

CENTRAL UNIVERSITY OF PUNJAB



M. Sc. Geology (Two Years)

**3 semester Course work and one Semester
of Research (3 + 1)**

Batch 2026 - 2028

Department of Geology

School of Environment and Earth Sciences

Graduate Attributes

The graduates of this MSc Geology program 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 programs, 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.

Program Outcomes

M.Sc. geology program provides the holistic knowledge about the Earth System Science and its relationship with other branches of science. Thus, by studying this program, students are prepared to pursue higher research in different field of geosciences. The program also makes them ready to prepare for different National and International level competitive examination for different scientific, professions and other posts related to civil and administration, etc. This program trains the students to be ready to become a professional geologist, to assume in different responsible positions in industry or in government agencies; to serve as academician; to pursue research as a career at universities and certain scientific organizations of Nation and International level; and further to become a global citizen.

**Course Structure of the M.Sc. Geology Program with 3 semester Course
work and one Semester of Research (3 + 1)**

Semester-I

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
MEGS.401	Mineralogy and Crystallography	Discipline Specific Core	3	0	0	3
MEGS.402	Mineralogy and Crystallography (Practical)	Ability Enhancement	0	0	4	2
MEGS.403	Structural Geology and Geotectonics	Discipline Specific Core	3	0	0	3
MEGS.404	Structural Geology (Practical)	Ability Enhancement	0	0	2	1
MEGS.413	Applied Paleontology and Paleobiology	Discipline Specific Core	3	0	0	3
MEGS.414	Applied Paleontology and Paleobiology (Practical)	Skill Based	0	0	2	1
MEGS.517	Hydrogeology, Remote Sensing and GIS	Discipline Specific Core	3	0	0	3
MEGS.518	Hydrogeology, Remote Sensing and GIS(Practical)	Ability Enhancement	0	0	4	2
MEGS.596	Field Training	Skill Based	0	0	4	2
	Tutorial	Remedial class	0	2	0	0
Select any one from the following Discipline Elective course ^{\$}						
MEGS.408	Geomorphology	Discipline Elective	3	0	0	3
MEGS.409	Natural Resource Management		3	0	0	3
MEGS.410	Meteorites & Planetary Sciences		3	0	0	3
MEGS.548	Advanced Hydrogeology and Water Management		3	0	0	3
Total			15	2	16	23

Semester-II

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
MEGS.415	Igneous Petrology	<i>Discipline Specific Core</i>	3	0	0	3
MEGS.416	Igneous Petrology (Practical)	<i>Skill Based</i>	0	0	2	1
MEGS.417	Metamorphic Petrology	<i>Discipline Specific Core</i>	3	0	0	3
MEGS.418	Metamorphic Petrology (Practical)	<i>Skill Based</i>	0	0	2	1
MEGS.516	Geochemistry and Isotope Geology	<i>Discipline Specific Core</i>	3	0	0	3
MEGS.520	Entrepreneurship in Geosciences	<i>Entrepreneurship</i>	2	0	0	2
MEGS.536	Solid Earth Geophysics	<i>Ability Enhancement</i>	3	0	0	3
MEGS.539	Ore Geology	<i>Discipline Specific Core</i>	3	0	0	3
MEGS.540	Ore Geology (Practical)	<i>Skill Based</i>	0	0	2	1
	Tutorial	<i>Remedial class</i>	0	2	0	0
Interdisciplinary course						
	Interdisciplinary course#	<i>IDC</i>	2	0	0	2
Total			19	2	6	22

Interdisciplinary course offered by the Department						
MEGS.506	Introduction to Disaster Management	<i>IDC</i>	2	0	0	2
MEGS.507	Introduction to Earth System Science	<i>IDC</i>	2	0	0	2
MEGS.508	Geoheritage and Geotourism	<i>IDC</i>	2	0	0	2

Students, who opt to exit the program with PG-Diploma in Geology at the end of the 1st year, need to complete internship/mini project/industrial training/MOOC course of minimum 2 credits in addition to above courses.

Semester – III

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
MEGS.519	Analytical Techniques and Geo-Statistics	Ability Enhancement	3	0	0	3
MEGS.544	Indian Stratigraphy	Discipline Specific Core	3	0	0	3
MEGS.545	Sedimentology	Discipline Specific Core	3	0	0	3
MEGS.538	Sedimentology (Practical)	Skill Based	0	0	2	1
MEGS.546	Engineering Geology	Ability Enhancement	2	0	0	2
Select any one from the following Discipline Elective course\$						
MEGS.521	Mineral Exploration and Petroleum Geology	Discipline Elective	3	0	0	3
MEGS.522	Oceanography		3	0	0	3
MEGS.523	Watershed Management		3	0	0	3
Select any one from the following Discipline Elective course\$						
MEGS.541	Environmental Geology	Discipline Elective	3	0	0	3
MEGS.542	Quaternary Geology		3	0	0	3
MEGS.543	Geomagnetism		3	0	0	3
MEGS.547	Research Methodology in Geoscience		3	0	0	3
	Tutorial	Remedial class	0	2	0	0
Select Any One Value Added Course (VAC)\$						
MEGS.511	Geological Mapping	VAC	2	0	0	2
Total			19	2	2	20

Semester – IV

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
MEGS.599	Dissertation	Dissertation	0	0	40	20
Total			0	0	40	20
Grand total for all semesters (I+II+III+IV)						
			50	6	66	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.

→ **Students, who opt to exit the program with PG-Diploma in Geology at the end of the 1st year, need to complete internship/mini project/industrial training/MOOC course of minimum 2 credits in addition to above courses.**

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→ 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).

→ 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 carryout 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 following 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 up to 100%, Objective up to 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 Entrepreneurship Course: Total Marks 100

Mid Semester Test (50 Marks): Subjective test up to 100%, Objective up to 30% and preparing a business plan/innovative idea.
 End semester exam (50 marks): Subjective Test up to 100%, Objective up to 30% [15 marks]

Evaluation Criteria for Dissertation/ Field training / specialized courses are given in the detailed syllabus.

Examination pattern from 2025-2026 sessions onwards:

Core, Discipline Elective, and Compulsory Foundation Courses			IDC, VAC, Entrepreneurship, Innovation and Skill Development Courses (≤ 2 credits) or any other theory course of ≤ 2 credits	
	Marks	Evaluation	Marks	Evaluation
Internal Assessment	25	Various methods	-	-
Mid-semester test (MST)	25	Descriptive	50	Descriptive (up to 100%) Objective (up to 30%)
End-semester exam (ESE)	50	Descriptive (up to 100%) Objective (up to 30%)	50	Descriptive (up to 100%) Objective (up to 30%)

Dissertation (Fourth Semester)		
	Marks	Evaluation
Supervisor/ co-supervisor(s)	50	Continuous assessment (regularity in work, mid-term evaluation) dissertation report, presentation, final viva-voce
External expert	50	Report of dissertation (25), presentation (10), novelty/originality (5) and final viva-voce (10).

Marks for internship shall be given by the supervisor/internal mentor and external mentor.

Semester – I

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
MEGS.401	Mineralogy and Crystallography	Discipline Specific Core	3	0	0	3
MEGS.402	Mineralogy and Crystallography (Practical)	Ability Enhancement	0	0	4	2
MEGS.403	Structural Geology and Geotectonics	Discipline Specific Core	3	0	0	3
MEGS.404	Structural Geology (Practical)	Ability Enhancement	0	0	2	1
MEGS.413	Applied Paleontology and Paleobiology	Discipline Specific Core	3	0	0	3
MEGS.414	Applied Paleontology and Paleobiology (Practical)	Skill Based	0	0	2	1
MEGS.517	Hydrogeology, Remote Sensing and GIS	Discipline Specific Core	3	0	0	3
MEGS.518	Hydrogeology, Remote Sensing and GIS(Practical)	Ability Enhancement	0	0	4	2
MEGS.596	Field Training	Skill Based	0	0	4	2
	Tutorial	Remedial class	0	2	0	0
Select any one from the following Discipline Elective course ^{\$}						
MEGS.408	Geomorphology	Discipline Elective	3	0	0	3
MEGS.409	Natural Resource Management		3	0	0	3
MEGS.410	Meteorites & Planetary Sciences		3	0	0	3
MEGS.548	Advanced Hydrogeology and Water Management		3	0	0	3
Total			15	2	16	23

Course Code: MEGS.401

Course Title: Mineralogy and Crystallography

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: 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	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. Learning Activities: Hands on exercise of mineral specimens, Use of stick-ball model to check bonding and packing.	CLO1 CLO4
II/11	Crystallography: Crystal Morphology, Crystal Symmetry, Crystallographic Axes, Crystal systems, Introduction to symmetry, 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. Learning Activities: Hands on exercise of crystal models, drawing of stereographic projections, Powder XRD data analysis.	CLO2 CLO4
III/12	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,	CLO4

	determination of optic sign, 2V and 2E. Learning Activities: Use of petrological microscope and analyzing each parameter.	
IV/12	A detailed study of the important silicates (listed below) mineral (a) Nesosilicates/Orthosilicates: olivine group, garnet group, aluminosilicate group, humite group, zircon. (b) Sorosilicates: melilite, axinite and epidote group. (c) Cyclosilicates: beryl, tourmaline, cordierite, eudialyte (d) Inosilicates: pyroxene group, amphibole group and wollastonite (e) Phyllosilicates: mica group, kaolinite-serpentine group, talc-pyrophyllite, chlorite, smectite. (f) Tectosilicates: silica group, feldspar group, zeolite and feldspathoid Learning Activities: Mini project and student presentation on different silicate and non-silicate minerals, Group discussion	CLO2 CLO3 CLO4

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. William D. Nesse & Graham B. Baird. 2025. *Introduction to Mineralogy*. Oxford University Press Inc. ISBN13: 9780197614600.
3. Perkins Dexter, 2012. *Mineralogy*, Pearson Education.
4. 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.
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, ISBN: 9780199827381.
8. William Nesse, 2012. *Introduction to Optical Mineralogy*, Oxford University Press, ISBN: 9780199846276.
9. Cornelius Klein, 2007. *Minerals and Rocks-Exercises in Crystallography, Mineralogy and Hand Specimen Petrology*, Wiley publisher.
10. Berry, L.G., Mason, B. and Dietrich, R.V., 2004. *Mineralogy*, CBS Publishers, ISBN 10: 8123911483, ISBN 13: 9788123911489.

11. Introduction to the Rock-Forming Minerals by Deer W.A., Howie R.A. and Zussman, J., 2013, Mineralogical Society of America.
12. Gribble, 2005. *Rutley's Elements of Mineralogy*, CBS Publishers, ISBN-10: 8123909160.
13. 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: MEGS.402

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.

Web Resources: <http://webmineral.com/>
<https://www.mindat.org/>
<https://sketchfab.com/tags/minerals>
<http://www.minsocam.org/>

Course Code: MEGS.403

L	T	P	Credits
3	0	0	3

Course Title: Structural Geology and Geotectonics

Total Hours: 45

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

CLO1: Determine the geological structures related to stress and strain.

CLO2: Develop the idea regarding rock failures in compressional and extensional regime.

CLO3: Understand about the structural features formed due to folding and faulting.

CLO4: Build concepts on crust building process in various geological time.

CLO5: Differentiate between the various elements of plate tectonics.

CLO6: Recognize the elements of paleomagnetism and appreciate the geodynamic evolution of the Great Himalaya.

Unit/ Hour	Contents	Mapping with CLO
I/10	Structural elements and measurements, Stress and analysis of stress in two and three dimensions; Plane stress analysis and Mohr stress circle, and its relationship with faulting and fracture mechanics; Theory of rock failure: brittle failure – shear and tensile failures. Fault plane solution; Fault related folds; Ductile deformation; Dynamic recrystallization; Pure shear vs. simple shear deformation; Strain analysis– finite and infinitesimal, homogeneous and inhomogeneous strains; Progressive deformation. 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.	CLO1 CLO2
II/15	Mechanism of folding, Classification of folds, fold development and distribution of strains in folds; Buckling and shearing process; Analysis and interpretation of superimposed folding. Mechanics and geometric aspects of thrust, normal and strike-slip faults, and associated structural features. Planar and linear fabrics (Foliation and Lineation) in deformed rocks: description, classification, genesis and significance. Brittle and ductile shear zones, Geometry and products of shear zones, Mylonites and Cataclasites. Learning Activities: Assignment, student Seminar, group discussion on rock deformation patterns at different regimes.	CLO2 CLO3
III/10	Crustal evolution: Crust building process during Archean and Proterozoic Era; Archean Nuclei and their geotectonic appraisal; Concepts of Mobile Belts; Indian Mobile Belts; Major tectonic features of the oceanic and continental crust; Seafloor spreading and plate tectonics. Learning Activities: Assignment, Group discussions, seminars on the geotectonic features of different cratons and mobile belts in India.	CLO4 CLO5
IV/10	Extensional tectonics: Mantle convection cells, block rotation models, Basin and ridge provinces, fault scarp retreat; Magnetic polarity on	CLO5 CLO6

the ocean floor; Transform and transcurrent faults; Euler pole and its significance; Concepts of declination and inclination; Apparent polar wandering path; Pull-apart basins; Compressional tectonics: Flip-flop subduction, Passive and active continental margin, Magmatic polarity at the subduction zone; Stability of Triple junction; Geodynamic Evolution of Himalaya through time. Geodynamics of the Indian plate.

Learning Activities: Student seminar, group discussion on global geodynamics and orogeny.
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Transactional Modes: Lecture, Demonstration, Lecture cum demonstration, Project Method, Inquiry training, Seminar, Group discussion, Blended learning, flipped learning, focused group discussion, Team teaching, Field visit, Brain storming, Mobile teaching, Collaborative learning, E-tutoring, Problem solving.

Suggested Readings:

1. Marland P. Billings, 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.
13. Passchier, C. W. & Trouw, R. A. J. 2006. *Microtectonics*, 2nd ed. xvi + 366 pp. Berlin, Heidelberg, New York: Springer-Verlag.

Web Resources:

https://www.gsi.gov.in/webcenter/portal/OCBIS/pageQuickLinks/pageTIStructuralGeology?_afrLoop=21149378600749056&_adf.ctrlstat e=zil7ujw74_38#!%40%40%3F_afrLoop%3D21149378600749056%2 6_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/previewhttps://ocw.mit.edu/courses/earth-atmospheric-and-planetary-sciences/12-113-structural-geology-fall-005/
<https://uh.edu/~jbutler/anon/anoncoursestructure.htm>
 (1233) STRUCTURAL GEOLOGY (Prof. Santanu Misra, IIT Kanpur) - YouTube

Course Code: MEGS.404

L	T	P	Credits
0	0	2	1

Course Title: Structural Geology (Practical)

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 Structural geology.

CLO2: Solve various stereo net problems and construct stereographic projection 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 the 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, Photoshop.

Evaluation Criteria:

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

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. 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/\(1233\)](https://geologyscience.com/applied-geology/hydrogeology/(1233))
[STRUCTURAL GEOLOGY \(Prof. Santanu Misra, IIT Kanpur\) - YouTube](#)

Course Code: MEGS.413

L	T	P	Credits
3	0	0	3

Course Title: Applied Paleontology and Paleobiology

Total hours: 45

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

- CLO1** Interpret the basic idea about the process of fossilization, the origin and the diversification of life. Knowledge of important invertebrate fossil fauna.
- CLO2** Knowledge of important invertebrate fossil fauna.
- CLO3** Basic ideas about the evolution of vertebrate life and the important fossil flora of India.
- CLO4** Understanding important groups of microfossils, their significance in understanding paleoecology, paleoclimate and paleoenvironments
- CLO5** Application of fossils in solving geological problems in space and time, Recent developments in understanding the evolution of biota.
- CLO6** Application of fossils in climate studies and hydrocarbon exploration.

Units	Contents	Mapping with CLO
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I/10	Taphonomy and its application; Condition and modes of fossilization; Origin and evolution of life; Concept of species and speciation; Precambrian microbiota and its significance Shell morphology, geological distribution and evolutionary trend of Bivalvia, Gastropoda, Brachiopoda, Cephalopoda, Echinoidea, and Trilobites. Learning Activities: Sessions on the evolution of life, assignments, take-home exercises, peer learning, seminars, and group discussions.	CLO1 CLO2
II/10	Vertebrate life through the ages; Evolution and extinction of dinosaurs with emphasis on Indian dinosaurs, Evolution of <i>Homo</i> and Indian record; Approach to palaeobotany. Pre-Gondwana and Gondwana flora and the significance of Gondwana flora in paleoclimatic studies; Indian Paleogene flora. Learning Activities: Mini projects on vertebrate life, assignment, home exercise, peer learning, seminar and group discussion.	CLO3
III/15	Types of Microfossils; Introduction to phytoliths and their significance in geosciences; Foraminifera: morphology of foraminifers and their role in understanding palaeoceanography, paleoclimate and biostratigraphy; Basic morphology of spores/pollen; Concept of palynofacies and its application; Introduction to dinoflagellates and acritarchs: their significance in stratigraphy and shoreline studies; Introduction to ostracods and their significance in geoscience; Calcareous nanoplanktons and their significance in paleoecological studies. Learning Activities: Assignment, take home exercise, peer learning, seminar and group discussion.	CLO4
IV/10	Micro and macroevolution; Introduction to phylogenetic analysis and molecular biology; Dendrochronology and its application; Application of plants in paleoclimate and depositional environment interpretation; Application of oxygen and carbon isotopes in climate studies; Response of fossils to Milankovitch and Wolf Gleissberg solar cycles; Major extinction events and their impact on biodiversity; Measures of biodiversity sustainability on the Earth. Learning Activities: Exercise on the application of fossils and correlation with other co-relatable sections, student seminar.	CLO5 CLO6

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).

L	T	P	Credits
0	0	2	1

Suggested Readings

1. Clarksons, E.N.K. (1998) *Invertebrate Paleontology and Evolution*, Allen and Unwin London.
2. Raup, D.M. and Stanley, S.M. (1985) *Principles of Paleontology*, CBS Publishers, New Delhi 2. Taylor, T.N., E.L. Taylor and M. Krings. 2009. *Palaeobotany- The Biology and Evolution of Fossil Plants*. Elsevier.
3. Anis Kumar Ray (2016) *Fossils in Earth Sciences* PHI learning Pvt ltd, pp 443
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. Stewart, W.N. and Rothwell, G.W. 1993. *Paleobotany and the Evolution of Plants*. Cambridge University Press; 2nd edition
8. 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.
9. Stoermer, E.F. and Smol, J.P. (1999)(Eds.) *The Diatoms: Applications for the Environmental and Earth Sciences*, Cambridge University Press, 469p
10. Kathal, P.K. (4011) *Applied Geological Micropaleontology*, Scientific Publishers, Jodhpur.
11. Saraswati, P.K. and Srinivasan, MS (2016) *Micropaleontology Principles and Application*, Springer. pp 219.
12. Braiser, M. D., 1980. *Microfossils*, George Allen and Unwin.
13. Shrock, N., 2005. *Principles of Invertebrate Paleontology*, CBS publication.

Web Resource

<https://www.ucl.ac.uk/GeolSci/micropal/welcome.html>
https://www.sciencedaily.com/news/fossils_ruins/paleontology
<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>
<https://www.priweb.org/science-education-programs-and-resources/digital-atlas-of-ancient-life>

Course Code: MEGS. 414

Course Title: Applied Paleontology and Paleobiology (Practical)

Total Hours: 30

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

- CLO1:** Understand techniques in the extraction of microfossils and apply the sample preparation methods for the separation of fossils. Cataloguing of samples for research and industrial applications.
- CLO2:** Understand modes of preservation of fossils.
- CLO3:** Understanding the morphology of important microfossils.
- CLO4:** Knowing the morphology of important fossils of invertebrates and plants for paleoenvironment and paleoclimatic interpretation

Unit/ hour	Contents	Mapping with CLO
I/30	Techniques for the processing of microfossils	CLO 1
	Study of modes of preservation of fossils.	CLO 2
	Morphology and description of foraminifera	CLO 3
	Morphology and description of pollen and spores	CLO 3
	Study of the Morphology of Gastropods and bivalves	CLO 4
	Study of the Morphology of Cephalopods and Trilobites	CLO 4
	Study of the Morphology of Brachiopods and Echinoids.	CLO 4
	Study of important plant fossils	CLO 4

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

Suggested Readings:

1. Henry Wood, 2004. *Paleontology Invertebrate*, CBS Publication
2. Bignot, G., 1985. *Elements of Micropaleontology*, Graham and Trotterman, London.
3. Haq and Boersma, 1978. *Introduction to Marine Micropaleontology*, Elsevier.
4. Smith, A. B., 1994. *Systematics & Fossil Record-Documenting Evolutionary Patterns*, Blackwell publisher.
5. Jones, R. W., 1996. *Micropaleontology in Petroleum exploration*, Clarendon Press Oxford.
6. Saraswati, P.K. and Srinivasan, MS (2016) *Micropaleontology Principles and Application*, Springer. pp 219.
7. Kathal, P.K. 2011 *Applied Micropaleontology*, Scientific Publishers, Jodhpur.
8. 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://serc.carleton.edu/research_education/paleontology/general.html
https://www.palaeontologyonline.com/?doing_wp_cron=1621058580.7671799659729003906250
<https://www.priweb.org/blog-post/learn-at-home>
<https://www.nationalgeographic.org/encyclopedia/paleontology/>
<https://naturalhistory.si.edu/education/teaching-resources/paleontology>

<https://www.priweb.org/science-education-programs-and-resources/digital-atlas-of-ancient-life>

Course Code: MEGS.517

L	T	P	Credits
3	0	0	3

Course Title: Hydrogeology, Remote Sensing and GIS

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 the hydrological cycle, groundwater flow pattern in different terrains.
- CLO2:** Estimate quantity and assess quality aspects of groundwater for better management.
- CLO3:** Formulate the evolution of water chemistry through hydro-geochemical processes across different terrains.
- CLO4:** Develop utilization of satellite data in various applications such as geology, hydrogeology, climatology, forestry, town planning, etc.
- CLO5:** Maximize digital image processing techniques of satellite data for various applications such as land use/land cover, digital elevation model (DEM).

Unit/ Hour	Contents	Mapping with CLO
I/11	Hydrosphere and groundwater system: hydrological cycle; groundwater origin, type, and occurrences. Scope and importance of hydrogeology. Occurrence, distribution, and quality of groundwater: vertical distribution of subsurface water. Principles of groundwater flow: Darcy's law and its validity, concept of permeameter, water table, and piezometric surface. Tracing of groundwater movement with flow nets; Pumping tests: principles, types of pumping tests, procedures, data analysis. Learning Activities: Design a model of the hydrologic cycle and the concept of Darcy's law.	CLO1 CLO2
II/12	Hydrologic properties of rocks: porosity, permeability, hydraulic conductivity, storativity. Types of aquifers: unconfined and confined aquifers. Behavior of sedimentary, crystalline, and volcanic rocks as aquifers. Impact of climate change in aquifer groundwater system. Groundwater quality assessment: the concept of clean water; hydrochemical parameters; hydrochemical data presentation and data analysis. Concept and evaluation of hydrochemical facies. Use of environmental isotopes in groundwater studies.	CLO1 CLO2 CLO3

	Learning Activities: Group discussion on local major aquifer types and groundwater occurrence.	
III/11	Fundamentals of Remote Sensing: Electromagnetic spectrum; scattering, absorption, refraction, path radiance, reflection, transmission, absorption. Energy-Earth interaction. Atmospheric windows. types of satellites: Polar sun-synchronous, geo-stationary. Platforms: types and their orbital characteristics; sensor types: active and passive; sensor systems: whiskbroom and push broom. Characteristics of resolutions of sensor: spatial, spectral, radiometric, and temporal; Basics of digital Image Processing; image enhancement, radiometric correction, image classification. Learning Activities: Group discussion on recent developments in satellite technology, exercises on satellite data mining from open sources, and development of different thematic layers using open data sources.	CLO4 CLO5
IV/11	Applications of Remote Sensing and GIS in Geology: Concept and applications of GIS. Geographic information database management system: datatypes (map, attributes, image data) and structure; spatial and non-spatial data. Applications of remote sensing: in geological mapping; in groundwater exploration; in geomorphic mapping, in identification of rocks, structures, and drainages; in mineral exploration. Learning Activities: Brainstorming on the impacts of engineering projects on the environment 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, Brainstorming, 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. Singh, C.K. (2018). *Geospatial Applications for Natural Resources Management*, CRC Press.
7. Shellito, B. (2017). *Geospatial Technologies*, 4th edition, W. H. Freeman Publisher.
8. Shamsi, U.M. (2012). *GIS Applications for Water, Wastewater, and Stormwater Systems*, CRC Press.
9. Bhatt, B. (2011). *Remote Sensing and GIS*, New Delhi: Oxford University Press.
10. Skidmore, A. (2010). *Environmental Modeling with GIS and Remote Sensing*, New Delhi, CRC Press.
11. Abbasi, T. (2010). *Remote Sensing, GIS and Wetland Management*, Discovery Publishing House.
12. Lillisand, T.M., Keifer, R.W. (2007). *Remote Sensing and Image Interpretation*, USA: John Wiley and Sons.
13. Joseph, G. (2003). *Fundamentals of Remote Sensing*, Hyderabad: Universities Press.
14. Chang, K. (2002). *Introduction to Geographic Information Systems*, USA: Tata McGraw-Hill.
15. Barrett, E.C. and Curtis, L.F. (1999). *Introduction to Environmental Remote Sensing*, USA: Chapman and Hall Publishers.
16. Curran, P.J. (1988). *Principles of Remote Sensing*, ELBS: Harlow, Longman Scientific and Technical.

Web Resources:

<https://iah.org/education/>
<https://www.routledge.com/Hydrogeology>
<https://www.youtube.com/watch?v=G7CnE5NBxZs>
<https://geologyscience.com/applied-geology/hydrogeology/>
https://bhuvan.nrsc.gov.in/bhuvan_links.php
<https://landsat.gsfc.nasa.gov/data>
<https://www.esri.com/en-us/home>

Course Code: MEGS.518

L	T	P	Credits
0	0	4	2

Course Title: Hydrogeology, Remote Sensing and GIS (Practical)

Total hours: 60

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

- CLO1:** Construct water table maps for evaluation of groundwater flow and discharge site identification
- CLO2:** Maximize exploration of groundwater resources using hydrogeology and GIS GIS-integrated approach
- CLO3:** Assess the quality of groundwater for different uses and top propose the development and management of groundwater resources
- CLO4:** Design various experiments for familiarization with satellite images mapping, and layout
- CLO5:** Apply remote sensing and GIS software for image interpretation
- CLO6:** Develop the analytical skills for pre-processing, image classification, and post-processing

Unit/ Hour	Contents	Mapping with CLO
I/30	- The following exercise will be conducted in the lab - Water table contour mapping - Interpretation of flow network: groundwater flow movement, delineation of recharge and discharge areas - Representation of hydrochemical data in various graphical diagrams and interpretation - Evaluation of hydrochemical facies in the Trilinear diagram and interpretation	CLO1 CLO2 CLO3
II/30	- Photogeology: Interpretation of aerial photographs. - Stereoscopic Vision: The Process of perceiving stereoscopic vision using a stereoscope. - Types of Stereoscopes: Use of the 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 - GIS database mining: point, polygon, and line features capture, editing and manipulation, topology building, joining attribute table with spatial data.	CLO4 CLO5 CLO6

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), Continuous assessment (30 marks), Lab record (10 marks), Viva (10 marks).

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

Web Resources:

<https://iah.org/education/><https://www.routledge.com/Hydrogeology>
<https://www.youtube.com/watch?v=G7CnE5NBxZs><https://geologyscience.com/applied-geology/hydrogeology/>
<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: MEGS.596

L	T	P	Credits
0	0	4	2

Course Title: Field Training**Total Hours: 60****Course Learning Outcomes (CLO):** Upon successful completion of this course, the student will be able to**CLO1:** Apply geological theories and classroom knowledge to field

observations and develop essential geological field skills.

CLO2: Identify and classify different rock types, minerals, fossils, and geological structures in the field and interpret the geological processes responsible for their formation.

CLO3: Analyze and document structural and stratigraphic features, including folds, faults, joints, lithological contacts, and depositional structures, during geological field investigations.

CLO4: Prepare geological maps, field sketches, lithologs, and geological cross-sections using standard field techniques and geological tools.

CLO5: Collect, record, and interpret field data systematically and communicate geological findings through field reports and presentations.

Unit/ Hour	Contents	Mapping with CLO
I/60	Field training will be conducted during this semester or in the semester break between I and II or II and III at a suitable time. Geological field training will be carried out according to the guidelines of the University at selected sites for about two weeks.	CLO1 CLO2 CLO3 CLO4 CLO5

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 presentation during the end semester exam. Prior to fieldwork, a literature review on the selected/proposed field area will be carried out by the students, and basic information 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 a seminar, report writing, and partial lab work/mathematical modelling work to fulfill the credit requirement, and a separate evaluation criterion 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 (5marks), 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.

Tutorial/ Remedial Class

L	T	P	Credits
0	2	0	0

A two-hour non-credit tutorial class is designed for remedial teaching. Scheduled classes will be assigned in the timetable. As per the requirement of students, remedial classes will be conducted in these periods.

Discipline Elective course

Course Code: MEGS.408

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 a relevant solution to elucidate geomorphologic problems.

Unit/ Hours	Content	Mapping with CLO
I/11	Historical development in geomorphology, geomorphic processes: weathering, mass movement, erosion, transportation and deposition, landforms: Characterization and process involved in their formation. Learning Activities: Design a note on the concept of origin, the evolution of landforms, historical development, scope, etc.	CLO1, CLO2
II/12	Geomorphic processes and landforms- fluvial, glacial, aeolian, coastal, and karst. River forms and processes- streamflow, Environmental change- causes, effects on processes and landforms. Learning Activities: Brainstorming on geomorphic processes for landform development, landforms under different environments, etc.	CLO3
III/12	Physiographic division of India, Landscape evolution and the involved process. Concept of Form-Process relationship in landscape evolution, Submarine relief Learning Activities: Design a conceptual model on the importance of topography, DEM, and maps in geomorphology.	CLO1, CLO4
IV/10	Definition and scope of tectonic geomorphology, Eustatic sea-level change and impact of coastal geomorphology, Applications of geomorphology in mineral prospecting, civil engineering, hydrology, and environmental studies. Learning Activities: Student seminar on recent advancements 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. *Fundamentals 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. Mc L.D. Duff, 1993. *Holmes ' Principles of Physical Geology*, Chapman and Hall, London.
8. R.J. Allison, 2002. *Applied Geomorphology: Theory and Practice*, Wiley.
9. Douglas W.B., and Robert S.A., 2011. *Tectonic Geomorphology*, Wiley-Blackwell; ISBN-13:978-1444338867
10. Robert S.A., and Suzanne P.A., 2010. *Geomorphology: The Mechanics and Chemistry of Landscapes*, Cambridge University Press.
11. Paul R.B., and David R.M., 2013. *Key Concepts in Geomorphology*, W.H. Freeman.
12. Sharma, H.S., 1991. *Indian Geomorphology*, Concept Publishing Co., New Delhi.
13. Mahapatra, G.B., 2008. *Text book of Physical Geology*, CBS Publishers & Distributors Private Ltd.

Web Resources:

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

Course Code: MEGS.409

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 : Appraisal of the types of natural resources available and their relation to geological processes

CLO2 : Invention of new ideas to conserve, manage, and develop the Earth's natural resources available

CLO3 : Evaluation of the validity and limitations of new scientific theories and their claims about the environment.

CLO4 : Appraising the interactions among physical, biological, chemical, and human components of our environment.

Units/ Hours	Content	Mapping with CLO
I/11	Natural resources: Classification of natural resources; natural resource degradation and conservation; Environmental impacts of resource depletion. Forest Resources: Forest cover of India and world; forest types, Conservation of forests, Exploitation of forest resources, Afforestation, Desertification, Forest policy Learning Activities: Develop a sustainable model on the natural resources of India. Presentation on the forest resources of India	CLO1, CLO2
II/12	Water Resources: Surface, groundwater, resources assessment and utilization; Rivers and Lakes in India; hydrological cycle; Groundwater depletion; Water logging and salinity; Water Conservation and management techniques; Rainwater harvesting; Watershed management; Restoration of Lakes; Interlinking of rivers; conflicts over water. Learning Activities: Design a concept model on water resources, drought, flood issues of India, restoration etc.	CLO1, CLO2
III/12	Land resources: Land degradation due to mining, exploration, industrialization, irrigation, and natural disasters; Soil erosion, loss of soil fertility, Soil conservation methods; Learning Activities: Group discussion on organic farming, green manuring, etc., to highlight the salient points	CLO2, CLO3
IV/10	Mineral resource: Type of mineral resources, reserve, policy, and management. Rock and other building materials. Ocean resources, International territorial policy, and geopolitics. Mineral resource management using geospatial technologies. SDG goals. Learning Activities: Group discussion on the ocean resources of India. Student seminar.	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 the 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: MEGS.410

L	T	P	Credits
3	0	0	3

Course Title: Meteorites and Planetary Science**Total Hours: 45****Course Learning Outcomes (CLO):**

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

- CLO1:** Understand thoroughly the different types of meteorites, their classification, composition, and physical characteristics.
- CLO2:** insights into the processes that govern the formation and evolution of planetary bodies, including asteroids and other celestial objects.
- CLO3:** learn how meteorites provide valuable geological records of early solar system history and planetary differentiation processes.
- CLO4:** enhance their critical thinking abilities by evaluating the significance of meteorite research in addressing broader questions in planetary science and geology.

Unit/Hour	Contents	Mapping with CLO
I/12	Introduction to meteorites, Classification of meteorites, Oxygen isotopes, Asteroids, Asteroid-meteorite connection, chondritic and differentiated meteorites Learning Activities: Assignment, take-home exercise, and	CLO1 CLO3 CLO4

	student seminar.	
II/12	Chondrules and Calcium-aluminum-rich inclusions (CAIs), Volatility and metal fractionation in the solar nebula, Early timescales, Formation of Moon. Learning Activities: Assignment, student seminar, and group discussion.	CLO1 CLO2 CLO3 CLO4
III/11	Stellar life cycles and nucleosynthesis, pre-solar grains, Organic matter in meteorites, Differentiation Learning Activities: Assignment, student seminar, and group discussion.	CLO2 CLO3 CLO4
IV/10	Thermal models, Impacts and collisions, Lunar meteorites, Martian meteorites, Lunar Geology, Martian Geology. Learning Activities: Assignment, student seminar, and group discussion.	CLO2 CLO3 CLO4

Transactional Modes: Lecture, Demonstration, Lecture cum demonstration, Project Method, Seminar, Group discussion, Blended learning, flipped learning, Focused group discussion, Brain storming, Mobile teaching, Collaborative learning, E-tutoring, Problem solving.

Suggested Readings:

1. Krot A.N., K. Keil, E.R.D. Scott, C.A. Goodrich and M.K. Weisberg (2014) Classification of meteorites and their genetic relationships. In Treatise on Geochemistry, 2nd Ed., Elsevier, pp. 1-63. classification.
2. Gaffey M.J., E.A. Cloutis, M.S. Kelley and K.L. Reed (2002) Mineralogy of asteroids. In Asteroids III (eds. W.F. Bottke, Jr., A. Cellino, P. Paolicchi, and R. Binzel), pp. 183-204.
3. Burbine T.H., T.J. McCoy, A. Meibom, B. Gladman and K. Keil (2002) Meteoritic parent bodies: Their number and identification. In Asteroids III (eds. W.F. Bottke, Jr., A. Cellino, P. Paolicchi, and R. Binzel), pp. 653-667.
4. Hewins R.H. (1997) Chondrules. In Ann. Rev. Earth Planet. Sci. 25, 61-83. A short review of evidence pertaining to chondrules and what they might tell us about the solar nebula.
5. MacPherson G. J., S.B. Simon, A.M. Davis, L. Grossman and A.N. Krot (2005) Calcium-aluminum-rich inclusions: major unanswered questions. In Chondrites and the Protoplanetary Disk (eds. A.N. Krot, E.R.D. Scott, and B. Reipurth), pp. 225-250. ASP Conference Series, vol. 341. Astronomical Society of the Pacific: San Francisco.
6. Jones R.H., T. Lee, H.C. Connolly Jr., S.G. Love and H. Sheng (2000) Formation of chondrules and CAIs: Theory vs. observation. In Protostars and Planets IV (eds. V. Mannings, A.P. Boss, S.S. Russell), pp. 927-962.
7. Davis A. (2006) Volatile evolution and loss. In Meteorites and the Early Solar System II (eds. D.S. Lauretta and H.Y. McSween Jr.), pp. 295-307.
8. Wood J. (2005) The chondrite types and their origins. In Chondrites and the Protoplanetary Disk (eds. A.N. Krot, E.R.D. Scott, and B. Reipurth), pp. 953-971. ASP Conference Series, vol. 341. Astronomical Society of the Pacific: San Francisco.

9. Dauphas N. and M. Chaussidon (2011) A perspective from extinct radionuclides on a young stellar object: The sun and its accretion disk. In *Ann. Rev. Earth Planet. Sci.* 39, 351-386.
10. Lugmair G.W. and A. Shukolyukov (2001) Early solar system events and timescales. *Meteorite. Planet. Sci.* 36, 1017-1026.
11. Huss G.R., A.E. Rubin and J.N. Grossman (2006) Thermal metamorphism in chondrites. In *Meteorites and the Early Solar System II* (eds. D.S. Lauretta and H.Y. McSween Jr.), pp. 567-586. University of Arizona Press: Tucson.
12. Brearley A. (2006) The action of water. In *Meteorites and the Early Solar System II* (eds. D.S. Lauretta and H.Y. McSween Jr.), pp. 587-624. University of Arizona Press: Tucson.
13. Clayton D.D. and L.R. Nittler (2004) Astrophysics with presolar stardust. In *Annu. Rev. Astron. Astrophys.* 42, 39-78.
14. Gilmour I. (2005) Structural and isotopic analysis of organic matter in carbonaceous chondrites. In *Meteorites, Comets, and Planets* (ed. A.M. Davis), Ch. 1.10, pp. 269-290. Elsevier: Amsterdam.
15. McSween H.Y.Jr. (1989) Achondrites and igneous processes on asteroids. *Ann. Rev. Earth Planet. Sci.* 17, 119-140.
16. Wasson J.T. (1985) Iron meteorites: Evidence for and against core origins. In *Meteorites- Their Record of Early Solar-system History*, Ch. IV, pp.76-99. W.H. Freeman & Co.: New York.
17. McSween H.Y., Jr, A. Ghosh, R.E. Grimm, L. Wilson, E.D. Young (2002) Thermal evolution models of asteroids. In *Asteroids III* (eds. W.F. Bottke, Jr., A. Cellino, P. Paolicchi, R.P. Binzel, pp. 559-571. University of Arizona Press: Tucson.
18. Stöffler D., A. Bischoff, V. Buchwald and A.E. Rubin (1988) Shock effects in meteorites. In *Meteorites and the Early Solar System* (eds. J.F. Kerridge and M.S. Matthews), pp. 165-202.
19. Scott E.R.D. and R.S. Rajan (1981) Metallic minerals, thermal histories and parent bodies of some xenolithic, ordinary chondrite meteorites. *Geochim.Cosmochim.Acta* 45, 53-67.
20. Udry A. et al. (2020) What martian meteorites reveal about the interior and surface of Mars. *JGR Planets* 125, <https://doi.org/10.1029/2020JE006523>.

Web Resources:

<https://meteorites.pdx.edu/>

<https://web.pdx.edu/~ruzickaa/meteorites/gallery/gallery.html>

Course Code: MEGS. 548

L	T	P	Credits
3	0	0	3

Course Title: Advanced Hydrogeology and Water Management

Total hours: 45

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

CLO1: Evaluate the significance of groundwater in the hydrological cycle and analyze groundwater flow patterns across various terrains.

CLO2: Develop the influence of aquifer matrix and its properties to groundwater occurrence, movement and distribution.

CLO3: Establish the potential of aquifers for sustainable groundwater resources by identifying the types of terrain, geomorphology and rock

CLO4: Formulate the evolution of water chemistry due to hydrogeochemical processes in the aquifer system.

CLO5: Estimate both the quantity and quality aspects of groundwater to enable more effective management.

Unit/ Hour	Contents	Mapping with CLO
I/11	Hydrological Cycle and processes: systems concept of hydrological cycle, water budget, precipitation, evaporation and transpiration, run off, baseflow, infiltration, global and Indian distribution of water resources. Learning Activities: Design a model of the hydrologic cycle and the concept of groundwater distribution.	CLO1 CLO2
II/12	Hydrological Characteristics of Aquifer: porosity, void ratio, permeability, transmissivity, storativity, specific yield, specific retention, diffusivity, velocity; elasticity of confined aquifers. Laws of groundwater movement: Bernoulli's equation, Darcy's Law, Laplace equation, flow nets, steady and unsteady unidirectional flow; radial flow. Learning Activities: Group discussion on local major aquifer types and groundwater occurrence.	CLO1 CLO2
III/11	Groundwater Hydrology: origin of groundwater, subsurface profile of groundwater, classification of rocks with respect to water bearing characterizes, geomorphic and geologic occurrence and flow controls of groundwater, groundwater provinces in India; Aquifers - unconfined, confined, and semi-confined; water table and piezometric surface; genetic classification of groundwater. Learning Activities: Group discussion on recent developments in satellite technology, exercises on satellite data mining from open sources, and development of different thematic layers using open data sources.	CLO3 CLO5
IV/11	Groundwater Management: recharge and discharge areas; safe yield and overdraft; land subsidence; rainwater harvesting and artificial recharge; consumptive and conjunctive use of water; parameters ascertaining groundwater quality; hydrochemical facies changes due to rock-water interaction; conservation of water; watershed management. Learning Activities: Brainstorming on the impacts of engineering	CLO4 CLO5

	projects on the environment and their importance to highlight the salient points, student seminar.	
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Transactional Modes: Lecture, Demonstration, Lecture cum demonstration, Project Method, Seminar, Group discussion, Team teaching, Field visit, Brainstorming, 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.

Web Resources:

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

Semester-II

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
MEGS.415	Igneous Petrology	<i>Discipline Specific Core</i>	3	0	0	3
MEGS.416	Igneous Petrology (Practical)	<i>Skill Based</i>	0	0	2	1
MEGS.417	Metamorphic Petrology	<i>Discipline Specific Core</i>	3	0	0	3

MEGS.418	Metamorphic Petrology (Practical)	<i>Skill Based</i>	0	0	2	1
MEGS.516	Geochemistry and Isotope Geology	<i>Discipline Specific Core</i>	3	0	0	3
MEGS.520	Entrepreneurship in Geosciences	<i>Entrepreneurs hip</i>	2	0	0	2
MEGS.536	Solid Earth Geophysics	<i>Ability Enhancement</i>	3	0	0	3
MEGS.539	Ore Geology	<i>Discipline Specific Core</i>	3	0	0	3
MEGS.540	Ore Geology (Practical)	<i>Skill Based</i>	0	0	2	1
	Tutorial	<i>Remedial class</i>	0	2	0	0
Interdisciplinary course						
Interdisciplinary course#		<i>IDC</i>	2	0	0	2
Total			19	2	6	22

Interdisciplinary course offered by the Department						
MEGS.506	Introduction to Disaster Management	<i>IDC</i>	2	0	0	2
MEGS.507	Introduction to Earth System Science	<i>IDC</i>	2	0	0	2
MEGS.508	Geoheritage and Geotourism	<i>IDC</i>	2	0	0	2

Students, who opt to exit the program with PG-Diploma in Geology at the end of the 1st year, need to complete internship/mini project/industrial training/MOOC course of minimum 2 credits in addition to above courses.

Course Code: MEGS.415

L	T	P	Credits
3	0	0	3

Course title: Igneous Petrology

Total Hours: 45

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

CLO1: Understand the genesis and evolution of magma.

CLO2: Evaluate key textural/microstructural features of igneous rocks.

CLO3: Do the nomenclature of igneous rocks using IUGS recommendations.

CLO4: Understand the Magmatic processes using multiple proxies.

CLO5: Explain the petrogenesis of igneous rocks using phase diagrams and thermodynamics.

CLO6: Apprise the geochemical behavior during the igneous processes.

CLO7: comprehend the mantle petrology.

Unit/ Hour	Contents	Mapping with CLO
I/12	Physical properties of magma: viscosity, density, temperature; Magma Generation & Evolution: Partial melting (batch, fractional), fractional crystallization, assimilation, liquid immiscibility, double diffusion, and magma-mixing. Learning Activities: Assignment, Take-home exercise, mini projects.	CLO1 CLO4
II/11	Introduction to thermodynamics and its application in Igneous petrology; The phase equilibrium of unary, binary, and ternary systems and its relation to magma genesis and crystallization; Nucleation and crystal growth; Igneous textures. Learning Activities: Group discussion and take-home exercise.	CLO1 CLO2 CLO4 CLO5
III/11	Mineralogical and chemical classification (IUGS system); CIPW Norm; Petrology and petrogenesis of ultramafic, basaltic, granitic, alkaline igneous rocks; layered igneous complex; Tectonic settings of magmatism. Learning Activities: Assignment, Take-home exercise, mini projects.	CLO1 CLO2 CLO4 CLO5 CLO6
IV/11	Mantle Petrology: Composition and structure of the mantle, Mantle plumes and hotspots; Geochemistry of Igneous Rocks; Geochemical modeling and its application to magmatic and allied processes. Learning Activities: Student seminar, assignment, and mini projects.	CLO1 CLO4 CLO5 CLO6 CLO7

Transactional Modes: Lecture, Demonstration, Seminar, Group discussion, Cooperative learning, Blended learning, flipped learning, focused group discussion, Team teaching, Field visit, Brainstorming, Mobile teaching and 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. Faure, G., 2001. *Origin of Igneous Rocks–The Isotopic Evidence*, Springer.
6. Hall A., 1997. *Igneous Petrology*, Longman.
7. LeMaitre, R.W., 2002. *Igneous Rocks: A Classification and Glossary of Terms*, Cambridge University Press.
8. McBirney, 1994. *Igneous Petrology*, CBS Publishers, Delhi.
9. Sood, M.K., 1982. *Modern Igneous Petrology*, Wiley-Interscience Publ., New York.
10. Srivastava Rajesh, K., Chandra, R. and Balkema, A.A., 1997. *Magmatism in Relation to Diverse Tectonic Settings*, Oxford University Press.
11. Spear, F.S. 1993. *Mineralogical Phase Equilibria and Pressure–Temperature–Time Paths*, Mineralogical Society of America.
12. Powell, R. 1978. *Equilibrium Thermodynamics in Petrology: An Introduction*, Harper & Row Publishers, London.
13. 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: MEGS.416

L	T	P	Credits
0	0	2	1

Course Title: Igneous Petrology (Practical)

Total Hours: 30

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

- CLO1:** Identify and inspect key textural/microstructural features of igneous rocks in hand specimens as well as under the microscope.
- CLO2:** Do nomenclature igneous rock based on its mineralogical and textural characteristics as recommended by IUGS.
- CLO3:** explain petrogenesis of igneous Rocks.

Unit/	Contents	Mapping
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Hour		with CLO
I/30	The following exercise will be conducted in the lab • Megascopic and microscopic study of different igneous rocks. • Textural identification and establishment of crystallization sequence. • Textural interpretation and petrogenesis using phase diagram. • Calculation of CIPW Norms. • Magma density calculation using geochemistry. • Crystal Size distribution (CSD) exercise. • Preparation of classification and variation diagrams and their interpretation.	CLO1 CLO2 CLO3

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.

Web Resources:

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/>

Course Code: MEGS.417

L	T	P	Credits
3	0	0	3

Course Title: Metamorphic Petrology

Total hours: 45

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

CLO1: Interpret mineral behavior in metamorphic environments

CLO2: Differentiate textures formed under various metamorphic conditions

CLO3: Analyze petrogenetic grids to solve metamorphic petrological problems

CLO4: Identifying equilibrium mineral assemblages through textural and mineralogical observations

CLO5: Explain the fundamental laws of thermodynamics in geological systems

CLO6: Analyze phase relationships and component behavior in metamorphic systems

CLO7: Apply metamorphic concepts to solve petrological and geological problems

Unit/ Hour	Contents	Mapping with CLO
I/12	Introduction- Significance of metamorphic studies, Definition and limits of metamorphism, Overview of different types of metamorphism; Factors controlling transformations, Heat flow, Minerals as pure and impure phases, Textures of contact and regional metamorphism, Tectonic context of metamorphic transformations, Concept and Classification of Metamorphic Facies and Facies Series. Learning Activities: Assignment, Take-home exercise, mini projects.	CLO1 CLO2
II/11	Isograds and Reaction Isograds, Advantages of Reaction Isograd concept over the concept of Isograd, Schriener's Rule and Construction of Petrogenetic Grids (Pseudosection Modelling): their application to petrological problems, Metamorphic Differentiation, Regional Metamorphism and Paired Metamorphic Belts in relation to Plate Tectonics, Pressure – temperature – time paths from a plate tectonic view. Learning Activities: Group discussion and take-home exercise.	CLO3 CLO4
III/11	Laws of Thermodynamics, Gibb's Free – Energy, Entropy, ΔG of Metamorphic Reactions (Solid-Solid and Dehydration Reactions). Clausius – Clapeyron Equation, Application of equilibrium thermodynamics to rocks, Geothermobarometry.	CLO5

	Learning Activities: Group discussion and take-home exercise.	
IV/11	Mineralogical Phase Rule for Closed and Open Systems. Nature of Metamorphic Reactions, Introduction to Ultrahigh Temperature and Ultrahigh Pressure Metamorphism, Extremities of metamorphism: Introduction and challenges of UHT and UHP metamorphism. Anatexis and Origin of Migmatites in the light of experimental studies: its implications for petrological problems. Learning Activities: Student seminar, assignment, and mini projects.	CLO6 CLO7

Transactional Modes: Lecture, Demonstration, Seminar, Group discussion, Cooperative learning, Blended learning, flipped learning, focused group discussion, Team teaching, Field visit, Brainstorming, Mobile teaching and 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 Turner, F.J., and Verhoogen, J., 1987. Igneous and Metamorphic Petrology*, CBS.
4. Myron G., 2002. *Igneous and Metamorphic Petrology*, Blackwell Science.
5. Bucher, K. and Martin, F., 2002. *Petrogenesis of Metamorphic Rocks*, Springer-Verlag.
6. Yardley, B.W.D., 1989. *An Introduction to Metamorphic Petrology*, Longman Scientific & Technical, New York.
7. Spear, F.S. 1993. Mineralogical Phase Equilibria and Pressure–Temperature–Time Paths, Mineralogical Society of America.
8. Powell, R. 1978. *Equilibrium Thermodynamics in Petrology: An Introduction*, Harper & Row Publishers, London.
9. Bose, M.K., 1997. *Igneous Petrology*, World Press, Kolkata.
10. Sharma, Ram. S., 2016. Metamorphic Petrology: Concepts and Methods, Geological Society of India.
11. Bucher, K. and Martin, F. 2002. Petrogenesis of Metamorphic Rocks, Springer – Verlag, 7th Revised Edition • Frost, B.R. and Frost, C.D. 2014, Essentials of Igneous and Metamorphic Petrology, Cambridge University Press.

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://www.tulane.edu/~sanelson/eens212/>

Course Code: MEGS.418

L	T	P	Credits
0	0	2	1

Course Title: Metamorphic Petrology (Practical)

Total Hours: 30

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

CLO1 Analyze hand specimens to interpret the sequence and timing of deformation phases and mineral recrystallization in rocks.

CLO2 Identify metamorphic rocks in thin sections and interpret their facies, origin, and mineral assemblages with graphical representation.

CLO3 Understand the graphical representation ACF, AKF, and AFM values from mineral chemistry.

CLO4 Estimate pressure and temperature using geothermo-barometric models.

Unit/ Hour	Contents	Mapping with CLO
I/30	• A detailed study of rocks, with emphasis on hand specimens, focusing on the temporal relationships between deformation phases and mineral recrystallization. • Study of Metamorphic Rocks in thin sections belonging to different facies with emphasis on texture/structure, mineral composition, parent rock, metamorphic facies / sub-facies / zone to which the rock can be assigned and graphical representation of the assemblage. • Calculation of ACF, AKF and AFM values from chemical and structural formulation of minerals and their graphical representation. • Estimation of Pressure and Temperature from important models of Geothermobarometry.	CLO1 CLO2 CLO3 CLO4

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

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 Turner*, F.J., and Verhoogen, J., 1987. *Igneous and Metamorphic Petrology*, CBS.
4. Myron G., 2002. *Igneous and Metamorphic Petrology*, Blackwell Science.
5. Bucher, K. and Martin, F., 2002. *Petrogenesis of Metamorphic Rocks*,

Springer-Verlag.

6. Yardley, B.W.D., 1989. *An Introduction to Metamorphic Petrology*, Longman Scientific & Technical, New York.
7. Spear, F.S. 1993. Mineralogical Phase Equilibria and Pressure–Temperature–Time Paths, Mineralogical Society of America.
8. Powell, R. 1978. *Equilibrium Thermodynamics in Petrology: An Introduction*, Harper & Row Publishers, London.
9. Sharma, Ram. S., 2016. Metamorphic Petrology: Concepts and Methods, Geological Society of India
10. Bucher, K. and Martin, F. 2002. Petrogenesis of Metamorphic Rocks, Springer – Verlag, 7th Revised Edition .
11. Frost, B.R. and Frost, C.D. 2014, Essentials of Igneous and Metamorphic Petrology, Cambridge University Press.

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://www1.mans.edu.eg/FacSciM/english/courses/geology/Dr_Mahrous/Abu%20El-nen%20Metamorphic%20Petrology%20Course/Metamorphic%20Petrology%20-%20Lecture%20I.ppt)

<http://www.tulane.edu/~sanelson/eens212/>

Course Code: MEGS.516

L	T	P	Credits
3	0	0	3

Course Title: Geochemistry and Isotope Geology

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 the basics of isotope systematics and radioactive decay.

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

CLO4 : Discuss the principles and applications of radiogenic isotope systems 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 to geochemistry and cosmochemistry. The abundance of elements in the solar system and the chemical composition and properties of Earth's layers. Atmosphere: its layers, chemical composition, and evolution of the atmosphere. Meteorites, classification, mineralogy, origin, significance, and phenomena of fall. Learning Activities: Assignments, Take-home exercises, and Group discussions.	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/complexes 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 Method: decay schemes, U-Pb isochron, U-Pb mineral dating, and application. Learning Activities: Hands-on exercise during class, take-home exercise, assignment, and student seminar.	CLO4 CLO5
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 Publications.
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.wr.camnl.wr.usgs.gov/isoig/isopubs/itchch2.html>
<https://www.southalabama.edu/geology/haywick/GY112/ppt/112-pp8a.pdf>
https://ocw.mit.edu/courses/earth-atmospheric-and-planetary-sciences/12-742-marine-chemistry-fall-2006/lecture-notes/lecture_2_notes.pdf

Course Code: MEGS.520

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, students will be able to

CLO1 : Understand the basic concepts of entrepreneurship, its importance.

CLO2 : Aware of the issues, challenges, and opportunities in entrepreneurship.

CLO3 : Develop the 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
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I/7	Introduction to entrepreneurship and entrepreneurship; Characteristics of an entrepreneur; Characteristics of entrepreneurship; entrepreneurial traits and skills; innovation and entrepreneurship; Types of entrepreneurial ventures; enterprise and society in the Indian context; Importance of women entrepreneurship. Learning Activities: Group discussion and student seminar.	CLO1 CLO2
II/8	Opportunity analysis, external environment 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: Brainstorming session and case study.	CLO3 CLO4
III/8	Scope and opportunities in the field of mineral exploration, groundwater exploration, geotechnical solutions, and geo-consultancy. Basic requirements for establishing a small business, Possible avenues for developing Geo-entrepreneur; Requirements and demand for geo-consultancy. Learning Activities: Student seminars and proposal on development and scope of possible Geo-entrepreneur	CLO3
IV/7	Preparation of Impact Assessment Report (IAR) / Comprehensive Hydro Geological Report (CHR)/ Modelling Reports as per the guidelines issued by Central Ground Water Authority, Ministry of Jal Shakti. Learning Activities: Mini projects, Case studies, and live interaction with the Geo-entrepreneur.	CLO2 CLO3 CLO4

Transactional Modes: Lecture, Project Method, Inquiry Training, Seminar, Group Discussion, Co-operative Learning, Blended Learning, Flipped Learning, Team Teaching, Brainstorming, Mobile Teaching, Collaborative Learning, Self-learning, Case-based Study, Through SOLE (Self-Organized Organized Environment)

Suggested readings:

1. Arora, Renu (2008). *Entrepreneurship and Small Business*, Dhanpat Rai & Sons Publications.
2. Chandra, Prasanna (2018). *Project Preparation, Appraisal, Implementation*, Tata McGraw-Hill.
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-Kottameta_03.06.22.pdf

Course Code: MEGS.536

L	T	P	Credits
3	0	0	3

Course Title: Solid Earth Geophysics

Total hours: 45

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

CLO1 : Able to understand the application of Geophysics

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 use seismological data for understanding the Earth's subsurface.

Unit/ Hour	Contents	Mapping with CLO
I/11	Introduction to geophysics; shape and size of the Earth; gravitational field of the Earth; variation of gravity on the Earth's surface; principles of gravity methods and instruments used; The Bouguer anomaly; regional and residual anomalies; 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 magnetic fields over earth's surface, magnetic declination, Inclination, magnetic susceptibilities, type of magnetizations. Rock magnetism, Magnetic domains,	CLO1 CLO2

	Anisotropy of magnetic susceptibility. Learning Activities: Problem solving after each method, take-home exercise.	
III/12	Seismic methods: principles and instruments used; seismic velocity, Derivation of travel time calculation in Seismic refraction and reflection methods. Geometry of refraction and reflection paths in layered earth. Seismic noise, reflection, and refraction field methods. Conventional and modern (CDP) methods of acquisition of seismic reflection data. Learning Activities: Assignment, take-home exercise, lab-based exercise.	CLO3
IV/11	Electrical methods: basic principles and various types of electrode configuration: Wenner and Schlumberger; Electrical resistivity method, self-potential and resistive surveying; field procedures and interpretation of field data. Applications of electricity in groundwater exploration. Learning Activities: Assignment, student's seminar, and a mini project.	CLO4

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

Suggested readings:

1. Lowrie, W., 1997. *Fundamentals 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 into 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*, McGraw-Hill Exclusive.
9. Gadallah, Mamdouh R. and Fischer, R.L., 2009. *Exploration Geophysics*, Springer-Verlag Berlin Heidelberg.

10. Albert Tarantola, 2005. Inverse Problem Theory and Model Parameter Estimation. SIAM
11. Thorne Lay and Terry Wallace, 1995. Modern Global Seismology, Academic Press.

Web Resources:

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

Course Code: MEGS.539

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 their knowledge of the basic concepts of ore geology, ore localization and spatial and temporal distribution.
- CLO2:** Understand the various process associated with ore formation in specific environment.
- CLO3:** Elaborate overall geometry, texture, zonation, and alteration patterns of rock associations to specific classes of metallic mineral deposits.
- CLO4:** Describe the various types of ore metallogenesis and their overall assemblages.
- CLO5:** Explain the distribution pattern of ore minerals in India in terms of their strategic, critical, and essential perspectives.
- CLO6:** Build their concepts on Fuel geology, especially on coal, petroleum, and nuclear resources.
- CLO7:** Evaluate the importance and applications of fluid inclusion in ore geology.

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, physicochemical and stratigraphic controls of ore localization; processes of formations of ore mineral deposits; Spatial and temporal distribution of ore deposits – a global perspective. Ore deposits in relation to plate	CLO1 CLO2

	tectonics. Learning Activities: Assignment, take home exercise, seminars, Group discussions	
II/11	Texture, paragenesis and zoning of ores and their significance; Introduction to Ore microscopy: Qualitative and Quantitative methods in the identification of Ore minerals; Ore deposits and their distributions; VMS, SEDEX, MVT, Porphyry, Skarn, IOCG deposits; Learning Activities: Hands on exercise and group discussion.	CLO3 CLO4
III/12	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. Critical mineral and green/clean energy; Strategic, and essential minerals. Fundamentals of coal petrology; Petroleum geology; Nuclear and Non-conventional source of energy. Learning Activities: Student seminar, assignment and take-home exercise.	CLO5 CLO6
IV/11	Principle of Fluid inclusion study and its applications in ore genesis: Basic definitions and history; Types of fluid inclusions; formation mechanism; Fluid inclusion petrography; Sample preparation techniques; Principles of micro-thermometry; Binary and ternary systems of related to fluid inclusion studies. Learning Activities: Assignment, take home exercise, seminar.	CLO7

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. *Oregeology 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.
 10. T. J. Shepherd, A. H. Rankin, D. H. M. Alderton, 1985, *A Practical Guide to Fluid Inclusion Studies*, Publisher: Blackie, Page: 239. ISBN-0412006014, 9780412006012.

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: MEGS.540

L	T	P	Credits
0	0	2	1

Course Title: Ore Geology (Practical)

Total Hours: 30

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 familiar 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:** understand the methods to identify various fluid inclusions associated with minerals and their application in ore geology.

Unit/ Hour	Contents	Mapping with CLO
I/30	- 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 - Practical on fluid inclusion petrography	CLO1 CLO2 CLO3

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), Continuous assessment (30 marks), Lab record (10 marks), Viva (10 marks).

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. T. J. Shepherd, A. H. Rankin, D. H. M. Alderton, 1985, *A Practical Guide to Fluid Inclusion Studies*, Publisher: Blackie, Page: 239. ISBN-0412006014, 9780412006012.

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/pageViewGSIPublication?adf.ctrl-state=w5w97un87_5&afrLoop=21339913384895836#!

Tutorial/ Remedial Class

L	T	P	Credits
0	2	0	0

Two hours non-credit tutorial class is designed for remedial teaching. Scheduled classes will be assigned in the timetable. As per the requirement of students, remedial classes will be conducted in these periods.

Interdisciplinary Course (IDC) offered by the department

Course Code: MEGS.506

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: Define key terms in disaster management and explain the disaster management cycle.

CLO 2: Classify types of natural and human-made disasters, with emphasis on those affecting India.

CLO 3: Describe the main national and international disaster management frameworks and policies.

CLO 4: Identify the roles and responsibilities of institutions and stakeholders in disaster management.

Unit/ Hour	Contents	Mapping with CLO
I/7	Disaster Management: definition, scope, Objectives and Approaches, Definitions and concepts of Hazard, Vulnerability, Risk, Resilience, Concept of Disaster Management Cycle – Response, Recovery, Mitigation and Preparedness. Learning Activities: Group Discussion and brainstorming session on disaster and hazards.	CLO1
II/9	Introduction to various Hazards both Natural and Man-Made Hazards- earthquake, volcanoes landslide, flood, cyclone, tsunami, droughts, forest fires, industrial accidents, biological disasters, climate change, global warming etc. Learning Activities: Student seminar, discussion and brain storming session	CLO2
III/8	Introduction to National Disaster Management Plan-2019, PM's Ten-Point Agenda for Disaster Risk Reduction, Main Pillars of NDMP, Global Frameworks—Disasters, Sustainable Development and Climate Change, objectives of the National Policy on Disaster Management, Disaster Management Act, Disaster mitigation: Concept, importance, tools, strategies with reference to specific disasters;	CLO3 CLO 4

	Learning Activities: Student presentation and group discussion on the case study on Indian disasters, and their mitigation and preparedness techniques.	
IV/7	Basic Institutional Framework- national, state-level disaster management, Key National-Level Decision-Making Bodies for Disaster Management, Role and responsibility of Central, State, District, and Local Administration, Armed Forces, NGOs, media, etc. Disaster relief; Reconstruction planning; Learning Activities: Student Seminar and brainstorming session on the disaster management system of India.	CLO3 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. Textbook 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: MEGS.507

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 of the origin of Earth, major components and processes of the Earth systems, and the 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 shreds of evidence 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 brain storming 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, and 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.	CLO2, CLO3

	Learning Activities: Group discussion on important 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 the ocean floor; Oceanic current system and effect of Coriolis force; Natural resources and their management; 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_th0lfkW5

Course Code: MEGS.508

L	T	P	Credits
2	0	0	2

Course Title: Geoheritage and Geotourism

Total Hours: 30

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

- CLO1:** Familiar with the general concepts of the world's geological heritage and India.
- CLO2:** Understand the major contemporary evolutionary trends in Geoheritage and Geotourism.
- CLO3:** Know the different institutional figures of nature conservation areas and their importance in Geoheritage and Geotourism.
- CLO4:** Curate and communicate geoheritage inventory.

Unit/Hour	Contents	Mapping with CLO
I/15	Concepts of geodiversity, geosites, geoheritage, geoconservation, geotourism, and geoparks. Classification and significance. International geoconservation designations: World Heritage Sites, Ramsar Sites, European Designations Learning Activities: Assignment, take-home exercise, and student seminar.	CLO1 CLO3 CLO4
II/15	Geoheritage elements across the Indian sub-continent. National Geological Monuments (NGM). Aspiring and prospective geopark localities of India. Organizational efforts towards geoconservation. Learning Activities: Assignment, student seminar, and group discussion.	CLO1 CLO2 CLO3 CLO4
III/15	Definition of geoparks. Objectives of geoparks. History of development of geoparks: role of UNESCO, international promotional events. Infrastructural elements of geoparks: geoguides and georangers, geopaths, georoutes, information panels and signages, geomuseums, geoshops, geohotels, geoproductions. Learning Activities: Assignment, student seminar, and group	CLO2 CLO3 CLO4

	discussion.	
IV/15	Geotourism routes: inventory, evaluation, conservation, and enhancement of Geoheritage. Case studies of the Geoheritage sites of India and the world. International Geopark Networks. Learning Activities: Assignment, student seminar, and group discussion.	CLO2 CLO3 CLO4

Transactional Modes: Lecture, Demonstration, 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, E-tutoring, Problem solving.

Suggested Readings:

- 1.C. Anze, L. Yunting and C.Y. Ng. Young (2015). The Principles of Geotourism, Science Press, Beijing
- 2.C.V. Burek and C.D. Prosser (2008). The History of Geoconservation, The Geological Society, London, Special Publications, 300
- 3.D.R. Reddy (2020). A Monograph on Potential Geoparks of India, INTACH, New Delhi
- 4.36th IGC (2016). Geotourism Hotspots of Indian Subcontinent, GSI, New Delhi
- 5.C. Sharples (2002). Concepts and Principles of Geoconservation, Tasmanian Parks and Wildlife Service, Australia
- 6.R.K. Dowling and D. Newsome (2006). Geotourism – Sustainability, Impacts and Management, Elsevier Butterworth-Heinemann, Oxford
- 7.R, Crofts, J.E. Gordon, J. Brilha, M. Gray, J. Gunn, J. Larwood, V.L. Santucci, D. Tormey and G.L. Worboys (2020). Guidelines for Geoconservation in Protected and Conserved Areas, Best Practice Protected Area Guidelines, Series No. 31, IUCN, Switzerland
- 8.M.H. Henriques, R.P. dos Reis, J. Brilha, T. Mota (2011). Geoconservation as an Emerging Geoscience. Geoheritage, 3, 117–128.

Web Resources:

<http://www.globalgeopark.org/homepageaux/tupai/6513.htm>
[IUGS | International Commission on Geoheritage](#)
[Geodiversity, World Heritage and IUCN | IUCN](#)
[IUGS Geological Heritage sites | UNESCO](#)
[UNESCO Global Geoparks | UNESCO](#)
[International Geoscience and Geoparks Programme | UNESCO](#)
[Guardians of GEOHERITAGE:-A THE SOCIETY OF EARTH SCIENTISTS' Initiative](#)

Semester – III

Course Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	Cr
MEGS.519	Analytical Techniques and Geo-Statistics	<i>Ability Enhancement</i>	3	0	0	3
MEGS.544	Indian Stratigraphy	<i>Discipline Specific Core</i>	3	0	0	3
MEGS.545	Sedimentology	<i>Discipline Specific Core</i>	3	0	0	3
MEGS.538	Sedimentology (Practical)	<i>Skill Based</i>	0	0	2	1
MEGS.546	Engineering Geology	<i>Ability</i>	2	0	0	2

		Enhancement				
Select any one from the following Discipline Elective course ^{\$}						
MEGS.521	Mineral Exploration and Petroleum Geology	Discipline Elective	3	0	0	3
MEGS.522	Oceanography		3	0	0	3
MEGS.523	Watershed Management		3	0	0	3
Select any one from the following Discipline Elective course ^{\$}						
MEGS.541	Environmental Geology	Discipline Elective	3	0	0	3
MEGS.542	Quaternary Geology		3	0	0	3
MEGS.543	Geomagnetism		3	0	0	3
MEGS.547	Research Methodology in Geoscience		3	0	0	3
	Tutorial	Remedial class	0	2	0	0
Select Any One Value Added Course (VAC) ^{\$}						
MEGS.511	Geological Mapping	VAC	2	0	0	2
Total			19	2	2	20

Course Code: MEGS.519

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

CLO 1: Explain principle, instrumentation and application of instruments

CLO 2: Distinguish steps and working principle of electrochemical, and spectrometric

CLO 3: Describe the types, principle and applications of chromatographic techniques

CLO 4: 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. Introduction to mass spectrometry, Spectrometric Methods for elemental analysis: U.V. spectrophotometer, Flamephotometry, 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). Learning Activities: Hands on exercise, assignment and student seminar.	CLO1 CLO2
II/12	Introduction to working principles, concepts, sample preparation, applications and limitations of X-ray Diffractions (XRD), Scanning Electron Microscope(SEM), X-ray fluorescence(XRF), Energy-dispersive X-ray spectroscopy (EDS, EDX, or XEDS), Electron Probe Micro Analyzer (EPMA), Proton Induced X-ray Emission (PIXE). Learning Activities: Assignment, take home exercise and student seminar.	CLO3 CLO4
III/11	Principle and applications of Chromatography techniques; Inductive Coupled Plasma Mass Spectroscopy (ICP-MS): Quadruple and magnetic sector; Multicollector 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. Learning Activities: Assignment, take home exercise, seminar	CLO3 CLO4
IV/11	Application of different statistical tool to interpret the geological data such as sampling, descriptive statistics, central tendency of data, probability function, hypothesis testing, Anova, exponential smoothing, regression and correlations, cross correlation, sampling, moving average for time-series data, Fourier transformation, matrix, PCA analysis and Eigen value, intrapolation, Markovchain, segmenting sequences,	CLO3 CLO4

	splines and semi variograms.	
	Learning Activities: Assignment, take home exercise and student seminar	

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

Suggested readings:

1. Bruce, L.B. 2001. *Qualitative Research Methods for Social Sciences*, Allyn and Bacon, Boston.
2. John, W.C., 2011. *Research Design: Qualitative, Quantitative and Mixed Methods Approaches*, Sage Publications, Thousand Oaks.
3. Potts, P.J., 1997. *Silicate rock analysis*
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). *Hand book of environmental analysis*, CRC Press, USA
11. Rouessac, F., Roussac, A. (2008). *Chemical analysis: modern instrumentation and techniques*, Wiley, England.
12. Skoag, D.A., Holler, F.J., Crouch, S.R. (2007). *Principles of Instrumental Analysis*, CENGAGE ELearning.
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 waste water*, 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

Course Code: MEGS.544

L	T	P	Credits
3	0	0	3

Course Title: Indian Stratigraphy

Total hours: 45

Course Learning Outcomes (CLO): Upon successful completion of 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** Makeup: 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 of surface geological and subsurface geological analysis (i.e., outcrop, well log, seismic).

Unit/ Hour	Contents	Mapping with
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		CLO
I/10	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, biostratigraphy, and chronostratigraphic); Concepts of magneto stratigraphy, chemo-stratigraphy, event stratigraphy, and sequence stratigraphy. Learning Activities: Discussion and practical exercises on the preparation of lithologs and their correlations.	CLO1 CLO2
II/13	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. Learning Activities: Group Discussion on Archean-Precambrian geology of India. Exercise on mapping certain geological formations, assignment.	CLO3 CLO4 CLO5 CLO6
III/12	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. Gondwana stratigraphy: Concepts, classification, fauna, flora, and age limits of Gondwana Supergroup and related palaeogeography, palaeoclimate, depositional characteristics, igneous activity, and formation. 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. Learning Activities: Assignment, student presentation, and brainstorming sessions.	CLO3 CLO4 CLO5 CLO6
IV/10	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	CLO3 CLO4 CLO5 CLO6

	in India. Quaternaries of Peninsular India; Neogene-Quaternary boundary. Stratigraphy and tectonics of the Siwalik Formation. Quaternary relative sea level changes. Learning Activities: Take-home exercises and brainstorming sessions, student seminar, and group discussion.	
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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, ISBNNo: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. Pomeroy, 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 Wiley.

Web Resources:

<http://www.sepmstrata.org/page.aspx?pageid=15><https://www.gsi.gov.in/webcenter/portal/OCBIS/pageQuickLinks/pageEducationalVideos?>

Course Code: MEGS.545

Course Title: Sedimentology

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

- CLO4** Explain the origin, classification, petrography, and petrogenesis of sedimentary rocks
- CLO5** Interpret sedimentary structures, bed forms, diagenetic processes, and provenance indicators for understanding depositional and post-depositional history.
- CLO6** Analyze sedimentary facies, depositional environments, Walther's Law, and environmental processes in different sedimentary settings.
- CLO7** Evaluate the relationship between tectonics and sedimentation, sedimentary basin evolution, and the economic significance of Indian sedimentary basins.

Unit/ Hour	Contents	Mapping with CLO
I/11	Origin of sedimentary rocks. Types of sandstones and their petrogenesis; Grawacke and Grawacke problem, plate tectonics and sandstones composition. Argillaceous rocks, their classification and genesis. Volcaniclastic sediments and their characteristics. Limestone and dolomites: classification and petrography, Models of dolomitization. Study of evaporites such as gypsum, and anhydrite. Learning Activities: Assignment, Take-home exercise, mini projects.	CLO1
II/12	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. Evidence of diagenesis in sandstones, mudrocks, and carbonate rocks. Evaporites, siliceous, phosphatic, and ferruginous rocks. Heavy minerals and their importance in the determination of provenance. Learning Activities: Group discussion and take-home exercise.	CLO2
III/11	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.	CLO3

	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. Learning Activities: Group discussion and take-home exercise.	
IV/11	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. Learning Activities: Group discussion and take-home exercise	CLO4

Transactional Modes: Lecture, Demonstration, Seminar, Group discussion, Cooperative learning, blended learning, flipped learning, focused group discussion, Team teaching, Field visit, Brainstorming, Mobile teaching and tutoring, Problem solving, Self-learning, Case-based study, etc.

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. Allen (2005): *Basin Analysis: Principles and Application*, Blackwell Publ.
7. Miall, A.D. (2000): *Principles of Basin Analysis*, Springer-Verlag.
8. Perry, C.T. and Taylor, K.G. (2006): *Environmental Sedimentology*, Blackwell Publ., U.K.
9. Reading, H.G. (1996): *Sedimentary Environments and facies*, Blackwell Scientific Publ.
10. Reineck, H.E. and Singh, I.B. (1978): *Depositional Sedimentary Environments*, Springer-Verlag.
11. Lindholm, R.C. (1987) *A Practical Approach to Sedimentology*. Allen & Unwin, London.

Web Resources:

https://onlinecourses.nptel.ac.in/noc25_ce140/preview
<https://www.priweb.org/blog-post/learn-at-home>
<https://www.nationalgeographic.org/encyclopedia/>
<https://naturalhistory.si.edu/education/teaching-resources/>
[Basin Analysis Overview and Methods | PDF | Plate Tectonics | Sedimentary Basin](#)

Course Code: MEGS.538

L	T	P	Credits
0	0	2	1

Course Title: Sedimentology (Practical)

Total Hours: 30

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

CLO1: Classify the various sedimentary rocks.

CLO2: Analyze sedimentary rock samples for paleo-environment and paleoclimatic interpretation.

CLO3: Reconstruct paleoenvironmental setup based on sedimentological records.

CLO4: understand the properties of various building materials

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
	Heavy mineral separation; their microscopic characters, graphic representation, and interpretation	CLO2 CLO3
	Assemblages of sedimentary structures and their palaeo-environmental significance	
	Palaeo-current analysis	
	Study of vertical profile sections of some selected sedimentary environments	
	Analysis of engineering properties of building materials and aggregate	CLO4

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. Sengupta, S., 1997. *Introduction to Sedimentology*, Oxford-IBH.

Web Resources:

<https://www.priweb.org/blog-post/learn-at-home>
<https://www.nationalgeographic.org/encyclopedia/>
<https://naturalhistory.si.edu/education/teaching-resources/>

Course Code: MEGS. 546

L	T	P	Credits
2	0	0	2

Course title: Engineering Geology

Total hours: 30

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

- CLO1** Scope, importance and applications of Engineering Geology in civil engineering.
- CLO2** Evaluate the engineering properties of rocks and soils and apply rock mass classification systems in engineering practices.
- CLO3** Assess geological and geotechnical considerations for dams, tunnels, transportation routes and other engineering structures.
- CLO4** Apply geological knowledge for sustainable infrastructure development, resource management and hazard mitigation.

Unit/ Hour	Contents	Mapping with CLO
I/06	Scope, importance and applications of Engineering Geology in civil engineering. Geological investigations for dam, tunnel, highways, bridges and urban development. Learning Activities: Assignment, Take-home exercise, mini projects.	CLO1
II/07	Engineering properties of rocks and soils: porosity, permeability, compressive strength, durability and weathering. Physical characters of building stones. Metal and concrete aggregates. Rock mass classification	CLO2

	systems: RQD, RMR, Q-system and GSI. Learning Activities: Group discussion and take-home exercise.	
III/09	Geological consideration for evaluation of dams and reservoir sites. Dam foundation, rock problems, geotechnical evaluations of tunnel alignments and transportation routes. Methods of tunneling; Classification of ground for tunneling purposes; various types of support. Geological considerations involved in the construction of roads, railways, bridges and buildings. Improvement of sites for engineering projects. Learning Activities: Group discussion and take-home exercise.	CLO3
IV/08	Geological investigation for safe infrastructure development. Aseismic design of building. Case study of engineering projects and geological causes for mishaps and failures of engineering structures. Material assessment for Sustainable construction. Apply geological knowledge for sustainable resource management and hazard mitigation. Learning Activities: Group discussion and take-home exercise	CLO4

Transactional Modes: Lecture, Demonstration, Seminar, Group discussion, Cooperative learning, blended learning, flipped learning, focused group discussion, Team teaching, Field visit, Brainstorming, Mobile teaching and tutoring, Problem solving, Self-learning, Case-based study, etc.

Suggested readings:

1. Bell, F.G., 1992. *Fundamentals of Engineering Geology*, Aditya Books Pvt. Ltd., Indian Edn.
2. Krynine, D.H. and Judd, W.R., 1998. *Principles of Engineering Geology*, C.B.S. Edition. Delhi.
3. Jaeger J., Cook N. G. and Zimmerman R., 2007. *Fundamentals of Rocks Mechanics*, Wiley-Blackwell
4. Reddy, D.V., 1995. *Engineering Geology for Civil Engineers*, IBH Publishing Co. Pvt. Ltd.

Web Resources:

<https://naturalhistory.si.edu/education/teaching-resources/>

Discipline Elective: Select any one

Course Code: MEGS.521

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** : Evaluates ore deposit types, including genesis and exploration requirements;
- CLO2** : Designing an understanding of petroleum geology, exploration techniques, and resource evaluation;
- CLO3** : Explain the concept-oriented approaches in the analysis of geological data.
- CLO4** : Assess and apply geochemical exploration methods and geochemical data presentation/analysis;
- CLO5** : Discusses 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, and types of exploration. 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	Occurrence and Source rocks: Classification and composition of Petroleum; Physical properties of petroleum; Occurrence of petroleum; Nature of source rock, composition of biomass; Kerogen: Composition and types; Reservoir rocks, pore space and fluids; Reservoir Traps; Origin, migration and accumulation of petroleum. Basin Analysis. Transactional Modes: A case study by a different group followed by discussion and assignment.	CLO1
IV/11	Indian Oil Fields- Prospecting and Drilling: Oil bearing basins of India and the world; India's position regarding	CLO2 CLO5

	petroleum and natural gas future prospects; Geophysical prospecting for petroleum; Drilling, logging, and subsurface correlation. Importance of micropaleontology in the field of petroleum exploration. Transactional Modes: Student seminar and brainstorming.	CLO6
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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, Brainstorming, 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: MEGS.522

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 the theories related to the origin and evolution of the oceans.

CLO2: Understand the various topographical features associated with the ocean systems.

CLO3: Describe the process, causes, and effects of ocean water circulation.

CLO4: Grasp the concepts of ocean currents and their distribution in all the major oceans of the Earth's surface.

CLO5: Develop an understanding of the Indian Monsoon and its impacts.

CLO6: Learn the important concepts related to the waves, tides, and tsunamis.

CLO7: Expand their knowledge in the field of ocean chemistry and sedimentation.

Unit/ Hour	Contents	Mapping with CLO
I/11	Origin and evolution of ocean basins; Importance of oceans; Paleoceanography: Theories, proxies and significance; Hydrological cycle; Hypsometric Curve; Ocean bottom relief; Bottom relief of Pacific, Atlantic and Indian Ocean; Salinity of the ocean: Sources, factors and distribution; Salt budget. Learning Activities: Assignment, take-home exercise, peer learning on oceanic topography.	CLO1 CLO2
II/12	Ocean water circulation; Convection cells of the Earth; Coriolis forces: Its cause and effects; Wind drags; Ekman Spiral; Mechanism of Hurricanes and its difference from Tornadoes; Storm surges; Gyres; Geostrophic currents; Western Intensifications. Learning Activities: Exercise on the mechanics of atmospheric and oceanic circulation.	CLO3
III/11	Ocean currents: causes and impacts; Currents of Pacific, Atlantic, and Indian Ocean; Gulf Stream; Concepts of Indian Monsoon; Retreat Monsoon; Walker Circulation; Southern Oscillation; El Niño and La Niña; El Niño Southern Oscillation (ENSO); Indian Ocean Dipole (IOD). Learning Activities: Group discussions, Assignments,	CLO4 CLO5

	Term papers.	
IV/11	Ocean waves: Wave dynamics, deep water waves, shallow water waves, progressive waves, wave interference, wave dispersion, wave transformation and wave breaks; Tsunami; Tides; chemical properties of seawater; Principal of constant proportion; Ocean acidification and pH buffer; Ocean sediments and marine deposits; Coral reefs: Origin, distribution and significance; Coral bleaching; Exclusive Economic Zone (EEZ); India's Exclusive Economic Zone (EEZ)..; Learning Activities: Assignment on wave dynamics and ocean chemistry, group discussion on EEZ of the Indian Ocean.	CLO6 CLO7

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, Brainstorming, 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: MEGS.523

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: exploration of water resource through watershed management and exploration methods

CLO2: Evaluation of the validity and limitations of scientific theories and claims about the watershed management

CLO3: Appraisal of the interactions among the physical, biological, chemical, and human components controlling the watershed area.

Units/ Hours	Content	Mapping with CLO
I/11	Introduction to water shed management concept, different stakeholders and their relative importance. Fundamental policies for watershed management and decision-making. Issues related to watershed management, approach and components. Role of structure, relief, physiography, drainage systems in watershed management. Learning Activities: Group discussion on watershed management policies in India, to highlight the salient points.	CLO1
II/12	Importance of rivers and lakes in India; hydrological cycle; Water conservation and management techniques; Wetland-definition, classification, functions, ecological importance and conservation. Rainwater harvesting; concept of Micro Watershed Management; Watershed Management using Geo-spatial technologies. Learning Activities: Prepare a note on watershed management plan of India, followed by student presentation on that note.	CLO2, CLO3
III/11	Community participation, private sector participation, Institutional issues, Socio-economy, Integrated development; Watershed Management in India, Water	CLO3

	legislation and implementations, policies and decision making. Learning Activities: Group discussion on water legislation and implementations and its presentation.	
IV/11	Storm water management: design of drainage system, flood routing through channels and reservoir. Flood control and reservoir operation. Case studies on flood damage. Drought assessment and classification, drought analysis techniques, drought mitigation planning. Learning Activities: Mini project and student presentation on mechanism of Indian monsoon system and climatic regimes.	CLO2, CLO3

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

Suggested Readings:

2. Murthy, K.S. 1998. *Watershed Management in India*, Wiley Eastern Ltd. /New Age International Ltd.
3. Tideman, E.M., 1996. *Watershed Management: Guidelines for Indian Conditions*, Omega, New Delhi.
4. Verghese, B.G., 1990. *Water of Hope: Integrated Water Resource Development and Regional Co-operation within the Himalayan-Ganga-Brhamaputra-Barak Basin*, Oxford-IBH
5. Kathy Wilson Peacock, 2008. *Natural resources and sustainable developments*, Facts on file Inc.
6. Daniel R. L., 2009. *Sustainable natural resource management for scientists and engineers*, Cambridge University press
7. 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

Discipline Elective: Select any one

Course Code: MEGS.541

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; Biogeochemical cycles of carbon, nitrogen, phosphorus and sulfur; Life-cycle assessment of resource extraction Learning Activities: Take home exercise and brain storming session on importance of environmental geology.	CLO1 CLO2
II/12	Environmental issues: Water pollution : types of water pollution, ground water 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 ground water 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; waste management of energy resources. Learning Activities: Assignment and group discussion on environmental pollution.	CLO2 CLO3
III/12	Introduction to natural and manmade disasters; Dimensions of natural and anthropogenic disasters; flood hazards, urbanization and flooding, flood hydrographs, Dams barrages and river diversions; Landslides; Coastal hazards – tropical cyclone, coastal	CLO2 CLO4

	erosion, sea level changes, coastal zone management; Earth quakes – Seismic waves, quake resistant buildings and dams; Tsunamis; Volcanoes; Wildfires; Oil spills; Urban hazards and disasters. Learning Activities: Preparation of assessment reports, assignments and brain storming session on types of disasters and its management.	
IV/11	Risk Assessment and Preparedness for Natural Hazards; Hazard zonation maps; Recent Environmental Issue and possible solutions: Global warming, Sea level rise, Acid rain, Ozone layer depletion. Acid Mine drainage (AMD), Ground water contamination, Water stress and water scarcity, River interlinking conflict in India. Learning Activities: Assignment and brainstorming session on disaster risk management.	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.Murketal.,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/>
<https://researchbysubject.bucknell.edu/c.php?g=25632&p=156829>
<https://guides.lib.jmu.edu/geol/websites>

Course Code: MEGS.542

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	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. Learning Activities: Exercises and brainstorming session and group discussion.	CLO1
II/11	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. Learning Activities: Student seminar and group discussion.	CLO2
III/11	Radiometric dating techniques (e.g. ^{14}C , 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;	CLO3

	Learning Activities: Assignments and take home exercise.	
IV/11	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. Learning Activities: Student Seminar and group discussion.	CLO4

Transactional Modes: Lecture, Project Method, Inquiry training, Seminar, Group discussion, Blended learning, Flipped learning, Focused group discussion, Team teaching, Brainstorming, 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/>

L	T	P	Credits
3	0	0	3

Course Code: MEGS.543

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	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. Learning Activities: Group discussion on origin of Earth's magnetic field.	CLO 1
II / 11	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. Learning Activities: Prepare a note on primary magnetisation, followed by student presentation	CLO 1 CLO 2
III / 11	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. Learning Activities: Group discussion on suitable Demagnetisation techniques in different rock types and analytical methods used in paleomagnetism.	CLO 2 CLO 3
IV / 11	Magnetic Field Reversals, Normal, Reverse & Intermediate magnetic polarity direction, Geomagnetic Polarity Time Scale (GPTS), Magneto-stratigraphy, Applications to paleogeography and Apparent Polar Wander Paths. Learning Activities: Understanding of Geomagnetic Polarity Time Scale (GPTS) and correlation of data at global level,	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=Pvk9q7gdR8M&list=PLsfizngNlx8suxYQjXSZiHxlarp8wwERG&index=17>

Course Code: MEGS. 547

L	T	P	Credits
3	0	0	3

Course title: Research Methodology in Geosciences

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 of the limitations of particular research methods

CLO3: Justify knowledge of the selection of various instruments and sample preparation techniques for addressing the 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/10	Concept and definition of Research: academic research, basic and fundamental research, applied research, theoretical, conventional, and experimental research. Concepts and needs of the research hypothesis. Research proposal and concepts; developing a research proposal in the field of geosciences; research approach and identifying gap areas from the literature review; problem formulation and statement of research objective. Learning Activities: Assignment, take-home exercise on identifying research gaps from different selected topics, and discussion.	CLO1 CLO2
II/11	Literature survey and review, use of digital library, online resources; Problem formulation and statement of research objective; Development of bibliography. Concepts on plagiarism, ISSN and ISBN numbers, impact factors, and citation index of research articles, and assessing the quality of research articles. Learning Activities: Assignments and exercises on developing bibliography, referencing.	CLO4 CLO5
III/11	Pre-field preparations: field mapping and documentation, procedure of sampling, Introduction to field mapping and section measurement. Recent advancements in analytical techniques, field gear, data sciences, and AI in the field of Earth Sciences. Learning Activities: Assignment, take-home exercise, and student seminar.	CLO1 CLO2 CLO3 CLO4
IV/12	Types of data: primary and secondary data, source, and authenticity of secondary data. Introduction to analytical data treatment and Geochemical modelling.	CLO1 CLO2 CLO3

	Application of software in Earth science. Writing a scientific paper, abstract and summary writing, organizing a thesis, and project reports. Learning Activities: Assignment, take-home exercise, and student seminar.	
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Transactional Modes: Lecture, Lecture cum demonstration, Project Method, Seminar, Group discussion, Co-operative learning, Blended learning, Flipped learning, Team teaching, Brainstorming, 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://ww.modares.ac.ir/uploads/Agr.Oth.Lib.17.pdf>

<https://fac.ksu.edu.sa/sites/default/files/introduction-to-research-and-research-methods.pdf>

Tutorial/ Remedial Class

L	T	P	Credits
0	2	0	0

Two hours non-credit tutorial class is designed for remedial teaching. Scheduled classes will be assigned in the timetable. As per the requirement of students, remedial classes will be conducted in these periods.

Value Added Course

L	T	P	Credits
2	0	0	2

Course Code: MEGS.511

Course Title: Geological Mapping

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 include 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 fieldwork- use of clinometer, compass, Brunton compass, GPS, altimeter.	CLO2

	Attitude measurements: measurement of true thickness and distance, section measurement techniques, and significance. Learning Activities: Hands-on exercise on the application of geological tools, section measurement, and group discussion.	
III/12	Geological mapping procedures: Geological mapping of igneous terrains, geological mapping of sedimentary terrains. Geological mapping of metamorphic terrains and recording of structural information, preparation of Geological Cross-section. Learning Activities: Hands-on exercise on the geological mapping and cross-section preparations, assignments, and group discussion.	CLO3
IV/13	Techniques for sample collection: Sampling and oriented sampling, their significance; sampling for isotopic, geochronological, and geochemical studies, and their significance. Sampling strategies for micro-palaeontological and biostratigraphic studies and recording of palaeontological information. Learning Activities: Hands-on exercise on the sampling processes for certain geological analysis, assignments, and group discussion.	CLO4

Transactional Modes: Lecture, practical demonstration, Video demonstration, Lecture cum demonstration, ICT methods, web resource, Brainstorming 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/Broken>

[HillOlary/Mapping.html](https://www.gsi.ie/en-ie/programmes-andprojects/minerals/activities/mineral-exploration/Pages/Geological-Mapping)
<https://www.gsi.ie/en-ie/programmes-andprojects/minerals/activities/mineral-exploration/Pages/Geological-Mapping>

Semester IV

Course Code	Course Title	Course Type	Credit Hours			Credit
			L	T	P	Cr
MEGS.599	Dissertation	Dissertation	0	0	40	20
Total			0	0	40	20

Course Code: MEGS.599

L	T	P	Credits
0	0	40	20

Course Title: Dissertation / 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	Each candidate required to submit a dissertation	CLO1

	based on his/her research work carried out towards the fulfillment of his/her M.Sc. dissertation. It will have the following components: (a) Origin of the research problem and literature review (b) Objective of the research work (c) Methodology of the work, field observations (if any), and data recorded by the candidate, (d) Details of laboratory investigation (if any) carried out by the candidate, (e) Synthesis of results and interpretation (f) Concluding remarks and future direction 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.	CLO2 CLO3 CLO4 CLO5 CLO6
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Evaluation Criteria: The evaluation of the dissertation in the fourth semester will carry 50% weightage by the supervisor and 50% by the external expert. Distribution of marks as per the table given below. Marks for internship shall be given by the supervisor/internal mentor and external mentor. The final viva-voce will be through offline or online mode. The workload of one contact hour per student will be calculated for the dissertation in the fourth semester.

Dissertation (Fourth Semester)		
	Marks	Evaluation
Supervisor/ co-supervisor(s)	50	Continuous assessment (regularity in work, mid-term evaluation) dissertation report, presentation, final viva-voce
External expert	50	Report of dissertation (25), presentation (10), novelty/originality (5) and final viva-voce (10).

Students may opt for any internship/ academic or industrial training during the semester break with approval from the 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 NIR ranking. Group dissertation may be opted for, with a group consisting of a maximum of four students. These students may work using a single approach or a multidisciplinary approach. The research project can be taken up in collaboration with industry or in a group from within the discipline or across the discipline.