Annexure 4

Central University South Bihar, Gaya
DEPARTMENT OF GEOLOGY

M.Sc. (Geology) SYLLABUS, SEMESTER SYSTEM w.e.f. (1 July 2020)

Candidates who have passed the three year B.Sc. or B.Sc. (Hons) with Geology as one of the major subjects or B.Sc. (Hons) with honors in Geology examination from any University or equivalent examination of other academic institution will be considered eligible for admission to the Four Semester M.Sc. course in Geology.

The M.Sc. course in Geology shall be imparted to the students for two academic sessions consisting of four semesters as given below. Candidates will be examined and evaluated on grade basis at the end of each semester in the different courses of theory and practical as per the credits given against each course. The M.Sc. Geology will consist of (a) Core Courses (b) Elective Courses and (c) Elective Courses from Swayam portal.

(a) The Core courses will be compulsory for all the students admitted to M.Sc. Geology. There will be thirteen core courses covering major branches of Geology and three sessions of two to three weeks of geological field training and viva-voce examinations in the field. The attendance in the geological field training will be compulsory for all the students. The field training and viva-voce examination will be conducted by at least two internal examiners (faculty members) during first to third semesters. For the geological field training 2 credits (50 marks) including viva-voce examination in the field shall be assigned to evaluation of the report. The semester breaks can also be utilized for the geological field training. After the field training, the students will be required to submit a detailed field report to the concerned teachers for evaluation.

(b) Project Oriented Dissertation, Presentation and viva-voce of four credits (Total of 100 marks) will be part of the Core Courses in the fourth semester. The area of Dissertation shall be assigned to the students before the commencement of the classes for the III semester based on the merit of up to II semester, the choice the students and expertise available in the Department. The Project Oriented Dissertation must be submitted at least one month before the commencement of fourth Semester's final examination. There will be a short presentation of 45 minutes in the presence of faculty members and the board of examiners for the purpose of evaluation before the submission of Project Oriented Dissertation. During completion of the Dissertation work the students will be required to complete various assignments given to them by their respective supervisors for the purpose of their evaluation. The distribution of credits and marks will be as under:

(i) Dissertation Evaluation of 3 credits (equivalent to 70 marks) by the supervisor.

(ii) Project dissertation will necessarily have a component of field work

(iii) Seminar presentation and viva-voce of one credit (equivalent to 30 marks) by the Board of Examiners and one External Examiner.

(c) The students shall select the Elective Courses in the beginning of all Semesters according to the scheme mentioned below.

Marks for theory and practical examinations shall be as per the following.

Exam. Components	Marks for Semester Exam.	**Sessional** Mid Semester Test + class assessment/presentation/quiz	Total Marks
Theory	70	30 (20+10)	100
Practical	70	30 (20+10)-	100

M.Sc. Geology Syllabus

SEMESTER - I			
Course Code	**Core Courses**	**Credits**	**Hrs/week**
MSGEL1001C03	Geomorphology and Remote Sensing	3	3
MSGEL1002C03	Mineralogy, Optical mineralogy, and Crystallography	3	3
MSGEL1003C03	Micropaleontology and vertebrate Palaeontology	3	3
MSGEL1004C03	Stratigraphy	3	3
	Total of Theory	**12**	**12**
MSGEL1005C02	Lab: Geomorphology and Remote Sensing and Mineralogy, Optical mineralogy, & Crystallography	2	4
MSGEL1006C02	Lab: Micropaleontology, vertebrate Palaeontology and Stratigraphy	2	4
MSGEL1007C02	Geological Field Training (Palaeontology and stratigraphy of 14 days)	2	4
	Total of Practical	**6**	**12**
	Total of Core Courses	**18**	
Course Code	**Elective Courses**	**Credits**	
MSGEL1008E03	Oceanography	**3**	**3**
MSGEL1009E03	Applied Palaeontology and Principle of stratigraphy (also for students of other PG Programs)	**3**	**3**
MSGEL1010E03	Palaeobotany (also for students of other PG Programs)	**3**	3
	Total of Elective Courses	**9**	
	Total	**27**	
SEMESTER - II			
Course Code	**Core Courses**	**Credits**	
MSGEL2001C03	Igneous Petrology	3	3
MSGEL2002C03	Structural Geology	3	3
MSGEL2003C03	Invertebrate Palaeontology	3	3
MSGEL2004C03	Sedimentology	3	3
	Total of Theory	**12**	**12**
MSGEL2005C02	Lab: Igneous Petrology and Structural Geology	2	4
MSGEL2006C02	Lab: Invertebrate Palaeontology and Sedimentology	2	4

MSGEL2007C02	Geological Field Training (Geological mapping of 21 days)	2	4
	Total of Practical	**6**	
	Total of Core Courses	**18**	**24**
Course Code	**Elective Courses**	**Credits**	
MSGEL2008E03	Application of Remote Sensing and GIS in Geosciences	3	3
MSGEL2009E03	Geochemistry	**3**	3
MSGEL2010E02	Life Through Ages (also for students of other PG Programs)	**2**	2
	Total of Elective Courses	**08**	
	Total	**26**	
SEMESTER - III			
Course Code	**Core Courses**	**Credits**	
MSGEL3001C03	Metamorphic Petrology	**3**	3
MSGEL3002C03	Hydrogeology	**3**	3
MSGEL3003C03	Economic Geology	**3**	3
	Total of Theory	**9**	**9**
MSGEL3004C02	Geological field work (Applied geology and mining for 14 days)	**2**	4
MSGEL3005C02	Lab: Metamorphic Petrology	**2**	4
MSGEL3006C02	Lab: Hydrogeology and Economic Geology	**2**	4
	Total of Practical	**6**	
	Total of Core Courses	**15**	
Course Code	**Elective Courses (Any four)**	**Credits**	
MSGEL3007E03	Elements of Mining and Ore Dressing	**3**	3
MSGEL3008E03	Computer application in Geosciences	**3**	3
MSGEL3009E03	Engineering Geology	**3**	3
MSGEL3010E02	Disaster Management (also for students of another PG Program)	**2**	2
MSGEL3011E03	Metamorphic Petrology and Thermodynamics from Swayam Portal: https://swayam.gov.in/nd2_cec20_mm03/	**3**	16 weeks
MSGEL3012E03	Geophysics and Mineral Exploration	**3**	
	Total of Elective Courses	**11 or 12**	
	Total	**26 or 27**	
SEMESTER - IV			
Course Code	**Core Courses**	**Credits**	
MSGEL4001C03	Environmental Geology and Natural Hazards	**3**	3
MSGEL4002C04	Field based project-oriented dissertation, presentation & viva-voce	**4**	
	Total of Theory	**7**	
Course Code	**Core Courses**	**Credits**	
MSGEL4003C02	Lab: Environmental Geology and Natural	**2**	4

	Hazards		
	Total of Practical	**2**	
	Total of Core Courses	**9**	
Course Code	**Elective Courses (any four)**	**Credits**	
MSGEL4004E03	Watershed Management	**3**	3
MSGEL4005E03	Sequence Stratigraphy	**3**	3
MSGEL4006E03	Petroleum Exploration	**3**	3
MSGEL4007E02	Preparation of fossils, rock thin-sections and polished sections	**2**	4
MSGEL4008E03	Photogeology in Terrain evaluation from Swayam Portal: https://swayam.gov.in/nd1_noc20_ce60/	**3**	8 weeks
	Total of Elective Courses	**11 or12**	
	Total	**20 or 21**	
	GRAND TOTAL	**101**	

Core 60 Credits
Elective 41 Credits

SEMESTER I

Course Code	Core Course	Credits	Hrs/week
MSGEL1001C03	Geomorphology and Remote Sensing	3	3

Section A

Fundamental concepts of Geomorphology and their significance, Cycle of erosion, Weathering, soil processes and mass wasting, Fluvial landforms and drainage patterns; Evolution of landforms in Aeolian, marine, glacial and karst landscapes. An elementary idea about morphogenesis and morphography; Morphometric parameters analysis, Neotectonics. Geomorphology of India - Peninsular, extra-peninsular and Indo-Gangetic Plains. Application of Geomorphology in Mineral Prospecting, Civil Engineering, Military purposes, Hydrogeology and Environmental studies. Remote sensing applications in interpreting structure and tectonics; Lithological mapping, mineral resources, environmental monitoring.

Section B

History and Development of Remote Sensing, Fundamental Principles of Remote Sensing, Electromagnetic radiation – characteristics, remote sensing regions and bands; General orbital and sensor characteristics of remote sensing satellites; Spectra of common natural objects – soil, rock, water and vegetation. Elements of satellite image interpretation.

Section C

Platforms- Satellite Orbits: Geostationary, Sun synchronous Satellites- Resolution: Spatial Resolution, Spectral Resolution, Radiometric Resolution, Temporal Resolution, Multispectral Resolution. Satellites & Sensors Landsat Series, SPOT Series, Indian Remote Sensing Satellites, Quick bird Satellite, World View, Geo Eye, ASTER.

Text & References:

Bloom, A. L. 2011: Geomorphology: A systematic analysis of Late Cenozoic Landforms 3rd Edition.
Condie, Kent. C. 1982. Plate Tectonics and Crustal Evolution Pergamon Press Inc.
Drury, S.A. (2001): Image Interpretation in Geology, Allen and Unwin.
Gass I.G. et al 1982: Understanding the Earth. Artemis Press (Pvt) Ltd. U.K.
Gautam, A. 2015 : Geomorphology 5th Edition. Sharda Pustak Bhavan Allahabad.
Gupta, R.P. (1991): Remote Sensing Geology, Springer-Verlag.
Halis, J.R. 1983: Applied Geomorphology
Hall, London. Halis, J.R. 1983: Applied Geomorphology
Holmes, A. 1992: Holmes Principles of Physical Geology Edited by P. McL. D. Duff. Chapman and Hall, London.
Kale V S and Avijit Gupta 2010: Introduction to geomorphology. University Press
Lillesand, T.M. and Kiefer, R.W. 1987: Remote Sensing and Image Interpretation, John Wiley.
Sharma, H.S. 1990: Indian Geomorphology. Concept Publishing Co. New Delhi.
Siddhardha, K. 2016: The Earth's Dynamic Surface- A book of Geomorphology, Kitab Mahal.
Siegal, B.S. and Gillespie, A.R. 1980: Remote Sensing in Geology, John Wiley.
Singh Savindra 2016: Geomorphology. Pravalika Publication Allahabad
Small, R.J. 1978: Study of Landforms: A Textbook of geomorphology (2nd Edition), Cambridge University Press.
Summerfield M.A 2011: Geomorphology and Global Tectonics, Wiley India Pvt Ltd.
Thornbury, W.D. 2004: Principles of Geomorphology. Wiley Easton Ltd., New York or 2nd edition CBS Publication.
Windlley B. 1973: The Evolving continents. John Wiley & Sons, New York.

Course Code	Core Course	Credits	Hrs/week
MSGEL1002C03	Mineralogy, Optical mineralogy, and Crystallography	3	3

Section A

Structure and classification of silicates.

A detailed study of the important silicates (listed below) with reference to general and structural formulae, classification atomic structure, polymorphs/structural states, chemistry including substitution of elements/solid solution and experimental work on pressure-temperature stability of the minerals, modes of occurrence and alterations.

a) Nesosilicates/Orthosilicates: Olivine Group, Garnet Group, Aluminosilicate Group (Andalusite, Kyanite, Sillimanite).
b) Cyclosilicates: Beryl
c) Inosilicates; Pyroxene Group; Amphibole Group.
d) Phyllosilicates: Kaolinite Group, Serpentine Group, Pyrophyllite, Talc, Mica Group, Chlorite.
e) Tectosilicate: Feldspar Group, Cordierite.

Section B

Optical Mineralogy

Petrological microscope and function of its parts and accessories. Optical crystallography of uniaxial and biaxial crystals, Indicatrix, pleochroism, Interference figures, crystal orientation, 2V and 2E.

Section C

Crystallography

32 crystals classes and description of the different classes.
Different types of crystal projections – spherical and stereographic and their uses.
Twinning and Twin Laws: common types of twins and their examples in minerals.
Space Lattice and Symmetry of internal structures – 14 Bravais Lattice. Introduction to space group.
Historical development of X-ray Crystallography, and Bragg's Equation.
Powder method in X-ray crystallography.

Text & References

Dana, E.S. and Ford, W.E.: A textbook of Mineralogy
Kerr, P.F. 1959 Optical Mineralogy, McGraw Hill Book Company Inc., New York.
Keer, W.A., Howie, R.A. & Zussman, J.:An Introduction to the rock forming minerals, ELBS and Longman
Berry, L.G., Mason, B. and Dietrich, R.V.: Mineralogy, CBS Publishers
Phillips, F.C. Introduction to Crystallography
Moorhouse, W.W.: Optical Mineralogy
Winchell, E.N.: Elements of Optical Mineralogy
Nesse, D.W.: Optical Mineralogy, McGraw Hill

Course Code	Core Course	Credits	Hr
MSGEL1003C03	Micropaleontology and vertebrate Palaeontology	3	3

Section A

Introduction to Palaeontology, subdisciplines and significance. Micropaleontology and its scope; Relationship of micropaleontology with ocean sciences; Modern field and laboratory techniques in the study of microfossils (collection, sampling and processing techniques, scanning electron microscopy and mass spectrometry).
An account of the concepts and methods for the development of micropalaeontological indicators useful in reconstruction of history of past, environmental changes and biostratigraphic correlation.
Foraminifera: Larger foraminifera, their outline of morphology and application in Indian Stratigraphy. Benthic foraminifera - their morphology and application in bottom water palaeoceanography and palaeobathymetric reconstructions. Planktic foraminifera - outline of morphology and their modern biogeography, significance in Cenozoic oceanic biostratigraphy and palaeoceanographic, palaeoclimatic interpretations.

Section B

Morphology, their significance in environmental studies, biostratigraphy and palaeoceanographic, palaeoclimatic reconstructions of the following groups.
Calcareous nannofossils, **Ostracoda, Pteropoda**; calpionellids and calcareous algae, **Radiolaria, diatoms, silicoflagellate**, and **Conodonts.**

Spores, Pollen, Dinoflagellates and Acritarchs: Morphology and their significance. Factors controlling distribution of dinoflagellates, biostratigraphic significance of spores, pollen, dinoflagellates and acritarchs. Micropaleontology in petroleum exploration.

Section C

Vertebrate Palaeontology

Origin of vertebrate animals. Vertebrate life through ages, and Landmarks in Evolution.
Collection and preparation of vertebrate fossil remains.
Main classificatory characters and divisions of the vertebrates. An outline classification of Agnathans, Pisces, Amphibia, Reptilia, Aves and Mammalia.
General Account of the Gondwana Vertebrates, and Siwalik Mammals and the possible causes of their extinction. Dinosaurs and their extinction. Evolution of horse, elephant and man.

Text & References

Alfred Traverse (1988): Paleopalynology, Unwin Hyman, USA.
Arnold (2002): Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford University Press, New York.
Bignot, G., Grahm and Trottman (1985): Elements of Micropaleontology, London.
Braiser M.D. Geogrge 1980 Microfossils by Allen and Unwin
Clarkson, E. N. K. (1979 & 2002), Invertebrate Paleontology & Evolution, London Gorge Allen & Unwin.
Cushman, J. A. (1947): Foraminifera Their Classification & Economic Uses, Harvard Univ.
David Tolmazin (1985): Elements of Dynamic Oceanography, Allen and Unwin
Glassener, M. F. (1945): Principles of Micropaleontology, Haftner Press, New York, 645 p.
Grant Gross, M. (1977): Oceanography; A view of the Earth, Prentice Hall.
Haq, B. U. & Boersma, A. (Eds.), (1978): Introduction to Marine Micropaleontology, Elsevier, New York, 250 p.
Houghton John (1997): Global Warming, Cambridge Univ. Press.
Howard A. Armstrong and Martin D. Brasier (2005) MICROFOSSILS (IInd Ed.) Blackwell Publishing Ltd.
Jones R.W. 1996. Micropaleontology in Petroleum exploration by Clarendon Press Oxford
Jones, T.P. and Rowe, T.P. (1999): Fossil plants and spores, Modern Techniques, Geological Soc. of London.
Kathal P. K. (2012): Applied Geological Micropaleontology, Scientific Publishers (India)
Kathal P. K., Rajiv Nigam, Abu Talib (2017): Micropaleontology and Its Applications Scientific Publishers (India).
Kennet, J. P. and Srinivasan, M. S. (1983): Neogene-Planktonic Foraminifera. Hutchison Ross Publ. Co., U. S. A.
Kennett and Srinivasan 1983 Neogene Planktonic Foraminifera: A phylogenetic Atlas, by, Hutchinson Ross, USA.
Loelich, A. R. (Jr.) & Tappan, J. (1988): Foraminifera Genera & Their Classification (v. 1 & 2), Van Nostrand Renhold.
Murray, John, (2006): Ecology & Application of Benthic Foraminifera, Cambridge University Press.
Saraswati Pratul Kumar, Srinivasan M. S. (2016): Micropaleontology – Principles and Applications, Springer.
Sen Gupta, B. K. (1998): Modern Foraminifera, Kluwer Academic Publishers.

Simon K. Haslett (Ed.) Quaternary Environmental Micropaleontology Arnold; Oxford University Press, New York Year. 2002
Sinha Devesh. K.: Micropaleontology. Narosa Publishing House, New Delhi
Colbert E.H., 1984: Evolution of the Vertebrates. Wiley Eastern Limited.
Dobzhansky, Ayala, Stebbins & Valentine (1977) - Evolution (Freeman)
Olson, E.G. (1971) Vertebrate Palaeozoology, Viley, New York
Romer, A.S. (1966) Vertebrate Palaeontology (3rd Edn.) Chicago University Press

Course Code	Core Course	Credits	Hr
MSGEL1004C03	Stratigraphy	3	3

Section A

General

Approaches to measurements of Geological time. Concepts of Sequence stratigraphy; brief ideas of quantitative-, magneto-, seismic-, chemo- and event stratigraphy. Approaches to paleogeography. Stratigraphic correlations.

Precambrian stratigraphy:

Precambrian geochronology. Chronostratigraphy of the Precambrian of Rajasthan Dharwar Craton, Eastern Ghats Belt, Southern Granulite Belt and Singhbhum-Chotanagpur-Orissa Belt. Proterozoic stratigraphy of Son Valley, and Cuddapah-Kurnool basins.
Precambrian-Cambrian boundary.

Section B

Marine Paleozoic stratigraphy:

Igneous activities and palaeogeography during the Palaeozoic Era.
Stratigraphy, facies, and fossil contents of the Palaeozoic rock formations of India. Permian-Triassic boundary.

Gondawana stratigraphy:

Concepts, classification, fauna, flora and age limits of Gondwana Supergroup and related palaeogeography, palaeoclimate, depositional characteristics and igneous activity.

Section C

Mesozoic stratigraphy

Classification, depositional characteristics, fauna, and flora of Triassic, Jurassic and Cretaceous systems in principal basins of India.
Cretaceous-Tertiary boundary.

Cenozoic stratigraphy

Classification, depositional characteristics, fauna, and flora of the Palaeogene and Neogene systems in their type localities and their equivalents in India.
Epoch boundaries of the Cenozoic in India.

Text & References

Danbar, C.O. and Rodgers, J. (1957) Principles of Stratigraphy. John Wiley & Sons.
Naqvi, S.M. and Rogers, J.J.W. (1987) Precambrian Geology of India. Oxford University Press
Krishnan, M.S. (1982) Geology of India and Burma. C.B.S. Publishers & Distributors, Delhi
Pascoe, E.H. (1968) A Manual of the Geology of India & Burma (Vols.I-IV) Govt. Of India Press, Delhi
Pomerol, C. (1982) The Cenozoic Era? Tertiary and Quaternary. Ellis Harwood Ltd., Halsted Press

Schoch, Robert, M. (1989) Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York
Doyle, P. & Bennett. M.R. (1996) Unlocking the Stratigraphic Record (John Villey)
Ravinder Kumar: Stratigraphy of India.
Wadia, D.N (1966) Geology of India

Course Code	Core Course	Credits	Hr
MSGEL1005C02	Lab: Geomorphology and Remote Sensing and Mineralogy, Optical mineralogy, & Crystallography	2	4

Lab: Geomorphology and Remote Sensing:
Introduction to ERDAS IMAGINE and ARC GIS software
Geomorphological interpretation from Toposheets and satellite Images.
Drainage Morphometric Analysis.
Slope Analysis
Terrain aspect Mapping

Lab: Mineralogy, Optical mineralogy, & Crystallography:
Mineralogy
Identification of rock-forming minerals in hand specimens.
Optical Mineralogy
Determination of length fast and length-slow characters of minerals
Scheme of pleochroism and absorption of a given mineral in thin section.
Determination of extinction angle and composition of plagioclase.
Study of interference figures of uniaxial and biaxial crystals, determination of optic signs.
Crystallography
Goniometer and its use in measuring interfacial angle of crystals and calculation of axial ratio.
Representation of symmetry elements of crystals belonging to 32 classes of symmetry and study of their stereograms.

Course Code	Core Course	Credits	Hr
MSGEL1006C02	Lab: Micropaleontology, Vertebrate Palaeontology and Stratigraphy	2	4

Lab: Micropalaeontology
Techniques of separation of microfossils from matrix; Preparation of micro-faunal slides of microfossils; Types of microfossils - calcareous, siliceous, phosphatic and organic walled microfossils; Foraminifera: Morphology, wall composition, geological range, ecology and paleoecology. SEM applications in micropaleontology; Study of surface ultrastructures of foraminifera; Study of important planktic foraminifera useful in surface water, paleoceanography and oceanic biostratigraphy; Study of larger benthic foraminifera useful in Indian stratigraphy with special reference to Cenozoic petroliferous basins of India; Important palynomorphs of Cretaceous and Paleogene age.

Ostracoda: Morphology, geological range, ecology and paleoecology of important groups of Ostracoda. Nannoplanktons: Study of SEM images; Identification of representatives of different groups of nannofossils in SEM photomicrographs. Preparation of range charts of Foraminifera, Ostracoda and Nannofossils. Ecological interpretation based on foraminiferal assemblages with special emphasis on conditions for oil formation.

Lab: Vertebrate Palaeontology

Study of fossil teeth and vertebrate. Study of models showing evolution of man, horse, etc. Study of skulls and limbs of some fossil genera. Study of some models of extinct vertebrate animals.

Lab: Stratigraphy

Study of rocks in hand specimens from known Indian stratigraphic horizons and type localities.

Exercises on stratigraphic correlation and classification.

Exercises on Seismic and magneto-stratigraphic interpretations.

Study and understanding of plate-movements through important periods during Phanerozoic Eon.

Evolution of ocean systems during Phanerozoic.

Course Code	Core Course	Credits	Hr
MSGEL1007C02	Geological Field Training (Palaeontology and stratigraphy of 14 days)	2	4

Geological fieldwork of 14 days in either of the two areas

Kachchh Basin

Jaisalmer Basin

Submission of field report and presentation

Course Code	Elective Cours	Credits	
MSGEL1008C03	Oceanography	**3**	**3**

Section A

Introduction to oceanography; Sampling of modern ocean biogenic flux including sediment trap sampling; Methods of measuring properties of sea water; Temperature and salinity distribution (horizontal and vertical) in ocean waters; Dissolved gases in sea water, factors affecting the concentration of gases in sea water; Carbon dioxide equilibria, precipitation and dissolution of carbonates; Biological – chemical - physical interactions in the oceans; Oxygen minimum layer in the ocean.

Section B

Scientific ocean drilling and its major accomplishments; Ocean circulation, surface circulation; Concept of mixed layer, thermocline and pychnocline, Coriolis force and Ekman spiral, upwelling, El nino, deep ocean circulation, concept of thermohaline circulation, formation of bottom waters, water masses of the world oceans, oceanic sediments.

Section C

Lab: Oceanography

Depth biotopes and estimation of palaeodepth of the ocean using benthic foraminiferal assemblages; Identification of modern and ancient surface water mass with the help of

planktic foraminiferal assemblages; Identification of benthic foraminifera characteristic of low oxygen environment; Identification of Planktic foraminifera characteristic of warm and mixed layer, thermocline and deep surface water of the modern oceans; Study of modern surface water, mass assemblages of planktic foraminifera from Indian ocean, Atlantic ocean and Pacific ocean.

Text & References

David Tolmazin (1985): Elements of Dynamic Oceanography, Allen and Unwin
Grant Gross M. 1977 Oceanography; A view of the Earth by. Prentice Hall
Grant Gross, M. (1977): Oceanography; A view of the Earth, Prentice Hall.

Course Code	Elective Course	Credits	
MSGEL1009E03	Applied Palaeontology and Principle of stratigraphy (also for students of another PG Program)	**3**	**3**

Section A

Evolution: mechanism, fundamentals, evidences and theories. Micro and macro-evolution, types of heterochrony in evolutionary lineages, application to biochronology. Distribution, migration, and dispersal of organisms applied to palaeobiogeography and plate-tectonics.

Section B

Requisites of fossilization. Mode of preservation of fossils. Significance of fossils. Classification: taxonomy and species nomenclature, type material.

Section C

Principles of Stratigraphy. Code of stratigraphic nomenclature. Standard stratigraphic scale and Indian equivalent. Stratigraphic classification: lithostratigraphy, biostratigraphy and chronostratigraphy and their units. Sequence stratigraphy: concept and application. Magnetostratigraphy, Climatostratigraphy. Graphic representation of stratigraphic data

Text & References

Babin Claude, 1980: Elements of Palaeontology. Johan Wiley & Sons.
Boardman, R.S., Cheetham, A.H. and Rowell, A.J. 1987: Fossil Invertebrates. Blackwell Science
Boardman, R.S., Cheetham, A.H. and Rowell, A.J. 1987: Fossil Invertebrates. Blackwell Science
Bromley R.G., 1996: Trace Fossils – Biology, Taphonomy and applications. Chapman & Hall.
Clarkson, E.N.K. 1988: Invertebrate palaeontology and Evolution. IV Ed. Blackwell.
Clarkson, E.N.K. 1988: Invertebrate palaeontology and Evolution. IV Ed. Blackwell.
Danbar, C.O. and Rodgers, J. (1957) Principles of Stratigraphy. John Wiley & Sons.
Dodd, J.R. & Stenton, R.J. Palaeoecology-Concept and Applications
Dodd, J.R. & Stenton, R.J. Palaeoecology-Concept and Applications
Lehmann, U., Hillmer, G. 1983: Fossil Invertebrates. Cambridge University Press.
Nield, E.W. and Tucker V.C.T.: Palaeontology – An Introduction. Pergamon Press.
Schoch, Robert, M. (1989) Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York

Course Code	Elective Course	Credits	

MSGEL1010E03	Palaeobotany also for students of another PG Program)	**3**	3

Section A

Introduction and approaches to Palaeobotany. Preservation and kinds of fossil plants. Occurrence of plant fossils, their collection and preparation.

Techniques of palaeobotanical studies. Difficulties of identification. Concept of genera and species, 'Form' genera. Nature of palaeobotanical record. Palynology and its applications.

Section B

Classification of fossil plants and broad characters of major plant groups.

Brief morphology of different plant parts. Taxonomy, systematic position and distribution of common representative Indian plant genera as per list given below:

Lycopodiales – *Lycopodites*; **Lepidodendrales** – *Lepidodendron, Sigillaria, Stigmaria*. **Equisetales** – *Equisetites, Phyllotheca, Schizoneura, Dicroideum*. **Calamitales** – *Calamiltes, Annularia*, **Sphenophyllales** – *Sphenophyllum*. **Filicales** – *Cladophlebis, Cleichenites, Matonidium*. **Pteridospermae** – *Glossopteris, Gangamopteris, Vertebraria, Iaeniopteris, Weichselia, Sphenopteris, Neuropteris, Cyclopteris, Alethopteris, Pecopteris, Thinnfeldia, Rhacopteris. Cycadales – Nilssonia, Bucklandia.* **Bennettitales** – *Williamsonia, Ptilophyllum, Otozamites, Dictyozamites, Pterophyllum*. **Ginkgoales** – *Ginkgoites*. **Cordaitales** – *Neoggerathiopsis, Dadoxylon*. **Coniferales** – *Brachyphyllum, Pagiophyllum, Pdozamites, Elatocladus* and **Angiosperm** general Palmyxylon and Betula.

Section C

Distribution and composition of pre-Gondwana, Gondwana, Inter-trappean and Tertiary Floras of India with observations on their origin, and relationship with other contemporaneous fossil floras of the world.

Evolution of Flowering plants. Dendrochronology. Applications of Palaeobotany with particular reference to stratigraphic correlation and palaeoclimates.

Lab: palaeobotany

Study and identification of the important fossils plants as detailed in theory syllabus.

Text & References

Arnold, C.A. (1947) An introduction to Palaeobotany, McGraw Hill
Andrews Jr., H.N. Studies in Palaeobotony. Wiley, New Yorks.
Seaward, A.C. (1991) Plant fossils, Today's & Tomorrow, New Delhi.
Chester, R.A. (1987). An introduction to Palaeobotany, Tata McGraw Hill.

SEMESTER II

Course Code	Core Course	Credits	
MSGEL2001C03	Igneous Petrology	3	3

Section A

Igneous Petrology

Magma: its physics, nature, factors affecting magma and its evolution. Petrology and melting of mantle. Generation of magmas in different tectonic environments.

The Phase equilibrium of binary (Ab-An, Ab-Or, Di-An, Fo-Si) and ternary (Di-Ab-An, Di-Fo-Si, Di-Fo-An, Ne-Ks-Si, Fo-An-Si) systems and its relation to magma genesis and crystallization in the light of modern experimental works.

Section B

Interpretation of igneous textures in terms of rate of nucleation and crystal growth.

IUGS classification of the Igneous rocks. CIPW Norm. Elementary concepts of thermodynamics of igneous rock systems. Plume magmatism and hot spots. Mantle metasomatism. Mantle heterogeneities. Partial melting (batch and fractional melting), crystal fractionation (equilibrium and fractional (Rayleigh) crystallization), contamination (AFC process) and dynamic melting.

Section C

Petrology and petrogenesis of major igneous rock types, giving Indian examples, of Ultramafic, Basaltic, Granitic, Alkaline, Ophiolite, Carbonatite, Nephelinite-Ijolilte, Lamproits, and Layered igneous rocks.

Text & References

Winter, J.D. 2001 An introduction to Igneous and Metamorphic Petrology, Prentice Hall.

Philpotts, A.R. 1994 Principles of Igneous and Metamorphic Petrology, Prentice Hall.

Spear, F. S. 1993 Mineralogical Phase Equilibria and pressure – temperature – time Paths, Mineralogical Society of America.

Powell, R. 1978 Equilibrium thermodynamics in Petrology: An Introduction, Harper & Row Publishers, London.

Wood, B.J. and Fraser, D.G. 1976: Elementary Thermodynamics for Geologists, Oxford University Press, London.

Rastogy, R.P. and Mishra, R.R. 1993: An Introduction to Chemical Thermodynamics, Vikash Publishing House.

Blatt, H. and Tracy, R.J. 1996 Petrology (Igneous, Sedimentary, Metamorphic), W.H. Freeman & Co., New York.

Bose, M.K., 1997. Igneous Petrology, World Press, Kolkata.

Best, Myron G., 2002. Igneous and Metamorphic Petrology, Blackwell Science.

Cox, K.G., Bell, J.D. and Pankhurst, R.J.,1993: The Interpretation of Igneous Rocks. Champman & Hall, London.

Faure, G. Origin of Igneous Rocks, Springer.

Hall,A., 1997 Igneous Petrology, Longman.

Le Maitre, R.W., 2002. Igneous Rocks: A Classification and Glossary of Terms, Cambridge University Press.

Mc Birney, 1994. Igneous Petrology, CBS Publishers, Delhi.

Phillpotts, A.R., 1994. Pri;nciples of Igneous and Metamorphic Petrology, Prentice Hall of India.

Sood, M.K., 1982: Modern Igneous Petrology. Wiley-Interscience Publ., New York.

Srivastava, Rajesh K. and Chandra, R., 1995: Magmatism in Relation to Diverse Tectonic Settings.

A.A. Balkema, Rotterdam.

Wilson, M., 1993: Igneous Petrogenesis. Chapman & Hall, London.

Winter, J.D., 2001: An Introduction to Igneous and Metamorphic Petrology. Prentice Hall, New Jersey.

Course Code	Core Courses	Credits	
MSGEL2002C03	Structural Geology	3	3

Section A

Mechanical principles, properties of rocks and their controlling factors. Theory of rock failure. Concept of stress and strain; Two-dimensional strain and stress analyses; Types of strain ellipses and ellipsoids their properties and geological significance. Methods of strain measurements in naturally deformed rocks.

Section B

Mechanics of folding and buckling, Superposed folding patterns, Fold development and distribution of strains in folds.

Brittle and ductile shear zones, Geometry and products of shear zones, Mylonites and Cataclasites; Causes and dynamics of faulting: Strike-slip Faults, Normal Faults, Thrust Faults; Thin-skinned deformation; Decollement.

Section C

Planar and linear fabrics in deformed rocks, their origin and significance.

Basic idea about petrofabrics and use of Universal stage.

Stereographic and equal area projections for representing different types of fabrics, and π and β diagrams. Geometrical analysis of simple and complex structures on macroscopic scale.

Text & References:

Ramsay, J.G. (1967): Folding and fracturing of rocks. McGraw Hill.

Turner, F.J. and Weiss, L.E. (1963): Structural analysis of Metamorphic Tectonites McGraw Hill.

Hobbs, B.E., Means, W.D. and Williams, P.F. (1976): An outline of Structural Geology. John Wiley and Sons. New York.

Ghosh, S.K. (1993): Structural Geology: Fundamental and Modern Developments. Pergamon Press.

Ramsay, J.G. and Huber, M.I. (1983): Techniques of Modern Structural Geology. Vol. I. Strain Analysis. Academic Press.

Ramsay, J.G. and Huber, M.I. (1987): Techniques of Modern Structural Geology. Vol. II. Folds and Fractures. Academic Press.

Course Code	Core Course	Credits	
MSGEL2003C03	Invertebrate Palaeontology	3	3

Section A

General and Systematics

Modern systematics; concept and kind of type specimens.

Trans-specific evolution, speciation, and radiation.

Functional morphology: brachiopods, cephalopods, gastropods, belemnites, bivalves, echinoides and corals.

Evolutionary trends and geological history of Ammonoidea and Trilobita.

Section B

Ichnofossils-modes of preservation, behavioral classification and ichnofacies. Significance of trace fossils in palaeocological interpretation and Palaeoenvironmental reconstruction.

Palaeoecology: introduction, ecosystem, aspects, difference with modern ecology Biocoenosis, Taphonomy, Taphocoenosis, Thanatocoenosis, Time averaging.

Section C

Application

Approaches to palaeoenvironmental studies based on benthic communities, trace fossils, and taphonomic records. Intra-basinal to regional spatio-temporal distribution of fossil record applied to sequence stratigraphy, depositional environment and basin analysis. Shell beds and their significance

Text & References

Babin Claude, 1980: Elements of Palaeontology. John Wiley & Sons.

Benton, M.J. (1990) Vertebrate Palaeontology. Unwin Hyman, Lindon

Boardman, R.S., Cheetham, A.H. and Rowell, A.J. 1987: Fossil Invertebrates. Blackwell Science

Bromley R.G., 1996: Trace Fossils – Biology, Taphonomy and applications. Chapman & Hall.

Chester R.A., 1978: An Introduction to Paleobotany. Tata McGraw-Hill.

Clarkson, E.N.K. 1988: Invertebrate palaeontology and Evolution. IV Ed. Blackwell.

D.N. Wadia, Geology of India.

Horowitz, A.S. & Potter, E.D. (1971) Introductory Petrography of Fossils (Springer Verlag)

Lehmann, U., Hillmer, G. 1983: Fossil Invertebrates. Cambridge University Press.

Mayr, E. (1971) Population, Species and Evolution (Harvard)

Nield, E.W. and Tucker V.C.T.: Palaeontology – An Introduction. Pergamon Press.

Pascoe, E.H.: A Manual of Geology of India and Burma. Vol.I-IV. Govt of India Press.

Pettijohn, F.J.: Sedimentary Rocks. CBS Publishers.

Prothero, D.R. (1998) Bringing Fossil to Life – An Introduction to Palaeontology (McGraw Hill)

Raup, D.M. and Stanley, S.M. (1985) Principles of Palaeontology (CBS Publications)

Raymond C. Moore, Cecil G. Lalicker, Alfred G. Fischer: Invertebrate Fossils (Paperback). CBS Publisher and distributers

Smith, A.B. (1994) Systematics & Fossil Record – Documenting Evolutionary Patterns (Blackwell)

Strean, C.W. and Carroll, R.L. (1989) Palaeontology – the record of life (John Wiley)

Swnnerton, H.H. (1950) An outline of palaeontology.

Treatise on Invertebrate Palaeontology, Ed. Raymond C. Moore (complete series). The Geological Society of America and University of Kansa Press

Woods, H.: Palaeontology Invertebrate.

Course Code	Core Course	Credits	
MSGEL2004C03	Sedimentology	3	3

Section A

Geologic cycle; Sedimentary textures - shape, size, fabric and surface textures, methods of textural analysis, textural parameters and their significance. Sedimentary structures: physical sedimentary structures, biogenic sedimentary structures, diagenetic structures).

Section B

Heavy mineral and insoluble residue analysis; petrography of rocks of clastic, chemical and biochemical origin (Conglomerates, Sandstone, Mudstone, Limestone & Dolomite).
Evaporite, phosphorite, chert, iron and manganese rich sediments; volcanogenic sedimentary rocks.

Section C

Clastic transport and Fluid flow mechanics and formation of sedimentary bedforms; Implication of facies in environmental interpretation and basin analysis.
Digenesis of clastic and non-clastic rocks. Walther's law of facies succession. Concepts of sequence stratigraphy. Concept of Sedimentary facies association models (Marine, Nonmarine, and Mixed Depositional Environment); Sedimentation and Tectonics.

Text & References

Babu, S. K. & Sinha, D. K. (1987): Sedimentary Petrology Practical, CBS Pub., N. Delhi.
Blatt, H. E., (1972): Sedimentary Petrology, 2nd Ed. W. H. Freeman & Co. New York.
Blatt, H., Middleton, G.V. and Murray, R.C. (1980): Origin of Sedimentary Rocks, Prentice-Hall Inc.
Boggs, Sam (Jr.) (2006): Princiles of Sedimentology and. Stratigraphy 4nd Ed. Prentice Hall.
Collins, J.D., and Thompson, D.B. (1982): Sedimentary Structures, George Allen and Unwin, London.
Krumbein, W.C. and Sloss, L.L., 1963: Stratigraphy and Sedimentation. W.H. Freeman and Co., London.
Lindholm, R.C. (1987) A Practical Approach to Sedimentology, Allen and Unwin, London.
Miall, A.D. (2000): Principles of Basin Analysis, Springer-Verlag.
Pettijohn;, F.J. (1975): Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi.
Reading, H.G. (1997): Sedimentary Environments and facies, Blackwell Scientific Publication.
Reineck, H.E. and Singh, I.B. (1973): Depositional Sedimentary Environments, Springer-Verlag.
Selley, R. C. (2000) Applied Sedimentology, Academic Press.
Selly, R. C. (1976): An Introduction of Sedimentology. Academic Press London.
Sengupta, S. M. (2007): Introduction of Sedimentology. 2nd Ed. CBS Pub., New Delhi.
Sukhtankar, R. K. (2004): Applied Sedimentology. 1st Ed. CBS Pub. & Dist., New Delhi.
Tucker, M. E. (1981): Sedimentary Petrology: an introduction. John Willey & Sons, New York.
Tucker, M.E. (1981): Sedimentary Petrology: An Introduction, Wiley and Sons, New York.
Tucker, M.E. (1990): Carbonate Sedimentolgy, Blackwell Scientific Publication.

Course Code	Core Course	Credits	
MSGEL2005C02	Lab: Igneous Petrology and Structural Geology	2	4

Lab: Igneous Petrology

Megascopic and microscopic study of different igneous rocks.
Calculation of CIPW Norms.

Lab: Structural Geology

Preparation and interpretation of Geological maps and sections.

Structural problems based on orthographic and stereographic projections, concerning economic deposit.
Recording and plotting of the field data
Study of the hand specimen of deformed structures
Strain estimation from the data already collected from the field.
Study of dip-isogons from the fold profiles.

Course Code	Core Course	Credits	
MSGEL2006C02	Lab: Invertebrate Palaeontology and Sedimentology	2	4

Lab: Invertebrate Palaeontology
Study of the morphological characters of some important Invertebrate Fossils belonging to Brachiopoda, Bivalvia, Gastropoda, Ammonoidea, Trilobita, Echinoidea and corals. Determination of valves and dental formula of Heterodont Bivalves. Shell petrography of Bivalves and Brachiopods.
Study of an assorted group of trace fossils.
Study of ammonoid suture pattern, coiling, whorl section and ontogenic variation; exercises in ammonoid heterochrony.
Measurements of dimensional parameters and preparation of elementary bivariate growth curves and scatter plots.
Lab: Sedimentology
Size Analysis (Procedures, Cumulative curve, Histogram, Visher's curve and Statistical calculation); Shape analysis (Calculation and Classification). Heavy mineral analysis (Procedure and identification); Insoluble residue analysis (Procedure and identification).
Megascopic and studies of conglomerate and breccias; megascopic and microscopic study of sandstone; megascopic and microscopic study of limestone; sedimentary structure (identification and classification); paleocurrent and basin analysis calculation. Fence diagram, preparation and interpretation. Study of Vertical Profile Sections of some Selected Sedimentary Environment.

Course Code	Core Course	Credits	
MSGEL2007C02	Geological Field Training (Geological mapping of 21 days)	2	4

Geological Field-Training of structural and stratigraphic mapping for 21 days in a suitable area and submit a field report and presentation.

Course Code	Elective Course	Credits	
MSGEL2008E03	Application of Remote Sensing and GIS in Geosciences	3	3

Section A
Fundamental Concept of Thermal Remote Sensing, Physics of Thermal Remote Sensing, Thermal radiation principles, thermal process and properties, Characteristics of thermal IR

images and Factors affecting thermal images. Study of various types of thermal satellites and their characteristics such as Landsat, ASTER, MODIS, interpretation of thermal sensors and information extraction from thermal imagery. Spectral signatures of variety of surface materials.

Section B

Lithological interpretation of Igneous rocks. Lithological interpretation of Sedimentary rocks, Lithological interpretation of Metamorphic rocks Structure – Definition, types and structural mapping Interpretation of folds, faults, unconformities and lineaments. Relevant case studies. Applications of thermal Remote Sensing in Earth Sciences , Applications of thermal Remote Sensing Mineral Targetting

Section C

Thermal remote sensing in geological studies; Applications of remote sensing - identification of rocks, mineral explorations, geological surveys; alteration zones mapping; geomorphology applications, volcanic eruptions, surficial deposit / bedrock mapping; lithological mapping; structural mapping; sand and gravel (aggregate) exploration/ exploitation; hydrocarbon exploration; environmental geology; geobotany; sedimentation mapping and monitoring; event mapping and monitoring; geo-hazard mapping.

Lab: Application of Remote Sensing and GIS in Geosciences

Study of the marginal information given on the/Digital data
Import / Export of files using ERDAS IMAGINE
Geo-reference of the Toposheet and satellite Images
Display, Analysis and interpretation of black & white images and FCC
Map composition
Study of landforms and interpretation of lithology and structure from satellite images
Identification of landforms on toposheets, Aerial photographs, satellite images
Lineament Identification and mapping.
Slope Analysis from DEM

Text & References

Remote sensing and image interpretation by Lillisand, T. M. and Keifer, R. W., 2007, John Willey and Sons, USA
Introduction to environmental remote sensing by Barrett, E. C. and Curtis L. F., 1999, Chapman and Hall Publishers, USA.
Fundamentals of remote sensing by Joseph G., 2003, Universities Press, Hyderabad.
Introduction to geographic information systems by Chang, Kang-taung, 2002, Tata McGraw-Hill, USA.
Remote Sensing Geology, by Gupta, R.P., 1990, Springer Verlag.

Course Code	Elective Courses	Credits	Hrs./week
MSGEL2009E03	Geochemistry	**3**	3

Section A

Introduction of Geochemistry and Cosmochemistry with emphasis on cosmic abundance of elements. Principles of geochemistry. Introduction to the chemical composition and properties of Earth's layers, evolution of atmosphere, lithosphere and hydrosphere. Meteorites, their classification, mineralogy, and origin.

Section B

Geochemical classification of elements. Periodic table and trace element geochemistry with special reference to transition elements and trace element geochemistry. Stable isotope geochemistry of carbon and oxygen and its applications to Geology.

Radiogenic isotopes. Decay scheme of K-Ar, U-Pb and Rb-Sr and Sm – Nd. Radiometric dating of single minerals and whole rocks. Petrogenetic implications of Sm-Nd, Rb-Sr.

Geochemical cycles. Concepts of biogeochemical cycle.

Element partitioning in mineral/rocks formation and concept of simple distribution coefficient. Mineral stability in Eh-Ph diagrams.

Section C

Sampling procedures and introduction to analytical techniques used in geochemistry.

A brief introduction to geochemistry of natural waters**.** Introduction to sedimentary geochemistry. Geochemical processes involved in rock weathering and soil formation.

Principles of ionic substitution in minerals.

Crystal structure of some simple compounds – AX structures (NaCl, CsCl, ZnS, NiAs), AX_2 structure (Fluorite, Rutile).

A brief idea about some other compounds such as A_2X_3 (Corundum), ABX_3 (Calcite, Ilmenite) and AB_2X_4 (Spinel).

Lab: Geochemistry

Rock analyses (Rapid method of silicate analysis) and FeO determination by titration method.

Determination of Loss on Ignition (LOI) of rock samples.

Presentation of analytical data.

Preparation of classificatory and variation diagrams and their interpretation; plotting of REE data and their interpretation. Calculation of weathering indices in soil and sediments.

Text & References

Albarde Francis (2003): Geochemistry- Introduction. Cambridge University Press.

Chris Riddle (1993): Analysis of geological materials. Marcel Dekker Inc.

Easton, A.J. (1972): Chemical analysis of sillicate rocks. Elsevier

Faure, G. (1986): Stable Isotope Geochemistry. John Wiley & Sons.

Henderson, P. (1984): REE geochemistry. Elsevier.

Rankama, K. and Sahama Th. G. (1950) Geochemistry. Univ. Chicago Press.

Mason, B. and Moore, C.B. (1991) Introduction to Geochemistry, Wiley Eastern.

Krauskopf, K.B. (1967): Introduction to Geochemistry. McGraw Hill.

Evans, R.C., (1964): Introduction to Crystal Chemistry. Cambridge Univ. Press

Bloss, F.D., (1971): Crystallography and Crystal Chemistry. Holt, Rinehart, and Winston, New York.

Klein, C. and Hurlbut, C.S., 1993: Manual of Mineralogy. John Wiley & Sons, New York.

Rollinson, H.R. (1993): Using geochemical data: Evaluation, presentation, interpretation. Longman U.K.

Hoefs, J. (1980): Stable Isotope Geochemistry, Springer and Verlag.

Course Code	Elective Course	Credits	
MSGEL2010E02	Life Through Ages (also for students of another PG Program)	**2**	2

Section A

Modern thoughts on origin of life. Nature and evidences of primitive life. Fossils as interpretive tools for past life. Representative lives during different geological intervals. Major mass extinctions and diversification of life, processes, causes and evidences.

Section B

Techniques of dating ancient life.

a. Relative Dating: Pollen analysis, Varve analysis, Rate of Accumulation.

b. Absolute Dating: Dendrochronology, Oxidized Carbon Ratio dating, Potassium Argon dating, Radio-Carbon dating, Oxygen isotope dating and dating by Index fossils.

Text & References

N. Garylane (1986) - Life of Past (Merril)

S.K. Donovan-Mass Extinction:Process & Evidences (1992) (Columb.Univ.Press).

C.R. Knight (2001) -Life through Ages (Indiana Univ. Press).

SEMESTER III

Course Code	Core Course	Credits	
MSGEL3001C03	Metamorphic Petrology	**3**	3

Section A

Mineralogical Phase Rule for Closed and Open Systems. Nature of Metamorphic Reactions, Concept and Classification of Metamorphic Facies and Facies Series. Introduction to Ultrahigh Temperature and Ultrahigh Pressure Metamorphism. Description of each Facies of Low – Medium to High – Pressure and Very High -Pressure with special reference to characteristic Minerals, subdivision into Zones/Subfacies, Mineral Assemblages. Metamorphic Reactions and Pressure – Temperature conditions of Metamorphism.

Section B

Isograds and Reaction Isograds, Schrienemakers' Rule and Construction of Petrogenetic Grids. Metamorphic Differentiation, Anatexis and Origin of Migmatites in the light of experimental studies. Regional Metamorphism and Paired Metamorphic Belts with reference to the theory of Plate Tectonics, Pressure – temperature – time paths.

Section B

Laws of Thermodynamics, Gibb's Free – Energy, Entropy, Δ G of Metamorphic Reactions (Solid-Solid and Dehydration Reactions). Clausius – Clapeyron Equation, Geothermobarometry.

Text & References

Winter, J.D. 2001 An introduction to Igneous and Metamorphic Petrology, Prentice Hall.

Philpotts, A.R. 1994 Principles of Igneous and Metamorphic Petrology, Prentice Hall.

Bucher, K. and Martin, F. 2002 Petrogenesis of Metamorphic Rocks, Springer – Verlag, 7th Revised Edition.

Yardlley, B.W.D. 1989 An introduction to Metamorphic Petrology, Longman Scientific & Technical, New York.

Spear, F. S. 1993 Mineralogical Phase Equilibria and pressure – temperature – time Paths, Mineralogical Society of America.

Powell, R. 1978 Equilibrium thermodynamics in Petrology: An Introduction, Harper & Row Publishers, London.
Wood, B.J. and Fraser, D.G. 1976: Elementary Thermodynamics for Geologists, Oxford University Press, London.
Rastogy, R.P. and Mishra, R.R. 1993: An Introduction to Chemical Thermodynamics, Vikash Publishing House.
Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. 1995 Atlas of Metamorphic Rocks and their textures, Longman Scientific & Technical, England.
Spry, A. 1976 Metamorphic Textures, Pergamon Press.
Blatt, H. and Tracy, R.J. 1996 Petrology (Igneous, Sedimentary, Metamorphic), W.H. Freeman & Co., New York.
Kerr, P.F. 1959 Optical Mineralogy, McGraw Hill Book Company Inc., New York.
Bose, M.K., 1997. Igneous Petrology, World Press, Kolkata.
Best, Myron G., 2002. Igneous and Metamorphic Petrology, Blackwell Science.
Cox, K.G., Bell, J.D. and Pankhurst, R.J.,1993: The Interpretation of Igneous Rocks. Champman & Hall, London.
Faure, G. Origin of Igneous Rocks, Springer.
Hall, A., 1997 Igneous Petrology, Longman.
LeMaitre, R.W., 2002. Igneous Rocks: A Classification and Glossary of Terms, Cambridge University Press.
McBirney, 1994. Igneous Petrology, CBS Publishers, Delhi.
Phillpotts, A.R., 1994. Pri;nciples of Igneous and Metamorphic Petrology, Prentice Hall of India.
Sood, M.K., 1982: Modern Igneous Petrology. Wiley-Interscience Publ., New York.
Srivastava, Rajesh K. and Chandra, R., 1995: Magmatism in Relation to Diverse Tectonic Settings.
A.A. Balkema, Rotterdam.
Wilson, M., 1993: Igneous Petrogenesis. Chapman & Hall, London.
Winter, J.D., 2001: An Introduction to Igneous and Metamorphic Petrology. Prentice Hall, New Jersey.

Course Code	Core Courses	**Credits**	
MSGEL3002C03	Hydrogeology	**3**	3

Section A

Hydrological cycle and role of groundwater in the hydrological cycle; Controls of geology on groundwater occurrence, movement, and distribution; Classification of aquifers and aquifer systems; Mode of occurrence of groundwater in different geological formations and groundwater provinces of India.

Darcy's law – validity of Darcy's law – Hydraulic conductivity, transmissivity, storage coefficient and specific capacity; Water table contour maps, specific yield, storage coefficient. Pump tests and evaluation of hydrologic properties through various methods for steady and unsteady flow. Determination of hydraulic conductivity. Groundwater level and its fluctuations.

Section B

Surface and subsurface methods of groundwater exploration; Application of remote sensing in groundwater exploration; Collection of hydrogeological data and preparation of hydrographs; Selection of suitable site for well construction; Type and design of wells,

methods of well construction, well completion and well development. Groundwater exploration; Geological and surface geophysical methods for the selection of suitable site for well construction.

Section C

Artificial recharge to groundwater and rainwater harvesting; Management of groundwater resources; Conjunctive use of groundwater and surface water; Concept of watershed: Watershed characteristics, importance of water resources; Technical aspects of artificial recharge structures; Groundwater legislation; government policies problem of overexploitation; ground water legislation.

Groundwater quality and environmental aspects; Chemical characteristics of groundwater in relation to various uses – domestic, industrial and irrigation; Saline water intrusion in coastal and other aquifers and its preventive measures; Environmental effects of over-exploitation of groundwater; Water logging problems; Causative factors of groundwater level fluctuations and environmental influences; Groundwater quality Indexing.

Text & References:

Hiscock, K, Hydrogeology: Principles and Practice, Wiley-Blackwell, 2005
Todd, D.K. (1988): Ground Water Hydrology, John Wiley & Sons,New York.
Davies, S.N. and Dc-West, R.J.N. (1966): Hydrogeology,John Wiley & Sons, New York.
Ground Water and Wells (1977): UOP, Johnson, Div. St. Paul. Min.USA
Raghunath, H.M. (1983): Ground Water, Wiley Eastern Ltd., Calcutta
Driscoll, F.G. (1988): Ground Water and Wells, UOP, Johnson Div. St. Paul. Min. USA
Fetter,C.W., Applied Hydrogeology (3rd edition),New York, Macmillan,1994

Course Code	Core Courses	Credits	
MSGEL3003C03	Economic Geology	**3**	3

Section A

Sources and nature of ore-bearing fluids and recent concept of ore forming processes. Magma and its relation to mineral deposits. Classification of ore deposits. Magmatic deposit, Pegmatite deposits. Hydrothermal deposit. Pyrometasomatic deposit (Skarn deposit).

Residual concentration deposit. Sedimentation (Chemical Precipitation, Mechanical concentration). Gossans, interpretation and significance. Supergene enrichment and Metamorphism of ores. Mineralization related to Plate tectonics.

The stratigraphic position, occurrence, ore, gangue mineralogy and reserves of the following ore deposits in India: Chromium, nickel, gold, silver, Molybdenum, Tin Tungsten, Uranium, Iron and Manganese, Copper, Lead and Zinc and Aluminum.

The stratigraphic position, occurrence, mineralogy and reserves of the non-metallic industrial minerals.

Section B

Coal Geology

Definition and origin of coal. Sedimentology of coal bearing strata, types of seam discontinuities and structures associated with coal seams. Chemical analysis of coal (proximate and ultimate analysis). Classification of coal in terms of Rank, Grade and Type. Indian classification for coking and non-coking coals.

Coal Petrology; application. Elementary idea about coal preparation, coal carbonization, coal gasification, coal hydrogenation, coal combustion and fertilizer form coal. Coal as a source rock in petroleum generation. Coalbed methane.
Geological and geographical distribution of coal and lignite deposits in India.

Petroleum Geology

Petroleum – its composition, origin and migration. Reservoir rocks and traps – structural, stratigraphic and combination traps. Methods of prospecting for oil and gas (geological modeling). Oil shale. An outline of oil belts of the world. Onshore and offshore petroliferous basins of India.

Section C

Atomic Fuel

Concept of atomic energy. Mode of occurrence and association of atomic minerals in nature. Methods of exploration for atomic minerals. Productive geological horizons of atomic minerals in India.

Mineral Economics

Mineral economics and its concepts. Tenor, grade and specification. Strategic, critical and essential minerals. National mineral policy. United Nations Framework Classification (UNFC).

Text & References

Arogyaswami, R.P.N. (1996) Courses in Mining Geology.
Bagchi, T.C., Sengupta, D.K., Rao, S.V.L.N. (1979): Elements of Prospecting and Exploration.
Boyle, R.W., 1982: Geochemical prospecting for Thorium and Uranium deposits, Elsevier.
Branes, H.L. (1979): Geochemistry of Hydrothermal Ore Deposits, John Willey.
Chandra, D., Singh, R.M. Singh, M.P., 2000: Textbook of Coal (Indian context). Tara Book Agency, Varanasi.
Cuilbert, J.M. and Park,Jr. C.F.(1986): The Geology of Ore Deposits, Freidman.
Dahlkamp, F.J., 1993: Uranium Ore Deposits. Springer Verlag.
Durrance, E.M. 1986: Radioactivity in Geology-principles and application. Ellis Hoorwool.
Evans, A.M. (1993) Ore Geology and Industrial Minerals, Blackwell
Holson, G.D. and Tiratso, E.N., 1985: Introduction to Petroleum Geology. Gulf Publishing, Houston, Texas.
James R. Craig & David J. Vaughan (1994): Ore Microscopy & Petrography, John Wiley & Sons.
Jensen, M. L. & Bateman, A. M. (1981): Economic mineral deposits, John Wiley & Sons.
Klemm, D.D. and Schnieder, H.J. (1977): Time and Strata Bound Ore Deposits, Springer-Verlag.
Misra, K. C. (1999): Understanding Mineral Deposits, Kluwer Academic Publishers.
Mookherjee, A. (2000): Ore Genesis-A Holistic Approach, Allied Publisher.
North,F.K., 1985: Petroleum Geology. Allen Unwin.
Banerjee P.K. and S Ghosh (1997): Elements of prospecting for non-fuel mineral deposits
Ramdohr, P. (1969) The Ore Minerals and their Intergrowths. Pergamon Press
Scott, A.C., 1987: Coal and Coal-bearing strata: Recent Advances. The geological Society of London, Publication no. 32, Blackwell scientific Publications.
Selley, R.C., 1998: Elements of Petroleum Geology. Academic press.
Singh, M.P. (Ed.) 1998: Coal and organic Petrology. Hindustan Publishing Corporation, New Delhi.

Sinha, R.K. and Sharma, N.L. (1976) Mineral Economics.
Stach;, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and Teichmuller R., 1982: Stach Texbook of Coal petrology. Gebruder Borntraeger, Stuttgart.
Stanton, R. L. (1981): Ore Petrology, McGraw Hill.
Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R. and Robert P., 1998: Organic Petrology, Gebruder Borntraeger, Stuttgart.
Tissot, B.P. and Welte, D.H., 1984: Petroleum Formation andOccurrence, Springer – Verlalg.
Wolf, K.H. (1976-1981) Handbook of Stratabouond and Stratiform Ore Deposits. Elsevier

Course Code	Core Course	Credits	
MSGEL3004C02	Geological field work (Applied geology and mining for 14 days)	**2**	4

Students will be required to carry out geological fieldwork for 2 weeks related to the disciplines of semester III in suitable geological areas and submit a report thereon.

Course Code	Core Course	Credits	
MSGEL3005C02	**Lab: Metamorphic Petrology**	**2**	4

Lab: Metamorphic Petrology A detailed study of textures in Rock Sections with reference to time relations between the phases of deformation and recrystallization of minerals, Calculation of ACF, AKF and AFM values from chemical and structural formulation of minerals and their graphical representation. Study of Metamorphic Rocks in thin sections belonging to different facies with emphasis on texture/structure, mineral composition, parent rock, metamorphic facies / subfacies / zone to which the rock can be assigned and graphical representation of the assemblage in ACF, AKF and AFM diagrams. Study of metamorphic rocks of different metamorphic facies in Hand Specimens. Estimation of Pressure and Temperature from important models of Geothermobarometry.

Course Code	Core Course	Credits	
MSGEL3006C02	Lab: Hydrogeology and Economic Geology	**2**	4

Lab: Hydrogeology
Delineations of hydrological boundaries on water table contour maps.
Preparation of water level contour maps and their interpretation
Hydrogeological significance of drainage morphometric analysis
Estimation of aquifer properties as hydraulic conductivity. Storage coefficient and Transmissivity.
Groundwater prospect map generation.
Lab: Economic Geology
Study of Indian metallic ores and industrial minerals in hand specimens.
Study of ore structures in hand specimens.

Study of optical properties and identification of important ore minerals under ore-microscope.
Preparation of maps showing distribution of metallic and industrial minerals in India and also classical world mineral deposits.
Macroscopic characterization of banded coals. Completion of outcrop in the given maps and calculation of coal reserve. Preparation of polished particulate mounts of coal. Microscopic examination of polished particulate mounts (identification of macerals). Proximate analysis of coal.
Macroscopic and microscopic study of cores and well cuttings. Study of geological maps and sections of important oilfields of India. Calculation of oil reserves.
Study of uranium and thorium bearing geological sections of the country. Macroscopic examination of some uranium and thorium bearing minerals and rocks.

Course Code	Elective Course	Credits	
MSGEL3007E03	Elements of Mining and Ore Dressing	**3**	3

Section A

Elements of Mining

Classification of mining methods: Placer mining methods, open pit methods, Underground mining methods, Coal Mining methods and Ocean bottom mining methods; their advantages and disadvantages.
Ventilation in underground mining: Purpose, types, and arrangements of ventilation in underground mining. Mining hazards and safety measures.

Section B

Ore Dressing

Ore dressing and its importance, low grade ores and their beneficiation; Ore-microscopy and its contribution to ore-dressing techniques. Aggregate properties of minerals and rocks and their consideration in ore dressing techniques. Basic ore dressing operations viz. crushing, grinding, sizing, screening, and classification.

Section C

Concentration processes: Magnetic and electrostatic separation, gravity concentration; Froth Floatation, Amalgamation and Agglomeration.
Dressing of Indian Metallic and non-metallic ores: Sulphide ores, non-sulphide ores, native metals, coal washing and Beneficiation of Beach Sand.

Lab: Elements of Mining

Study of various methods of metal and local mining and their diagrammatic representation. Exercises on mine sampling and determination of tenor, cut-off grades, ore reserves, etc.

Lab: Ore Dressing

Study of flow sheets of important metallic and non-metallic ores and minerals with particular reference to Indian Ores and Minerals.

Text & References

McKinstry, H.E. Mining Geology, Prentice Hall, Englewood Clifts, N.J.
Clark, G.B. (1967) Elements of Mining, III ed. John Wiley
Arogyaswami, R.P.N. (1996) Courses in Mining Geology, IV Ed. Oxford IBH
Gaudin, A.M. Principles of Mineral Dressing. McGaw Hill Pub. Co. Ltd. Bombay

Course Code	Elective Course	Credits	
MSGEL3008E03	Computer application in Geosciences	**3**	3

Section A

Development of algorithms and flowcharts. Basic elements of FORTRAN: variables, data types, declarations. Expressions: literals, characters and strings. Arithmetic operations, order of operations, intrinsic functions. Simple inputs and outputs, Input/output formats.

Section B

Conditional expressions. Logical operations. If statements. Loops. Implementation, testing/debugging. File operations: open, read, write, close. Arrays: static and dynamic array declaration, accessing array elements; arrays of strings, multidimensional array declaration. Functions and subroutines. Derived data types: definition, declaration, arrays of derived data.

Section C

Modules. Programming exercises in simple numerical analysis and in geoscience application areas. Brief overview of C language.

Text & References

Metcalf, M. and Reid, J., 1996, The F Programming language. Oxford University Press.
Rajaraman, V., 2004, Computer Programming in Fortran 90 and 95. Prentice-Hall of India Pvt. Ltd.
Brainerd, W. S., 2015, Guide to Fortran 2008 Programming. Springer-Verlag, London.
Chivers, I. and Sleightholme, J., 2015, Introduction to Programming with Fortran (With Coverage of Fortran 90, 95, 2003, 2008 and 77). Springer Publishers.
Kanetkar, Y. P., 2016, Let us C. BPB publications.

Course Code	Elective Course	Credits	
MSGEL3009E03	Engineering Geology	**3**	3

Section A

Role of engineering geology in civil constructions. Various stages of engineering geological investigation for civil engineering projects. Soil mechanics – three phases of soil, consistency limits, particle size distribution, soil classification, consolidation and compaction, and shear strength of soil. Engineering properties of rocks; rock discontinuities. Physical characters of building stones. Metal and concrete aggregates.

Study of maps & plans, Aerial Photographs and Images. Remote Sensing, Site reconnaissance. Site Investigation Report: Style and Content; Factual Reports and its interpretation. Geotechnical treatments including Grouting and Rock Bolting; Foundation Treatment. Ground Investigation: Boreholes and Trial Pits; Drilling, Sampling and Logging etc.

Section B

Mass movements with special emphasis on landslides and causes of hill slope instability. Earthquakes and seismicity, seismic zones of India. Seismic design of building. Influence of geological conditions on foundation and design of buildings. Case history of engineering projects and geological causes for mishaps and failures of engineering structures.

Section C

Impact of civil engineering projects on Environment, Nature's Equilibrium, Reservoir Induced Seismicity; Alternatives for environmental protection**.** Effect of natural disasters on engineering structures and its remedial/preventive measures. Examples and Case histories from India and other important worldwide projects.

Lab: Engineering Geology

Study of properties of common rocks with reference to their utility in engineering projects.
Study of maps and models of important engineering structures as dam sites and tunnels.
Interpretation of geological maps for landslide problems.
Various problems of soil and rock mechanical properties.
Study of seismic and flood-prone areas in India.

Text & References:

Bell: F.-, 2006. Basic Environmental and Engineering Geology Whittles Publishing.
Bell, F.G, 2007. Engineering Geology, Butterworth-Heinemann
Krynine, D.H. and Judd, W.R., 1998. Principles of Engineering Geology CBS Edition. '
Murthy, Y.N.S:, 2002. Geotechnical Engineering: Principles and Practices of Soil! Mechanics and Foundation Engineering CRC P
Schultz, J. R. and Cleaves, A, B 1951. Geology in Engineering, John Willey & Sons, New York.

Course Code	Elective Course	Credits	
MSGEL3010E02	Disaster Management	**2**	2

Section A

Concepts and definitions of hazard, disaster, vulnerability and risk, disaster risk reduction, disaster management cycle, paradigm shift of Disaster Management. Disaster profile of India. Pre-disaster: risk assessment and vulnerability analysis, prevention & risk reduction, preparedness and response to disaster. Early warning system, capacity development, awareness, risk mapping and zonation. During- disaster: coordination and communication, evacuation, search and rescue emergency operation centre, relief and rehabilitation and response to psychological crises and stress. Post-disaster: recovery, rehabilitation and reconstruction, damage assessment, epidemiological surveillance, role of local institutions: insurance, police, media. Mobilization of communities/agencies for resource generation, temporary livelihood options and socio-economic rehabilitation. Crisis intervention, critical incident stress management.

Section B

National institutional framework (NDRF, NDMA, SDMA, & NIDM, SIDM and other related Departments.), Natural Disaster Management Plan, Best practices in disaster management. Role of NGOs at local, state and national level. Geo-informatics in Disaster Management (RS &GIS, GPS). Land use planning and development for mitigating disaster – disaster resistant house construction. Study of case studies such as Gujarat earthquake, South India Tsunami, Bihar flood Kedarnath (Uttarakhand), Flood disaster, Air pollution disaster in Delhi, Indian parliament attack (2001), Uttarakhand Forest fire (2016). Mumbai attack (2008), building collapse in Mumbai (2017), landslides in north –eastern States.

Text & References

An overview on natural & man-made disasters and their reduction, R K Bhandani, CSIR, New Delhi
Coppola D P, 2007. Introduction to International Disaster Management, Elsevier Science (B/H), London.
Disasters in India Studies of grim reality, Anu Kapur & others, 2005, 283 pages, Rawat Publishers, Jaipur
Disaster Mitigation in Asia & Pacific, Asian Development Bank
Disaster Management and education in India (http://www.chillibreeze.com/articles various/disaster management .asp)
Encyclopedia of disaster management, Vol I, II and IIIL Disaster management policy and administration, S L Goyal, Deep & Deep, New Delhi, 2006
Encyclopedia of Disasters – Environmental Catastrophes and Human Tragedies, Vol. 1 & 2, Angus M. Gunn, Greenwood Press, 2008
Manual on natural disaster management in India, M C Gupta, NIDM, New Delhi
Management of Natural Disasters in developing countries, H.N. Srivastava & G.D. Gupta, Daya Publishers, Delhi, 2006, 201 pages
National Disaster Management Plan (NDMP), and National Disaster Management Authority (NDMA) Govt. of India , NDMA Bhawan, New Delhi

Course Code	Elective Courses (Any four)	Credits	
MSGEL3011E03	Metamorphic Petrology and Thermodynamics from Swayam Portal: https://swayam.gov.in/nd2_cec20_mm03/	**3**	16 weeks

For details Check in https://swayam.gov.in/nd2_cec20_mm03/

Course Code	Elective Course	Credits	
MSGEL3012E03	Geophysics and Mineral Exploration	**3**	

Section A

Geophysics

Concept of Seismic waves (body wave, surface wave), seismology and internal structure of the earth, variation of density, velocity, pressure, temperature, electrical and magnetic properties of the earth; earthquakes, Methods of geophysical exploration (Gravity, Magnetic, Electrical, Seismic and Radiometric), **Electrical methods**: Conduction of electricity through rocks, electrical conductivities of metals, non metals, rock forming minerals and different rocks, Elements of SP, IP and resistivity methods, Wenner and Schlumberger configurations, methods of resistivity profiling and sounding, **Seismic Methods**: Elementary principle of reflection and refraction methods, two layer reflection and refraction problems including inclined layer, fundamentals of conventional seismic instruments, **Gravity Methods**: Absolute and relative gravity measurements; Gravimeters, Land, airborne, shipborne and bore-hole gravity surveys; various corrections for gravity data reduction, Bouguer and isostatic anomalies; density estimates of rocks; regional and residual gravity separation; gravity anomalies and their interpretation

Section B

Mineral Exploration

Selection of minerals for explorations. Use of GIS and remote sensing in mineral exploration. Criteria and guides for mineral search.

Stages of mineral exploration in India. Field observations and field equipment.

Geochemical exploration: mobility of elements and their primary & secondary dispersion. Geochemical approaches, mapping and sample material.

Section C

Drilling: objectives of drilling, types of drilling for exploration and their advantages. Geological and mineable ore reserves and their calculation. Geological modeling for mineral exploration.

Introduction to geobotanical exploration methods. Use of geostatistics in exploration.

SEMESTER IV

Course Code	**Core Course**	**Credits**	
MSGEL4001C03	Environmental Geology and Natural Hazards	**3**	3

Section A

Fundamental concepts of environmental geosciences, its scope and necessity; Definition, structure, composition and general characteristics of lithosphere, hydrosphere, atmosphere and biosphere. The interdisciplinary approach to environmental geology. Geological characteristics of various environmental regimes. Biogeochemical cycles of carbon, nitrogen, phosphorus, and sulfur; Physiography, drainage, climate, soils and natural resources of India.

Section B

Water pollution: types of water pollution, groundwater pollution sources, pathways and mechanism, attenuation processes, case histories of natural (arsenic and fluoride poisoning) and man-made water pollution; water logging, causes, effects and remedial measures, aquifers; declining groundwater tables, subsidence and compaction of aquifers; Soil pollution- sources, causes and effects; Soil pollution control measures; Air pollution: definition, terminology, sources and classification of air pollutants; effects of air pollution- acid rain, green house effects and ozone layer depletion; Air pollution control and management.

Section C

Introduction to natural and manmade disasters; Dimensions of natural and anthropogenic disasters; Floods –nature and frequency of flooding, flood hazards, urbanization and flooding, flood hydrographs, Distribution, magnitude and intensity of earthquakes. Neotectonics and seismic hazard assessment. Preparation of seismic hazard maps. Impact of seismic hazards on long- and short-term environmental conditions.

Mechanism of landslides, type of landslide, causes of major floods, cyclones and storms. Deforestation and land degradation. Role of Government, Non-Governmental and media agencies, Reconstruction and Rehabilitation; Awareness through print and electronic media, involving youth in field observations. Application of remote sensing & GIS in natural hazards monitoring & management.

Text & References

Bell, F.G, 1999. Geological Hazards, Routledge, London.
Bryant, E., 1985. Natural Hazards, Cambridge University Press.
KelIer, E.A., 1978. Environmental Geology, Bell and HowelI, USA.
Patwardhan, A.M., 1999. The Dynamic Earth System. Prentice Hall.
Smith, K., 1992. Environmental Hazards.Routledge, London.
Subramaniam, V., 2001. Textbook in Environmental Science, Narosa International.
Valdiya, X.S., 1987. Environmental Geology - Indian Context. Tata McGraw Hill.

Course Code	Core Course	Credits	
MSGEL4002C04	Field based project-oriented dissertation, presentation & viva-voce	**4**	12

This is the second and final Core Course of the fourth semester. The students will carry out geological field work and lab work assigned to them by the supervisor for one month followed by lab work for two months. Project dissertation will necessarily have a component of field work. 45 minutes of presentation and submission of the Dissertation thesis to the supervisor at least one month before the commencement of final semester examination.

Course Code	Core Course	Credits	
MSGEL4003C02	Lab: Environmental Geology and Natural Hazards	**2**	4

Lab: Environmental Geology and Natural Hazards

Study of seismic and flood-prone areas in India and Seismic and flood hazard map preparation using GIS.

Landslide hazard zonation mapping in GIS

Analyses for alkalinity, acidity, pH and conductivity (electrical) in water samples.

Classification of ground water for use in drinking, irrigation and industrial purposes.

Course Code	Elective Course	Credits	
MSGEL4004E03	Watershed Management	**3**	3

Section A

Introduction and Concept of watershed management, different stakeholders and their relative importance, watershed management policies and decision making. Watershed Characterization, Components of watershed, Watershed delineation and codification. Watershed Conservation Planning and Management

Sustainable integrated watershed management, natural resources management, agricultural practices, Soil erosion and conservation; Watershed Management Practices in Arid and Semiarid Regions, Integrated water resources management, conjunctive use of water resources, rainwater harvesting; roof catchment system. Drought assessment and classification, drought analysis techniques.

Section - B

Use of modern techniques in watershed management, Applications of Geographical Information System and Remote Sensing in Watershed Management, Role of Decision

Support System in Watershed Management. Analysis and DEM generation: slope, Aspect, flow direction, Flow accumulation for watershed Analysis.

Section – C

Community participation, private sector participation, Institutional issues, Socio-economy, Integrated development; Watershed Management in India, Water legislation and implementations, policies and decision making. Community participation, Private sector participation, Case studies.

Lab: Watershed Management

Watershed identification and delineation from toposheet and satellite data.
Hydrogeological modeling using ARC GIS
Vegetation and Draught Indexing using satellite data

Text and References

Thornbury, W. D., (I969): Principles of Geomorphology, John Wiley and Sons, New York
Allam, Gamal Ibrahim Y. (1994) Decision Support System for Integrated Watershed Management, Colorado State University.
Black Peter E., Watershed Hydrology, Prentice Hall, London.
Michael A.M., Irrigation Engineering, Vikas Publishing House.
Murty, J.V.S. "Watershed Management", New Age Intl., New Delhi.
Murthy, J.V.S., Watershed Management in India, Wiley Eastern, New Delhi,
Purandare, A.P., Jaiswal A.K., Watershed Development in India, NIRD, Hyderabad.
Vir Singh, Raj , Watershed Planning and Management, Yash Publishing House, Bikaner.
Tideman, E.M., 1996. Watershed Management: Guidelines for Indian Conditions, Omega, New Delhi

Course Code	Elective Course	Credits	
MSGEL4005E03	Sequence Stratigraphy	**3**	**3**

Section A

Introduction - Sequence Stratigraphy—An Overview, Approach. Methods of Sequence Stratigraphic Analysis - Facies analysis: Outcrops, Well Logs, Seismic Data. Age Determination Techniques.

Section B

Accommodation and Shoreline Shifts. Sequence stratigraphic Surfaces - Transgressive surface, Maximum flooding surface. Systems Tracts - Highstand Systems Tract, Falling-stage Systems Tract, Lowstand Systems Tract, Transgressive Systems Tract, Regressive Systems Tract. Hierarchy of Sequences and Sequence Boundaries

Section C

Sequence Models - types of stratigraphic sequences, sequences in Fluvial Systems, sequences in Coastal to Shallow-Water Clastic Systems, sequences in Deep-Water Clastic Systems, Sequences in Carbonate Systems

Text and References

Coe, A. L. (Ed.) (2003). *The Sedimentary Record of Sea-Level Change*. Cambridge University Press, New York, p. 287.
Danbar, C.O. and Rodgers, J. (1957) Principles of Stratigraphy. John Wiley & Sons.

Haq, B. U. (1991). Sequence stratigraphy, sea-level change, and significance for the deep sea. *In Sedimentation, Tectonics and Eustasy* (D. I. M. Macdonald, Ed.), pp. 3–39. International Association of Sedimentologists Special Publication **12**.
Haq, B. U., Hardenbol, J., and Vail, P. R. (1987). Chronology of fluctuating sea levels since the Triassic (250 million years ago to present). *Science*, Vol. **235**, pp. 1156–1166.
Haq, B. U., Hardenbol, J., and Vail, P. R. (1988). Mesozoic andCenozoic chronostratigraphy and cycles of sea-level change. *In Sea Level Changes–An Integrated Approach* (C. K. Wilgus, B. S. Hastings, C. G. St. C. Kendall, H. W. Posamentier, C. A. Ross and J. C. Van Wagoner, Eds.), pp. 71–108. SEPM Special Publication **42**.
Miall, A. D. (1997). *The Geology of Stratigraphic Sequences*. Springer-Verlag, p. 433.
Octavian Catuneanu 2006. Principles of Sequence Stratigraphy Elsevier

Course Code	Elective Course	Credits	
MSGEL4006E03	Petroleum Exploration	**3**	3

Section A

Identification and characterization (Petrographic and geochemical) 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 (geological modeling). Quantitative evaluation of oil and gas prospects through geochemical modeling. Reconstruction of paleogeothermal gradient. Migration modeling. Inputs for the assessment of accumulation of petroleum.

Section B

Elementary knowledge of geophysical methods of exploration: Magnetic, Gravity and Seismic methods. Elementary knowledge of well drilling: cable-tool drilling, rotary drilling and various types of drilling units Elementary knowledge of Logging: Electric, Radioactive and Sonic logs. Application of logs in petrophysical analysis and facies analysis.

Section C

Lab: Petroleum Exploration

Megascopic and microscopic study of cores. Preparation of geological maps and sections, and derivation of geologicval history in relation to petroleum prospects. Calculation of oil reserves. Exercise on maturation studies. Petrographic characterization of petroleum source rocks. Preparation of SP and Resistivity logs for hydrocarbon reservoirs.

Text & References

Holson, G.D. and Tiratso, E.N. (1985) Introduction of Petroleum Geology. Gulf Publishing, Houston, Texas
Tissot, B.P. and Welte, D.H. (1984) Petroleum Formation and Occurrence. Springer – Verlag
North, F.K. (1985) Petroleum Geology. Allen Unwin.
Selley, R.C. (1998) Elements of Petroleum Geology. Academic Press.
Hunt, J.M. (1996) Petroleum Geochemistry and Geology, 2nd Edition Freeman, San Francisco.
Jahn, F. Cook, M. and Graham, M. (1998) Hydrocarbon exploration and production. Elsevier.
Barker, C. (1996) Thermal Modeling of Petroleum Generation, Elsevier.

Course Code	Elective Course	Credits	
MSGEL4007E02	Preparation of fossils, rock thin-sections and polished sections	**2**	4

Section A

Preparation of fossils - tools

Preparation of thin sections – Requisites: source, sampling: collection, size of sample, oriented samples, diamond saw, numbering, coordinates, packing, transport, official formalities. Tools and chemicals used in preparation of the thin sections.

Section B

Instrument: thin section cutting machine: types, structure, protection of the machine, safety. Grinding machine: carborundum powder plate, carborundum powder paper carborundum powder, water, cloths, paper role, Canada balsam, glass slides, coverslip. Process - cutting polishing and mounting. Checking the thin section.

Text & References

(PDF) Preparation methods in Mineralogy and Geology: The ...
www.researchgate.net › publication › 275948069_Prepar..

MAKING THIN SECTIONS BY HAND revised 2007
www.lpl.arizona.edu › ~rhill › fossil › thin-Section

ink.springer.com/chapter/10.1007%2F978-94-017-0581-3_20
Owen R. Green. A Manual of Practical Laboratory and Field Techniques in Palaeobiology pp 182-210, Thin Section and Slide Preparation Techniques of Macro- and Microfossil Specimens and residues

Course Code	Elective Course	Credits	
MSGEL4008E03	Photogeology in Terrain evaluation from Swayam Portal: https://swayam.gov.in/nd1_noc20_ce60/	**3**	8 weeks

Chairman D. K. Pandey

Member

Member