PROPOSED SEMESTER-WISE STRUCTURE, REGULATIONS AND DETAILED SYLLABUS OF M.Sc. (GEOLOGY), 2020

THE UNIVERSITY OF BURDWAN,
RAJBATI, BURDWAN,
WEST BENGAL

Semester I

Course				Lect. Hr /week	Dur. of Exam (in H)	Marks			Credit
Course code	Type	T/P	Name			I.A.	E.T	Total	
MSGL101	Core	T	Mineralogy & Geochemistry	4-0-0	2	10	40	50	4
MSGL102	Core	T	Igneous Petrology	4-0-0	2	10	40	50	4
MSGL103	Core	T	Sedimentology	4-0-0	2	10	40	50	4
MSGL104	Core	T	Metamorphic Petrology	4-0-0	2	10	40	50	4
MSGL105	Core	P	Mineralogy & Igneous Petrology	0-0-8	4	10	40	50	4
MSGL106	Core	P	Sedimentary & Metamorphic Petrology	0-0-8	4	10	40	50	4
					Total credit				24

Semester II

Course				Lect. Hr /week	Dur. of Exam (in H)	Marks			Credit
Course code	Type	T/P	Name			I.A.	E.T	Total	
MSGL201	Core	T	Structural Geology & Geotectonics	4-0-0	2	10	40	50	4
MSGL202	Core	T	Palaeontology	4-0-0	2	10	40	50	4
MSGL203	Core	T	Advanced Stratigraphy	4-0-0	2	10	40	50	4
MSGL204	Core	P	Structural Geology	0-0-8	4	10	40	50	4
MSGL205	Core	P	Palaeontology	0-0-8	4	10	40	50	4
MSGL206	Core	P	Field Geology	0-0-0	4	10	40	50	4
					Total credit				24

Semester III

Course				Lect. Hr /week	Dur. of Exam (in H)	Marks			Credit
Course code	Type	T/P	Name			I.A.	E.T	Total	
MSGL301	Core	T	Economic Geology	4-0-0	2	10	40	50	4
MSGL302	Core	T	Fuel Geology	4-0-0	2	10	40	50	4
MSGL303	Core	T	Hydrogeology	4-0-0	2	10	40	50	4
MSGL304	GE	T	Any One • Environmental Geology (MSGL304-1) • Natural hazards and mitigation (MSGL304-2) • Photogeology & Remote Sensing (MSGL304-3) • Introduction to Hydrogeology (MSGL304-4)	2-0-0	1	5	20	25	2
MSGL305	DE	T	Any One • Remote Sensing & GIS (MSGL305-1) •Rock deformation & Structural analysis (MSGL305-2) • Advanced Metamorphic Petrology (MSGL305-3) • Palaeobiology: Modern Concepts (MSGL305-4) • Oceanography (MSGL305-5) • From **SWAYAM** (MSGL305-6)	4-0-0	2	10	40	50	4
MSGL306	DE	P	Any One • Ore Geology • Hydrogeology • Photogeology & Remote Sensing	0-0-8	4	10	40	50	4
MSGL307	CE	N.A.	N.A.	N.A.	N.A.	5	20	25	2
					Total credit				24

CE: Community Engagement Activities; DE: Discipline-centric Elective; GE: Generic elective

Semester IV

Course				Lect. Hr /week	Dur. of Exam (in H)	Marks			Credit
Course code	Type	T/P	Name			I.A.	E.T	Total	
MSGL401	Core	T	Mineral Exploration and reserve estimation	4-0-0	2	10	40	50	4
MSGL402	Core	T	Mining & Engineering Geology	4-0-0	2	10	40	50	4
MSGL403	DE	T	Any One • Sedimentary Environment & Sedimentary basin analysis (MSGL404-1) • Petroleum Exploration (MSGL404-2) •Micropalaeontology Application to exploration sector (MSGL404-3) • Applied Coal Petrology (MSGL404-4) • Applied Geophysics (MSGL404-5) • Geostatistics (MSGL404-6) • Mineral Beneficiation & Mineral Economics (MSGL404-7)	4-0-0	2	10	40	50	4
MSGL404	DE	P/Term Paper	As chosen in MSGL404	0-0-8	4	10	40	50	4
MSGL405	Dissertation	N.A.	N.A.	0-0-0	---	20	80 (Thesis-60 Seminar-10 Viva-10)	100	8
					Total credit				24

PROLOGUE

1. Total duration of a Semester: 20 weeks (including holidays and vacations and excluding examination dates); effective contact being 12 to 13 weeks.

2. In M.Sc. (Geology) program the evaluation of the candidate shall be based on continuous assessment. Thus, each semester may be divided in three discrete component viz. C_1, C_2 and C_3. The outline for continuous assessment activities of different components will be proposed by the teacher(s) concerned before the commencement of the course and will be discussed and decided in appropriate forum. The students should be informed about the modalities well in advance. The first component (C_1) of assessment is for 10% of total marks of semester. This will be based on class test or assignment or seminar etc. During the first half of each semester, 50% of the syllabus will be completed. The continuous assessment and the scores of first half, C_1 will be consolidated during the 8^{th} week of the semester. The second component (C_2) of assessment is for 10% of total marks. This will also be based on class test or assignment or seminar etc. C_2 will be consolidated during the 16^{th} week of the semester. During 18^{th} to 20^{th} week of semester, a semester end examination (c_3) shall be conducted for each course. The total marks for C_3 is 80%. The result for each course in a semester will be based on the performance of C_1, C_2 and C_3 and it will be on the basis of grade point as fixed by the University of Burdwan.

3. In Semester II, there will be a compulsory field work that will cover structural and petrological studies of poly-deformed terrain.

4. In Semester III, students of Geology have to choose a Generic Elective course from a pool of courses from other departments of the University of Burdwan.

5. In Semester IV, every student has to submit a dissertation on the basis of his or her observations in the field and/or in the laboratory in any branch of Geology under the guidance of teacher(s). The dissertation thesis will be evaluated by the internal and external examiners separately. The dissertation also includes viva-voce conducted jointly by the external and internal examiners and a departmental seminar. Each student will have to present the dissertation work in an open seminar and will be evaluated by a panel of internal examiners. The Community Engagement Activities will be evaluated by one Internal Adjudicator.

Course Wise Content Details for M.Sc. Programme

1st Semester

Course Code: MSGL101
Mineralogy & Geochemistry

Course Objectives:

To understand (1) the characteristics of major rock forming mineral groups (2) crystal symmetry, crystallography, and atomic structure (3) formation environments and associations of rock-forming minerals (4) techniques of mineral characterization.
Geochemistry aims to give an introduction in how chemical principles are used to explain the mechanisms that control the large geological systems such as the Earth´s mantle, crust, ocean and atmosphere, and the formation of the solar system.

Course Learning Outcomes:

1) Identify common rock-forming minerals in hand specimen and in thin section using diagnostic physical, optical, and chemical properties (2) infer about the formation environment of a silicate mineral (3) ability to understand the information that minerals can provide about Earth processes and Earth history (4) understanding of basic techniques of mineral characterization. (5) to understand evolution of the early Earth from proto-planetary material and its differentiation to present day state. (6) to describe the composition of the Earth´s main geochemical reservoirs. (7) to explain element fractionation and how this can be used to understand geochemical processes. (8) to apply radiogenic isotope signatures to trace the source of minerals, rocks and to date magmatic and metamorphic events. (9) to understand how chemical weathering of minerals and rocks control the composition of sediments/soil and natural water (10) to demonstrate their ability to obtain, analyze and synthesize information relevant to Geochemistry.

Content:
Group A: Mineralogy (MSGL101A)

1. Different types of Si- O bond: Electro-neutrality principles (with reference to forsterite); Substitution principles – Review of Goldschmidt's Principles – Controls of element substitution; Common substitution in rock forming minerals.
2. Principles of X -Ray powder method; Bragg's equations and its application: X-ray camera. Diffractogram procedures for identification of minerals from X-ray powder diagram. Use of powder method in determination of "obliquity" of K-feldspar, cell-edge of isometric crystals.
3. Generalized formula, classification and structure of pyroxene, amphibole, olivine, mica and feldspar, phase inversion of pyroxene and olivine. Order-disorder in feldspar. Thermometric application of pyroxene and feldspar.

Group B: Geochemistry (MSGL101B)

1. Calculation of cation proportions; chemical formula, vacant site from chemical analysis.
2. Earth in relation to solar system and universe. Cosmic abundance of elements, Comparisons of planets and meteorites. Structure and composition of earth and distribution of elements. Trace element geochemistry.
3. Different types of radioactive decay; brief outline of dating by Rb-Sr, K-Ar, Sm-Nd, U-Pb and C-14 methods. Radioactive dating of single minerals and whole rocks. Application of oxygen, carbon and sulfur isotopes.

4. General chemical characteristics of sedimentary rocks; role of ionic potential, H-ion concentration and oxidation-reduction potential in sedimentation. Eh-pH diagrams of Mn-H_2O systems and Fe- H_2O systems with/without CO_2.
5. The evolution of atmosphere, constancy of atmospheric composition; evidences in favour of presence of oxygen in Archean atmosphere. Formation and destruction of ozone layer.

Unit-1	6 Hours
Different types of Si- O bond: Electro-neutrality principles (with reference to forsterite); Substitution principles – Review of Goldschmidt's Principles – Controls of element substitution; Common substitution in rock forming minerals.	
Unit-2	8 Hours
Principles of X -Ray powder method; Bragg's equations and its application: X-ray camera; Diffractogram procedures for identification of minerals from X-ray powder diagram; Use of powder method in determination of "obliquity" of K-feldspar, cell-edge of isometric crystals.	
Unit-3	5 Hours
Generalized formula, classification and structure of pyroxene, amphibole, olivine, mica and feldspar, phase inversion of pyroxene and olivine; Order-disorder in feldspar; Thermometric application of pyroxene and feldspar.	
Unit-4	4 Hours
Calculation of cation proportions; chemical formula, vacant site from chemical analysis.	
Unit-5	6 Hours
Earth in relation to solar system and universe; Cosmic abundance of elements; Comparisons of planets and meteorites; Structure and composition of earth and distribution of elements; Trace element geochemistry.	
Unit-6	6 Hours
Different types of radioactive decay; Brief outline of dating by Rb-Sr, K-Ar, Sm-Nd, U-Pb and C-14 methods; Radioactive dating of single minerals and whole rocks; Application of oxygen, carbon and sulfur isotopes.	
Unit-7	6 Hours
General chemical characteristics of sedimentary rocks; role of ionic potential, H-ion concentration and oxidation-reduction potential in sedimentation; Eh-pH diagrams of Mn-H2O systems and Fe- H2O systems with/without CO2.	
Unit-8	8 Hours
The evolution of atmosphere, constancy of atmospheric composition; Evidences in favour of presence of oxygen in Archean atmosphere; Formation and destruction of ozone layer.	

Suggested Readings:

1 Deer,W.A., Howie,R.A., and Zussman, J.(1996): The rock forming minerals: Longman
2 Klein, C. and Hurlbert, C.S. (1993): Manual of mineralogy, John Willy.
3 Putnis, A. (1992): Introduction to Mineral Sciences, Cambridge University Press.
4 Spear, F.S. (1993): Metamorphic Phase Equilibria and P-T-Time Path, Mineralogical Society ofAmerica Publication.
5 Phillips.W.R. and Grieffen, D.T.(1986): Optical Mineralogy, CBS pub.
6 Hutchinson, C.S., (1974), Laboratory Handbook of petrographic techniques: John Willey
7 Mason, B. and Moore,C.(1991)"Introduction to Geochemistry"-Willey Eastern
8 Krauskopf, K.B. (1967) "Introduction to Geochemistry"- Mcgraw-Hill.
9 Brownlow, "Geochemistry".

10 Faure, G. (1986) “Principles of Isotope geology” – John Willey.
11 Hoefs,J.(1980) “Stable Isotope Geochemistry” – Springer-Verlag.
12 Govett, G.J.S. ed. (1983) “Handbook of exploration geochemistry”.Elsevier
13 Handerson,P.(1987) “Inorganic Geochemistry” – Pergamon Press.
14 Nordstron, D.K. and Munoz.J.L.(1986) “Geochemistry Thermodynamics – Blackwell.
15 Albarede. F. (2003), “Geochemistry-an Introduction”- Cambridge University Press. U.K.

Course Code: MSGL102

Igneous Petrology

Course Objectives:

Igneous petrology in the field of geology, the objective of the study to gain an appreciation for how the final appearance of characteristics of igneous rocks is controlled by chemical and physical properties of magmas and their surroundings.

Course Learning Outcomes:

Study of igneous rocks is a key component of geology curriculum (because these rocks not only abundant throughout the crust of the Earth, but, dominate some crustal and upper mantle environments) that provides understanding of melt generation and crystallization mechanisms, diverse rock types and their link to tectonic settings.

Content:

1. Phase equilibria studies in binary, ternary and quaternary silicate system with reference to petrogenesis; Cryoscopic equation; Solubility of H_2O, CO_2 , S etc. in silicate melts; Role of oxygen fugacity in phase equlibria.
2. Physical state, chemical and mineralogical composition of upper mantle; Partial melting processes in the upper mantle; Segregation and ascent of magma.
3. Variation diagrams and their uses to model magmatic evolution; Stable and radiogenic isotopic composition and their role in igneous petrognenesis; Geochemical criteria to identify palaeotectonic settings; Distribution of igneous rocks in space and time.
4. Mineralogy, geochemical characteristics, mode of occurrences, classification and origin of basalt, granite, andesite, peridotite, anorthosite, kimberlite and carbonatite.

Unit-1	8 Hours
Phase equilibria studies in binary, ternary and quaternary silicate system with reference to petrogenesis; Cryoscopic equation.	
Unit-2	6 Hours
Solubility of H_2O, CO_2, S etc. in silicate melts; Role of oxygen fugacity in phase equlibria.	
Unit-3	10 Hours
Physical state, chemical and mineralogical composition of upper mantle; Partial melting processes in the upper mantle; Segregation and ascent of magma.	
Unit-4	6 Hours
Variation diagrams and their uses to model magmatic evolution	
Unit-5	10 Hours
Stable and radiogenic isotopic composition and their role in igneous petrognenesis; Geochemical criteria to identify palaeotectonic settings; Distribution of igneous rocks in space and time.	
Unit-6	8 Hours
Mineralogy, geochemical characteristics, mode of occurrences, classification and origin of basalt, granite, andesite, peridotite, anorthosite, kimberlite and carbonatite.	

Suggested Readings:

1 Bose;M.K. (1997) Igneous petrology, The World Press Pvt. Ltd.
2 Hall, A., (1996) Igneous petrology, Longman Group Ltd. England.
3 McBirney.A.R.(1994), Igneous petrology, CBS Pub.& Distributors.
4 Philpotts.A.R.(1994) Principles of igneous and metamorphic petrology, Prentice Hall
5 Wilson.M. (1989) Igneous petrogenesis, Unwin-Hyman.
6 Winter.J.D.(2001) An introduction to igneous and metamorphic petrology,Prentice Hall.

Course Code: MSGL103
Sedimentology

Course Objectives:

Sedimentary rocks are storehouse of many basic necessities of modern civilization viz. water, hydrocarbon etc. Major objective of the course is to make students understand fundamentals of sedimentary processes and their products, formation and filling history of sedimentary basins in different tectonic backdrop. Nuances of both clastic and chemical sedimentation processes will be covered.

Course Learning Outcomes:

1. To understand fundamentals of fluid flow, fluid- sediment interaction and formation of bedforms at various scales in different flow regime conditions
2. To describe scales of sedimentary grain size measurement and statistical analysis of data to interpret provenance, transportation history or depositional environment
3. To understand texture and structure of clastic sedimentary rocks; procedure and importance of paleocurrent analysis
4. To comprehend concept of sedimentary environment and description of processes and

products of different sedimentary environments viz. continental, marginal marine and marine

5. To understand origin, mineralogy and signatures of diagentic overprinting of chemical sedimentary rocks viz. carbonate, chert, phosphorite, Evaporite etc.

6. To comprehend relationship between tectonics and sedimentary basin formation vis-a-vis their depositional motif.

Content:

1 Type of sedimentary rocks and brief description of different terrigenous and carbonate rocks. Distribution of sedimentary rocks in space and time. Scope of sedimentology.
2 Weathering processes, soil- forming processes, Paleosols and its recognition, Fluid flow and sediment transport.
3 Sedimentary structures- types, origin and significance. Paleocurrent analysis from sedimentary structures.
4 Diagenesis of terrigenous and carbonate rocks- Stages and realms of Diagenesis, major diagenetic processes and changes; Dolomitisation.
5 Composition, classification and origin of Evaporite, Chert, Iron-rich sediments and Phosphorite.
6 Depositional Environment: Terrestrial environment, marginal marine environment, siliciclastic marine environment and carbonate environment.
7 Sedimentary facies, cyclic succession, effect of climate and sea level on sedimentation. Patterns; Sequence stratigraphy: principles and its application.
8 Sedimentary basins and basin analysis: Kinds of sedimentary basins, Tectonics and sedimentation, Techniques of basin analysis; Siliciclastic petrofacies studies; Importance of basin analysis.

Unit-1	4 Hours
Type of sedimentary rocks and brief description of different terrigenous and carbonate rocks. Distribution of sedimentary rocks in space and time. Scope of sedimentology.	
Unit-2	6 Hours
Weathering processes, soil- forming processes, Paleosols and its recognition, Fluid flow and sediment transport.	
Unit-3	6 Hours
Sedimentary structures- types, origin and significance. Paleocurrent analysis from sedimentary structures.	
Unit-4	6 Hours
Diagenesis of terrigenous and carbonate rocks- Stages and realms of Diagenesis, major diagenetic processes and changes; Dolomitisation.	
Unit-5	6 Hours
Composition, classification and origin of Evaporite, Chert, Iron-rich sediments and Phosphorite.	
Unit-6	8 Hours
Depositional Environment: Terrestrial environment, marginal marine environment, siliciclastic marine environment and carbonate environment.	
Unit-7	6 Hours
Sedimentary facies, cyclic succession, effect of climate and sea level on sedimentation. Patterns; Sequence stratigraphy: principles and its application.	
Unit-8	6 Hours
Sedimentary basins and basin analysis: Kinds of sedimentary basins, Tectonics and sedimentation, Techniques of basin analysis; Siliciclastic petrofacies studies; Importance of basin analysis.	

Suggested Readings:

1 Pettijohn. F.J., Potter, P.E. and Siever.R.(1990) Sand and sandstone, Springer Verlag.
2 R.L.Folk (1981), Petrology of sedimentary rocks.
3 M.E. Tucker, Sedimentary petrology
4 Harvey Blatt, Sedimentary petrology
5 Collinson& Thompson, Sedimentary Structures.
6 SEPM short course, Conglomerate (Chapter-7)
7 Sengupta.S. (1997): Introduction to sedimentology, Oxford-IBH.
8 Boggs Sam Jr. (2014) Principles of Sedimentology and Stratigraphy
9 Blatt.H., Murray.G.V. and Middleton, R.C. (1980): Origin of sedimentary rocks.
10 Fritz & Moore, Origin of physical strtigraphy and sedimentology.
11 Allen, J.R.L. (1985) Principles of physical sedimentation, George Allen & Unwin.
12 Reading, H.G. (1996): sedimentary environments. Blackwell.
13 Prothero, D.R. and Schwab, F. (1996) sedimentary Geology, Freeman.
14 Reineck, H.E. and Singh, I.B. (1980) Depositional sedimentary environments. Springer Verlag.
15 M.E.Tucker and V. Paul Wright (1991), Carbonate Sedimentology.
16. OCTAVIAN CATUNEANU (2006), PRINCIPLES OF SEQUENCE STRATIGRAPHY.

Course Code: MSGL104
Metamorphic Petrology

Course Objectives:

Dynamic nature of lithosphere leads to solid state transformations of rocks which hold clue to the past processes which are not possible to reconstruct by other means. This course aims to enable students to identify critical data as well as provide theoretical basis for interpreting this data for past geodynamic processes, especially the orogenic events.

Course Learning Outcomes:

1. Identifying equilibrium mineral assemblages through textural and mineralogical observations
2. Plotting the quantitative as well as qualitative mineral and mineral assemblage data to interpret the discontinuous reactions and to infer the nature of continuous reactions
3. Learn the basics of Schreinemakers geometric plots for a set of reactions

Content:

1. Concepts of metamorphic zones and metamorphic facies
2. ACF, AKF and AFM diagrams
3. Regional and thermal metamorphism of some common rocks
4. Paired metamorphic belts
5. Concepts of metamorphic equilibrium and disequilibrium
6. Metamorphic differentiation and metasomatism
7. Interpretations of some metamorphic textures and structures
8. Anatexis and migmatites
9. Eclogites
10. Metamorphism in relation to magma and orogeny

Unit-1	6 Hours
Concepts of metamorphic zones and metamorphic facies; Paired metamorphic belts.	
Unit-2	6 Hours
ACF, AKF and AFM diagrams.	
Unit-3	10 Hours
Regional and thermal metamorphism of some common rocks.	
Unit-4	8 Hours
Concepts of metamorphic equilibrium and disequilibrium; Metamorphic differentiation and metasomatism.	
Unit-5	6 Hours
Interpretations of some metamorphic textures and structures.	
Unit-6	6 Hours
Anatexis and migmatites.	
Unit-7	6 Hours
Metamorphism in relation to magma and orogeny; Eclogites.	

Suggested Readings:

1 Miyashiro,A. (1973), Metamorphism and Metamorphic Belts. George Allen and Unwin.
2 Phipotts.A.R. (1994) Principles of Igneous Metamorphic Petrology, Prentice- Hall
3 Spry. A.,(1969), Metamorphic Textures, Pergamon Oxford.
4 Turner, F.J. and Verhoogen.J.,(1960) Igneous and Metamorphic Petrology, McGrow-Hill.
5 Winter. J.D.(2001) An introduction to Igneous and Metamorphic Petrology, Prentice-Hall.
6 Yardley. B.D.(1989) An introduction to metamorphic petrology, Longman.

Course Code: MSGL105
Mineralogy and Igneous Petrology

1. Determination of optic sign in oriented and un-oriented mineral grains. Study of inter-eraltionship of optical directions and the crystallographic axes in a few rock forming minerals. Study of pleochroism and absorption in a few rock minerals.
2. Study of common important rocks and rock associations in hand s specimens and in thin section with special reference to texture and structure.

Course Code: MSGL106
Sedimentology & Metamorphic Petrology

1. Description and interpretation of primary, secondary and biogenic sedimentary structures in hand specimen.
2. Study of sandstones (with special emphasis on diagnosis and provenance) and lime stones (with special emphasis on components and diagenesis).
3. Exercises related to paleocurrent and granulometic data.
4. Detail studies of some metamorphic rocks under microscope.

2nd Semester

Course Code: MSGL201
Structural Geology and Geotectonics

Course Objectives:

Due to the dynamic instability of the lithosphere, continuous and discontinuous deformation takes place within the rocks in solid or semi-solid state, at different scales, which manifests in a variety of complex structures in these rocks. The present course will teach the student how to unravel the underlying deformation processes and mechanisms through an accurate geometric and kinematic analysis of these natural structures.

Course Learning Outcomes:

(List of outcomes in terms of learnings which student will be able to acquire due to this course)

1. Accurate geometric description of the structures observed in natural deformed rocks.
2. Measurement of various orientation data from the structures, plotting them in suitable diagrams and make a quantitative analysis.
3. Basic concepts of the rheological properties of rocks and their control on the deformation processes
4. Understanding deformation mechanisms at micro-, meso- and macroscopic scales.

Content:
Group A: Structural Geology (MSGL201A)

1. Rheology: Behaviors of rocks under stress; Rheological models; Flow law for steady state creep; factors; influencing flow of rocks; Deformation mechanism; Estimation of paleostress;
2. Stress; Basic concept of stress; Analysis of stress in 3 – Dimensions; stress filed description; Equilibrium condition; Trajectory patterns and boundary condition.
3. Strain: Infinitesimal strain; Measurement of strain; Progressive deformation
4. Folds; Fold mechanics for single and multilayer bodies; Distribution of strain in fold; Fold interference in single and multilayer; Structural analysis for areas of superposed folding.
5. Shear Zone; Fault; Fractures; Joints; Origin, Mechanics and significance.
6. Foliation; Lineation; Boudinage; Origin and significance

Unit-1	4 Hours
Rheology: Behaviors of rocks under stress; Rheological models; Flow law for steady state creep; factors; influencing flow of rocks; Deformation mechanism; Estimation of paleostress	
Unit-2	6 Hours
Stress; Basic concept of stress; Analysis of stress in 3 – Dimensions; stress filed description; Equilibrium condition; Trajectory patterns and boundary condition.	
Unit-3	6 Hours
Strain: Infinitesimal strain; Measurement of strain; Progressive deformation	
Unit-4	6 Hours
Folds; Fold mechanics for single and multilayer bodies; Distribution of strain in fold; Fold interference in single and multilayer; Structural analysis for areas of superposed folding.	
Unit-5	6 Hours
Shear Zone; Fault; Fractures; Joints; Origin, Mechanics and significance.	
Unit-6	6 Hours
Foliation; Lineation; Boudinage; Origin and significance	

Suggested Readings:

1 Twiss,R.J. and Moore, E.M.(1992): Structural Geology, Freeman & Co.
2 Ramsay,J.G. and Huber, M.L.(1983): The techniques of Modern Structural Geology Vol.-1,2,3 Academic Press.
3 Ramsay.J.G. (1967): Folding and Fracturing of rocks, McGraw Hill.
4 Means.W.D. (1979): Stress and Strain, Springer and Verlag.
5 Passchier.C.W. and Trouw.R.A.J. (1996): Microtechtonics, Springer-Verlag,Berlin.
6 Ghosh,S.K. (1993): Structural Geology-Fundamentals and Modern Developments. Pergamon Press.

Group B: Geotectonics (MSGL201B)

1. Methods of study of Geotectonics including study of earthquake, volcanism, plutonism, paleomagnetism etc.
2. Geology of the plate margins with an introduction of the concept of super continent
3. Elements of Neotectonics

Unit-1	4 Hours
Methods of study of Geotectonics including study of earthquake, volcanism, plutonism, paleomagnetism etc.	
Unit-2	6 Hours
Geology of the plate margins with an introduction of the concept of super continent	
Unit-3	4 Hours
Elements of Neotectonics	

Suggested Readings:

1 Condie,K.C. Plate Tectonic and Crustal Evolution.
2 Wilson,M.: Igneous Rocks.
3 Moores and Twiss, Tectonics.
4 Keary and Vine, F.J., Global Tectonics

Course Code: MSGL202
Palaeontology

Course Objectives:

To understand the Invertebrate, Vertebrate and Micropalaeontology in the light of their morphology, adaptation, ecology and Evolution. The present course will also teach on the evidences and records of the earliest life on the earth.

Course Learning Outcomes:

1. Identification of older life forms with their external and internal features.
2. Application of morphological modifications to deduce the ecology.
3. Application of principles of speciation and evolution.

Content:

1 Species concept
2 Growth and allometry
3 Evolutionary Systematics
4 Evolution theories, modes, patterns, processes and trends
5 Functional morphology
6 Palaeoecology and Palaeobiogeography
7 Biostraigraphy
8 Micropalaeontology: introduction, micro vs. mega palaeontology, importance
9 Foraminifera: morphology, palaeocology, evolution
10 Palynology: introduction, palynomorphs, morphology of spores and pollens
11 Terrestrial habitat- challenges met by vertebrates
12 Dinosaur: major subdivision, a broad account through ages, Indian occurrences, causes of extinction
13 Evolution of Ammonoidea and Equidae as examples of studying evolution

14 Emergence of life: different theories, present status, evidence of Precambrian life, Indian occurrences, paleontology of Precambrian –Cambrian boundary, origin of hard part, Cambrian exploration, Ediacaran fauna, Burgess Shale fauna, SSF.

Unit-1	4 Hours
Species concept, Growth and allometry, Evolutionary Systematics	
Unit-2	8 Hours
Evolution theories, modes, patterns, processes and trends	
Unit-3	8 Hours
Functional morphology, Palaeoecology and Palaeobiogeography, Biostraigraphy	
Unit-4	8 Hours
Micropalaeontology: introduction, micro vs. mega palaeontology, importance, Foraminifera: morphology, palaeocology, evolution	
Unit-5	4 Hours
Palynology: introduction, palynomorphs, morphology of spores and pollens	
Unit-6	8 Hours
Terrestrial habitat- challenges met by vertebrates, Dinosaur: major subdivision, a broad account through ages, Indian occurrences, causes of extinction	
Unit-7	4 Hours
Evolution of Ammonoidea and Equidae as examples of studying evolution	
Unit- 8	4 Hours
Emergence of life: different theories, present status, evidence of Precambrian life, Indian occurrences, paleontology of Precambrian –Cambrian boundary, origin of hard part, Cambrian exploration, Ediacaran fauna, Burgess Shale fauna, SSF.	

Suggested Readings:

1 Raup, D.M. and Stanley, S.M.(1985):Principles of Palaeontology CBS Publishers & Dist.
2 Stern,C.W. and Carroll,R.L. (1989):Palaeontology- the record of life. John Wiley.
3 Prothero,D.R.(1998) : Bringing fossils to life- an introduction to palaeobiology McGrow Hill
4 Brasier, M.D.(1980): Microfossils, George Allen & Unwin, London
5 Bignot,G.(1985): Elements of Micropalaeontology Graham & Trotman Ltd. London
6 Haq. B.U. and Boersma. A.(Eds).(1978): Introduction to Marine Micropalaeontology, Elsevier, New York.

Course Code: MSGL203
Advanced Stratigraphy

Course Objectives:

The course is intended to familiarise the student with stratigraphic principles and nomenclature, major stratigraphic units, methods of stratigraphic correlation, depositional environments and tectonostratigraphic framework of various lithostratigraphic units of India spanning Archaean to Holocene, and mass extinction boundaries.

Course Learning Outcomes:
On successful completion of the course, the student will be able to:

1. Understand basic principles of stratigraphy, different types of stratigraphic units and how they are named.
2. Know the crustal evolution during the Precambrian in peninsular India and how the biosphere responded to the Precambrian-Cambrian boundary events.
3. Appreciate how plate tectonic movements separated India from contiguous landmasses and shaped the depositional basins of the Indian Phanerozoic, and what were their effects on climate and life.
4. Learn about large igneous provinces and their role in mass extinction events and important mass extinction boundary sections.
5. Gain knowledge on stratigraphy and sedimentation in India – Asia continental collision zone and Himalayan foreland basin.

Content:
Group A: Precambrian Stratigraphy (MSGL203A)

1 Method in stratigraphy: Building-up of regional stratigraphy and its positioning in geological time scale.
2 Evolution of crust in Precambrian as reflected in the geology of Singhbhum- Orissa Iron Ore Craton.
3 Temporal transition in rock records across Archaean-Proterozoic (A-P) boundary.
4 General characteristics of the Proterozoic Purana Basin of India.
5 Evolution of the Precambrian atmosphere, hydrosphere and their change across Proterozoic- Paleozoic (P-P) boundary.

Group B: Phanerozoic Stratigraphy (MSGL203B)

1 Phanerozoic successions at different parts of India and their interrelationship in terms of plate tectonics (supercontinental cycle, paleolatitudes, etc.), eustasy, and paleoenvironment.
2. Stratigraphic framework of Marine Palaeozoic and Mesozoic rocks of Himalaya with special reference to Kashmir and Spiti.
3 Gondwana Supergroup of rocks, its fauna and flora, depositional history, economic importance and climate; Mesozoic and Cenozoic sedimentary basins of Kachchh; Jaisalmer; Cauvery Basin and Narmada Valley.
4 Phanerozoic igneous activity and its relation with northward advent of the Indian plate. Deccan Volcanic Province.
5 Stratigraphy of the Himalayan foreland basin (Subathu, Murree/Dagshai-Kasauli, Siwalik)
6 Boundary problems and their critical evaluation in the context of Indian Phanerozoic stratigraphy of the following boundaries: P-T, K-T and Palaeogene – Neogene.

Group C: Quaternary Stratigraphy (MSGL203C)

1 Definition, scope and methods of quaternary Geology.
2 Quaternary Environments: An introduction & Milankovitch Hypothesis and quaternary Environments.
3 Quaternary Sea-level changes; Oxyzen isotope chronostratigraphy.
4 Magneto-Stratigraphy; Amino acid Diagenesis; Glacial varves; Dendrochronology; Tephrochronology.
5 Outline of significant fossil records of the Quaternary; Pollen analysis, Mammalian fauna, Deep sea Biostratigraphy.
6 Outline of Quaternary deposits- Indian examples. Quaternary deposits of Kashmir (Karewa), Andaman Islands, continental Quaternary deposits and their significance.

Unit-1	4 Hours
Method in stratigraphy: Building-up of regional stratigraphy and its positioning in geological time scale.	
Unit-2	8 Hours
Evolution of crust in Precambrian as reflected in the geology of Singhbhum- Orissa Iron Ore Craton.	
Unit-3	2 Hours
Temporal transition in rock records across Archaean-Proterozoic (A-P) boundary.	
Unit-4	6 Hours
General characteristics of the Proterozoic Purana Basin of India.	
Unit-5	4 Hours
Evolution of the Precambrian atmosphere, hydrosphere and their change across Proterozoic-Paleozoic (P-P) boundary.	
Unit-6	2 Hours
Phanerozoic successions at different parts of India and their interrelationship in terms of plate tectonics (supercontinental cycle, paleolatitudes, etc.), eustasy, and paleoenvironment.	
Unit-7	5 Hours
Stratigraphic framework of Marine Palaeozoic and Mesozoic rocks of Himalaya with special reference to Kashmir and Spiti.	
Unit-8	4 Hours
Gondwana Supergroup of rocks, its fauna and flora, depositional history, economic importance and climate; Mesozoic and Cenozoic sedimentary basins of Kachchh; Jaisalmer; Cauvery Basin and Narmada Valley.	
Unit-9	2 Hours
Phanerozoic igneous activity and its relation with northward advent of the Indian plate; Deccan Volcanic Province.	
Unit-10	4 Hours
Stratigraphy of the Himalayan foreland basin (Subathu, Murree/Dagshai-Kasauli, Siwalik).	
Unit-11	3 Hours
Boundary problems and their critical evaluation in the context of Indian Phanerozoic stratigraphy of the following boundaries: P-T, K-T and Palaeogene – Neogene.	
Unit-12	5 Hours
Definition, scope and methods of quaternary Geology; Quaternary Environments: An introduction & Milankovitch Hypothesis and Quaternary Environments; Quaternary Sea-level changes; Oxyzen isotope chronostratigraphy; Magneto-Stratigraphy; Amino acid Diagenesis; Glacial varves; Dendrochronology; Tephrochronology; Outline of significant fossil records of the Quaternary; Pollen analysis, Mammalian fauna, Deep sea Biostratigraphy; Outline of Quaternary deposits- Indian examples; Quaternary deposits of Kashmir (Karewa), Andaman Islands, continental Quaternary deposits and their significance.	

Suggested Readings:

1 Krisnan, M.S. (1982) Geology of India and Burma, CBS India
2 Naqvi & Rogers (1987) Precambrian of India, Oxford University Press
3 Roy, A.B.(1998) Precambrian of India, Oxford University Press.

4 Roy, A.B. (1998) Precambrian of the Aravalli Mountain, Rajasthan, India, Geological Society of India, Memoir-7
5 Radhakrishnan, B.P. & Baidyanathan, M. Geology of Karnataka, Geological Society of India, Memoir.
6 Saha, A.K. Geology of Singbhum, Monograph.
7 Condie K.C. (1989) Plate tectonics and Crustal evolution, 3rd. Edition, Pergamon Press.
8 Bowen, D.Q. (1978) Quartenary Geology. Pergamon Press. Ltd. UK.
9 Willams, M.Dunkerley, D.De Dekkar, P. Kershaw, P. Chappel,J.(1998). Quarternary Environment, Arnold London, 2nd. Edition.
10. A.B. Roy and Ritesh Purohit (2018) Indian Shield Precambrian Evolution and Phanerozoic Reconstitution
11. Soumyajit Mukherjee Editor (2019) Tectonics and Structural Geology: Indian Context
12. M. E. A. Mondal Editor (2019) Geological Evolution of the Precambrian Indian Shield
13. Bastia and Radhakrishna (2012) Basin Evolution and Petroleum Prospectivity of the Continental Margin of India
14. K.S Valdiya (2015) The Making of India
15. Jai Krishna (2017) The Indian Mesozoic Chronicle
16. B.K. Chakrabarti (2016) Geology of the Himalayan Belt Deformation, Metamorphism, Stratigraphy

Course Code: MSGL204

Structural Geology

1 Use of the stereographic projection and graphical methods to solve advanced structural problems.
2 Analysis of stress orientation on the basis of fracture data
3 Interpretation of outcrop patterns of different kinds of mesoscopic folds and faults involving polyphase deformation on flat and undulating topography.
4 2D and 3D strain analysis
5 Field Work and Field Report (20Marks): There will be one compulsory geological field work for 2 weeks and training will be imparted on structural and petrological studies of a poly- deformed terrain.

Course Code: MSGL205

Palaeontology

1 Exercise on ontogenetic growth patterns by biometric analysis
2 Exercise on numerical techniques to study populations
3 Exercise on phonetic and cladistic analysis
4 Functional morphological analysis of invertebrates and vertebrates
5 Study of microfossils

Course Code: MSGL206

Field Geology

Course Objectives:

Geology is an applied subject that largely depends on data collection and its interpretation to develop an idea on the evolution of the earth starting from local to regional to global level. Field work in Geology gives a first-hand experience of data acquisition and its application from a complex terrain.

Course Learning Outcomes:
Students will be able to unfold the complex history of evolution of a complex terrain.

Content:
Structural and petrological studies in a polydeformed terrain. Preparation of lithological and structural map and its interpretation. Field report and viva voce.

3rd Semester

Course Code: MSGL301
Economic Geology

Course Objectives:
The objectives of this course are to: (a) familiarize with common ore minerals and their identifying criteria at various scales of study, (b) to understand the genetic controls exerted by physical and chemical processes on ore formation in various geologic settings.

Course Learning Outcomes:
On completion of this course, students should have developed skills in the following areas:

1. Recognize common ore minerals in hand samples and under microscope
2. Knowledge about a wide range of ore deposits, the geometry of ore bodies, alteration patterns and assemblage of ore and gangue minerals
3. Awareness about distribution of mineral deposits in India

Content:
Group A: Ore Geology (MSGL301A)

1 Spatial and temporal distribution of ore: Metallogenic Epoch, Metallogenic Province and ore mineralization in relation to plate tectonics.
2 Systematic study of ore deposits (Mode of occurrence and its importance, ore textures and their genesis, Sulphide and oxide phase equilibria and its significance)
3 Important ore-associations and their genetic models, Applications of geochemistry in ore deposit modeling (Orthomagmatic ores of mafic-ultramafic association, Ores of silicic igneous rock association, Ores of sedimentary association: Sedimentary deposits, placer deposits, Ores of volcanic- Volcano-sedimentary association, Ores of metamorphic association, Ores associated with weathering surfaces)
4 Indian scenario of Fe, Mn, Cu, Pb, Zn, Cr, Ni, Sn and W deposits.

Group B: Non-metallic deposits (MSGL301B)

Mode of Occurrence, Lithoassociation, Genesis of the following non-metallic minerals: diamond, graphite, barite, gypsum, phosphorite, mica and asbestos.

Unit-1	6 Hours
Spatial and temporal distribution of ore: Metallogenic Epoch, Metallogenic Province and ore mineralization in relation to plate tectonics.	
Unit-2	6 Hours
Systematic study of ore deposits (Mode of occurrence and its importance, ore textures and their genesis, Sulphide and oxide phase equilibria and its significance).	
Unit-3	12 Hours
Important ore-associations and their genetic models; Applications of geochemistry in ore deposit modeling (Orthomagmatic ores of mafic-ultramafic association, Ores of silicic igneous rock association, Ores of sedimentary association: Sedimentary deposits, placer deposits, Ores of volcanic- Volcano-sedimentary association, Ores of metamorphic association, Ores associated with weathering surfaces).	
Unit-4	9 Hours
Indian scenario of Fe, Mn, Cu, Pb, Zn, Cr, Ni, Sn and W deposits.	
Unit-5	15 Hours
Mode of Occurrence, Lithoassociation, Genesis of the following non-metallic minerals: diamond, graphite, barite, gypsum, phosphorite, mica and asbestos.	

Suggested reading

1. Ridley, John. (2013). *Ore deposit geology*. Cambridge University Press.
2. Barnes, H.L., 1979. Geochemistry of Hydrothermal Ore Deposits, John Wiley.
3. Mookherjee, A, 2000. Ore Genesis - A Holistic Approach. Allied Publisher.
4. Craig, J. R., and D. J. Vaughn. "Ore microscopy and ore mineralogy." (1994).
5. Pracejus, Bernhard. *The ore minerals under the microscope: an optical guide*. Vol. 3. Elsevier, 2015.
6. Bateman, Alan Mara, and Mead L. Jensen. *Economic mineral deposits*. Vol. 259. New York: Wiley, 1950.
7. Robb, L (2005) INTRODUCTION TO ORE-FORMING PROCESSES
8. Walter L. Pohl (2011) Economic Geology Principles and Practice Metals, Minerals, Coal and Hydrocarbons – Introduction to Formation and Sustainable Exploitation of Mineral Deposits
9. Stephen E. Kesler, Adam C. Simon (2015) Mineral Resources, Economics and the Environment
10. P. R. Ineson (1989), INTRODUCTION TO PRACTICAL ORE MICROSCOPY
11. Mihir Deb, Sanjib Chandra Sarkar (2017) Minerals and Allied Natural Resources and their Sustainable Development Principles, Perspectives with Emphasis on the Indian Scenario
12. Nicholas Arndt, Stephen Kesler, Clément Ganino (2010) Metals and Society An Introduction to Economic Geology
13. A.M. EVANS (1993) Ore Geology and Industrial Minerals An Introduction
14. K.C.Misra (1999) Understanding Mineral Deposits
15. Florian Neukirchen, Gunnar Ries (2020) The World of Mineral Deposits A Beginner's Guide to Economic Geology
16. Franco Pirajno (2000) Ore Deposits and Mantle Plumes

Course Code: MSGL302
Fuel Geology

Course Objectives:

To make students understand fundamentals of coal, coal forming environments and processes, coal: petrography, classification, analytical techniques of coal. Concept of macerals and its application in

climate and paleogeography and coal seam correlation will be covered. Application of coal for various industries will be discussed. Understanding will be developed for coal as an unconventional source of energy viz. CBM and synthetic crude oil and its environmental impact. This will also introduce the composition, origin of Petroleum, Organic Petrology and Petroleum Formation and Occurrence. To understand the geochemistry and distribution of radioactive minerals.

Course Learning Outcomes:

1. To understand fundamentals of coal and petroleum, definition and coal and petroleum forming sedimentary environments, effect of tectonics and sea-level changes on coal and petroleum formation.
2. To describe the basis of coal classification, concept of grade, type and rank in coal.
3. To understand analytical techniques in coal and its importance in coal classification and utilization for various industries.
4. To comprehend concept of macerals its gross diagnostic properties under microscope and implications in climate and paleogeography.
5. To understand concept of underground coal gasification, clean coal technology, carbonization etc. coal as unconventional source of energy (CBM, Coal liquefaction) and its potential in Indian and environmental impact.
6. To understand the plate tectonic and supercontinent configuration in terms of coal deposits in India vis-a-vis rank, grade and their geological and geographical distribution and utilization.
7. To comprehend concept of kerogen and its type and its control on origin of fossil fuel.
8. To understand the petroleum system from origin to accumulation.

Content:

1. **Coal (MSGL302A)**

   Origin of coal, Macroscopic ingredients and Microscopic constituents, concept of macerals and micro lithotypes, Physical properties and chemical characterization: Proximate and ultimate analysis, Classification of coal in terms of type, grade and rank. Classification of coal (coking coal, non-coking coal, international classification, Biochemical and dynamo chemical changes in coal formation, Distribution of coal in space and time with special reference to India. Concept of Coal Bed Methane (CBM) an unconventional source of energy, concept of generation of methane in coal seam, potential of CBM in India. Concept of underground coal gasification (UGC), clean coal technology-coal liquefaction, coal carbonization, coal gasification,

2. **Petroleum (MSGL302B)**

   Composition of petroleum and natural gas, Kerogen and their types. Origin and migration of natural hydrocarbons, Characters of source and reservoir rocks. Traps: Structural, stratigraphic and combination traps, Techniques of exploration, Petroliferous basins of India.

3. **Nuclear Fuels (MSGL302C)**

   Mineralogy, Geochemistry and mode of occurrence of radioactive minerals. Techniques of detection and measurements of radioactivity, Distribution of radioactive minerals in India.

Unit-1	3 Hours
Origin of coal; Macroscopic ingredients and Microscopic constituents; Concept of macerals and micro lithotypes.	
Unit-2	6 Hours
Physical properties and chemical characterization: Proximate and ultimate analysis; Classification of coal in terms of type, grade and rank; Classification of coal (coking coal, non-coking coal, international classification).	
Unit-3	4 hours
Biochemical and dynamo chemical changes in coal formation.	
Unit-4	2 Hours
Distribution of coal in space and time with special reference to India.	
Unit-5	6 Hours
Concept of Coal Bed Methane (CBM) as an unconventional source of energy; Concept of generation of methane in coal seam; Potential of CBM in India; Concept of underground coal gasification (UGC), clean coal technology-coal liquefaction, coal carbonization, coal gasification.	
Unit-6	6 Hours
Composition of petroleum and natural gas; Kerogen and their types.	
Unit-7	5 Hours
Origin and migration of natural hydrocarbons.	
Unit-8	2 Hours
Characters of source and reservoir rocks.	
Unit-9	2 Hours
Traps: Structural, stratigraphic and combination traps,	
Unit-10	6 Hours
Techniques of exploration; Petroliferous basins of India.	
Unit-11	6 Hours
Mineralogy, Geochemistry and mode of occurrence of radioactive minerals; Techniques of detection and measurements of radioactivity; Distribution of radioactive minerals in India.	

Suggested Readings:

1 Durrance E.M. (1986) Radioactivity in Geology. Principles and applications. Ellis Hoorwool.
2 Scott, A.C., (1987): Coal and coal bearing strata: Recent Advances, Blackwell Scientifics Publications.
3. Stach, E., Mackowsky, M-Th., Tylor, G.H., Chandra, D., Teichumullelr, L . and Teichumuller, R. (1982): Text book on coal petrology, Gebruder Borntreager Stuttgart.
4 Levvorsen A.I. 1985, Geology of petroleum, CBS Publishers and Distributors, Delhi.
5 North F.K., 1985, Petroleum Geology, Allen and Unwin, London.
6 Ross C.A., Ross J.R.P., 1983, Geology of coal, a benchmark book.

7 G.V. Chilingar, L.A. Buryakovsky, N.A. Eremenko & M.V. Gorfunkel (2005) geology and geochemistry of oil and gas
8. Thomas Larry (2002): Coal Geology. John Wiley and Sons. Ltd. England.
9. RICHARD C. SELLEY STEPHEN A. SONNENBERG (2015) ELEMENTS OF PETROLEUM GEOLOGY

Course Code: MSGL303
Hydrogeology

Course Objectives:
Water is a basic life supporting system. The rise in global population and the quest for better living standard has greatly stressed the water resources. The course content primarily focuses on groundwater, which being easily available is amenable to greater exploitation. Thus this course aims to enable students to acquire knowledge about the physical and chemical attributes, occurrence, movement and exploration of the groundwater resources.

Course Learning Outcomes:
1. The students will learn about occurrence of groundwater, water bearing properties of formations, aquifer types and aquifer parameters.
2. The course imparts knowledge about construction, design and development of water wells, aquifer parameter estimation and the science of groundwater flow under different conditions.
3. The students will learn about the concepts of groundwater exploration in an integrated way and also understand about groundwater chemistry.

Content:
1 Groundwater: Origin, types, Importance, Reservoirs and movement.
2 Hydrogeologic properties of rocks, Water table contour map, Hydrostratigraphic units.
3 Groundwater quality, Estimation and methods of treatment for various uses, Groundwater provinces of India. Groundwater contaminants and pollutants, Problem of Arsenic and Fluorite with special reference to Indian conditions.
4 Artificial recharge of groundwater, Consumptive and conjunctive use of surface and groundwater, Problems of over exploitation, Groundwater legislation and management.
5 Well hydraulics: Confined, unconfined, steady, unsteady and radial flow. Water level fluctuations: Causative factors and their measurements. Methods of pumping tests and analysis of test data.
6 Water well technology: Water management in rural and urban areas; Salt water intrusion in coastal areas, Remedial measures.
7 Groundwater prospecting: Remote sensing technique, Geological and geophysical methods.

Unit-1	4 Hours
Groundwater: Origin, types, Importance; Reservoirs and movement.	
Unit-2	4 Hours
Hydrogeologic properties of rocks; Water table contour map; Hydrostratigraphic units.	
Unit-3	6 Hours
Groundwater quality; Estimation and methods of treatment for various uses; Groundwater provinces of India; Groundwater contaminants and pollutants; Problem of Arsenic and Fluorite with special reference to Indian conditions.	
Unit-4	10 Hours
Artificial recharge of groundwater; Consumptive and conjunctive use of surface and groundwater; Problems of over exploitation; Groundwater legislation and management.	
Unit-5	8 Hours
Well hydraulics: Confined, unconfined, steady, unsteady and radial flow.	
Unit-6	8 Hours
Water level fluctuations: Causative factors and their measurements; Methods of pumping tests and analysis of test data.	
Unit-7	8 Hours
Water well technology: Water management in rural and urban areas; Salt water intrusion in coastal areas, Remedial measures; Groundwater prospecting: Remote sensing technique, Geological and geophysical methods.	

Suggested Readings:

1 Todd, D.K.: Groundwater Hydrology, John Willey & Sons. Inc.
2 Wilson, E.M.: Engineering Hydrology, ELBS with Macmillan.
3 Raghunath, H.M.: Willey Eastern Ltd.

Course Code: MSGL304

GENERIC ELECTIVES

Course Objectives:

To introduce the students of other courses about the earth processes, interdependence of human and nature, land or water use- its depletion and degradation and use of different techniques to mitigate natural hazards for sustainable development.

Course Learning Outcomes:

Students will be able to apprehend the dynamic natural processes, learn the human activities that are responsible for degradation and depletion of earth resources and different techniques to address the problems and their solutions.

Content:

MSGL304-1: ENVIRONMENTAL GEOLOGY

1 Our place in the environment, global degradation of environment, human as agents of geological change, Fundamental concepts of environmental geology.
2 Hazardous geological processes: Types, prediction and warning
3 Land-its use and management, assessment of impact of land-use
4 Mineral resources: Mineral consumption on reserves, conservation of mineral resources, impact of mining activity on the environment, environmental managemental in mining.
5 Alternative sources of energy: Energy crisis, strategies of planning our energy, future alternatives to fossil fuels, nuclear energy option.
6 Nature and effects of air and water pollution, disposal of solid wastes and nuclear wastes.
7 Concepts of E I A

Unit-1	2 Hours
Our place in the environment; Global degradation of environment; Human as agents of geological change; Fundamental concepts of environmental geology.	
Unit-2	2 Hours
Hazardous geological processes: Types, prediction and warning.	
Unit-3	4 Hours
Land-its use and management, assessment of impact of land-use.	
Unit-4	6 Hours
Mineral resources: Mineral consumption on reserves, conservation of mineral resources, impact of mining activity on the environment, environmental managemental in mining.	
Unit-5	4 Hours
Alternative sources of energy: Energy crisis, strategies of planning our energy, future alternatives to fossil fuels, nuclear energy option.	
Unit-6	4 Hours
Nature and effects of air and water pollution, disposal of solid wastes and nuclear wastes; Concepts of E I A.	

Suggested Readings:

1 Anjaneyulu, Y. Introduction to Environment Science (2004), BS Publishing, Hyderabad.
2 Keller, E.A. Environmental Geology (6th.edition, 1988), Macmillan Publishing Company, New York.
3 Bell, F.G. Environmental Geology (1998), Blackwell Science, London.

MSGL304-2: NATURAL HAZARDS AND MITIGATION

Floods, Earthquakes, Cyclones, Landslides and disaster management. (Detail syllabus is to be given soon)

MSGL304-3: PHOTOGEOLOGY AND REMOTE SENSING

1 Remote Sensing: Definition, scope and purpose. Types or classification of Remote Sensing (RS). Digital imagery vs. conventional photography. Different stages or requirements for the successful execution of the remote sensing operation.

2 Electromagnetic spectrum (EM-spectrum): Fundamental concepts and theories. Subdivisions of the EM- spectrum. Basic laws governing the behavior of the EM-radiation, and the interrelationships among these laws in view of remote sensing. The common wavelength bands used in RS and their characteristic purposes.

3 Different interactions of energy or radiation with matter in different scales. Role of atmosphere in remote sensing. Concept of atmosphere windows.

4 Aerial photography and aerial photographs. Features air-photos, scale, photomosaics, air-photo stereo-pairs, Stereoscopic vision and pseudoscopic vision. Different elements of air-photo (or image) interpretation.

Unit-1	4 Hours
Remote Sensing: Definition, scope and purpose; Types or classification of Remote Sensing (RS); Digital imagery vs. conventional photography; Different stages or requirements for the successful execution of the remote sensing operation.	
Unit-2	6 Hours
Electromagnetic spectrum (EM-spectrum): Fundamental concepts and theories; Subdivisions of the EM- spectrum; Basic laws governing the behavior of the EM-radiation and the interrelationships among these laws in view of remote sensing; The common wavelength bands used in RS and their characteristic purposes.	
Unit-3	2 Hours
Different interactions of energy or radiation with matter in different scales; Role of atmosphere in remote sensing; Concept of atmosphere windows.	
Unit-4	10 hours
Aerial photography and aerial photographs; Features air-photos, scale, photomosaics, air- photo stereo-pairs; Stereoscopic vision and pseudoscopic vision; Different elements of air- photo (or image) interpretation.	

Suggested Readings:

1 Sabbins, F.F. 1985: Remote Sensing- Principles and applications, Freeman.
2 Drury.S.A. 1987: Image interpretations in geology. Allen and Unwin.
3 Gupta.R.P. 1990: Remote sensing geology- Springer Verlag

MSGL304-4: INTRODUCTION TO HYDROGEOLOGY

1. Groundwater: Origin, types, Importance, Reservoirs and movement.
2. Hydrogeologic properties of rocks, Water table contour map.
3. Groundwater quality, Estimation and methods of treatment for various uses. Groundwater provinces of India. Groundwater contaminants and pollutants, Problems of Arsenic and Fluorite with special reference to Indian conditions.
4. Artificial recharge of groundwater, Consumptive and conjunctive use of surface and ground water.

Unit-1	2 Hours
Groundwater: Origin, types, Importance, Reservoirs and movement.	
Unit-2	3 Hours
Hydrogeologic properties of rocks; Water table contour map	
Unit-3	12 Hours
Groundwater quality, Estimation and methods of treatment for various uses; Groundwater provinces of India; Groundwater contaminants and pollutants; Problems of Arsenic and Fluorite with special reference to Indian conditions.	
Unit-4	5 Hours
Artificial recharge of groundwater; Consumptive and conjunctive use of surface and ground water.	

Suggested Readings:

1 Todd, D.K.: Groundwater Hydrology, John Willey & Sons. Inc.
2 Wilson, E.M.: Engineering Hydrology, ELBS with Macmillan.
3 Raghunath, H.M.: Willey Eastern Ltd.
4 Fetter, C.W.: Applied Hydrology, CBS Publ. & Dist.

Course Code: MSGL305
DEPARTMENT CENTRIC ELECTIVES

Course Objectives:

To introduce the students about the application of some advanced techniques in geology that are helpful in unraveling the complexities more accurately (e.g. covering large areas with ease as in RS-GIS or by advanced techniques of rock deformation and deducing PTT path). Oceanography will introduce the students about the treasure of oceans, human dependence on ocean, the processes of ocean that regulate the physical, chemical and biological vistas of the earth. Palaeobiology will introduce the students about the advanced techniques to learn the evolution and extinction in a better way.

Course Learning Outcomes:

The students will be able to apply different techniques in natural systems for the better understanding of an area or life forms. They will learn the importance of ocean as a modifier of the earth systems as well as its potentiality of future resource.

Content:
MSGL305-1: REMOTE SENSING AND GIS

1 Remote Sensing: Definition, scope and purpose. Types or classification of Remote Sensing (RS).
Digital imagery vs. conventional photography. Different stages or requirements for the successful execution of the remote sensing operation.
2 Electromagnetic spectrum (EM-spectrum) :Fundamental concepts and theories.
Subdivisions of the EM- spectrum. Basic laws governing the behavior of the EM-radiation, and the interrelationships among these laws in view of remote sensing. The common wavelength bands used in RS and their characteristic purposes.
3 Different interactions of energy or radiation with matter in different scales. Role of atmosphere in remote sensing. Concept of atmosphere windows.
4 Basic ideas about the working principles of various sensors: Simple cameras, Vidicon

cameras, Push broom system using charge-coupled devices (CCDs). Line scanners, Multi-spectral scanners, Microwave imaging system (using LASER and RADAR). Thermal infra-red imagers, Spectroradiometers.

5 Basic knowledge about the different satellite exploration programmes of the world and their characteristics (viz. LANDSAT, SEASAT, SPOT, TRS, IKONOS etc.) Introducing satellite images (both Hard- copy and Soft-copy formats)

6 Aerial photography and aerial photographs. Features air-photos, scale, photomosaics, air-photo stereo-pairs, Stereoscopic vision and pseudoscopic vision. Stereoscopic study of air-photos, parallax, vertical exaggeration and its various factors. Hands-on use of mirror and pocket stereoscopes. Ideas about possible sources of errors in aerial photography and/or satellite imagery.

7 Different elements of air-photo (or image) interpretation. Photogeology, Elementary practical exercises on photogeological mapping.

8 Photogrammetry, Use of parallax bar. Basic idea about how to measure height, area, dip/slope, vertical exaggeration, image distortion etc. from air-photos.

9 Digital remote sensing: Pixel and resolution. DN-code. Digital remote sensing images. False colour composite (FCC). Computer assisted (i.e.digital) image processing techniques. Digital classification- unsupervised and supervised. Hands-on training of digital image interpretation using easily available packages and images (PC-mode). Application of RS techniques for terrain analysis (Geomorphological). Land- use detection, litho-mapping, structural mapping, mineral exploration, environmental hazards assessment, groundwater prospecting.

10 Geographical Information System (GIS): Introduction, components, data presentation, digitization and scanning, vector and raster methods, input and output device, software and definition/description of equipment. Database designing and structure. Data analysis and cartographic modeling. Data representation and techniques of data integration. Application of integrated GIS. Data updating and merging. Multilayer data products.

11 Global Positioning System (GPS): Definition, scope and purpose. Advantage of GPS: Principles of GPS position determination, receiver types, and survey techniques, Geodetic implication. RS-GIS- GPS integration. Special discussion and practical demonstration of such integration in Geoscientific arena and in our day-to-day socio-economic activities.

Unit-1	6 Hours
Remote Sensing: Definition, scope and purpose. Types or classification of Remote Sensing (RS); Digital imagery vs. conventional photography; Different stages or requirements for the successful execution of the remote sensing operation; Electromagnetic spectrum (EM-spectrum): Fundamental concepts and theories; Subdivisions of the EM- spectrum; Basic laws governing the behavior of the EM-radiation and the interrelationships among these laws in view of remote sensing; The common wavelength bands used in RS and their characteristic purposes.	
Unit-2	6 Hours
Different interactions of energy or radiation with matter in different scales; Role of atmosphere in remote sensing; Concept of atmosphere windows; Basic ideas about the working principles of various sensors: Simple cameras, Vidicon cameras, Push broom system using charge-coupled devices (CCDs); Line scanners, Multi- spectral scanners, Microwave imaging system (using LASER and RADAR); Thermal infra- red imagers, Spectroradiometers; Basic knowledge about the different satellite exploration programmes of the world and their characteristics (viz. LANDSAT, SEASAT, SPOT, TRS, IKONOS etc.); Introducing satellite images (both Hard- copy and Soft-copy formats).	
Unit-3	12 Hours
Aerial photography and aerial photographs; Features air-photos, scale, photomosaics, air- photo stereo-pairs, Stereoscopic vision and pseudoscopic vision; Stereoscopic study of air- photos, parallax, vertical exaggeration and its various factors; Hands-on use of mirror and pocket stereoscopes; Ideas about possible sources of errors in aerial photography and/or satellite imagery; Different elements of air-photo (or image) interpretation; Photogeology, Elementary practical exercises on photogeological mapping; Photogrammetry, Use of parallax bar; Basic idea about how to measure height, area, dip/slope, vertical exaggeration, image distortion etc. from air-photos.	
Unit-4	12 Hours
Digital remote sensing: Pixel and resolution; DN-code; Digital remote sensing images; False colour composite (FCC); Computer assisted (i.e.digital) image processing techniques; Digital classification- unsupervised and supervised; Hands-on training of digital image interpretation using easily available packages and images (PC-mode); Application of RS techniques for terrain analysis (Geomorphological); Land- use detection, litho-mapping, structural mapping, mineral exploration, environmental hazards assessment, groundwater prospecting.	
Unit-5	6 Hours
Geographical Information System (GIS): Introduction, components, data presentation, digitization and scanning, vector and raster methods, input and output device, software and definition/description of equipment; Database designing and structure; Data analysis and cartographic modeling; Data representation and techniques of data integration; Application of integrated GIS; Data updating and merging; Multilayer data products.	
Unit-6	6 Hours
Global Positioning System (GPS): Definition, scope and purpose; Advantage of GPS: Principles of GPS position determination, receiver types, and survey techniques, Geodetic implication; RS-GIS-GPS integration; Special discussion and practical demonstration of such integration in Geoscientific arena and in our day-to-day socio-economic activities.	

Suggested Readings:

1 Miller.V.C. 1961: Photogeology, McGraw Hill.
2 Sabbins, F.F. 1985: Remote Sensing- Principles and applications, Freeman.
3 Ray.R.G. 1969: Aerial photographs in geologic interpretations. USGS Prof. Paper 373.
4 Drury.S.A. 1987: Image interpretations in geology. Allen and Unwin.
5 Lillesand, T.M. and Kieffer. R.W. 1987: Remote sensing and image interpretation. John Wiley.
6 Panday.S.N. 1987: Principles and applications of photogeology. New Age International.
7 Gupta.R.P. 1990: Remote sensing geology- Springer Verlag
8 Siegal.B.S. and Gillespie.A.R. 1980: Remote sensing in geology. John Wiley.
9 Allum.J.A.E. 1985: Photogeology and regional mapping Pergamon press.

MSGL305-2: ROCK DEFORMATION & STRUCTURAL ANALYSIS

1 Techniques in structural analysis (Advanced fieldwork and mapping techniques including outcrop pattern analysis in relation to topography, litho contacts and traverse selection; Data types and its collection, and sampling; Structure contour and cross section; Regional and global correlation; Stereographic projection and its significance; Fold shape analysis, Fourier analysis, Flattened folds, fold section and profile, down plunge projection of folds)
2 Experimental studies (Deformation of natural rocks; Determination of fabrics in deformed rocks; Fabric interpretation; Use of X-ray texture goniometer and U-stage)
3 Deformation mechanisms (Inter and Intra-crystalline slip; associated microstructures)
4 Folds and folding (small scale structures in folds; Deformed lineation in superposed fold system)
5 Faults (analysis of movement on fault surfaces by graphical method; Palaeostress estimation; Balanced cross section)
6 Shear zones (Ductile and brittle shear zones; Shear and dilational components in different profiles)
7 Heterogeneous finite strain (Classification and interpretation of simple and general shear zones, C-, P- and F- bands, Conjugate shear zones, Rotation of objects in shear zones; Superposed strain fields in shear zones and shear folds; Strain trajectories and cleavage patterns; 3-dimensional strain, basic theory and signification).

Unit-1	10 Hours
Techniques in structural analysis (Advanced fieldwork and mapping techniques including outcrop pattern analysis in relation to topography, litho contacts and traverse selection; Data types and its collection, and sampling; Structure contour and cross section; Regional and global correlation; Stereographic projection and its significance; Fold shape analysis, Fourier analysis, Flattened folds, fold section and profile, down plunge projection of folds).	
Unit-2	8 Hours
Experimental studies (Deformation of natural rocks; Determination of fabrics in deformed rocks; Fabric interpretation; Use of X-ray texture goniometer and U-stage); Deformation mechanisms (Inter and Intra-crystalline slip; associated microstructures).	
Unit-3	8 Hours
Folds and folding (small scale structures in folds; Deformed lineation in superposed fold system)	
Unit-4	6 Hours
Faults (analysis of movement on fault surfaces by graphical method; Palaeostress estimation; Balanced cross section);	
Unit-5	6 Hours
Shear zones (Ductile and brittle shear zones; Shear and dilational components in different profiles).	
Unit-6	10 Hours
Heterogeneous finite strain (Classification and interpretation of simple and general shear zones, C-, P- and F- bands, Conjugate shear zones, Rotation of objects in shear zones; Superposed strain fields in shear zones and shear folds; Strain trajectories and cleavage patterns; 3-dimensional strain, basic theory and signification).	

Suggested Readings:

1 Ramsay, J.G. and Huber,M.I.: Modern Structural Geology, Vols. I & II
2 Ramsay, J.G. and Lisle, R.J.: Modern Structural Geology, Vols. III
3 Passchier and Trouw: Microtechtonics
4 Ghosh, S.K.: Structural Geology- Fundamentals and modern developments.
5 Ramsay, J.G. : Folding and Fracturing of rocks.
6 Turner, F.J. and Weiss, L.E. : Structural Analysis of Metamorphic Techtonics.
7 Price, N.J. and Cosgrove, J.W.: Analysis of Geological Structures

MSGL305-3: ADVANCED METAMORPHIC PETROLOGY

1 Ultrahigh temperature (UHT) and ultrahigh pressure (UHP) metamorphism calculation of Metamorphic Phase Equilibria through P-T-X-M (mineral mode) relations. The origin and interpretation of zoned metamorphic minerals: Characterization of chemically zoned crystals,
Growth zonation-P-T-X-M phase relation. Diffusion during cooling of high and low grade rocks; P-T path from zoned minerals.
2 Metamorphic P-T paths and tectonics evolution: Interpretation of textural and mineral chemical data in inferring P-T path; Subduction zone metamorphism, Continental collisional zone metamorphism; Metamorphic core complex, Granulites and interpretation of P-T paths from the granulites.

Unit-1	10 Hours
Ultrahigh temperature (UHT) and ultrahigh pressure (UHP) metamorphism; Calculation of Metamorphic Phase Equilibria through P-T-X-M (mineral mode) relations.	
Unit-2	10 Hours
The origin and interpretation of zoned metamorphic minerals: Characterization of chemically zoned crystals; Growth zonation-P-T-X-M phase relation.	
Unit-3	8 Hours
Diffusion during cooling of high and low grade rocks; P-T path from zoned minerals.	
Unit-4	10 Hours
Metamorphic P-T paths and tectonics evolution: Interpretation of textural and mineral chemical data in inferring P-T path; Subduction zone metamorphism; Continental collisional zone metamorphism; Metamorphic core complex.	
Unit-5	10 Hours
Granulites and interpretation of P-T paths from the granulites.	

Suggested Readings:

1 Miyashiro, A. (1973): Metamorphism and Metamorphic Belts. George Allen and unwin.
2 Philpotts, A.R., (1994): Principles of Igneous and Metamorphic Petrology, Prentice-Hall.
3 Spry, A., (1969): Metamorphic Textures, Pergamon, Oxford.
4 Turner, F.J. and Verhoogen, J., (1960): Igneous and Metamorphic Petrology, McGrow-Hill.
5 Winter, J.D., (2001). An Introduction to Igneous and Metamorphic Petrology, Prentice-Hall.
6 Yardley, B.D. (1989). An Introduction to Metamorphic petrology, Longman.
7 Spear, F.S. (1993): Metamorphic phase equilibria and Pressure- Temperature-Time paths. Mineralogical Society of America, Monograph Series.

MSGL305-4: PALAEOBIOLOGY: MODERN CONCEPTS

Theoretical and functional morphology- Use of modern techniques: Evolution- gradualism and punctuated equilibria, rate of evolution; evolutionary trend, Cope's rule- recent views; Paleobiogeography and plate tectonics. Cladistic biogeography

Unit-1	8 Hours
Theoretical and functional morphology.	
Unit-2	25 Hours
Use of modern techniques: Evolution- gradualism and punctuated equilibria, rate of evolution; evolutionary trend, Cope's rule- recent views.	
Unit-3	7 Hours
Paleobiogeography and plate tectonics.	
Unit-4	8 Hours
Cladistic biogeography	

Suggested Readings:

1 Briggs, D.E.G. and Crowther, D., 1990: Paleobiology: A synthesis, Blackwell, Oxford.
2 Skelton, P.(Ed.): 1993: Evolution, Addison-Wesley, Harlow.
3 Gould, S.J., : Ontogeny and Phylogeny. Belhnap Press of Harvard University Press, Cambridge, Massachusetts, USA.
4 Humpphries, C.J. and Parenti, L.R., 1986, Cladistic Biogeography. Clarendon Press, Oxford.

MSGL305-5: OCEANOGRAPHY

1 Definition, Earth and Ocean; The World Ocean: Two views; The origin of life; The ocean world; The distant future of earth; History of marine science; the rise of oceanographic institution.
2 Ocean circulation, forces that drive currents, wind induced vertical circulation, thermohaline circulation, studying currents.
3 Ocean waves and tides; Classifying waves, wave dynamics and wind waves; A word about tidal waves; storm surges, Seiches, Tsunami and Seismic sea waves tides and forces that generate them; The equilibrium and dynamic theory of tides; Tides and marine organisms; Power from the tides.
4 Coastal and estuarine oceanography; classifying coasts, features of primary and secondary coasts, coasts formed by biological activities; Beaches and estuaries; Lagoons and wetlands; Human interferences in coastal processes.
5 Sea water chemistry; Major and minor constituents of sea water and their residence times; Processes controlling the composition of sea water, Dissolved gases in sea water-their sources and sinks, Biogeochemical eye ling and its effects on atmospheric composition and climate. Interrelationships between ocean circulation, primary productivity and chemical composition of the atmosphere and ocean.
6 Marine Geology; Morphological and tectonic domains of the ocean floor; Mid oceanic ridge systems; Hydrothermal vents and seawater- basalt interaction; Modes and rates of sedimentation in the oceans; Nature of deep sea sediments and processes regulating sedimentary composition;
7 Marine Resources; Types of marine resources; Physical, energy, biological and non-extractive resources; Laws of the sea.
8 Marine Biology; Sea as a biological environment; Divisions of marine environment and their characteristic flora and fauna and their adaptations; Community structure and function; Primary, Secondary and Tertiary Production; Food web and trophic Structure; Living resources of the Indian seas; Mari culture activities.
9 Environmental Concerns; Marine pollution; Pathways of transfer of various pollutants and their fates in the sea; Chemistry of marine natural products; Biomedical potential of marine biota; Habitat distribution; Global changes.

Unit-1	4 Hours
Definition, Earth and Ocean; The World Ocean: Two views; The origin of life; The ocean world; The distant future of earth; History of marine science; the rise of oceanographic institution.	
Unit-2	6 Hours
Ocean circulation, forces that drive currents, wind induced vertical circulation, thermohaline circulation, studying currents; Ocean waves and tides; Classifying waves, wave dynamics and wind waves; A word about tidal waves; storm surges, Seiches, Tsunami and Seismic sea waves tides and forces that generate them; The equilibrium and dynamic theory of tides; Tides and marine organisms; Power from the tides.	
Unit-3	4 Hours
Coastal and estuarine oceanography; classifying coasts, features of primary and secondary coasts, coasts formed by biological activities; Beaches and estuaries; Lagoons and wetlands; Human interferences in coastal processes.	
Unit-4	5 Hours
Sea water chemistry; Major and minor constituents of sea water and their residence times; Processes controlling the composition of sea water, Dissolved gases in sea water-their sources and sinks, Biogeochemical eye ling and its effects on atmospheric composition and climate; Interrelationships between ocean circulation, primary productivity and chemical composition of the atmosphere and ocean.	
Unit-5	10 Hours
Marine Geology; Morphological and tectonic domains of the ocean floor; Mid oceanic ridge systems; Hydrothermal vents and seawater- basalt interaction; Modes and rates of sedimentation in the oceans; Nature of deep sea sediments and processes regulating sedimentary composition; Marine Resources; Types of marine resources; Physical, energy, biological and non- extractive resources; Laws of the sea.	
Unit-6	10 Hours
Marine Biology; Sea as a biological environment; Divisions of marine environment and their characteristic flora and fauna and their adaptations; Community structure and function; Primary, Secondary and Tertiary Production; Food web and trophic Structure; Living resources of the Indian seas; Mari culture activities.	
Unit-7	9 Hours
Environmental Concerns; Marine pollution; Pathways of transfer of various pollutants and their fates in the sea; Chemistry of marine natural products; Biomedical potential of marine biota; Habitat distribution; Global changes.	

Suggested Readings:

1 Siddhartha, K., (1999): Oceanography: A brief introduction, Kisalaya Publ. Pvt. Ltd.

2 Gordon Prie, R., (1997): Oceanography: Contemporary readings in ocean sciences, University of Wisconsin-Milwaukee, Oxford University Press

3 Anderson, R.N.: Marine Geology: A Planet Earth Perspective, John Wiley & Sons.

4 Weisberg, J. and Paris, H., (1974): Introduction Oceanography. McGraw-Hill, Kogakusha Ltd.

5 Ghosh, A.K.and Mukherjee, R. (1999): Mineral wealth of the ocean, Oxford & IBH pub. Co.Pvt. Ltd., New Delhi.

6 Pinet, P.R., (2006): Invitation to oceanography, Jones & Berlett Pub.

MSGL305-6: Through SWAYAM

Course Code: MSGL306

MSGL306-1: Ore Geology

Study of ores under the microscope with emphasis on mineralogy, texture, structure and paragenesis.

MSGL306-2: Hydrogeology

Preparation and interpretation of depth to water level maps and water level contour maps. Study, preparation and analysis of hydrographs for differing groundwater conditions. Water potential zones of India (map study). Graphical representation of chemical quality data. Determination of hydraulic gradient/slope from water table depth data. Simple numerical problems related to: determination of permeability.

MSGL306-3: Photogeology & Remote Sensing

Aerial Photo interpretation, identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms. Introduction to DIP and GIS software. Identification of Land forms and Land use pattern from standard false colour composite satellite imagery – Visual Interpretation. Digital Image Processing exercises including analysis of satellite data in different bands and interpretation of various objects on the basis of their spectral Signatures.

4th Semester

Course Code: MSGL401

Mineral Exploration and Reserve Estimation

Course Objectives:

To understand the concept of exploration, different techniques used to find out a hidden mineral treasure, advantages and disadvantages of these techniques and to estimate the content of the treasure.

Course Learning Outcomes:

The students will be able to judge the suitability of a technique for a particular type of deposit and its limitation. They will be aware of the required information that to be collected for reserve estimation.

Content:

1 Concept of mineral exploration, stages of mineral exploration and tasks accomplished under them. Surface and subsurface methods of exploration.
2 Introduction of various methods of geophysical prospecting – magnetic, gravity, electrical, seismic and radiometric methods. Brief outline of various well logging techniques.
3 Geochemical methods for mineral exploration- lithogeochemical, pedogeochemical, hydrogeochemical, biogeochemical and atmogeochemical methods
4 Geobotanical and photogeochemical methods.
5 Drilling, sampling methods and estimation of reserves.

Unit-1	8 Hours
Concept of mineral exploration, stages of mineral exploration and tasks accomplished under them; Surface and subsurface methods of exploration.	
Unit-2 A	9 Hours
Introduction of various methods of geophysical prospecting – magnetic, gravity, electrical.	
Unit-2 B	4 Hours
Seismic and radiometric methods of geophysical prospecting	
Unit-3	3 Hours
Brief outline of various well logging techniques.	
Unit-3	5 Hours
Geochemical methods for mineral exploration- lithogeochemical, pedogeochemical, hydrogeochemical, biogeochemical and atmogeochemical methods	
Unit-4	5 Hours
Geobotanical and photogeochemical methods.	
Unit-5	15 Hours
Drilling, sampling methods and estimation of reserves.	

Suggested Readings:

1 Brooks, R.R., Geobotany and Biogeochemistry in Mineral Exploration, Harper and Row., New York.

2 Ginzburg, I.I., Principles of Geochemical Prospecting, Pergamon Press, London

3 Hawkes, H.E. and Webb. J.S.: Geochemistry in Mineral Exploration, Harper and Row, New York.

4 Levinson, A.A.: Introduction to Exploration Geochemistry, Applied Publishing Ltd. Calgary

5 Malyuga, D.P: Biochemical Methods of prospecting. Cosultants Bureau. New York

6 Reedman, J.H.: Techniques in Mineral Exploration, Applied Science Publishers Ltd. London

7 Benjamin F., Howell, JR.: Introduction to Geophysics, McGraw-Hill Book Co., New York

8 Dobrin, M.B.: Introduction to Geophysical Prospecting, McGraw-Hill Book Co., New York

9 Kearey, P. andBrooks, M. An Introduction to Geophysical Exploration, ELBS, Blackwell Scientific
Publication

10 Nettleton, L.L., Geophysical Prospecting for Oil. Mc-Graw-Hill Book Co., New York

11 Parasnis, D.S. Principles of Applied Geophysics. Methuen and Co, London.

12 Telford, W.M. Geldart, L.P., Sheriff, R.E. and Keys, D.A.: Applied Geophysics. Cambridge University Press.

13 William Lawrie. Fundamentals of Geophysics, Cambridge University Press.

Course Code: MSGL402
Mining and Engineering Geology

Course Objectives:

Mining Geology unravel the relationship between geology and ore formation and localisation of mineral resources. It also helps for assessing and analysing geological data in order to advise on short-term and long-term mine production plans. The subject Engineering Geology is aimed at studying the geology of an area for the purpose of assuring that the geological factors regarding the location, design, construction, operation and maintenance of engineering works, are perfect for the project implementation. It is also done during post-construction and forensic phases of the projects.

Course Learning Outcomes:

The students will learn to make design of creating safe and effective means to extract metals and minerals for industrial, commercial and scientific purposes. They are also expected to have an advanced and dynamic understanding of geological sciences. The study of engineering geology helps the students to properly plan a project when considering the design, location, and other important geological factors.

Content:

Group A: Mining Geology (MSGL402A)

1 Methods of mining- Placer/alluvial, opencast & underground mining for metallic, non-metallic. Placer/ alluvial deposits. Environmental impacts in mining industries with special emphasis on coal mining.
2 Mining terminologies. Shaft sinking , drifting, cross-cutting, sloping, Mine subsidence, mine support, room & piller, top slicing, caving (sublevel caving & block caving), mining hazards, mine inundation, fire & rock blast.
3 Drilling methods (percussion, rotary, core drilling- diamond drilling)
4 Sampling, bench mapping, underground mine mapping, preparation of plans & sections, ore reserve estimation, mineral beneficiation & mineral economics.
5 Planning, exploration and exploratory mining of surface and underground deposits.
6 Mine hazards.

Suggested Readings:

1 McKinstry, H.E., 1962: Mining Geology.2nd. Ed. Asia Publishing House
2 Clark, G.B., 1967: Elements of Mining 3rd. Ed. John Wiley
3 Arogyaswami, R.P.N., 1996: Courses in Mining Geology 4th. Ed. Oxford IBH.

Group B: Engineering Geology (MSGL402B)

1 Role of Engineering Geology in civil construction & mining industry. Various stages of engineering geological investigation for civil engineering projects. Engineering properties of rock & their measurements.
2 Slope stability & mass movements, classifications, detailed study of landslides, factors influencing different mass movements in nature & their remedial measures. Studies of the processes responsible for the evolution of typical structures such as solifluction, liquefaction etc. Study of typical landslides of India & the world.
3 Concept of Building materials/ dimension stones- its different properties,. Study of occurrence of good building materials/dimension stones in different stratigraphic horizons of India.
4 Dams & reservoir, different types of dams, different parts of dams & reservoirs, stability of dams & reservoir, seepage & leakage, factors responsible for dam & reservoir failure &

their remedial measures, criteria for selecting sites for construction of dams & reservoirs in nature & geo- environmental considerations.

5 Tunnels & their different types, different parts of a tunnel, stability of tunnel, factors responsible for tunnel failure & their remedial measures, criteria for selecting sites for construction of tunnels in different geological situation & geo-environmental considerations.

6 Role of geophysical techniques in engineering geological investigation

Suggested Readings:

1 Krynine, D.H. and Judd, W.R.: Principles of Engineering Geology, CBS Publ. & Dist.
2 Legget, R.F. and Hatheway, A.W.: Geology and Engineering. McGraw-Hill Int. Edn.
3 Bowen, R.: Geology in Engineering. Elsevier Applied Science Publ. Ltd.
4 Ries, H. and Watson, T.L.: Engineering Geology, John Wiley & Sons.

Unit-1	10 Hours
Methods of mining- Placer/alluvial, opencast & underground mining for metallic, nonmetallic; Placer/ alluvial deposits; Mining terminologies: Shaft sinking , drifting, cross-cutting, sloping; Mine subsidence, mine support, room & piller, top slicing, caving (sublevel caving & block caving), mining hazards, mine inundation, fire & rock blast; Environmental impacts in mining industries with special emphasis on coal mining.	
Unit-2	4 Hours
Drilling methods (percussion, rotary, core drilling- diamond drilling).	
Unit-3	6 Hours
Sampling, bench mapping, underground mine mapping, preparation of plans & sections, ore reserve estimation, mineral beneficiation & mineral economics; Planning, exploration and exploratory mining of surface and underground deposits.	
Unit-4	6 Hours
Role of Engineering Geology in civil construction & mining industry; Various stages of engineering geological investigation for civil engineering projects; Engineering properties of rock & their measurements.	
Unit-5	6 Hours
Slope stability & mass movements, classifications, detailed study of landslides, factors influencing different mass movements in nature & their remedial measures; Studies of the processes responsible for the evolution of typical structures such as solifluction, liquefaction etc; Study of typical landslides of India & the world.	
Unit-6	4 Hours
Concept of Building materials/ dimension stones- its different properties; Study of occurrence of good building materials/dimension stones in different stratigraphic horizons of India.	
Unit-7	6 Hours
Dams & reservoir, different types of dams, different parts of dams & reservoirs, stability of dams & reservoir, seepage & leakage, factors responsible for dam & reservoir failure & their remedial measures, criteria for selecting sites for construction of dams & reservoirs in nature & geo- environmental considerations.	
Unit-8	7 Hours
Tunnels & their different types, different parts of a tunnel, stability of tunnel, factors responsible for tunnel failure & their remedial measures, criteria for selecting sites for construction of tunnels in different geological situation & geo-environmental considerations; Role of geophysical techniques in engineering geological investigation.	

Course Code: MSGL403
DEPARTMENT CENTRIC ELECTIVES

Course Objectives:

To develop the skill of a student so that he/ she can:
apply different concepts of Geology in evaluating ancient depositional setting and its resource potential/ aware of the techniques used in exploration of petroleum/ apprehend the application of microfossils in deducing hydrocarbon potential/ use coal petrology to assess the quality and origin of coal/ understand the applicability of geophysical techniques in groundwater, petroleum and mineral exploration/ understand the use of statistical analysis in different fields of Geology/ learn the process of ore dressing and the economic aspect of mineral deposits, necessity of mineral policy.

Course Learning Outcomes:

Students will be able to:
Deduce the opening and closing of a basin and its resource potential/ apprehend the chances of success and failure of petroleum exploration/ identify microfossils and to apply in hydrocarbon potential assessment/ identify macerals, micro lithotypes in microscope, use different indices to assess coal forming conditions and their control on coal quality/ assess the suitability of a geophysical technique for groundwater, petroleum and mineral exploration/ use statistical analytical methods in the field of Geology/ appreciate the merits and demerits of different ore dressing techniques and justification of mineral policy.

Content:

MSGL403-1: SEDIMENTARY ENVIRONMENT & SEDIMENTARY BASIN ANALYSIS

1. Modern laboratory techniques in sedimentological studies
2. Detail study of volcanoclastics, chemical precipitates. Clay deposits: mineralogy, physical properties, chemistry and genesis. Processes of dolomitisation and phospatization. Origin of various types of cements.
3. Use of trace fossils, stromatolities, thrombolites and related structures in palaeoenvironment analysis. Methods of palaeocurrent determination and basin analysis.
4. Tectonics and evolution of the sedimentary basins. Sedimentary cycles, rhythms and cyclothems. Analysis of sedimentary facies and preparation of facies maps. Lithofacies, biofacies, dynamics and primary structures associated with the following environments: deserts, alluvial fans, river planes, glaciers, deltas, estuaries, clastic shorelines, clastic shelves, marine evaporate basins, carbonate platforms. Deep sea and ocean bottom, deep sea trench and rise. Sequence stratigraphy.
5. Sedimentation pattern and depositional environment of selected undeformed and deformed sedimentary basins of India representing Precambrian, Phanerozoic and contemporary basins.

Unit-1	10 Hours
Modern laboratory techniques in sedimentological studies; Detail study of volcanoclastics, chemical precipitates; Clay deposits: mineralogy, physical properties, chemistry and genesis; Processes of dolomitisation and phospatization; Origin of various types of cements.	
Unit-2	7 Hours
Use of trace fossils, stromatolities, thrombolites and related structures in palaeoenvironment analysis; Methods of palaeocurrent determination and basin analysis.	
Unit-3	3 Hours
Tectonics and evolution of the sedimentary basins	
Unit-4	3 Hours
Sedimentary cycles, rhythms and cyclothems ; Analysis of sedimentary facies and preparation of facies maps; Lithofacies, biofacies.	
Unit-5	9 Hours
Dynamics and primary structures associated with the following environments: deserts, alluvial fans, river planes, glaciers, deltas, estuaries, clastic shorelines, clastic shelves, marine evaporate basins; carbonate platforms; Deep sea and ocean bottom, deep sea trench and rise	
Unit-6	6 Hours
Sequence stratigraphy.	
Unit-7	10 Hours
Sedimentation pattern and depositional environment of selected undeformed and deformed sedimentary basins of India representing Precambrian, Phanerozoic and contemporary basins.	

Suggested Readings:

1 Allen, J.R.L. (1985): Principles of physical sedimentation, George Allen & Unwin.
2 Allen, P. (1997): Earth surface processes. Blackwell.
3 Nochols, G. (1999): Sedimentology and stratigraphy. Blackwell.
4 Reading, H.G.(1996): Sedimentary Environment, Blackwell
5 Davis, R.A.Jr., (1962): Depositional system. Prentice Hall.
6 Einsele, G., (1992): Sedimentary basins. Springer Verlag.
7 Reineck, H.E. and Singh, I.B., (1980): Depositional sedimentary environments. Springer Verlag.
8 Prothero, D.R. and Schwab,F.,(1996): Sedimentary Geology. Freeman
9 Miall, A.D., (2000): Principles of sedimentary basin analysis, Springer Verlag.
10 Pettijohn, F.J., Potter,P.E. and Siever,R.(1990): Sand and sandstone. Springer Verlag.
11 Blatt, H., Murray, G.V. and Middleton, R.C., (1980): Origin of sedimentary rocks.
12 Bhattacharya, A. & Chakraborty, C., (2000): Analysis of sedimentary successions. Oxford-IBH.
13 Boggs, Sam. Jr., (1995) Principles of sedimentology and stratigraphy. Prentice Hall.
14 Sengupta, S., (1997): Introduction to sedimentology. Oxford-IBH.

MSGL403-2: PETROLEUM EXPLORATION

1 Identification and characterization of petroleum source rocks. Amount, type and maturation of organic matter. Oil and source rock correlation. Locating petroleum prospects based on principles of petroleum generation and migration. Quantitative evaluation of oil and gas prospects through geochemical modeling. Reconstruction of the ancient geothermal gradient. Migration modeling. Inputs for the assessment of accumulation of petroleum.
2 Elements of geophysical methods of exploration. Magnetic, gravity and seismic methods. Interpretation of seismic data in basin modeling and preparation of subsurface geological maps.
3 Elements of well drilling. Cable-tool drilling, rotary drilling, various types of drilling units. Elements of logging. Electric, radioactivity and the sonic logs. Nuclear magnetic resonance and di-electric logging. Application of logs in petrophysical analysis and facies analysis.

Unit-1	2 Hours
Identification and characterization of petroleum source rocks;	
Unit-2	
Amount, type and maturation of organic matter; Oil and source rock correlation;	3 Hours
Unit-3	
Locating petroleum prospects based on principles of petroleum generation and migration;	3 Hours
Unit-4	
Quantitative evaluation of oil and gas prospects through geochemical modeling;	2 Hours
Unit-5	
Reconstruction of the ancient geothermal gradient; Migration modeling;	3 Hours
Unit-6	
Inputs for the assessment of accumulation of petroleum.	2 Hours
Unit-7	9 Hours
Elements of geophysical methods of exploration. Magnetic, gravity and seismic methods	
Unit-8	6 Hours
Interpretation of seismic data in basin modeling and preparation of subsurface geological maps.	
Unit-9	9 Hours
Elements of well drilling. Cable-tool drilling, rotary drilling, various types of drilling units;	
Unit-10	8 Hours
Elements of logging; Electric, radioactivity and the sonic logs; Nuclear magnetic resonance and di-electric logging; Application of logs in petrophysical analysis and facies analysis.	

Suggested Readings:

1 North.F.K. (1985): Petroleum Geology, Allen and Unwin.
2 Tissol. B.P. and Welte.D.H. (1984): Petroleum Formation and Occurrence. Springer Verlag.
3 Selley.R.C. (1998): Elements of Petroleum Geology. Academic Press.

MSGL403-3: MICROPALAEONTOLOGY: APPLICATION TO EXPLORATION SECTOR

1 Microfossils- definition, occurrence, collection and preparation of samples, methods of study.
2 Common marine microfossils.
3 Usefulness of microfossils in stratigraphic studies and hydrocarbon exploration. Indian examples.

Unit-1	10 Hours
Microfossils- definition, occurrence, collection and preparation of samples, methods of study.	
Unit-2	25 Hours
Common marine microfossils.	
Unit-3	12 Hours
Usefulness of microfossils in stratigraphic studies and hydrocarbon exploration. Indian examples.	

Suggested Readings:

1 Brasier, M.D., (1980): Microfossils. George Allen & Unwin, London.
2 Bignot, G., (1985): Elements of Micropaleontology. Graham & Trotman Ltd., London.
3 Haq, B.U. and Boersma, A. (Eds.), (1978); Introduction to Marine Micropalaeontology. Elsevier, New York.
4 Baker, R., (1979): A primer of Oil well drilling Petroleum extention service, The University of Texas at Austin, Austin.

MSGL403-4: APPLIED COAL PETROLOGY

The concept of maceral and microlithotype. Origin of macerals, methods and tools of microscopic examination of coal, coal seam identification using microscopic methods. Concept of coal rank, microscopic techniques for the evaluation of rank of brown and branded coals. Application of rank studies in determining coalification time and temperature, palaeo-geothermal gradient and burial depth. Coal bed methane: a new energy resource. Generation of coal bed methane. Fundamentals of coal bed methane exploration and production.

Unit-1	12 Hours
The concept of maceral and microlithotype. Origin of macerals, methods and tools of microscopic examination of coal, coal seam identification using microscopic methods.	
Unit-2	8 Hours
Concept of coal rank, microscopic techniques for the evaluation of rank of brown and branded coals	
Unit-3	8 Hours
Application of rank studies in determining coalification time and temperature, palaeo-geothermal gradient and burial depth.	
Unit-4	10 Hours
Coal bed methane: a new energy resource; Generation of coal bed methane.	
Unit-5	10 Hours
Fundamentals of coal bed methane exploration and production.	

Suggested Readings:

1. Chandra.D.Sinsh. R.M. and Singh.M.P. (2000): Textbook of coal. Tara Book Agency, Varanasi
2. Stach.E., Mackowsky.M.T.H., Taylor.G.H., Chandra. D., Teichmuller,M. and Teichmuller, R.(1982): Stach's text book of coal petrology, Gebruder Borntraeger.
3. Fetter, C.W.: Applied Hydrology, CBS Publ. & Dist.
4. Kazmann, R.G.: Modern Hydrology, Harper & Row Publ.

MSGL403-5: APPLIED GEOPHYSICS

1. Gravity Method: Gravity and its variation over the surface of the earth. Principles of Gravimeters, Gravity field surveys. Various types of corrections applied to gravity data. Preparation of gravity maps and their interpretation in terms of shape, size and depth.
2. Magnetic Method: Geomagnetic field and basic magnetic properties. Working principle of magnetometers. Field surveys and data reductions. Preparation of magnetic anomaly maps and their qualitative interpretation. Magnetic anomalies due to single pole and dipole. Determination of depth for single pole anomalies. Introduction to aeromagnetic survey.
3. Electrical Method: Basic of electrical properties and principle. Resistively methods: basic properties, field procedures, electrode arrays and equipment. Interpretation of electrical profile and sounding curves. Application of electrical methods in groundwater prospecting and civil engineering
   Problems.
4. Seismic Method: Fundamental principles of wave propagation. Refraction and Reflection seismic surveys for single interface both horizontal and dipping cases. Concept of seismic channel and multi- channel recording of seismic data. End-on-and split spread shooting techniques. CDP method of data acquisition, sorting, gather, stacking and record station. Seismic velocity and interpretation of seismic data. Application petroleum and mineral exploration.
5. Brief outline of application and importance of various well Logging methods. Principle of electrical logging and its application in petroleum, groundwater and mineral exploration.

Unit-1	10 Hours
Gravity Method: Gravity and its variation over the surface of the earth; Principles of Gravimeters, Gravity field surveys; Various types of corrections applied to gravity data; Preparation of gravity maps and their interpretation in terms of shape, size and depth.	
Unit-2	10 Hours
Magnetic Method: Geomagnetic field and basic magnetic properties; Working principle of magnetometers; Field surveys and data reductions; Preparation of magnetic anomaly maps and their qualitative interpretation; Magnetic anomalies due to single pole and dipole; Determination of depth for single pole anomalies; Introduction to aeromagnetic survey.	
Unit-3	10 Hours
Electrical Method: Basic of electrical properties and principle; Resistively methods: basic properties, field procedures, electrode arrays and equipment; Interpretation of electrical profile and sounding curves; Application of electrical methods in groundwater prospecting and civil engineering problems.	
Unit-4	10 Hours
Seismic Method: Fundamental principles of wave propagation; Refraction and Reflection seismic surveys for single interface both horizontal and dipping cases; Concept of seismic channel and multi- channel recording of seismic data; End-on-and split spread shooting techniques; CDP method of data acquisition, sorting, gather, stacking and record station; Seismic velocity and interpretation of seismic data; Application petroleum and mineral exploration.	
Unit-5	7 Hours
Brief outline of application and importance of various well Logging methods; Principle of electrical logging and its application in petroleum, groundwater and mineral exploration.	

Suggested Readings:

1 Dobrin, M. B.: Introduction to Geophysical Prospecting. Mc-Graw-Hill Book Co., New York.
2 Kearey, P. and Brooks, M.: An introduction to Geophysical Exploration. ELBS. Blackwell Scientific Publications.
3 Nettleton, L.L.: Geophysical Prospecting for Oil. Mc-Graw-Hill Book Co., New York.
4 Parasnis, D. S.: Principles of Applied Geophysics, Methuen and Co., London.
5 Telford, W. M., Geldart, L.P., Sheriff, R.E. and Keys, D.A., Applied Geophysics, Cambridge University Press.
6 William Lawrie, Fundamentals of Geophysics, Cambridge University Press.

MSGL403-6: GEOSTATISTICS

1 Role of mathematical and numerical techniques in geological sciences.
2 Classical statistics : Population, Sample; Measures of central tendency- Mean, median and mode; Measures of variability- variance standard deviation, skewness and kurtosis; Correlation and regression- simple linear model; Analysis of multivariate data- discriminant function, factor analyses- geological application; Trend surface analysis, inverse distance square method; Concept of probability; Population distribution- normal, binomial and Poission; Principles of statistical tests and their use in geology. Chi-square test, F-test, t-test and Kolmogorov- Smirnov test; ANOVA; Analysis of sequential data- Markov chain, auto- correlation and cross-correlation.
3 Geostatistics: Definition purpose and scope; Regionalised variable theory, schools of

geostatistics; Definition of semi-variogram-characteristics, relation between semi-variaogram and co-variogram, graphical and numerical calculation of semi-variogram, mathematical models of semivariogram; Krigging- definition, point and block estimation procedure.

Unit-1	7 Hours
Role of mathematical and numerical techniques in geological sciences.	
Unit-2	3 Hours
Classical statistics : Population, Sample; Measures of central tendency- Mean, median and mode; Measures of variability- variance standard deviation, skewness and kurtosis;	
Unit- 3	6 Hours
Correlation and regression- simple linear model; Analysis of multivariate data- discriminant function, factor analyses- geological application;	
Unit- 4	6 Hours
Trend surface analysis, inverse distance square method;	
Unit- 5	10 Hours
Concept of probability; Population distribution- normal, binomial and Poission; Principles of statistical tests and their use in geology. Chi-square test, F-test, t-test and Kolmogorov- Smirnov test; ANOVA; Analysis of sequential data- Markov chain, auto- correlation and cross-correlation.	
Unit-3	15 Hours
Geostatistics: Definition purpose and scope; Regionalised variable theory, schools of geostatistics; Definition of semi-variogram-characteristics, relation between semi- variaogram and co-variogram, graphical and numerical calculation of semi-variogram, mathematical models of semivariogram; Krigging- definition, point and block estimation procedure.	

Suggested Readings:

1 Davies, J.C. (1973): Geostatistics and data analysis in geology, John Wiley & Sonlnc., New York.
2 Krumbien and Graybill. An Introduction to Statistical Methods in Geology
3 Clark Isobel (1979): Practical Geostatistics, Applied Science Publishers Ltd., London.

MSGL403-7: Mineral Beneficiation and Mineral Economics

1 Beneficiation- necessity, importance, advantages;
2 Crushing- Construction and operational features of primary and secondary crushers. Jaw and Gyratory crushers, cone and roll crushers.
3 Grinding theory, Ball and Rod mills- construction and operation.
4 Laboratory sizing and industrial screening, rake, spiral and hydrocyclone classifiers.
5 Size, specific gravity and surface property dependent beneficiation processes-gravity concentration- theory and practice of Jigging, heavy media separation and flowing film concentration. Froth flotation. Drying and dewatering.
6 Mineral economics and its concept. Specialities inherent in mineral industry. Strategic, critical and essential minerals. Reserve- resources classification; Conservation and substitution, National Mineral Policy.

Unit-1	4 Hours
Beneficiation- necessity, importance, advantages.	
Unit-2	4 Hours
Crushing- Construction and operational features of primary and secondary crushers; Jaw and Gyratory crushers, cone and roll crushers.	
Unit-3	6 Hours
Grinding theory, Ball and Rod mills- construction and operation; Laboratory sizing and industrial screening, rake, spiral and hydrocyclone classifiers.	
Unit-4	9 Hours
Size, specific gravity and surface property dependent beneficiation processes-gravity concentration- theory and practice of Jigging,	
Unit-5	9 Hours
Heavy media separation and flowing film concentration; Froth flotation; Drying and dewatering.	
Unit-5	10 Hours
Mineral economics and its concept; Specialities inherent in mineral industry; Strategic, critical and essential minerals	
Unit-6	6 Hours
Reserve- resources classification; Conservation and substitution, National Mineral Policy.	

Suggested Readings:

1 Barry A. Wills, Mineral Processing Technology, Pergamon Press, New York
2 Gaudin, A.M., Principles of Mineral Dressing. McGraw-Hill, London.
3 Taggart A.F., Handbook of Mineral Dressing. Wiley, New York
4 Chatterjee, K.K. An Introduction to Mineral Economics, Wiley Eastern Limited, Calcuuta.
5 Hussain, A.M.: The Economics and Economic Geology of the Mineral Industries, Applied Publishers.
6 Sinha, R.K. and Sarma, N.L., Mineral Economics. Oxford and IBH Publishing Co.

MSGL404: As chosen in MSGL404

MSGL405: Dissertation

Course Objectives:

To give the students an idea of Research Methodology, data acquisition techniques, analysis of data and representation of the data both verbally and printed form.

Course Learning Outcomes:

Students will be equipped with a first-hand training of reproduction of an original work that will make him ready for future whether it is in job to submit a project report or in his research work.