harkins rule. Elemental mobility in surface environment, Eh-pH diagram. Concept of geochemical-biogeochemical cycling: Minor cycle and major cycle. Chemical weathering of minerals and rocks. Learning Activities: Take home exercise, peer learning and plotting of Eh-pH diagram for stability of different species/complex of elements.	CLO3
III/12	Isotope Geology: The law of radioactive decay; principles of mass spectrometry; Principles, methods and applications of K-Ar method, Ar-Ar method, Rb-Sr method, Sm-Nd Method, U-Th-Pb	CLO4 CLO5

	Method: decay schemes, U-Pb isochron, U-Pb mineral dating and application. Learning Activities: Hands on exercise during class and take home exercise, assignment, student seminar.	
IV/12	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. Learning Activities: Assignment, student seminar and group discussion.	CLO4 CLO5

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/~GEOL195-Geochemistry>
- <http://www.geo.cornell.edu/geology/classes/Geo656/656notes03.html>
- <https://www.rcamnl.wr.usgs.gov/isoig/isopubs/itich2.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.530

L	T	P	Credits
3	0	0	3

Course Title: Geological Time and Stratigraphy

Total hours: 45

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

- CLO1 Construct stratigraphic cross sections into a historical summary that expresses environmental states and changes.
- CLO2 Design appropriate nomenclature.
- CLO3 Adapt the base level concept in reasoning through the succession of paleogeographic changes during which a series of strata accumulated.
- CLO4 Discuss multiple variables that contribute to the accumulation of strata (e.g., tectonic subsidence, sediment supply, sea level change) in deducing plausible scenarios.
- CLO5 Make up reasoning to construct one or more hypotheses for the paleogeographic and environmental histories that produced a series of strata.
- CLO6 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).

Unit/ Hour	Contents	Mapping with CLO
I/10	<p>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.</p> <p>Learning Activities: Discussion and practical exercises on the preparation of lithologs and their correlations.</p>	CLO1 CLO2
II/13	<p>Precambrian stratigraphy of India: Precambrian stratigraphic framework of India; Classification, structure and tectonics of the Indian cratons; Mobile belts; 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; Stratigraphy, geology, tectonics and evolution of the Proterozoic basins/Purana formations in India.</p> <p>Learning Activities: Group Discussion on Archean-</p>	CLO3 CLO4 CLO5 CLO6

	Precambrian geology of India. Exercise on mapping certain geological formations, assignment.	
III/12	<p>Palaeozoic stratigraphy: Magmatic provenances and palaeogeography during the Palaeozoic Era. Stratigraphy, facies, and fossil contents of the Palaeozoic rock formations of Peninsular and extra-peninsular India. Permian-Triassic (P-T) boundary.</p> <p>Gondwana stratigraphy: Concepts, classification, fauna, flora and age limits of Gondwana Supergroup and related palaeogeography, palaeoclimate, depositional characteristics and igneous activity and formation.</p> <p>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 (DVP); Cretaceous-Palaeogene (C-P) boundary.</p> <p>Learning Activities: Assignment, student presentation and brainstorming sessions.</p>	CLO3 CLO4 CLO5 CLO6
IV/10	<p>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.</p> <p>Learning Activities: Take home exercise and brainstorming sessions, student seminar and group discussion.</p>	CLO3 CLO4 CLO5 CLO6

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?>

Course Code: EGS.555

L	T	P	Credits
3	0	0	3

Course title: Analytical techniques and geostatistics

Total hours: 45

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

- CLO1 Explain principle, instrumentation and application of instruments
- CLO2 Distinguish steps and working principle of electrochemical, and spectrometric
- CLO3 Describe the types, principle and applications of chromatographic techniques
- CLO4 Solve quantitative problems of geosciences

Unit/ Hour	Contents	Mapping with CLO
I/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).	CLO1 CLO2

	Learning Activities: Hands on exercise, assignment and student seminar.	
II/12	<p>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).</p> <p>Learning Activities: Assignment, take home exercise and student seminar.</p>	CLO3 CLO4
III/11	<p>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.</p> <p>Learning Activities: Assignment, take home exercise, seminar</p>	CLO3 CLO4
IV/11	<p>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.</p> <p>Learning Activities: Assignment, take home exercise and student seminar</p>	CLO3 CLO4

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*
4. Reed, S. J. B., 1990. *Recent developments in geochemical microanalysis: Chemical Geology*, Volume.83, PP. 1-9.
5. Frank A. Settle, 1997. *Handbook of Instrumental Techniques for Analytical Chemistry*, Prentice Hall, Upper Saddle River, NJ.
6. Hussain, C. H., Kecili, R (2020). *Modern Environmental Analysis Techniques for Pollutants*, Elsevier Book, ISBN: 9780128169346.
7. Ahluwalia V. K. (2015). *Instrument Methods of chemical analysis*, Ane Books Pvt. Ltd.
8. Holler F. J., Crouch, S. R. (2014). *Skoog & West's Fundamental of Analytical Chemistry*, 9th edition, CENGAGE learning.
9. Chatwal, G. R., Anand, S. K. (2013). *Instrumental Methods of Chemical Analysis*, Himalaya Publishing House, New Delhi
10. Patnaik, P. (2010). *Handbook of environmental analysis*, CRC Press, USA
11. Rouessac, F., Roussac, A. (2008). *Chemical analysis: modern instrumentation and techniques*, Wiley, England.
12. Skoog, D. A., Holler, F. J., Crouch, S. R. (2007). *Principles of Instrumental Analysis*, CENGAGE Learning.
13. Skoog D. A., Holler, F. L., Crouch, S. R. (2007). *Principles of instrumental analysis*, USA: Thomson Brooks/Cole Publishers.
14. Rajvaidya, N., Markandey, D. (2005). *Environmental Analysis and Instrumentation*, APH Publisher.
15. 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.
16. Wiersma, G. (2004). *Environmental monitoring*, CRC Press, UK.
17. Svehla, G. (1996). *Vogel's qualitative inorganic analysis, 7th Edition*, Prentice Hall, USA
18. Shukla, S. K., Srivastava, P. R. (1992). *Methodology for environmental monitoring and assessment*, New Delhi: Commonwealth Publishers.
19. Ewing, G. W. (1985). *Instrumental methods of chemical analysis, 5th edition*, USA: McGraw Hill Publications
20. 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.#xray

Discipline Elective course

Course Code: EGS.518

L	T	P	Credits
3	0	0	3

Course Title: Geomorphology

Total Hours: 45

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

- CLO1 Demonstrate the principal theories and models for landscape evolution.
- CLO2 Assess the mode of formation, age and history of landforms in India.
- CLO3 Distinguish landforms and their processes of formation in different climate zones and tectonic regimes.
- CLO4 Develop relevant solution for elucidate geomorphologic problems.

Unit/Hours	Content	Mapping with CLO
I/11	Historical development in geomorphology, geomorphic processes: weathering, sediment production, mass movement, erosion, transportation and deposition, landforms: Characterization and process involved in their formation. Learning Activities: Design a note on the concept of origin, evolution of landform, historical development, scope etc.	CLO1, CLO2
II/12	Geomorphic processes and landforms-fluvial, glacial, aeolian, coastal and karst. River forms and processes-stream flow, Environmental change-causes, effects on processes and landforms. Learning Activities: Brain storming on geomorphic processes for landform development, landforms under different environments etc.	CLO3
III/12	Definition and scope of tectonic geomorphology. Landscape evolution and involved process. Concept of Form-Process relationship in landscape evolution. applications of geomorphology in mineral prospecting, civil engineering, hydrology and environmental studies.	CLO1, CLO4

	Learning Activities: Design a conceptual model on importance of topography, DEM, maps in geomorphology.	
IV/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 and morphology Learning Activities: Student seminar on recent advancement in geomorphological studies.	CLO2

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 & distributor 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->

Course Code: EGS.519

L	T	P	Credits
3	0	0	3

Course Title: Natural Resource Management

Total Hours: 45

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

- CLO1 Appraise the types of natural resources available and their relation with geology
- CLO2 Invent new ideas to conserve, manage and develop the Earth's natural resources available
- CLO3 Evaluate the validity and limitations of scientific theories and claims about the environment.
- CLO4 Appraise the interactions among physical, biological, chemical, and human components of the environment.

Units/ Hours	Content	Mapping with CLO
I/11	<p>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</p> <p>Learning Activities: Develop a sustainable model on natural resources of India. Presentation on forest resources of India</p>	CLO1, CLO2
II/12	<p>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.</p> <p>Learning Activities: Design a concept model on water</p>	CLO1, CLO2

	resources, drought, flood issues of India, restoration etc.	
III/12	<p>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.</p> <p>Learning Activities: Group discussion on organic farming, green manuring etc. to highlight the salient points</p>	CLO2, CLO3
IV/10	<p>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.</p> <p>Learning Activities: Group discussion on ocean resources of India. Student seminar.</p>	CLO1, CLO2, CLO4

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

L	T	P	Credits
3	0	0	3

Course Title: Watershed Management**Total Hours: 45****Course Learning Outcomes (CLO):** Upon successful completion of this course, the student will be able to integrate and apply technical knowledge in the following key areas

CLO1 Discuss exploration of water resource through watershed management and exploration methods

CLO2 Evaluate the validity and limitations of scientific theories and claims about the environment.

CLO3 Appraise the interactions among physical, biological, chemical, and human components of the environment.

Units/ Hours	Content	Mapping with CLO
I/11	<p>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.</p> <p>Learning Activities: Group discussion on watershed management policies in India, to highlight the salient points.</p>	CLO1
II/12	<p>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.</p> <p>Learning Activities: Prepare a note on watershed management plan of India, followed by student presentation on that note.</p>	CLO2, CLO3
III/11	<p>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.</p> <p>Learning Activities: Group discussion on water legislation and implementations and its presentation.</p>	CLO3
IV/11	<p>Storm water management, design of drainage system, flood routing through channels and reservoir, flood control and reservoir operation, case studies on flood</p>	CLO2, CLO3

	<p>damage. Drought assessment and classification, drought analysis techniques, drought mitigation planning. Perspective on recycle and reuse, Waste water reclamation.</p> <p>Learning Activities: Mini project and student presentation on mechanism of Indian monsoon system and climatic regimes.</p>	
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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

Course Code: EGS. 606

L	T	P	Credits
3	0	0	3

Course Title: Geomagnetism

Total Hours: 45

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

- CLO1 Understand about Earth’s Magnetic Field and how it has changed in recent and ancient time and their importance in earth sciences.
- CLO2 Understand the basics of the paleomagnetic theory and be able to determine the past magnetic field stored in different geological formation.
- CLO3 Undertake the field, laboratory investigations independently and also able to do the data interpretation related to Geomagnetism &

Paleomagnetism.
 CLO4 Interpret the history of continental motion and able to established Magnetostratigraphy their correlation with Geomagnetic Polarity Time Scale.

Unit / Hour	Contents	Mapping with CLO
I /12	<p>Introduction to geomagnetism, Early Measurements of the Earth's Magnetic Field, Origin of the magnetic field, Geocentric Axial Dipole Model, The Present Geomagnetic Field, Geomagnetic Secular Variation, Magnetic Properties of Solids- Diamagnetism, Paramagnetism, Ferro-, Antiferro-, and Ferrimagnetism.</p> <p>Learning Activities: Group discussion on origin of Earth's magnetic field.</p>	CLO 1
II /11	<p>Basics of Paleomagnetism, Early Work in Paleomagnetism, Domain theory- Single, Pseudo-single & multi domain grains, types of magnetic remanence- Natural Remanent Magnetism, Thermoremanent Magnetism, Chemical Remanent Magnetism, Detrital Remanent Magnetism, Viscous Remanent Magnetism, Paleomagnetism and Plate Tectonics.</p> <p>Learning Activities: Prepare a note on primary magnetisation, followed by student presentation</p>	CLO 1 CLO 2
III /11	<p>Sampling methods, Instruments and laboratory techniques, Statistical analysis of paleomagnetic data, Alternating field Demagnetisation, Thermal Demagnetisation, Chemical Demagnetisation, Identification of Magnetic Minerals, Curie Temperatures, Isothermal Remanent Magnetization, The Lowrie-Fuller Test, Hysteresis and Magnetic Grain Sizes.</p> <p>Learning Activities: Group discussion on suitable Demagnetisation techniques in different rock types and analytical methods used in paleomagnetism.</p>	CLO 2 CLO 3
IV /11	<p>Magnetic Field Reversals, Normal, Reverse & Intermediate magnetic polarity direction, Geomagnetic Polarity Time Scale (GPTS), Magnetostratigraphy, Applications to paleogeography and Apparent Polar Wander Paths.</p> <p>Learning Activities: Understanding of Geomagnetic Polarity Time Scale (GPTS) and correlation of data at global level. Development of Magnetostratigraphy. Student presentation.</p>	CLO 4

Transactional Modes: Lecture, Demonstration, Tutorial, Problem solving, Tools used: PPT, Video, Animation, Whatsapp, Software Tool: Remasoft, Anisoft, Paleomag.

Suggested readings:

1. D. H. Tarling, 1983. Palaeomagnetism. Principles and Applications in Geology, Geophysics and Archaeology. ix + 379 pp. London, New York: Chapman & Hall.
2. E. Irwing (1964), Paleomagnetism and its Applications to Geological and Geophysical Problems, Wiley, New York.
3. R. Thompson and F. Oldfield (1986), Environmental Magnetism, Allen and Unwin, London.
4. O'Reilly (1984), Rock and Mineral Magnetism, Chapman & Hall, New York.
5. Michael W Mc Elhinny and Philip L. Mc Fadden (2000), Paleomagnetism Continents and Oceans, Academic Press USA.
6. Robert F. Butler (1992); Paleomagnetism: Magnetic Domains to Geologic Terranes, Blackwell Science Inc.
7. R. Thompson and F. Oldfield (1986), Environmental Magnetism, Allen and Unwin, London.

Web Resources:

<https://websites.pmc.ucsc.edu/~njarboe/pmagresource/ButlerPaleomagnetismBook.pdf>

https://www.soest.hawaii.edu/GG/FACULTY/ITO/GG450/Lowrey_Geomagnetism.pdf

http://www-odp.tamu.edu/publications/190_IR/chap_05/c5_6.htm

<https://www.degruyter.com/document/doi/10.1525/9780520946378-016/html>

<https://www.sciencedirect.com/science/article/abs/pii/S0074614296800027>

https://www.researchgate.net/publication/23703966_On_Geomagnetism_and_Paleomagnetism

<https://www.wgtn.ac.nz/scps/research/research-groups/enviro-phys-geo/geomagnetism>

<https://earth-planets-space.springeropen.com/articles/10.1186/s40623-019-1060-4>

<https://www.youtube.com/watch?v=jpp672BBknA>

<https://www.youtube.com/channel/UCRVhgDx1dphMVnTJhdKKDZQ>

<https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2006RG000198>

https://www.youtube.com/watch?v=yzgGHAoN_68&list=PLyqSpQzTE6M_OXWtn1RUnuZNSbSSy6Lys

<https://www.youtube.com/watch?v=Pxk9q7gdR8M&list=PLsfizngNlx8suxYQjXSZiHxlarp8wwERG&index=17>

Semester-II

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
EGS.516	Hydrogeology and Engineering Geology	Core	3	0	0	3
EGS.522	Igneous and Metamorphic Petrology	Core	3	0	0	3
EGS.609	Petrology (I) and Hydrogeology (II) (Practical)	Skill Based	0	0	4	2
EGS.526	Field Training	Skill Based	0	0	2	1
EGS.556	Solid Earth Geophysics	Core	3	0	0	3
EGS.558	Entrepreneurship	Skill Based	2	0	0	2
	Tutorial	Remedial	0	2	0	0
Select any Two from the following Discipline Elective course^s						
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
EGS.537	Quaternary Geology		3	0	0	3
EVS.558†	Natural hazards and disaster management		3	0	0	3
GEO.507†	Climatology		3	0	0	3
Interdisciplinary course						
	Interdisciplinary course#	IDC	2	0	0	2
Total			19	2	6	22

Interdisciplinary course offered by the Department						
EGS.534	Introduction to Disaster Management	IDC	2	0	0	2
EGS.607	Introduction to Earth System Science		2	0	0	2

Course Code: EGS.516

L	T	P	Credits
3	0	0	3

Course Title: Hydrogeology and Engineering Geology

Total hours: 45

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

CLO1: Appraise the role of groundwater in hydrological cycle, groundwater flow pattern in different terrains.

CLO2: Estimate quantity and to assess quality aspects of groundwater for better management.

CLO3: Formulate the evolution of water chemistry through hydro-geochemical processes across different terrains.

CLO4: Understand the engineering properties of rock and soil materials, engineering geological investigations.

CLO5: Understand the importance of engineering geology related to technical issues during construction, and conduct basic engineering geological assessments and analyzes

Unit/ Hour	Contents	Mapping with CLO
I/11	Hydrosphere and Groundwater flow: 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. Learning Activities: Design a model on hydrologic cycle and concept of Darcy's law.	CLO1 CLO2
II/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. Groundwater quality: 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. Learning Activities: Group discussion on local major aquifer types and groundwater occurrence.	CLO1 CLO2 CLO3
III/11	Role of engineering geology in civil constructions. Various stages of engineering geological investigation for civil engineering projects. Introduction to soil mechanics, 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. Learning Activities: Group discussion on the popular engineering	CLO4 CLO5

	projects and highlight the salient points.	
IV/11	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. Learning Activities: Brain storming on the impacts of engineering projects to the environments and their importance to highlight the salient points, student seminar.	CLO4, CLO5

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/>

Course Code: EGS.522

L	T	P	Credits
3	0	0	3

Course title: Igneous and Metamorphic Petrology

Total Hours: 45

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

CLO1 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.

CLO2 Assess certain igneous and metamorphic rocks based on their mineralogical and textural characteristics.

CLO3 Interpret phase diagrams relevant to igneous systems and petrogenic grids relevant to metamorphic systems based on mineral assemblages recorded in the rock.

CLO4 Discuss the chemistry of certain igneous/metamorphic rocks and predict their environment(s) of formation.

Unit/ Hour	Contents	Mapping with CLO
I/12	<p>Magma: nature and evolution; Magmatic and allied process: Partial melting, fractional crystallization, assimilation, liquid immiscibility, double diffusion factors affecting magma and evolution, melting of mantle. Introduction to thermodynamics and its application in Magmatism; The phase equilibrium of unary, binary and ternary systems and its relation to magma genesis and crystallization in the recent experimental works; Interpretation of igneous textures in terms of rate of nucleation and crystal growth.</p> <p>Learning Activities: Assignment, Take home exercise, mini projects.</p>	CLO4
II/11	<p>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-ijolite, lamproites, 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.</p> <p>Learning Activities: Group discussion and take home exercise.</p>	CLO3
III/11	<p>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</p>	CLO4

	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. Learning Activities: Assignment, take home exercise and student presentation	
IV/11	Isograds and reaction isograds, Schriener's 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. Learning Activities: Student seminar, assignment and mini projects.	CLO1 CLO2

Transactional Modes: Lecture, Demonstration, Seminar, Group discussion, Cooperative learning, Blended learning, Flipped learning, Focused group discussion, Team teaching, Field visit, Brain storming, Mobile teaching 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*, Chapman & 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 Equilibria 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-nen%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. 609

L	T	P	Credits
0	0	4	2

Course Title: Petrology (I) and hydrogeology (II) (Practical)

Total Hours: 60

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

CLO1 Identify and Inspect key textural/micro structural features of igneous and metamorphic rocks in hand specimen as well as under the microscope.

CLO2 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.

CLO3 Construct water table maps for evaluation of groundwater flow, recharge and discharge site identification.

CLO4 Maximize exploration of groundwater resource using hydrogeology, remote sensing & GIS integrated approach

CLO5 Assess the quality of groundwater for different uses and to propose development and management of groundwater resource

Unit/ Hour	Contents	Mapping with CLO
I/30	Following exercise will be conducted in the lab • Megascopic and microscopic study of different igneous	CLO1 CLO2

	rocks <ul style="list-style-type: none"> • 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 	
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II/30	<ul style="list-style-type: none"> • Water table contour mapping • Interpretation of flow net: groundwater flow movement, delineation of recharge and discharge areas • Calculation of hydraulic gradients • Exercises on data mining from Groundwater Estimation and Management System (GEMS) portal of Central Ground Water Board, India • 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 	CLO3 CLO4 CLO5
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Transactional Modes: Demonstration, Group discussion, Problem solving, Case analysis, Case study, Self-learning, Case based study, Through SOLE (Self Organized Learning Environment), Experimentation.

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

Suggested readings:

1. LeMaitre, R. W., 2002. *Igneous 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*, Chapman & 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. Todd D.K., 2007. *Groundwater Hydrology*, John Wiley and Sons
 10. Gupta, S. K., 2011. *Modern Hydrology and Sustainable Water Development*, Wiley-Blackwell.
 11. Raghunath, H.M., 1985. *Groundwater*, Wiley Eastern Ltd.
 12. Karanth, K. R., 1987. *Groundwater Assessment Development and Management*, McGraw Hill Publishers
 13. Freeze and Cherry, 1979. *Groundwater*, Prentice-Hall.

Web Resources:

- <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>

Course Code: EGS 526

L	T	P	Credits
0	0	2	1

Course Title: Field Training

Total hours: 30

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

- CLO1** Apply theoretical knowledge at ground observation in field and to learn essential observational and practical skills.

- CLO2** Identification of rocks and interpreting the physical (including tectonic) processes that may have been involved in their formation.
- CLO3** Divide different rock type, different deformational structures, such as fold, fault, lithology and depositional features etc. in the field.
- CLO4** Assess how to prepare geological map, geological cross section.

Unit/ Hour	Contents	Mapping with CLO
I/30	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.	CLO1 CLO2 CLO3 CLO4

Transactional Modes: 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 field 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 fieldwork 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.

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.556

L	T	P	Credits
3	0	0	3

Course Title: Solid Earth Geophysics

Total hours: 45

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

CLO1 Adapt modern field instrumentation, theory, programming and/or advanced analysis on geophysical problems

CLO2 Evaluate and assess data quality and different information sources in geophysics

CLO3 Formulate process and implement strategies for data and theoretical analysis.

CLO4 Develop the ability to perform geophysical data analysis, interpretation and to use seismological data for understanding the earth sub surface.

Unit/ Hour	Contents	Mapping with CLO
I/11	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. Learning Activities: Assignment, take home exercise, group discussion.	CLO1
II/11	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. Learning Activities: Problem solving after each methods, take home exercise.	CLO1 CLO2
III/12	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.	CLO3

	<p>Conventional and modern (CDP) methods of acquisition of seismic reflection data. Applications of Seismic methods to oil exploration, groundwater exploration and engineering problems.</p> <p>Learning Activities: Assignment, take home exercise, lab based exercise.</p>	
IV/11	<p>Electrical methods: basic principles and various types of electrode configuration: Wenner and Schlumberger; 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.</p> <p>Brief outline of various well logging techniques: self-potential and resistivity logs, radioactive logs, induction logs, caliper logs, sonic logs, well logging applications in petroleum, groundwater and mineral exploration.</p> <p>Learning Activities: Assignment, take student seminar and mini project.</p>	CLO4

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/OV_ERVIEW.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 558

L	T	P	Credits
2	0	0	2

Course Title: Entrepreneurship in Geosciences

Total hours: 30

Course Learning Outcomes (CLO): Upon successful completion of this course, student will be able to

- CLO1 Understand the basic concepts of entrepreneur, entrepreneurship and its importance.
- CLO2 Aware of the issues, challenges and opportunities in entrepreneurship.
- CLO3 Develop capabilities of preparing proposals for starting small businesses.
- CLO4 Know the availability of various institutional/industrial supports for making a new start-up.

Unit/ Hour	Contents	Mapping with CLO
I/7	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. Learning Activities: Group discussion and student seminar.	CLO1 CLO2
II/8	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. Learning Activities: Brain storming session and case	CLO3 CLO4

	study.	
III/8	<p>Scope and opportunities in the field of mineral exploration, ground water exploration, geotechnical solution and geo-consultant; Basic requirements for establishing small business, Possible avenue for developing Geo-entrepreneur; Requirement and demand on geo-consultancy.</p> <p>Learning Activities: Student seminars and proposal on development and scope of possible Geo-entrepreneur</p>	CLO3
IV/7	<p>Preparation of IAR/ CHR/ Modelling Reports as per the guidelines issued by Central Ground Water Authority, Ministry of Jal Shakti: A) Impact Assessment Report For Infrastructure Projects Involving Dewatering, B) Comprehensive Hydro Geological Report On Ground Water Conditions In Both Core And Buffer Zones For Mining Projects, C) Ground Water Modelling Studies</p> <p>Learning Activities: Mini projects, Case studies and live interaction with the young and dynamic Geo-entrepreneur</p>	CLO2 CLO3 CLO4

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*, Dhanpat Rai & Sons Publications.
2. Chandra, Prasanna (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.

Web Resources:

<http://cgwb.gov.in/AR/Final-Guideline-IA-AR-Studies-submitted-website-hosting.pdf>
<https://cgwb.gov.in/Documents/GEC97.pdf>
<https://www.dalmiacement.com/wp-content/themes/DalmiaCement/assets/pdf/Final-CHG-Dalmia->

Discipline Elective: Select any Two

Course Code: EGS.528

L	T	P	Credits
3	0	0	3

Course Title: Mineral Exploration and Petroleum Geology

Total Hours: 45

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

- CLO1** evaluate ore deposit types, including genesis and exploration requirements;
- CLO2** designing understanding on petroleum geology, exploration techniques, and resource evaluation;
- CLO3** explain their concept-oriented approaches in the analysis of geological data;
- CLO4** assess and apply geochemical exploration methods and geochemical data presentation/analysis;
- CLO5** discuss the role of geology in mine design and operation.
- CLO6** evaluate the range of surface and underground mining techniques

Unit/ Hour	Contents	Mapping with CLO
I/10	Distribution of mineral resources in India; Gas hydrates and coal bed methane. Introduction to mineral exploration, stages of exploration, type of explorations. Transactional Modes: Assignment, Take home exercise, peer learning.	CLO1 CLO2 CLO5
II/12	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; Methods of petroleum exploration. Transactional Modes: Assignment, take home exercise, group discussion.	CLO3 CLO4 CLO5

III/12	<p>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.</p> <p>Transactional Modes: Case study by different group followed by discussion and assignment.</p>	CLO1
IV/11	<p>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.</p> <p>Transactional Modes: Student seminar and brainstorming.</p>	CLO2 CLO5 CLO6

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. Levenson, 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>

Course Code: EGS.532

L	T	P	Credits
3	0	0	3

Course Title: Oceanography

Total hours: 45

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

- CLO1** Explain and discuss oceanographic phenomena for both laymen and experts
- CLO2** Determine the history and development of oceanography including marine biogeochemistry
- CLO3** Formulate, process and implement strategies for data and theoretical analysis.

Unit/ Hour	Contents	Mapping with CLO
I/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. Learning Activities: Assignment, Take home exercise, peer learning on oceanic topography.	CLO1
II/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	CLO2

	<p>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.</p> <p>Learning Activities: Exercise on mechanics of atmospheric and oceanic circulation.</p>	
III/11	<p>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.</p> <p>Learning Activities: Group discussion on marine resources and exploration.</p>	CLO1 CLO2
IV/11	<p>Origin and evolution of the Indian Ocean, structure and physiography of the Indian Ocean, bathymetry and bottom characteristics, sediment distribution on the Indian 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.</p> <p>Learning Activities: Assignment on bathymetry, structure and EEZ of Indian ocean.</p>	CLO3

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. Merrill

- 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

L	T	P	Credits
3	0	0	3

Course Title: Palaeobotany

Total hours: 45

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

- CLO1 understand the development of palaeobotany
- CLO2 adapt modern field technique to apply palynology to understand the palaeobotany and understand the paleoclimate
- CLO3 Formulate, process and implement strategies for data and theoretical analysis.

Unit/ Hour	Contents	Mapping with CLO
I/10	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	CLO1

	(Palaeozoic). Learning Activities: Student seminar and brainstorming session.	
II/11	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, Corytospermales, 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. Learning Activities: Assignment, seminar and group discussion.	CLO2
III/11	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. Learning Activities: Assignment, take home exercise, peer learning.	CLO1, CLO3
IV/13	Fundamentals of palaeofloristics, palaeogeography, palaeoecology, paleoceanograph 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 tectonism. Important plant fossils and microfossils in Indian stratigraphy. Learning Activities: Assignment, Take home exercise, peer learning, seminar and group discussion.	CLO2 CLO3

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. *Paleobotany: 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/bonline/kerp/links.html>
- <http://www.equisetites.de/palbot/teach/palbotteach.html>
- <https://www.floridamuseum.ufl.edu/paleobotany/resources/link/>

Course Code: EGS.535

L	T	P	Credits
3	0	0	3

Course Title: Environmental Geology

Total Hours: 45

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

- CLO1 Discuss the role of geologic processes in assessment of environment
- CLO2 Formulate the occurrence and formation of earth resources and significant environmental effects caused by their extraction, processing, and use;
- CLO3 Predict the major sources of water, soil, and sediment pollution and methods for their management;
- CLO4 Evaluate the causes and effects of global climate change.

Unit/ Hour	Contents	Mapping with CLO
I/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,	CLO1 CLO2

	<p>phosphorus and sulfur; Physiography, drainage, climate, soils and natural resources of India.</p> <p>Learning Activities: Take home exercise and brain storming session on importance of environmental geology.</p>	
II/12	<p>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.</p> <p>Learning Activities: Assignment and group discussion on environmental pollution.</p>	CLO2 CLO3
III/12	<p>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.</p> <p>Learning Activities: Preparation of assessment reports, assignments and brain storming session on types of disasters and its management.</p>	CLO2 CLO4
IV/11	<p>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.</p> <p>Learning Activities: Assignment and brain storming session on disaster risk management.</p>	CLO1 CLO4

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

L	T	P	Credits
3	0	0	3

Course Title: Astro and Geobiology

Total hours: 45

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

- CLO1 Evaluate the deep connection of life to the cosmos.
- CLO2 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.
- CLO3 Justify how life survives in extreme environments and the search for extraterrestrial life in our solar system and elsewhere by certain agencies.
- CLO4 Discuss the chemical physical process involving the origin and evolution of life and its link with the extraterrestrial processes.

Unit/ Hour	Contents	Mapping with CLO
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I/10	<p>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.</p> <p>Learning Activities: Exercises and brainstorming session and group discussion.</p>	CLO1 CLO2
II/12	<p>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.</p> <p>Learning Activities: Student seminar and group discussion.</p>	CLO2
III/12	<p>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.</p> <p>Learning Activities: Assignments and take home exercise.</p>	CLO3
IV/13	<p>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.</p> <p>Learning Activities: Student Seminar and group discussion.</p>	CLO4

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. ISBN 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. Chela Flores, 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://distantearth.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>

Course Code: EGS.537

L	T	P	Credits
3	0	0	3

Course Title: Quaternary Geology**Total hours: 45**

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

- CLO1** Know the main principles, concepts and approaches pertaining to the study of Quaternary sediments and landforms.
- CLO2** Knowledge of the Quaternary stratigraphic framework
- CLO3** Knowledge of the basic applied glacial geology techniques
- CLO4** Appreciation and basic knowledge of the complexity of changes that have occurred worldwide throughout the Quaternary Period

Unit/ Hour	Contents	Mapping with CLO
I/12	<p>Quaternary time and its significance; Basic concept of Landform evolution; Geomorphology of Indo-Gangetic Plain and Himalaya; Climatic cycles during Quaternary: Milankovitch cycle; Terminal Pleistocene-Holocene climatic and sea level changes; Geomorphology and Quaternary climate studies of Thar Desert and Peninsular India; Exogenic processes: River basin and drainage network; Morphotectonics and associated landforms.</p> <p>Learning Activities: Exercises and brainstorming session and group discussion.</p>	CLO1
II/11	<p>Continental-marine correlation of Quaternary record. Quaternary geomorphic processes. Landscape evolution in Quaternary. Concept of tectonic geomorphology. Weathering and Erosion, Mass wasting; Geological works of glacier, wind, underground water, ocean and landforms produced by them. Wave erosion and beach processes.</p> <p>Learning Activities: Student seminar and group discussion.</p>	CLO2
III/11	<p>Radiometric dating techniques (e.g. ¹⁴C, K-Ar, OSL, cosmogenic dating), Incremental dating methods (Dendrochronology, varve chronology), Age-equivalent stratigraphic markers (e.g. paleomagnetism,), Use of Oxygen Isotopes in palaeoclimatic studies;</p> <p>Learning Activities: Assignments and take home exercise.</p>	CLO3
IV/11	<p>Significance of Quaternary studies; Quaternary Stratigraphy; Quaternary deposits in India; Neotectonics; Evolution of man and cultural stages; Criteria used for defining Pliocene-Pleistocene boundary; Pleistocene-Holocene boundary.</p> <p>Learning Activities: Student Seminar and group discussion.</p>	CLO4

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. Benn D.I., and Evans D.J.A. (2010) *Glaciers & Glaciation*. Second Edition, Hodder Education, 802 pages.
2. Lowe, J.J., and Walker, M.J.C. (1997) *Reconstructing Quaternary environments*. 2nd edition, Pearson, Prentice-Hall, 446 pages.

3. Menzies, J. (Ed.) (1996) Past glacial environments: Sediments, forms and techniques. Glacial Environments: Volume 2. Butterworth-Heinemann, Oxford, 598 pages.
4. Oerlemans, J. (2001) Glaciers and climate change,
5. A.A Balkema. Pomerol, (1982) The Cenozoic Era: Tertiary and Quaternary, Ellis Harwood Ltd

Web Resources:

- https://notendur.hi.is/oi/quaternary_geology.htm
- <https://www.ngu.no/en/topic/quaternary-landscape-development>
- https://www.youtube.com/watch?v=lQY5Oz_4JX0
- <https://www.ngu.no/en/topic/quaternary-landscape-development>
- <https://www.youtube.com/watch?v=MMjXyCjDiBA>
- <https://www.youtube.com/watch?v=e-clDUu7j54>
- <https://www.youtube.com/watch?v=vv2fu2blyzw>
- <https://opengeology.org/historicalgeology/case-studies/the-meghalayan-age/>

Interdisciplinary Course (IDC) offered by the department

Course Code: EGS. 534

L	T	P	Credits
2	0	0	2

Course Title: Introduction to Disaster Management

Total hours: 30

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

- CLO1** Discuss the concept of disaster risk management
- CLO2** Elaborate the both the Natural and Artificial disaster and their management techniques
- CLO3** Design concept on management and mitigation of disaster management
- CLO4** Choose appropriate scientific approaches in understanding causes of natural hazards.

Unit/ Hour	Contents	Mapping with CLO
I/7	Disaster Management: definition, scope, Objectives and Approaches; Elements of Disaster Management, Concept of hazard, risk, vulnerability and disaster Learning Activities: Group Discussion and brainstorming session on disaster and hazards.	CLO1
II/8	Classification of disasters- natural disasters and human induced disasters; Disasters in India- earthquake, landslide, flood, cyclone, tsunami, industrial disasters. Learning Activities: Student seminar, discussion and brainstorming session	CLO2
III/8	Disaster mitigation: Concept, importance, tools,	CLO3

	strategies with reference to specific disasters; Disaster preparedness: Concept, nature, measures, disaster preparedness plan. Learning Activities: Student presentation and group discussion on the case study on Indian disasters, and their mitigation and preparedness techniques.	
IV/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. Learning Activities: Student Seminar and brainstorming session of disaster management system of India.	CLO4

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>

Course Code: EGS. 607

L	T	P	Credits
2	0	0	2

Course Title: Introduction to Earth System Science

Total hours: 30

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

CLO1 Develop a basic understanding about the origin of Earth, major components and processes of the Earth systems and Evolution of life.

CLO2 Develop the essential properties of Earth's components including its core, mantle, asthenosphere, lithosphere, cryosphere, hydrosphere, atmosphere and biosphere.

CLO3 Explain the plate tectonic theory and its relationship to earth processes; identify common rocks and minerals and interpret their genesis; recognize the events in geologic history using geological evidences and discover how Earth works as a system of interacting components across geological timescales.

CLO4 Demonstrate how the oceans are connected to the atmosphere and plate tectonics.

Unit/ Hours	Contents	Mapping with CLO
I/7	Branches and scopes of Earth Sciences; General characteristics and origin of the Universe, solar system and its planets; Concepts of Meteorites its classification and implications to solar system formation; Planet Earth: Origin, size, shape, mass, density, rotation and revolution parameters; Origin of atmosphere, ocean and life; Mechanical layering of the Earth and its internal composition; Concepts of Convection currents and Earth's magnetic field. Learning Activities: Student seminar, discussion and brainstorming session	CLO1, CLO2
II/8	Concept of isostasy and geothermal gradient of the Earth; Plate tectonics: Continental drift and Sea floor spreading; Plates and plate boundaries: Convergent, Divergent and Transform Plate Boundaries; Seismic Waves and Earthquakes; Volcanoes and volcanic landforms. Learning Activities: Take home exercise on isostasy, finding earthquake epicenters, online monitoring the intensity map of earthquakes.	CLO2, CLO3
III/8	Cosmic abundance of elements: Distribution of elements in solar system and in Earth; Geochemical cycles; Concepts of uniformitarianism, catastrophism and neptunism; Laws of superposition and faunal succession; Concept of Geological Time Scale and Mass Extinction; Minerals and their characteristics; Rocks: Classification, origin and characteristics; Soils: types, soil profile, processes of formation of soil; Concept of weathering and erosion. Learning Activities: Group discussion on important	CLO2, CLO3

	geochemical cycles and theories.	
IV/7	Hydrologic cycle and groundwater system; Concepts of eustasy and Land-air-sea interaction; Ocean and atmospheric circulations; Bathymetry of ocean floor; Oceanic current system and effect of Coriolis force; Natural resources and their managements; Global Carbon Cycle. Learning Activities: take home exercise, budgeting of carbon in the different systems	CLO4

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. Bangar, K.M., 2020, Principles of Engineering Geology. Standard Publishers Distributors, ISBN: 978-8180141157.
2. Mahapatra, G.B., 2019, A Textbook of Geology. CBS Publishers, ISBN: 978-0824794446.
3. McConnell, D., Steer, D., Knight, C., Owens, K., and Park, L., 2016, The Good Earth: Introduction to Earth Science. McGraw Hill Publication, 1st Ed., ISBN: 978-0-07-301847-8.
4. Christiansen E.H., and Hamblin, W.K., 2015, Dynamic Earth: An Introduction to Physical Geology. 1st Ed., Jones and Bartlett Publishers, Inc., ISBN: 9781449659844.
5. Dasgupta, A., 2013, An Introduction to Earth Science. World Press, ISBN: 978-9382878001.
6. Mukherjee, P.K., 2013, Textbook of Geology. World Press, ISBN: 978-8187567547.
7. Grotzinger, J., Jordan, T.H., Press, F., and Siever, R., 2007, Understanding Earth (Fifth Edition). W. H. Freeman and company, New York.
8. Kump, L.R., Kasting, J.F., and Crane, R.G., 2004 The Earth System, Prentice Hall, 2nd Ed., ISBN 0-13-142059-3.
9. Jacobson, M. C., Charlson, R. J., Rodhe, H., and Orians, G. H., 2000, Earth System Science: San Diego, CA, Academic Press, 523 p., ISBN 0-12-379370-X
10. Patwardhan, A.M., 2004, The Dynamic Earth System, Prentice Hall India Learning Private Limited, New Delhi. ISBN -978-81-203-1496-2.
11. Duff, P.M.D., and Duff, D., (Eds.) 1993. Holmes' principles of physical geology. Taylor and Francis.

Web Resources:

- https://open.uci.edu/courses/ess_1_introduction_to_earth_system_science.html
- <https://ocw.mit.edu/courses/earth-atmospheric-and-planetary-sciences/12-001-introduction-to-geology-fall-2013/lecture-notes-and-slides/>
- <https://cosmolearning.org/courses/introduction-earth-system-science/>
- https://www.tulane.edu/~sanelson/Natural_Disasters/struct&materials.htm
- <https://www.eolss.net/sample-chapters/C12/E1-01-02.pdf>
- https://www.soas.ac.uk/cedep-demos/000_P500_ESM_K3736-Demo/module/pdfs/p500_unit_01.pdf

https://ucdavis.mediaspace.kaltura.com/media/Lecture+1+-+Intro+to+Earth+System+Science+-+ESM+120+%28Winter+2021%29/1_th0lkw5

Semester-III

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
EGS.514	Sedimentology and Paleontology	Core	3	0	0	3
EGS.510	Paleontology and Sedimentology (Practical)	Skill Based	0	0	4	2
EGS.529	Principals of Geospatial technology	Core	3	0	0	3
EGS.555	Research Methodology	Compulsory Foundation	3	0	0	3
EGS.572	Ore Geology	Core	3	0	0	3
EGS. XXX	Ore Geology and Geospatial technology (Practical)	Skill Based	0	0	4	2
EGS.600	Dissertation Part I	Skill Based	0	0	8	4
	Tutorial	Remedial	0	2	0	0
Value Added Course (VAC) (Any One)						
EGS.502	Geological Mapping	VAC	2	0	0	2
EGS.505	Environmental Magnetism	VAC	2	0	0	2
Total			14	2	16	22

Course Code: EGS.514

L	T	P	Credits
3	0	0	3

Course Title: Sedimentology and Paleontology

Total Hours: 45

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

- CLO1:** Interpret the processes responsible for the deposition of the sediment and formation of sedimentary textures and structures.
- CLO2:** Construct the depositional environment of certain sedimentary rock based on recognition of facies associations, lithology, textures and structures.
- CLO3:** Formulate the sedimentary basin forming processes and its environmental and economic significance.
- CLO4:** Identify certain fossils fauna.
- CLO5:** Experiment with the technique of fossil extraction and taxonomy.
- CLO6:** Elaborate the origin and evolutionary history of various fossils in time, space, and its application in hydrocarbon exploration.
- CLO7:** Formulate the paleoclimatic, paleoenvironmental and paleobiogeographic history of the earth.

Unit/ Hour	Contents	Mapping with CLO
I/10	<p>Important sedimentary bed forms and sedimentary structures—their genesis and stratigraphic significance. Application of sedimentary structures in palaeocurrent analysis; Diagenesis – Physical and chemical processes. Burial and Lithification. Evidences of Diagenesis in sandstones, mudrocks and carbonate rocks. Evaporites, siliceous, phosphatic and ferruginous rocks. Heavy minerals and their importance in determination of provenance.</p> <p>Learning Activities: Hands on exercise of and practices on sedimentary rock petrography and separation of heavy minerals, assignment.</p>	CLO1
II/11	<p>Concept of facies and methods of their analysis and interpretation of depositional environments. Walther's Law of superimposition and its implication. Processes and characteristics of Aeolian, fluvial, barrier-beach, tidal-flats and deep sea environments.</p> <p>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.</p> <p>Learning Activities: Exercises on sedimentary facies identification, mapping the sedimentary basins of India, student seminar, group discussion.</p>	CLO2 CLO3
III/13	<p>Conditions and modes of fossilization. Use of paleontological data in stratigraphy.</p> <p>Detailed shell morphology, classification, composition and structure of the shell and geological description of the invertebrate fossil groups; Brachiopoda, Bivalvia, Gastropoda and Cephalopoda. Morphology, classification and geological description of Echinoidea, Trilobita, and Graptoloidea. Evolutionary trends in Graptoloidea and Ammonoidea. Functional morphology of bivalvia. Buoyancy of cephalopod shells. Heteromorphs and extinction in ammonites.</p> <p>Learning Activities: Mini project on vertebrate fossils, Exercises and brainstorming session on the evolution of life, demarcating the vertebrate fossils of India through ages and their global comparison.</p>	CLO4
IV/12	<p>Principle of paleobiogeography. Elements of micropaleontology and its practical applications. Brief morphological study of the following types of microfossils and their paleoceanographic and paleoenvironmental significance; Calcareous (Foraminifera, Ostracoda, Pteropods and Calpionellids), Siliceous (Radiolaria, Diatoms).</p>	CLO5 CLO6 CLO7

	Learning Activities: Hand on exercise on the application of fossils of different sections and their correlation with other correlatable sections, student seminar.	
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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. Michael J. Benton 2014. *Vertebrate Palaeontology*. Fourth Edition, Wiley-Blackwell, p. 480. ISBN-13 : 978-1118406847
12. Michael J. Benton and David A. T. Harper, 2020. *Introduction to Paleobiology and the Fossil Record*, Wiley-Blackwell, p. 656. ISBN-13 : 978-1119272854

Course Code: EGS.510

L	T	P	Credits
0	0	4	2

Course Title: Sedimentology (I) and Paleontology (II)
(Practical)

Total Hours: 60

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

CLO1 Classify the various sedimentary rocks and fossils.

CLO2 Analyze certain fossils and rock samples for paleo-environment and paleoclimatic interpretation.

CLO3 Apply the sample preparation methods, separation of fossils and rocks, cataloguing of samples at research and industrial

applications.

CLO4 Correlate the multidisciplinary nature of modern palaeontology with lithostratigraphy, palaeoenvironment and paleogeography.

CLO5 Reconstruct paleoenvironmental and ecological set up based on sedimentological and faunal records.

Unit/ Hour	Contents	Mapping with CLO
I/30	Study of clastic and non-clastic rocks in hand specimens	CLO1
	Microscopic examination of important sedimentary rock types	CLO2
	Grain-size analysis by sieving method: plotting of size-distribution data as frequency and cumulative curves	CLO1 CLO3
	Heavy mineral separation; their Microscopic characters, graphic representation and interpretation	CLO3 CLO4
	Assemblages of sedimentary structures and their palaeoenvironmental significance	CLO4
	Palaeo-current analysis	CLO2
	Study of vertical profile sections of some selected sedimentary environment	CLO3
II/30	Separation, processing, wet sieve analyses, preparation of slides of microfossils (demonstration only)	
	Study of some vertebrate fossils of India	CLO1
	Morphology and morphological descriptions of planktonic & benthonic foraminifera, ostracods	CLO2 CLO5
	Morphology of radiolaria, diatoms, pollen and spores	
	Construction of range charts	CLO4
	Study of morphology of brachiopods, bivalves and gastropods, cephalopods, echinoids	CLO5

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), Continuous 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 Trotman, 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=1621058580.7671799_659729003906250
<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.529

L	T	P	Credits
3	0	0	3

Course Title: Principles of Geospatial technology

Total hours: 45

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

CLO1 Identify geospatial tools- remote sensing, GIS and GPS

CLO2 Develop utilization of satellite data in various applications such as geology, hydrogeology, climatology, forestry, town planning etc.

CLO3 Maximize digital image processing technique of satellite data for various applications such as land use/land cover, digital elevation model (DEM).

Unit/ Hour	Contents	Mapping with CLO
I/12	History of Remote Sensing, 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. Learning Activities: Assignment, Take home exercise, peer learning on atmospheric interaction.	CLO1
II/11	Characteristics of resolutions of sensor: Spatial, Spectral, Radiometric and Temporal; Basics of digital Image Processing; image enhancement, radiometric correction, image classification.	CLO1 CLO2

	<p>Elements of Image Interpretation; Visual Image Interpretation; Concept of SAR and UAV.</p> <p>Learning Activities: Assignment on visual interpretation on various aerial photographs and satellite images.</p>	
III/11	<p>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. Introduction to GNSS, concepts and type.</p> <p>Learning Activities: Digitization of various features from base maps/satellite data using GIS based software.</p>	CLO3
IV/11	<p>Applications of remote sensing: in geological mapping; in groundwater exploration; in geomorphic mapping, in identification of rocks, structures and drainages: in mineral exploration. Remote sensing in geo-hazard mapping; environmental geology.</p> <p>Learning Activities: Assignment on digital image processing using Erdas Imagine software.</p>	CLO2 CLO3

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 Stormwatersystems*, 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.555

L	T	P	Credits
3	0	0	3

Course title: Research Methodology

Total hours: 45

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

CLO1 Choose and propose appropriate research methods according to their research aims and objectives

CLO2 Aware the limitations of particular research methods

CLO3 Justify knowledge of the selection of various instruments and sample preparation techniques for addressing specific research problem

CLO4 Develop skills in qualitative and quantitative data analysis and presentation

CLO5 Design advanced critical thinking skills and enhanced writing skills

Unit/ Hour	Contents	Mapping with CLO
I/11	<p>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.</p> <p>Learning Activities: Assignment, take home exercise on identifying research gap from different selected topic, discussion.</p>	CLO1 CLO2
II/11	<p>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</p>	CLO4 CLO5

	<p>plagiarism, ISSN and ISBN numbers, impact factors and citation index of research articles and assessing the quality of research articles.</p> <p>Learning Activities: Assignments and exercise on developing bibliography, referencing.</p>	
III/12	<p>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.</p> <p>Learning Activities: Assignment, take home exercise and student seminar.</p>	<p>CLO1 CLO2 CLO3 CLO4</p>
IV/11	<p>Types of data: primary and secondary data, Source and authenticity of secondary data. Introduction to analytical data treatment and Geochemical modelling. Application of softwares in Earth science (e.g., GCD kit, Petrogram, Melt, Purpel-X, Arc-GIS, Surfer, Amphtab, AmphCalc, Isoplot etc.) 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.</p> <p>Learning Activities: Assignment, take home exercise and student seminar.</p>	

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.572

L	T	P	Credits
3	0	0	3

Course title: Ore Geology

Total hours: 45

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

- CLO1 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
- CLO2 Elaborate overall geometry, zonation and alteration patterns of rock associations to specific classes of metallic mineral deposits.
- CLO3 Evaluate different processes of element enrichment by fluids and melts to form ore bodies.
- CLO4 Assess the formation of ore bodies is important in the current debates about global resources.
- CLO5 Evaluate ore minerals in hand specimen and under the microscope.

Unit/ Hour	Contents	Mapping with CLO
I/11	Modern concept of ore genesis; mode of occurrence of ore bodies – morphology and relationship of host rock and migration, wall-rock alteration. Structural,	CLO1 CLO2

	<p>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.</p> <p>Learning Activities: Assignment, take home exercise, seminar</p>	
II/11	<p>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.</p> <p>Learning Activities: Hands on exercise and group discussion.</p>	CLO3 CLO4
III/12	<p>Study of ore minerals related to the following metals such as 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.</p> <p>Learning Activities: Student seminar, assignment and take home exercise.</p>	CLO2 CLO3 CLO5
IV/11	<p>Fundamentals of coal petrology, peat, lignite, bituminous and anthracite coal. Microscopic constituents of coal. Indian coal deposits. Nuclear and Non-conventional source of energy.</p> <p>Learning Activities: Assignment, take home exercise, seminar.</p>	CLO3 CLO4

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&_afLoop=21339913384895836#!

Course Code: EGS.610

L	T	P	Credits
0	0	4	2

Course Title: Ore Geology (I) and Geospatial technology (II) (Practical)

Total Hours: 60

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

- CLO1** Identify and Inspect common ore minerals in hand samples and under the microscope
- CLO2** Get familiarize with a wide range of mineral deposits, including recognizing the overall geometry, zonation and alteration patterns, grade and tonnage associated with specific classes of metallic mineral deposits
- CLO3** Design various experiments for familiarization with satellite images,

mapping and layout.

CLO4 Apply remote sensing and GIS software for image interpretation

CLO5 Develop the analytical skills for pre-processing, image classification and post-processing.

Unit/ Hour	Contents	Mapping with CLO
I/30	<ul style="list-style-type: none"> • Megascopic study of Indian metallic ores and industrial minerals in hand specimens • Study of optical properties and identification of important ore minerals under ore-microscope. • Preparation of maps showing distribution of metallic and industrial minerals in India and classical world mineral deposits • Estimation of grade, tonnage of ore deposits 	CLO1 CLO2
II/30	<ul style="list-style-type: none"> • Photogeology: Interpretation of aerial photographs. • Stereoscopic Vision: Process of perceiving stereoscopic vision using stereoscope. • Types of Stereoscope: Use of Pocket and Mirror stereoscope • 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) • GIS database mining: point, polygon and line features capture, editing and manipulation, topology building, joining attribute table with spatial data. • GPS mapping: GCP collection, tracking and mapping. 	CLO3 CLO4 CLO5

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

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

Suggested readings:

1. Evans, A.M. (1992). *Ore geology and industrial minerals*, Blackwell

Science.

2. A.E. Annels, (1992). *Mineral deposit evaluation*, Chapman and Hall, London.
3. Sinha, R. K. and Sharma, N.L., 1970. *Mineral economics*, Oxford & IBH.
4. Umeshwar Prasad, 2014. *Economic Geology: Economic Mineral Deposits (Second Edition)*, CBS Publishers & Distributors Pvt. Ltd., New Delhi
5. Kennedy, M. (2013). *Introducing geographic information systems with ArcGIS: A workbook approach to learning GIS*, Wiley & Sons Publications.
6. Chatwal, G. R., Anand, S. K. (2013). *Instrumental Methods of Chemical Analysis*, New Delhi: Himalaya Publishing House.
7. American Public Health Association (APHA) (2012). *Standard method for examination of water and wastewater*, 22nd edn. APHA, Washington.
8. Kennedy, M. (2010). *The Global positioning system and ArcGIS*. Crc Press.
9. Yadav, M. S. (2008). *Instrumental methods of chemical analysis*, New Delhi: Campus Books International.
10. Skoag, D. A., Holler, F. J., Crouch, S. R. (2007). *Principles of Instrumental Analysis*, CENGAGE Learning.
11. Rajvaidya, N., Markandey, D. (2005). *Environmental Analysis and Instrumentation*, APH Publisher.

Web Resources:

- <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/pageView/GSIPublication?_adf.ctrl-state=w5w97un87_5&_afLoop=21339913384895836#!
- <https://www.southalabama.edu/geography/allison/gy303/GY303Lectures.html>
- http://academic.sun.ac.za/natural/geology/undergraduate/modules/G214_course_notes_e.htm
- https://bhuvan.nrsc.gov.in/bhuvan_links.php
- <https://landsat.gsfc.nasa.gov/data>
- <https://www.esri.com/en-us/home>

Course Code: EGS 600

L	T	P	Credits
0	0	8	8

Course Title: Dissertation Part I

Total hours: 120

Course Learning Outcomes (CLO): After completion of the course, students will be able to

- CLO1 Identify the research gap
- CLO2 Potential literature review
- CLO3 Develop hypothesis to solve the problem
- CLO4 Make their own research proposal

Unit/ Hour	Contents	Mapping with CLO
I/120	<p>Each candidate required submitting a dissertation proposal / synopsis of research work carried out towards the fulfillment of his/her M.Sc. dissertation. It will have following components:</p> <ul style="list-style-type: none"> (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 <p>For those opting for short-term Internship / short-term Industrial Training in the third semester should continue the same in the fourth semester. Students are advised to take up the internship/training program during vacations with prior approval from the department.*</p>	CLO1 CLO2 CLO3 CLO4

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.

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

* Students may opt any internship/ academic or industrial training during semester

break with approval from department. Above experiential learning/internship equivalent to 40–45 contact hours will be considered as one credit (as per NCrf guidelines). Evaluation pattern similar to third semester dissertation will apply for internship/industrial training where supervisor and external co-supervisor will award 50% marks; HoD and senior-most faculty will award 50% marks. Student need to submit their report to the department; and present his/her work and attended the viva-voce for the assessment.

Value Added Course

Course Code: EGS.502

Course Title: Geological Mapping

L	T	P	Credits
2	0	0	2

Total Hours: 30

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

- CLO1 Aware the different field accessories in geosciences.
- CLO2 Measure the equipment is confidently at field.
- CLO3 Evaluate the processes and practices of geological mapping.
- CLO4 Assess the processes of sampling techniques.

Unit/ Hour	Contents	Mapping with CLO
I/10	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’. Learning Activities: Take home exercise assignment and group discussion.	CLO1
II/12	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. Learning Activities: Hands on exercise on the application of geological tools and section measurement and group discussion.	CLO2
III/12	Geological mapping procedures: Geological mapping of igneous terrains, geological mapping of sedimentary	CLO3

	terrains. Geological mapping of metamorphic terrains and recording of structural information, preparation of Geological Cross-section. Learning Activities: Hands on exercise on the geological mapping and cross-section preparations, assignments and group discussion.	
IV/13	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. Learning Activities: Hand on exercise on the sampling processes for certain geological analysis, assignments and group discussion.	CLO4

Transactional Modes: Lecture, practical Demonstration, Video demonstrations, 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>

Course Code: EGS.505

L	T	P	Credits
2	0	0	2

Course Title: Environmental Magnetism

Total Hours: 30

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

- CLO1 Understand the basics of Environmental Magnetism and Earth's Magnetic Field.
- CLO2 Understand the magnetic mineralogy and use them as proxy for Environmental Magnetism in various geologic settings.
- CLO3 Undertake the field & laboratory investigations independently and also able to do the data interpretation related to Environmental Magnetism.
- CLO4 Comprehend the basic of soil & rock magnetism and their role in Earth's Environment.

Unit/ Hour	Contents	Mapping with CLO
I/07	Prospect of Environmental Magnetism, Basic Magnetic properties of solids, Effects of crystal size, shape and structure- anisotropy, domain behaviour, Critical grain sizes, Time dependence of magnetisation, Magnetic remanence, Natural magnetic remanences, Laboratory-imparted remanences, Magnetic susceptibility. Learning Activities: Hands on exercise on the application of Environmental Magnetism and group discussion.	CLO 1
II/07	Enviromagnetic Parameters, Enviromagnetic minerals- magnetic mineralogy, Earth's magnetic field, Description of the geomagnetic field, Secular variation, Origin of the geomagnetic field, Palaeomagnetism, Techniques of magnetic measurements, Magnetic cleaning techniques, A basic environmental magnetic kit. Learning Activities: Take home exercise assignment and group discussion.	CLO 1 CLO 2
III/08	Magnetic minerals and environmental systems, Surface processes and magnetic minerals, Magnetism and Pollution, Soil contamination, Magnetic minerals and fluvial processes, Mineral magnetic studies of lake sediments, Magnetic minerals in the atmosphere, Mineral magnetism in marine sediments. Learning Activities: Hands on exercise on the application of Environmental Magnetism on road side soil & dust and group discussion.	CLO 2 CLO 3
IV/08	Basics of rock & soil magnetism, Magnetic properties of soil minerals, Magnetic proxy parameters used in soil magnetic studies, Sampling methodology for magnetic studies, Laboratory instrumentation and methods, The temporal variability of rock magnetic properties, Applications of soil magnetism, Future challenges in soil magnetism studies. Learning Activities: Hand on exercise on the sampling processes for rock and soil related to Environmental Magnetic study, assignments and group discussion.	CLO 4

Transactional Modes: Lecture, Demonstration, Tutorial, Problem solving, Tools used:

PPT, Video, Animation, Whatsapp, Software Tool: Remasoft, Anisoft, Paleomag.

Suggested readings:

1. Robert F. Butler (1992); Paleomagnetism: Magnetic Domains to Geologic Terranes, Blackwell Science Inc.
2. Evans ME, Heller F (2003) Environmental magnetism. Principles and applications of enviromagnetics. Academic Press, Elsevier Science.
3. R.Thompson and F.Oldfield (1986), Environmental Magnetism, Allen and Unwin, London
4. O'Reilly (1984), Rock and Mineral Magnetism, Chapman & Hall, New York.
- 5 Neli Jordanova (2017), Soil Magnetism. Applications in Pedology, Environmental Science and Agriculture. Academic Press, Elsevier Science.
6. Liu, Qingsong & Roberts, Andrew & Larrasoana, Juan & Banerjee, Subir & Guyodo, Yohan & Tauxe, Lisa & Oldfield, Frank. (2012). Environmental Magnetism: Principles and Applications. Reviews of Geophysics. 10.1029/2012RG000393.

Web Resources:

- <https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2012RG000393>
- <https://link.springer.com/article/10.1023/A:1003122305503>
- [https://www.geomorphology.org.uk/sites/default/files/chapters/1.4.1 Environment alMagnetism.pdf](https://www.geomorphology.org.uk/sites/default/files/chapters/1.4.1_Environment alMagnetism.pdf)
- <https://repositorio.usp.br/directbitstream/b50c2c8d-1141-4a69-bcd99b52c2f85c8e/3022611.pdf>
- <https://www.meteo.be/en/research-v1/scope-of-research/kmi-te-dourbes/omgevingsmagnetisme>
- https://openresearchrepository.anu.edu.au/bitstream/1885/69216/2/01_Liu_Envir onmental_magnetism:_2012.pdf
- <https://www.witpress.com/Secure/elibrary/papers/AIR06/AIR06033FU1.pdf>
- <https://www.youtube.com/watch?v=S37xEsdCEq4>
- <https://www.youtube.com/watch?v=jpp672BBknA&t=279s>
- <https://www.youtube.com/watch?v=2uIyUOAC1kU>

Semester IV

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

Course Code: EGS 600

L	T	P	Credits
0	0	40	20

Course Title: Dissertation Part II / Internship / Industrial Training

Total hours: 600

Course Learning Outcomes (CLO): After completion of the course, students

will be able to

- CLO1** Formulate a research problem and identify
- CLO2** Know the limitations and expected outcome
- CLO3** Synthesis and interpret the field and lab data
- CLO4** Draw the Inference from the result
- CLO5** Decipher the future direction of research from the result
- CLO6** Take up research for solving local/regional/global challenges

Unit/ Hour	Contents	Mapping with CLO
I/600	<p>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:</p> <ul style="list-style-type: none"> (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 <p>For those opting for Internship / Industrial Training in the fourth semester should submit their report to the department; and present his/her work and attended the viva-voce for the assessment.</p>	CLO1 CLO2 CLO3 CLO4 CLO5 CLO6

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 workload 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)
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Evaluation pattern similar to fourth semester dissertation will apply for internship/industrial training where supervisor and external co-supervisor will award 50% marks; HoD and senior-most faculty will award 50% marks.

Students may opt any internship/ academic or industrial training during semester break with approval from department. Above experiential learning/internship equivalent to 40–45 contact hours will be considered as one credit (as per NCrf guidelines). 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.