ಮಂಗಳೂರು ವಿಶ್ವವಿದ್ಯಾನಿಲಯ
MANGALORE UNIVERSITY
(Accredited by NAAC)

ಕ್ರಮಾಂಕ/ No. : MU/ACC/CR 13/2021-22/A2

ಕುಲಸಚಿವರ ಕಛೇರಿ
ಮಂಗಳಗಂಗೋತ್ರಿ – 574 199
Office of the Registrar
Mangalagangothri – 574 199
ದಿನಾಂಕ/Date:25.11.2021

NOTIFICATION

Sub: Revised syllabus of M.Sc. Marine Geology programme.
Ref: Academic Council approval vide agenda
No.: ಎಸಿಸಿ:ಶೈ.ಸಾ.ಸ.2:20(2021–22) dtd 27.10.2021.

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The Revised syllabus of M.Sc. Marine Geology programme which is approved by the Academic Council at its meeting held on 27.10.2021 is hereby notified for implementation with effect from the academic year 2021-22.

Copy of the Syllabus shall be downloaded from the University Website (www.mangaloreuniversity.ac.in)

REGISTRAR

To,

1. The Chairman, Dept. of Marine Geology, Mangalore University.
2. The Chairman, BOS in Marine Geology, Mangalore University.
3. The Registrar (Evaluation), Mangalore University.
4. The Superintendent (ACC), O/o the Registrar, Mangalore University.
5. The Asst. Registrar (ACC), O/o the Registrar, Mangalore University.
6. Guard File.

Mangalore University
Accredited by the NAAC
Department of Marine Geology
Mangalagangothri-574199

Revision of the Syllabus for MSc course in Marine Geology

Preamble

The recently approved syllabus during the last year has been revised by keeping in view of the main objectives (*skills, employability and entrepreneurship*) of the New Education Policy 2020. Nevertheless, this syllabus retains the major part of the Choice Based Credit System introduced in 2016, revised with minor changes in 2018 and revamped during the special BoS Meeting on 28th January 2020 with the expertise opinion from Dr. N. Maran, Deputy Director-General, Geological Survey of India (GSI), and HOD, MCSD, Mangalore and Dr. A.C. Dinesh, Director, MCSD, GSI, Mangalore. Similarly, the expertise opinions were sought from the external BoS members. This syllabus not only enriches knowledge to students, but also aimed for uplifting societal conditions, but also underscores (a) the latest developments in different branches of the subject, (b) increases students teacher interactions, (c) encouraged to undergo internships after the regular offline classes as well as during the vacation, (d) motivate students develop the confidence and expertise on the subject, (e) internships during vacation and carry out the IV Semester dissertation/project work (at national research instructions and multi-national companies), (f) perform better in competitive examinations, interviews to get employment, research positions and (g) overseas fellowships/employment.

Program learning outcomes

Marine Geology is one of the interdisciplinary branches of Earth Science that deals with the origin and evolution of ocean basins, including paleoclimate and paleoceanography, and natural resources exploration. Nevertheless, the course includes also the earth, atmospheric (meteorology and climatology) and ocean sciences including remote sensing and geographic information system (GIS), and global positioning system (GPS) in three semesters followed by intense fieldwork, visit to R & D labs./institutes related to the curriculum prescribed and carry out dissertation/project work in the IV semester. The outcomes of the programme of MSc in Marine Geology are given below:

PO01 Acquiring of sustainable knowledge in different fields of earth, atmosphere and ocean sciences to take up any work related to the earth science.

PO02 Skills development to learn, monitor and understand the spatio-temporal variability of vast data/big data pertaining not only to the earth system science but also those collected by satellites by using advanced remote sensing and processing data in geographic information systemtechniques.

PO03 Dissertation/project work either in the parent university or outside R & D labs, MNCs in any one of the aspects of the curriculum in order to help students to take up independent work after the course. This will help them in research / managerial positions in their employment career.

PO04 Experience gained during fieldwork, visiting R & D labs and visiting Oceanographic Research Vessels / Ships will motivate students to choose the career after the M.Sc. course.

PO05 Water, next to air is an important requirement for the sustenance of life. Skills developed during the course will help students to take up the work related to water harvesting methods and different exploration techniques to tap water and mineral resources, and

PO06 Due to population explosion and advancement of civilization, the earth'senvironments are under stress. The knowledge gained from subjects like environmental geology, geochemistry, and meteorology / climatology is useful to work on impact assessment and offer suggestions for mitigation.

Program specific outcomes

The syllabus of MSc, Marine Geology is quite unique as compared to other courses related to earth science, geology, geophysics, meteorology and oceanography, as it covers most of the syllabus prescribed for the NET and the UPSC geologist's examination. The successful students are able to get employment either in government (universities, undergraduate colleges, engineering institutes) and private companies including MNCs, research position in universities/research institutes. Based on the knowledge acquired over two years, students can start consultancies/take up an independent project as well as chances to get overseas research fellowships and employment.

Programme structure along with the percentage of Hard Core, Soft Core and Elective Paper:

Hard Core	Soft Core	Open Elective	Total credits
56 (60.87%)	30 (32.61%)	6 (6.52 %)	92(100 %)

Mangalore University

Department of Marine Geology

M.Sc. Marine Geology Syllabus (Choice Based Credit System)

Structure of the Course

Semester	Paper (Theory and Laboratory)	Instruction hrs/Week Lectures / Practicals	Duration of Exam (hrs)	Marks			Credits
				IA	Exam	Total	
First Semester: Five Hard Cores and One Soft Core							
MGH 401	Mineralogy and Geochemistry	4	3	30	70	100	4
MGH 402	Petrology	4	3	30	70	100	4
MGH 403	Stratigraphy and Palaeontology	4	3	30	70	100	4
MGP 404	Mineralogy and Geochemistry (Lab, hard core)	8	4	30	70	100	4
MGP 405	Petrology (Lab, hard core)	8	4	30	70	100	4
MGS 406	Geomorphology and Geodynamics	3	3	30	70	100	3
				Semester Total		**600**	**23**
Second Semester: Two Hard Cores, Four Soft Cores and One Open Elective							
MGH 451	Structural Geology and Hydrogeology	4	3	30	70	100	4
MGP 452	Structural Geology and Palaeontology (Lab, hard core)	8	4	30	70	100	4
MGS 453	Environmental Geology	3	3	30	70	100	3
MGS 454	Meteorology and Climatology	3	3	30	70	100	3
MGS 455	RS and Photogrammetry	3	3	30	70	100	3
MGP 456	Hydrogeology and Geostatistics and Comp. Appl. (Lab, soft core)	6	3	30	70	100	3
MGE 457	Geo-sciences (Open Elective)	3	3	30	70	100	3
				Semester Total		**700**	**20 + 3**
Third Semester: Two Hard Cores, Five Soft Cores and One Open Elective							

MGH 501	Oceanography - I (Physical and Chemical)	4	3	30	70	100	4
MGH 502	Oceanography - II (Geol and Biological)	4	3	30	70	100	4
MGS 503	Exploration and Engineering Geology	3	3	30	70	100	3
MGS 504	Economic Geology and Mining Geology	3	3	30	70	100	3
MGS 505	GIS and GPS	3	3	30	70	100	3
MGP 506	Remote Sensing and GIS (Lab.)	6	3	30	70	100	3
MGP 507	Physical Oceanography and Surveying (Lab, soft core)	6	3	30	70	100	3
MGE 508	Ocean and Atmospheric Science (Open Elective)	3	3	30	70	100	3
					Semester Total	**800**	**23 + 3**
Fourth Semester:							
MGP 551	Project Work - Dissertation					300	12
	Viva - Voce					100	4
	Field Work and Field Report					100	4
					Semester Total	**500**	**20**
					Grand Total	**2600**	**86+6***

Note: MG - Marine Geology, H - Hard core, S - Soft core, P - Practical / Project Work, and E - Elective.

Course / Credit Pattern:

Semester Credits	Hard Core (H)	Soft Core (S)	Elective (E)	Practical / Project Work (P)	Total Credits
First	12	3	--	8 (H)	23
Second	4	9	3	4 (H), 3 (S)	20 + 3
Third	8	9	3	--, 6 (S)	23 + 3
Fourth	--	--	--	20 (H)	20
Total	24	21	6*	32 + 9	86 + 6*

Total Credits from all the Four Semesters = 23 + 23 + 26 + 20 = 92

Total Hard Core Credits = 24 (T) + 12 (P) + 20 (Project) = 56= 60.87%

Total Soft Core Credits = 21 (T) + 9 (P) = 30= 32.61%,

*Open Elective Credits = 6 = 6.52%(**Not to be considered for CGPA calculation**)

First Semester

MGH 401: Minerology and Geochemistry

Skills, employability and entrepreneurship: This subject is a good opportunity for students not only to know about the formation of mineral from elements, useful to indentify in the field. Students exit with course have skills to work in quarrying, mining, rock polishing, cement, silica/glass, sand mining, brick, ceramic, pottery and refractory industries. They will be exposed to start their own entrepreneurship. Students are encouraged to undergo internships after the regular offline classes as well as during the vacation.

	Mineralogy	
Unit 1	Introduction to crystallography: Crystal systems and Elements of symmetry (32 classes). Principles of X-ray diffraction and its applications.	4 hrs
Unit 2	Introduction and Principles of Mineralogy: Definition and importance of minerals for sustainable development. Properties of minerals: chemical, physical, electrical, magnetic and thermal.	4 hrs
Unit 3	Principles of optical mineralogy: Introduction to optical mineralogy, polarized light and crossed nicols. Behaviour of isotropic and anisotropic minerals, refractive index, double refraction, birefringence, sign of elongation, interference figures, 2V, dispersion in minerals. Classification of minerals based on optical properties. Ore and ore forming minerals.	8 hrs
Unit 4	Descriptive Mineralogy:Silicates-Structural classifications. Description of major rock forming mineralsof the following groups;Olivine, Pyroxene, Amphibole, Garnet, Mica, Feldspar, Quartz, Aluminosilicate, Zeolites, Clay minerals. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	10 hrs
	Geochemistry	
Unit 5	Introduction to geochemistry and cosmochemistry: Origin of elements and their abundance in the universe. Structure and atomic properties of elements, Periodic Table. Chemical and geochemical classification of elements. Meteorites and their applications. Composition of planets and the Earth's interior.	6 hrs
Unit 6	Distribution of elements in igneous, sedimentary and metamorphic processes with an importance of magmatic and weathering and sedimentary processes. Aerosols, their composition, classification and importance. Brief geochemical aspects of soils and sediments.	6 hrs
Unit 7	Biogeochemistry: Introduction and the current relevance of biogeochemistry. Principles of geochemical cycle including human activity in altering the earth system. Bio-geochemical cycles of carbon, nitrogen and phosphorous.	6 hrs
Unit 8	Isotope geochemistry and principles of geochronology. Radioactive, stable isotopes and fission products; and their classifications, principles in determining ages of rocks, sediments, and applications in different fields of the earth science including paleoclimate.	8 hrs

Continued on next page

	Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	

List of References:

1. Rock Forming Minerals – Deer, Howie and Zussman: Longman Publishers (1983).
2. Text Book of Mineralogy – J. D. Dana, E. S. Asia Publ House (1985).
3. Elements of X-ray Crystallography – Azaraoff
4. Elements of Mineralogy – Rutley – CBS Publications
5. Elements of Optical Mineralogy – Winchell, Wiley eastern Limited (1937).
6. Mineralogy – Berry I. G. and Masson, B. Freeman and Co. (1959).
7. Introduction to Geochemistry – Krauskopf, E. B. McGraw Hill (1979).
8. Principles of Geochemistry – Brain Massan, Wiley eastern limited (1958).
9. Inorganic Geochemistry – Henderson P (1982) – Oxford – Pergamon.
10. Hand Book of Geochemistry – Goldchmidt, V. M. (1958).
11. Geochemistry – Hammer Fmiza (2008).

Free online books

12. Fundamentals of Geochemistry, W. M. Whitehttp://www.soest.hawaii.edu/krubin/GG325/textbook/
13. Geochemistry Earth's System ProcessesDionisiosPanagiotaras Online | 512 Pages
14. Geochemistry Lecture Notes by Glen S. Mattioli and Ralph K. Davis
15. Geochemistry Lecture Notes W. M. Whit
16. Trace Element Geochemistry, Frederick Frey

MGH 402: PETROLOGY

Skills, employability and entrepreneurship: Like the first subject, this one is a good opportunity for students especially about the formation of rocks which are useful to indentify the better quality material in the field for the major constructions/civil engineering projects as well as dimensional and decorative stones. Students exit with course have skills to work in industries related to earth resources, agricultural and soil survey and public works. They will be exposed to start their own entrepreneurship.

Igneous Petrology		
Unit 1	Magma and its properties: magma, its generation in the crust and mantle, physical and chemical properties. Bowen's reaction series. Magmatic Evolution: partial melting, magmatic differentiation fractional crystallization, liquid immiscibility, magma mixing and assimilation.	8 hrs
Unit 2	Forms and structures of igneous rocks. Classification of igneous rocks - IUGS and other standard classifications. Textures of igneous rocks.	6 hrs
Unit 3	Distribution and description of important igneous rocks: Granite, basalt, syenite, peridotite, carbonatite, dolerite, lamprophyre, kimberlite and their associated mineral deposits with special reference to India. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	6 hrs

Sedimentary Petrology

Unit 4	Sources and formation of sediments. Textures and primary structures of sedimentary rocks.	6 hrs
Unit 5	Diagenesis. Classification of sediments and sedimentary rocks.	6 hrs
Unit 6	Distribution and description of important sedimentary rocks:Rudites – Breccia and conglomerate; Arenites - sandstones, greywacke; Argillites – shale, Carbonates - limestone and dolomite. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	8 hrs

Metamorphic Petrology

Unit 7	Metamorphism: Introduction, definition and types, ocean-floor metamorphism, diagenesis vs. metamorphism. Factors of metamorphism: temperature, pressure and fluids.	6 hrs
Unit 8	Textures and structures of metamorphic rocks: Lineation and Foliation, Grades of metamorphism.Gneisses, granulites, quartzites, schists, slates and marbles.	6 hrs

Continued on next page

	Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	

List of References:

1. Sedimentary Petrology F. J. Pettijohn (2004).
2. Petrology of sedimentary rocks – Greensmith (1989).
3. Depositional Sedimentary environments, Springer–H.E. Reineck and I.B. Singh
4. Principles of Petrology – G. W. Tyrell, Asia Pub. House, New Delhi (1980).
5. Petrology – Ehlers and Blatt, CBS Publ (2006).
6. Igneous and Metamorphic Petrology – Best Myron G., CBS Publications (1986).
7. Students Petrology – Allen and Nockolds (1978).
8. A Practical Approach to Sedimentology - CBS Pub. – R.C. Lindholm (1987).
9. Sedimentary Rocks, CBS Pub. – F. J. Pettijohn (1984).
10. Petrology- Igneous, Sedimentary and Metamorphic (3rd Edition): Harvey Blatt, Robert J. Tracy, Brent E. Owens - Allied Publishers.
11. Igneous rocks and Processes: Practical Guide by robin Gill - Willey Blackwell.
12. Petrology of Sedimentary Rocks: Boggs Sam- CUP.

MGH 403: STRATIGRAPHY AND PALAEONTOLOGY

Skills, employability and entrepreneurship: This subject is a good opportunity for students to study evolution of life as well the history of the earth. Students exit from this course, especially from the biological discipline have scope to work on many unsolvable problems which are directly related t the evolution of human beings. Similarly they have chance to work in fossil fuel exploration (coal and petroleum).

Stratigraphy

Unit 1	Introduction:Principles of stratigraphy, Concept of measurement of time, geological time scale and global stratigraphic chart. Stratigraphic classification: Litho, bio, chrono, seismic and magneto stratigraphic units and their inter-relationships. A brief review of global stratigraphy.	8 hrs
Unit 2	Physiographic and tectonic subdivisions of India; Evolution of the Indian subcontinent since the Archaean Eon.	4 hrs
Unit 3	Proterozoic basins of India with emphasis on lithological, geochemical, stratigraphic and geochronological aspects. Geological setting and important stratigraphic features of Phanerozoic formations in India such as Gondwana, Deccan Traps, Indo-Gangetic Plain and Himalaya.	8 hrs
Unit 4	Boundary problem and its significance in stratigraphy with emphasis on the Cretaceous - Tertiary boundary. Importance of Cenozoic Era with reference to evolution of climate and life. Quaternary period:Glacial and inter-glacial epochs. Sea-level fluctuations, causes and consequences. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	6 hrs

Palaeontology

Unit 5	Introduction. Theories on origin of life. Organic evolution, mass extinctions and their causes. Fossils, fossilisation, conditions required for preservation of fossils. Species concept, trace fossils, index fossils and pseudo-fossils. Modes of preservation of fossils (petrification, mould, cast, compressions, impressions, tracks, trails, burrows, foot prints and resting marks). Applications of fossils in stratigraphic correlation.	8 hrs
Unit 6	Invertebrate and Vertebrate fossils - Morphology, classification, evolution, age and stratigraphic importance of Porifera, Coelenterata, Brachiopoda, Mollusca, Arthropoda and Echinodermata. Siwalik vertebrate fauna.	6 hrs
Unit 7	Palaeobotany: Evolution of plant life, plant fossils and fossilization. Gondwana and Tertiary flora. Description of Algae, Spores and Pollen.	6 hrs

Unit 8	Micropalaeontology: Extraction of microfossils from sediments. Microfossil groups: Foraminifera, Ostracoda, Acritarcha, Radiolaria, Diatoms. Nannoplankton and Dinoflagellates. Applications of microfossils and trace fossils in Earth Sciences, Environmental significance and in hydrocarbon exploration. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	8 hrs

List of References:

1) Stratigraphic Principles and Practice - M .J. Weller (1960).
2) Fundamentals of Historical Geology and Srtatigraphy of India by Ravindrakumar - New Age International Publication.
3) Stratigraphy and Sedimentation, W.H. Freeman – Krumbein and Sloss (1963).
4) Principles of Paleontology – Raup and Stanley – CBS Publications.
5) Principles of Invertebrate Paleontology – Shrock and Twenhofel – CBS Publications.
6) Elemental Geosystem - Printice Hall, Inc.- R.W. Christopherson (1995)
7) The dynamic Earth: An introduction, Skinner and S.C. Porter, John Wiley and Sons.
8) Fossil Invertebrates, Cambridge Univ.- Lehmann, U and Hilimer, G. (1983)
9) Distribution and Ecology of Living Benthonic Foraminifera - Murry, J. (1973)
10) Principles of Micropaleontology, Hafner - Glassner, M.F. (1972)
11) Micropalaeontology, George Allen and Unwin -Brasier M.D. (1980)
12) Micropalaeontology, Graham and Trotman - Bignot, G. (1985)
13) Invertebrate Fossils, Mcgraw Hill - Moore, Lalicker and Fisher (1952)
14) Introduction to Micropalaeontology - Haq, B.U.
15) An introduction to Paleobotany - Arnold, Chester R.
16) Palaeontology - Invertebrate 8th Ed, CBS Publ. and Distributors - Woods Henry (1981).
17) Sedimentology and Stratigraphy: Gary Nichols - Willey Blackwell.

MGP 404: MINERALOGY and GEOCHEMISTRY (Lab)

Skills, employability and entrepreneurship: This practical subject is very useful for transforming the knowledge from four walls to the field as the Earth Science is a field Science. Therefore, practical's of this subject are very relevant students to enhance skills to work in quarrying, mining, rock polishing, cement, silica/glass, sand mining, brick, ceramic, pottery and refractory industries and also in chemical labs to analyze the quality of water and sediment/soil. They will be suggested to start their own entrepreneurship.

Mineralogy (Lab)

1. Megascopic study of important rock forming minerals.
2. Crystallography: Crystal systems and angular relationships.
3. Calculation of mineral formula from chemical data of olivine, garnet, pyroxene and amphibole.
4. Identification of mineral samples collected by students during field work.
5. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.

Geochemistry (Lab.)

1. Introduction to principals of geochemical analyses.
2. Determinations of moisture content, porosity, and density of sediment samples.
3. Determination of chlorosity and estimation of salinity of water.
4. Measurements of hardness, calcium and magnesium carbonates.
5. Estimation of dissolved oxygen in natural waters. Importance of oxygen in aquatic, marine and terrestrial environments.
6. Determination of carbon dioxide, acidity/alkalinity of natural water samples. Estimation of partial pressure of carbon dioxide in water samples.
7. Standards of knowing the water quality: WHO, EPA and Indian standards.
8. Geochemical analysis of samples collected by students.
9. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.

MGP 405: PETROLOGY (Lab)

Skills, employability and entrepreneurship: Applications of this subject is similar to MGP 404 in the sense that this subject is essentially on petrology. Students can enhance their skills to work in quarrying, mining, rock polishing, cement, silica/glass, sand mining, brick, ceramic, pottery and refractory industries. They can start their entrepreneurship.

1. Identification of igneous, sedimentary and metamorphic rocks (hand specimen).
2. Study of mega structures, textures and mineralogy of igneous, sedimentary and metamorphic rocks.
3. Microscopic study of igneous, sedimentary and metamorphic rocks.
4. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.

MGS 406: GEOMORPHOLOGY AND GEODYNAMICS

Skills, employability and entrepreneurship: This subject is a good opportunity for students not only to know about the formation of continents and the oceans, as well as shaping the earth surface features. This is useful to indentify sites for tourism, urban development, mitigating geo-hazards and exploration of water, mineral and fossil fuel resources.

Geomorphology

Unit 1	Nature and scope of Geomorphology, Fundamental concepts- Recent trends in Geomorphology. Approaches to geomorphology- static, dynamic, environmental and applied. Earth movements – Landforms - endogenetic and exogenetic, epirogenic and orogenic, climatic and tectonic factors and rejuvenation of landforms. Dynamics of geomorphology; geomorphic processes and resulting landforms.	8 hrs
Unit 2	Basic principles. Concepts of gradation, types of weathering and mass wasting. Concept of erosion cycles. Geomorphology of fluvial tracts, arid zones, coastal regions, Karst landscapes and glacial regions.	6 hrs
Unit 3	Applied Geomorphology: Flood management. Applications of geomorphology in mineral prospecting, Geomorphology of India with special reference to Karnataka. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	6 hrs

Geodynamics

Unit 4	Introduction to Geodynamics. Seismic zones of India. Paleomagnetism: Polar wandering curve and magnetic reversals.	6 hrs
Unit 5	Plate Tectonics: Concept of Plate Tectonics. Major and minor plates. Mechanism of plate motion, Mantle convection. Rift Valleys.	6 hrs
Unit 6	Continental Drift: Concept and different lines of evidence. The concept of the Super continent - Gondwanaland and its fragments. Vertical Tectonics: Introduction to Vertical tectonics. Concept of Isostasy. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	8 hrs

References:

1. Physical Geology - Wm and C Brown - Montgomery, C.W. (1990)
2. An introduction to Coastal Geomorphology - Pethick, J. (1984), Edward Arnold, London, 259p.

3. Process Geomorphology, 5th edition - Ritter, D.F., R.C. Kochel and J.R. Miller (2011). McGraw Hill, NY. Rental text.
4. Global Geomorphology: An introduction to the study of landforms - Summerfield, M.A. (Editor), (1991). John Wiley and Sons Ltd., New York: 560p.
5. Principles of Geomorphology - Thornbury, W.D. (1969): Wiley Eastern Limited, New Delhi: 594 p.
6. A short history of Geomorphology - Tinkler (1985), Croom-Helm, London.
7. Fundamentals of Geomorphology - Rice (1998).
8. Introduction to Geomorphology - Kale and Gupta (2001).
9. The Evolving Continents - Brain F. Windley (1977), John Wiley and Sons. 385p.
10. The Geology of Continental Margins - SpringlerVerlag, NY - Burk C. A. and Drake, C. L. (1974).
11. Plate tectonics and Crustal Evolution - Condie, K.C. Pergamon Press, 288p.
12. Elemental Geosystems A foundation in Physical Geography - Christopherson, R. W. (1995) Printice Hall Inc., 580p.
13. Magnetic anomalies over ocean ridges - Vine, F. J., and Matthews, P. M. (1963) Nature, 199, 947-949.
14. The Interior of the Earth - Bott, M.H.P. (1982), Arnold, London, 316pp.
15. The Afro-Arabian Rift System - Khan, M. A., (1975). Sci. Prog.62, 207-236.
16. McElhinny, (1973) Palaeomagnetism and Plate Tectonics. Cambridge Univ. Press, 358p.
17. Ramachandra Rao, M. B. (1975). Outlines of Geophysical Prospecting: A manual for Geologist E.B.D. Educational Pvt. Ltd. Dehra Dun. 403p.
18. Parasnis, D. S. (1979). Principles of applied Geophysics. Chapman and Hall, - 275p.
19. Dobrin, M.B. (1976). Introduction to Geophysical Prospecting. New York McGraw-Hill, 630p.
20. Geodynamics Elsevier - Artyushkov E.V. (1983)
21. The Dynamic Earth - John Wiley - Skinner, B.J. and Porter, S.C. (1995)
22. Earth Dynamics - BLOCK 4, The Open University Press - Open University Series (1982)
23. Earth Structure - BLOCK 2. The Open University press (1982) - Open University Series.
24. The Evolution Passive Continental Margins - The Royal Society of London (1980) in the Light of Deep Drilling Results. Phil, Trans R. Soc. London, A. 294.
25. Geophysics: Annette Bolger- Oxford Book Company: SalvadariGlanfausta et al- Springer.
26. Introduction to Coastal Processes and Geomorphology: Robin Davidson – Arnott - CUP.

Second Semester

MGH 451: STRUCTURAL GEOLOGY AND HYDROGEOLOGY

Skills, employability and entrepreneurship: These subjects are good opportunity for students to learn not only to know the large-scale earth's features which favour water and mineral accumulations. Similarly, students who pay attention to this subject can become a hydrogeologist. They will be exposed to start their own entrepreneurship. Students are encouraged to undergo internships after the regular offline classes as well as during the vacation.

Structural Geology

Unit 1	**Introduction:** Importance ofstructural geology and its relationship with other branches of geology. Dip and strike. **Force, stress and strain:** Force and acceleration, composition and resolution of forces. Concept of stress and strain; strain analysis using deformation objects.	6 hrs
Unit 2	**Folds:** Parts of a fold. Geometrical classification of folds. Mechanics and causes of folding. Criteria for recognition of folds in the field.	6 hrs
Unit 3	**Faults**:General characteristics, nature of movement along faults. Geometric and genetic classification of faults. Mechanics of faulting. Criteria for recognition of faults in the field.	6 hrs
Unit 4	**Joints:** Geometry and classification. Field studies, importance of joints in geological, structural/civil engineering studies. **Unconformities:** Different types of unconformities. Recognition of unconformities in the field. Criteria to differentiate between faults and unconformities. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	8 hrs

Hydrogeology

Unit 5	**Introduction:** Origin of water, hydrological cycle and its components – precipitation, interception, runoff, evaporation and evapotranspiration. types, importance, occurrence, movement and vertical distribution of ground water; Water bearing geological formations; Springs, classification of aquifers, hydrologic properties of rocks: porosity; permeability; specific yield; specific retention, hydraulic conductivity, transmissivity, storage coefficient. Darcy's law and its applications.	
Unit 6	**Groundwater quality:** Physical and chemical properties of water, quality criteria for different uses, groundwater quality provinces of India, Groundwater contamination; water table fluctuation, water table contour maps; hydrostratigraphic units.	6 hrs
Unit 7	**Wells:** Types, drilling methods, construction, design, development and maintenance. Salt water intrusion in coastal and island aquifers; groundwater legislation in rural and urban areas.	4 hrs

Unit 8	Groundwater development and management: Methods of artificial groundwater recharge; rainwater harvesting, problems of over-exploitation of groundwater; water management in rural and urban areas, geological and geophysical methods of groundwater exploration. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	6 hrs

References:

1. Field Geology – McGraw Hill Book Co. - Lahee, F. H. (1961)
2. Folding and Fracturing of Rocks - McGraw Hill Book Co. - Ramsay, J.G. (1967)
3. Structural Geology – 3rd edition, Prentice Hall - Billings M.P. (1977)
4. Structural Geology of Rocks and Regions - John Wiley and Sons - Davis, G.H. (1984)
5. Structural Geology Principles, Concepts and Problems, 2nd Edition, New Jersey Prentice Hall - Hatcher, Robert D. (1995)
6. Structural Geology – W.H. Freeman, New York - Twiss, Robert J. (1992)
7. Structural Geology – McGraw Hill - Timothy Whetten (1975)
8. Knighton, D. (1998). Fluvial forms and processes: A new Perspective, Arnold, London, 385p.
9. Morisawa, M. 1985. Rivers, Longman, London 222p.
10. Murthy, K.S. 1998. Watershed management in India, 3rd edition, Wiley Eastern Ltd. New Age International Ltd, New Delhi, 198 p.
11. Groundwater – C. F. Tolman – McGraw-Hill Book Co. Inc.
12. Groundwater Hydrology (2nd Ed.) – D. K. Todd, John Wiley and Sons Inc. New York
13. Hydrology – S. N. Davis and R. J. M. Dewiest – John Wiley and Sons Inc. New York.
14. Groundwater Resources Evaluation - W.C. Walton - McGraw-Hill Book Co. New York
15. Hydrogeology (2nd ed.) – C.W. Fetter – Merrill Publishing Co. U.S.A.
16. Handbook of Applied Hydrology - V.T. Chow (Ed) – McGraw-Hill Book Co. New York
17. Hydrogeology – K. R. Karanth – Tata McGraw Hill Publishing Co. Ltd.
18. Ground Water Assessment, Development and Management – K. R. Karanath – Tata
19. McGraw Hill Publishing Co. Ltd.
20. Groundwater – H. M. Raghunath – Wiley Eastern Limited
21. Hydrology – H. M. Raghunath – Wiley Eastern Limited
22. Elements of Hydrology – V. P. Singh
23. Engineering Hydrology – K. Subramaniam – Tata McGraw Hill Publishing Co. Ltd.
24. Introduction to Hydrology – Viessman, W., Lewis, G. L. and Knapp, J. W. (3rded.) Harper and Row, New York
25. Applied Hydrology – Mutreja, K. N. – Tata McGraw Hill Publishing Co. Ltd.
26. Global Groundwater Resources and Management: Paliwal - Scientific publishers.

MGP 452: STRUCTURAL GEOLOGY AND PALAEONTOLOGY LAB

Skills, employability and entrepreneurship: These subjects are good for students to learn not only to know the large-scale earth's features which favour water and mineral accumulations. Similarly, students who pay attention to this subject can become a structural geologist and paleontologists. They will be exposed to start their own entrepreneurship related to geo-hazards mitigation and fossil collection.

Structural Geology (Lab)

1. Introduction Determination of strike and dip, and thickness of strata by graphical and mathematical methods.
2. Measurement of strike and dip by using compass clinometer/brunton compass in the field.
3. Construction of the geological cross-sections to identify the order sequence of formation, pre/post igneous and structural events, and unconformities.
4. Construction of contour maps and tracing the outcrops with geological interpretations.
5. Stereonet, its projections, structural calculations and practical applications.
6. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.

Palaeontology (Lab)

1. Invertebrate Fossils: Identification and descriptive morphology of Coelenterata
2. Brachiopoda Mollusca, Arthropoda and Echinodermata.
3. Plant Fossils: Identification and descriptive morphology of plant fossils.
4. Microfossils: Descriptive morphology, classification and identification of microfossils.
5. Chronological ordering of invertebrate fossils, plant fossils and microfossils.
6. Evolutionary trends in fossils.
7. Reconstruction and identification of fossils aided by morphological parts.
8. Identification of microfossils and shells in the sediment samples collected by students.
9. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.

MGS 453: ENVIRONMENTAL GEOLOGY

Skills, employability and entrepreneurship: This is an interdisciplinary subject with the links of chemistry, physics, life and computing sciences. This is useful to identify human impacts on the mother's natural environment especially with regards to the industrialization, urban development, tourism, and mitigating geo-hazards. Students emerge from this filed have opportunities to work in environmental research labs, and government departments.

Unit 1	Earth and its Environment: Introduction; Lithosphere, Hydrosphere and Atmosphere. Lithosphere; Earth's interior, structure and composition of Earth's crust, constituents of Earth's material. Soil profile, Soil Erosion - causes and effects, silting of estuaries and reservoirs, soil conservation measures.	8 hrs
Unit 2	Hydrosphere: global water distribution, Surface water bodies, glaciers, Water pollution – surface water, groundwater, marine water and their impacts. Hydrographs.	8 hrs
Unit 3	Atmosphere: Earth's atmosphere - evolution, structure and composition. Layer-wise characteristics, causes and effects of atmospheric pollution – acid rain, global warming, greenhouse effect, urban heat islands and heat wave.	8 hrs
Unit 4	Geological hazards: Earthquake, volcanic eruption, landslide, droughts, floods - their significance, causes, preparedness and mitigation. Seismic zones of India. CRZ Act and Coastal zone management.	8 hrs
Unit 5	Environmental considerations related to civil engineering and mining projects. A few case studies. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	8 hrs

List of References:

1. Physical Geology – Foster Robert, J. (1975).
2. Ecology, Environment and Pollution - A. Balasubramaian (1995) M/s Indira Publishers, Mysore.
3. Atmosphere, Weather and Climate: An introduction to Meteorology – Narora, S. B. Saunders Co., Philadelphia.
4. Physical Geology - A. N. Strahler
5. R.W. Tank: Focus on Environmental Geology (p.256)
6. Disaster Management: Dr. Ranita Nagar - APH publishers.
7. Disaster Management: 3 Volumes set - APH publishers.
8. Management of Natural and Man-made Disasters: AradhanaSalpekar - JnanadhaPrakashana.
9. Future Disasters: Dr. PriyaRanjan Trivedi - The Global Open University.
10. Management of Flood, Tropical Cyclones, Storms: Kadambari Sharma - JnanadhaPrakashana.
11. Landslides types Mechanism and Modelling: J. Clague and Douglas Stead.
12. Fundamentals of Weather and Climate. 2nd ed.: Mcilveen and Robin - OUP
13. Marine Pollution Control and Management: Dr. Tanmoy - JnanadhaPrakashana.
14. Water Pollution: Tripathi- Ashish Publishers.
15. Water: Characteristics and Properties: NeelimaRajavaidya - APH Publishers.

MGS 454: METEOROLOGY AND CLIMATOLOGY

Skills, employability and entrepreneurship: These subjects are mainly the basis for the MSc/M.Tech in Meteorology, climatology. The main purpose of introducing these subjects are to bring to the notice of students about the weather/climate change, their extreme variability including the study of the past weather/climate. This provides the basis for predicting the future. Students with these skill can serve in different R and D labs. Research institutions and private organizations.

Meteorology

Unit 1	Elements of meteorology and their significance. Precipitation and its types, temperature, atmospheric pressure, winds and humidity. Earth's radiation balance and human interference: relationships between the Earth and the Sun. Latitudinal, altitudinal and seasonal variations in the temperature including lapse rate. Atmospheric boundary layer and turbulence. Coupled ocean-atmosphere system, El Nino Southern Oscillation (ENSO).	6 hrs
Unit 2	Descriptive meteorology: Winds- geostrophic, and distribution of global winds, regional and local winds, land-sea breezes. Atmospheric pressure and air masses of the globe. Introduction to the global monsoons, jet streams, tropical cyclones and other related phenomena. Monsoon meteorology. Rainfall, measurements and its distribution over the globe with special emphasis on India. Onset and withdrawal of monsoons. General weather systems of India.	6 hrs
Unit 3	Weather monitoring, meteorological hazards and weather modification: Thunder storms, dust storms, cloud burst, cyclones and related processes, floods, drought and famine, and pollution/hazards from aircrafts and space crafts. General weather systems of India, - cyclone and jet stream, Western disturbances and severe local convective systems, distribution of precipitation over India. Western disturbances and severe local convective systems. Utilities of satellites in meteorology. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	8 hrs

Climatology

Unit 4	Principles of climatology: Differences between meteorology and climatology. Intergovernmental Panel on Climate Change.Causes of climate variation: tectonic (changes in the redistributions of continents and oceans), orbital (changes in the solar output) and sub-orbital parameters, including human factors (Changes in the concentration of Greenhouse Gases in the atmosphere).	6 hrs
Unit 5	Climate system and feedbacks. Classification of continental and oceanic climates : Greeks, Koppen's and Thornthwaite's schemes of classification. Climate and climatic zones of India. Principles of General Circulation and Climate Modelling.	6 hrs

Unit 6	Paleoclimatology: Principles of paleoclimate. Sources, records and proxies for paleoclimate. Records for paleoclimate – instrumental / meteorological data and archives: continental and oceanic sediments, speleothems, loess, ice cores, corals, tree rings, desert varnish. Proxies for paleoclimate - stable and radiogenic isotopes, trace elements, pollen, clay minerals, and microfossils. Short-term and long terms variations in the climate. Climate change and, short-term and long-term climate cycles. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	8

List of References

1) Physical Geology - C. W. Montgomery-Wm. C. Brown Publishing Co. Ltd.
2) Physical Geology – Judson Sheldon (1987).
3) Ecology, Environment and Pollution - A. Balasubramaian (1995) M/s. Indira Publishers, Mysore.
4) A Course in Elementary Meteorology – Meteorological Office Publications.
5) Atmosphere, Weather and Climate: An introduction to Meteorology-Narora - B. Saunders Co., Philadelphia.
6) Meteorology - William L. Donn (1975) - McGraw-Hill Book Co., New York.
7) An introduction to Dynamic Meteorology - J. R. Holton (1992) - III Ed, Academic Press.
8) Climate Processes and Change Cambridge Univ. Press – E. Bryant (1997).
9) Intergovernmental Panel for Climate Change reports 2007, 2013 (available in the internet).

MGS 455: REMOTE SENSING AND PHOTOGRAMMETRY

Skills, employability and entrepreneurship: These are advanced as well applied subjects in terms of studying the entire earth by using the computer and allied systems by making use of huge data collected from artificial satellites launched to the space and aircrafts. Data collected by the satellites are useful to monitor the entire world at different spatio-temporal scales. There is good scope of this subject in terms of employability in different organizations and MNCs. Students can start their entrepreneurship.

REMOTE SENSING

Unit 1	**Fundamentals of Remote Sensing:** History, basic concepts: Data acquisition and data analysis. Electromagnetic spectrum. Energy sources and radiation principles, energy interactions in the atmosphere, energy interactions with the earth surface features, spectral reflectance curves, spectral reflectance of various natural earth surface features like vegetation, soil and water.	5 hrs
Unit 2	**Earth Resource Satellites:** Introduction, early history of space imaging, POES and GOES series of satellites, platforms (ground, aerial and space) and sensors. Important earth observation satellites like Landsat, SPOT, NOAA, SEASAT, IKONOS, Quick bird, Orb view etc. Spatial, spectral, temporal and radiometric resolutions. Indian Remote sensing programs: IRS satellite missions and their capabilities, INSAT series. Advantages of satellite remote sensing.	5 hrs
Unit 3	**Principles of Thermal and Microwave Remote Sensing:** Introduction, Black body radiation, Temperature Radiations from the earth's surface, Applications of thermal remote sensing. Basic concepts of microwave remote sensing, Real Aperture Radars and Synthetic Aperture Radars, Microwave sensors, Interferometry. Applications of Microwave Remote Sensing. Visual and digital image analysis techniques.	5 hrs
Unit 4	**Remote Sensing Applications:** In Earth Sciences – Geological interpretation-identification and mapping of litho-units, structural mapping, geohydrological mapping and engineering projects, geomorphologic mapping, geoenvironmental studies, mineral exploration, land use and land cover classification. In Oceanography - monitoring littoral processes, suspended sediments and shoreline change detection studies. In weather forecasting, meteorological and climatic studies such as cloud drift, precipitation, temperature, tropical cyclone and in understanding earth's radiation budget. Case studies with examples from India. Vertical exaggeration and slopes. Factors affecting vertical exaggeration and slopes. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	5 hrs

Photogrammetry

Unit 5	Fundamentals of aerial photography and photogrammetry: History, aerial cameras, aerial films and processing. Types of aerial photos. Fundamentals and geometry of aerial photographs, Scale, Advantages and disadvantages of small-scale and large-scale aerial photographs, relief and tilt displacements, mosaics and types of mosaics, stereoscopic vision and stereoscopes, image displacement due to relief, concepts of stereo-photogrammetry, normal vision, depth perception and vertical exaggeration.	5 hrs
Unit 6	Planning for aerial photographs, flight procedures, planning and execution of photographic flights, radiometric characteristics. Elements of aerial photo interpretation: tone, colour, texture, pattern, shape, size and associated features, geotechnical analysis and convergence of evidence.	5 hrs
Unit 7	Principles and Applications of Aerial Photography: Aerial photo interpretation in resource evaluation – geology, delineation of geological structures, mineral exploration and geomorphology.	5 hrs
Unit 8	Digital photogrametry and interpretation techniques: definition, creation of digital images, automatic measurements and surface modeling, aerial triangulations, digital photogrammetric workstation. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	5 hrs

List of References:

1. Manual of Photo Interpretation – American Society of Photogrammetry.
2. Remote Sensing and Image Interpretation – T. M. Lillesand and R. W. Kiefer – John Wiley and Sons.
3. Fundamentals of Photogeology, Geomorphology – Verstappen – TTC Holland.
4. Remote Sensing and Photogrammetry, vol. 1 and vol. 2 – M. L. Jhanwar and T. S. Chouhan – VignanPrakasan, Jaipur.
5. Applied Remote Sensing and Photo Interpretation – T. S. Chouhan and K. N. Joshi – VignanPrakasan, Jaipur.
6. Remote Sensing in Geology – P. S. Siegal and A. R. Gillespie – John Wiley.
7. Remote Sensing and its applications to Geology - Drury, John Wiley and Sons.
8. Remote Sensing – Sabins, John Wiley and Sons.
9. Manual of Remote Sensing; American Association of Photogrammetry and Remote Sensing.
10. Photo geology and Image Interpretation – Shiv N. Pandey – Wiley Eastern, New Delhi.

MGP 456: HYDROGEOLOGY, GEO-STATISTICS and COMP APPL. (Lab)

Skills, employability and entrepreneurship: These are advanced as well applied subjects in terms of studying the entire water cycle by using multi-disciplinary data with the help of computer and allied systems by making use of huge hydro-geological data collected from insitu monitoring artificial satellites launched to the space and aircrafts. There is good scope of this subject in terms of employability in water resources and exploration in different government organizations and MNCs. Students can start their own entrepreneurship.

Hydrogeology (Lab, Soft Core)

1) Preparation of Isohyetal maps and calculation of depth of rainfall.
2) Calculation of Potential evapotranspiration.
3) Calculation of Actual evapotranspiration
4) Calculation of water budget/water balance.
5) Determination of aquifer parameters.
6) Calculation of Specific capacity of dug wells and bore wells.
7) Generation of hydrogeomorphological maps.
8) Generation of groundwater potential zone maps.
9) Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.

Geo-statistics and Computer Applications (Lab)

1) Mean, median and mode.
2) Quartiles, deciles and percentages.
3) Correlation co-efficient, regression analysis and skewness.
4) Measures of dispersion and other basic statistical parameters.
5) Cluster analysis, factor analysis and contouring.
6) Use of application software (MS Excel, SPSS, Minitab etc.) for graphical representation of statistical data and construction of bar diagrams, pie diagrams, rose diagrams histograms, scatter plots etc.
7) Programming languages and operating systems. Power Point slide preparation.
8) Computer aided design and graphics.
9) Components of a computer (hardware and software), Input-output devices (storage devices). Evolution of computers. Principles of data processing: Word processing,
10) Programming languages and operating systems. Flow chart, Algorithm.
11) Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.

MGE 457: GEOSCIENCES (Open Elective Paper)

Skills, employability and entrepreneurship: This paper is useful to the sister departments of the Earth Science, such as chemistry, physics, life sciences, statistics, computer as well as computing sciences. Usually science students other than earth science qualify NET exams/interviews in the institutes join earth science related organizations. They learn earth science in their area of research. However, with the knowledge of this subject (earth science), students can perform better in their career thereby utilizing the intension of studying the interdisciplinary science. Students have employability in many branches of science in different government organizations and MNCs. Students can start their own entrepreneurship.

Unit 1	Introduction to Geology, Earth and its environment - lithosphere, hydrosphere and atmosphere.	6 hrs
Unit 2	Geological time scale. Origin and evolution of life, fossils, fossilization and their applications.	6 hrs
Unit 3	Geological Agents and hazards: Weathering, Erosion, Transportation and Deposition. Volcanoes, Earthquake, Landslide, Salt water intrusion, Floods and droughts.	6 hrs
Unit 4	Geomorphology: Description of Earth surface features. Landforms, Physical divisions of India. Structure and composition of the Earth's interior: Crust, Mantle and Core.	6 hrs
Unit 5	Structural Geology: Primary structures, secondary structures - folds, faults, joints and unconformities.	8 hrs
Unit 6	Natural Resources: Renewable and non-renewable resources. Water as a resource. Origin, occurrence and distribution of oil and gas. Minerals, rocks. Soil. Economically and strategically important metallic and non-metallic mineral deposits of India. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	8 hrs

List of References:

1. Fundamentals of Historical Geology and Srtatigraphy of India, Ravindrakumar New Age International Pub.
2. Principles of Paleontology – Raup and Stanley – CBS Publications
3. Principles of Invertebrate Paleontology – Shrock and Twenhofel – CBS
4. Fossil Invertebrates, Cambridge Univ.- Lehmann, U and Hilimer, G. (1983)
5. Micropalaeontology, Graham and Trotman - Bignot, G. (1985)
6. An introduction to Paleobotany - Arnold, Chester R
7. Field Geology – McGraw Hill Book Co. - Lahee, F.H. (1961)
8. Structural Geology – 3rd edition, Prentice Hall - Billings M.P. (1977)
9. Stratigraphy and Sedimentation, W.H. Freeman – Krumbein and Sloss (1963)
10. Economic Mineral Deposits – Bateman

11. India's Mineral Wealth - Oxford Univ. Press - Brown and Dey (1975)
12. Industrial Minerals and Rocks of India - Allied Publishers - Deb, S. (1987).
13. Hydrogeology – K. R. Karanth – Tata McGraw Hill Publishing Co. Ltd.
14. Groundwater – H. M. Raghunath – Wiley Eastern Limited
15. Elements of Hydrology – V. P. SinghCourses in Mining Geology – R.N.P. Arogyaswamy, Oxford and IBH Publishing Co.

Third Semester

Skills, employability and entrepreneurship: This semester is quite unique opportunity for students not only to know about the oceans as they cover 71% of the earth surface, but explore further living and non-living mineral resources, in the scenario of depletion of continental resources. Students have chance to go on ocean expedition and exit with course have skills to work in organizations related to ocean and well as Navy. They will be exposed to start their own entrepreneurship. Students are encouraged to undergo internships after the regular offline classes and attend the webinars related to the oceans.

MGH 501: Oceanography – I

Skills, employability and entrepreneurship: These are similar to the above mentioned ones with an emphasis on the physics and chemistry of the oceans. Students have chance to go on ocean expedition and exit with course have skills to work in organizations related to ocean and well as Navy including the R & D Labs. and educational institutions.

Physical Oceanography

Unit 1	Wind generated waves in the oceans; their characteristics; shallow and deep water waves. Propagation, refraction, reflection and diffraction of waves. Wave spectrum, principles of wave forecasting. Mixing processes in the oceans; characteristics of important water masses. Tide-producing forces and their magnitudes; prediction of tides by the harmonic method; tides and tidal currents in shallow seas and estuaries.	6 hrs
Unit 2	Factors influencing coastal processes; transformation of waves in shallow water; effects of stratification; effect of bottom friction, littoral currents; wave action on sediment movement; rip currents; beach stability, ocean beach nourishment; harbour resonance; seiches; tsunami; interaction of waves with structures.	6 hrs
Unit 3	The global wind system; action of wind on ocean surface; Ekman's theory; Sverdrup, Stommel and Munk's theories; upwelling and sinking with special reference to the Indian ocean. Inertial currents; divergences and convergences; geostrophic motion; barotropic and baroclinic conditions; oceanic eddies, relationship between density, pressure and dynamic topography; relative and slope currents.	6 hrs
Unit 4	Wind driven coastal currents; typical scales of motion in the ocean. Characteristics of the global conveyor belt circulation and its causes. Formation of subtropical gyres; western boundary currents; equatorial current systems; El Nino and La Nina; monsoonal winds and currents over the North Indian Ocean; Somali current; Upwelling process in the Arabian Sea. Estuaries: classification and nomenclature; estuarine circulation and mixing; depth-averaged and breadth-averaged models; sedimentation in estuaries; salinity intrusion in estuaries; effect of stratification; coastal pollution; mixing and dispersal of pollutants in estuaries and near-shore areas. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises related coastal and beach protection, to the curriculum.	8 hrs

Chemical Oceanography

Unit 5	Introduction to Chemical Oceanography: Principles and processes regulating the composition of seawater – primary and secondary inputs. Rivers, atmosphere, hydrothermal and diagenesis.	6 hrs
Unit 6	Constancy of ionic composition of seawater. Composition of seawater – Classification of elements based on their distribution; major and minor constituents; behavior of elements; chemical exchanges across river-sea, particulate-dissolved and sediment-water interfaces.	6 hrs
Unit 7	Distribution of radionuclides and gases in the oceans for understanding water column and sedimentary particles scavenging in the oceans. Residence times of elements in seawater and processes regulating it.	6 hrs
Unit 8	Chemical and biological interactions – Ionic interactions; cycling and air-sea exchange of important biogenic dissolved gases; carbon dioxide-carbonate system; alkalinity and control of pH; abiotic and biotic controls of trace elements in the ocean; biological pump and controls on atmospheric composition. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	8 hrs

List of References:

1. Principles of Oceanography - M. Grant Gross.
2. Oceanography – J.J. Bhat.
3. The Open University Set Book (Second Edition) 314p.
4. Pinet P. R. (1992) Oceanography: An introduction to the Planet Oceanus, West Publ., Co. 571p.
5. Emerson, E and Hedges, J. (2008) Chemical Oceanography and the Marine Carbon Cycle. Cambridge University Press.
6. Riley, J. P. and Chester, R. 1971. Introduction to Marine Chemistry, Academic Press,
7. Chemical Oceanography, Vol. 1- 10 (2nd Ed.) - J. P. Riley and G. Skirrow, eds, Academic Press (1975–1989).
8. Fasham, Michael J.R. (2003) Ocean Biogeochemistry. The Role of the Ocean Carbon. Cycle in Global Change Series.
9. Komar, P. D., (1976) Beach Processes and Sedimentation, Prentice-Hall. 429p.
10. Reddy M.P.M. (2001) Descriptive Physical Oceanography, A ABalkema, Press, 440p.
11. Shepard, F.P. (1963), Submarine Geology. 2nd. Ed. New York: Harper Row.557p.
12. Shepard, F.P. (1937), Retreived classification of marine shoreline. J. Geology 45: 602-24.
13. Schulz, H.D. and Zabel, M. (2006) Marine Geochemistry. Springer. 221p.
14. Coastal Engineering Processes: Dominic Reeve, Andrew Chadwick and Chris Fleming -Allied Publishers

15. Marines on the Beach: Christopher Paul -Allied Publishers. .
16. Coastal Processes with Engineering Applications: Robert A. Darylampe - Limited.
17. The Indian Ocean Tsunami: KaronPradhyumna and SubbiahShanmugham- Foundation.
18. Coastal Zone Management: United Nations Convention on Law of the Sea-Uncclos III: Ar.DushyantKamat - Jnanadha Prakash.
19. Coastal Hydrodynamics: J. S. Mani - PHI Learning Pvt Ltd.
20. Ocean Energy: R. H. Charlies and C. W. Finkl - Springer.
21. Coastal and Marine: Geospatial Tech David R. Green – Springer.
22. Glossary of Geoscience and Oceanography: TanmayaRudra - JnanadhaPrakashana.
23. Understanding Sea Level Rise and Variability: Church John A. - John Velly and sons.
24. Coasts, Marine Structures and Breakwaters: Adapting to change: Allsop N. W. H. - Telford, Thomas.
25. Indian Ocean Studies Cultural, Social and Political Perspectives: Shanta Murthi and Jamal Shraf - Routledge.

MGH 502: OCEANOGRAPHY – II

Skills, employability and entrepreneurship: These are similar to the above mentioned ones with an emphasis on the geological and biological processes taking place in the oceans, and their exploration. Students have chance to go on ocean expedition and exit with course have skills to work in organizations related to ocean and well as Navy including the R & D Labs. and educational institutions.

Geological Oceanography

Unit 1	Introduction to Geological Oceanography. Classification of coasts: Valentin's Coastal Classification. Description of Beaches andpalaeobeaches, Sea Stacks, Sea Caves and Notches. Ocean floor morphology: Description of Continental shelf, slope, rise and abyssal plains. Mid-oceanic ridge, Subduction zone and description of trenches, Ocean basins, Island arcs, Hot spots, Transform faults and Triple junction. Plate tectonics and Neotectonic processes.	8 hrs
Unit 2	Factors controlling the deposition and distribution of oceanic/marine sediments - Biogenous, Cosmogenous, Hydrogenous, Terrigenous and Authigenic. Tectonic evolution of the ocean basins. Reconstruction of monsoon variability by using marine proxy records. Opening and closing of ocean gateways and their effect on circulation and climate during the Cenozoic era. Sea-level change and methods to determine paleo-sea surface temperature.	8 hrs
Unit 3	Ocean-energy resources:Introduction, importance, general characteristics; Tidal energy-potential, harnessing, special features of tidal power plants in operation/under active consideration; the Indian scenario; Wave energy-potential. Special characteristics, the Indian scenario-potential, IIT-Madras wave energy programme "oscillating water column" chamber, Ocean Energy Thermal Conversion- Principle, factors affecting OTEC, special features, land-based/grazing types of plants.	6 hrs
Unit 4	Definition, characteristics, marine geological setting, genesis and occurrence of Metalliferous sediments, Phosphorites (including mineralogy and geochemical environments of modern deposition). Marine mineral resources:Importance, biotic and abiotic. Polymetallic nodules, Cobalt and other related crusts, Hydrothermal sulfide deposits including black and white smokers.	6 hrs
Unit 5	Placers: placer minerals, classification, environments of placer mineral deposition - rivers, beaches and offshore areas; Sand as a resource. Law of the Sea Treaty: Introduction, UNCLOS I, II and III, LOS Treaty – demarcation of various zones (Territorial Sea, Contiguous Zone, Exclusive Economic Zone, Legal Continental Shelf, High Sea,	6 hrs

	International Area of the Seabed), rights of coastal nations. International Seabed Authority. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	

Biological Oceanography

Unit 6	Introduction:Physico-chemical factors affecting marine life – light, temperature, salinity, pressure, nutrients, dissolved gases; adaptation and biological processes. Diversity index and its use in biological oceanography. Food-web. Case-I and Case-II water characteristics. Human impacts on marine communities; impacts of climate change on marine biodiversity. Impact of pollution on marine environments including fisheries.	6 hrs
Unit 7	Classification of the marine environment and marine organisms. Primary and secondary production; factors controlling phytoplankton and zooplankton abundance and its diversity. Plankton and harmful algal blooms. Nekton and introduction to fishery oceanography, benthos, coral reefs, foraminifera, diatoms, ostracods and dinoflagellates. Benthic organisms, coastal- marine communities. A glimpse of ecology – estuaries, coral reefs and mangrove, deep-sea including hydrothermal vent communities.	6 hrs
Unit 8	Outline of microbenthos, meiobenthos and macrobenthos in the ocean. Chlorophyll distribution in oceans. Sampling methods and introduct- ion to Hyperspectral spectroradiometer, use of spectrophotometer. Secchi disc, D.O meter, Salinometer etc. Multiparametric Ocean probes to record salinity, temperature, chlorophyll, Dissolved oxygen. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	6 hrs

List of References:

1) Pinet, P. R. (1992) Oceanography: An introduction to the Planet Oceanus, West Publ., Co. 571p.
2) Komar, P. D. (1976) Beach Processes and Sedimentation, Prentice-Hall. 429p.
3) Reddy M.P.M. (2001) Descriptive Physical Oceanography, AA Balkema Press. 440p.
4) Seibold, E. and Berger: The seafloor (1982).
5) Horne, R.A. (1969) Marine Geology; the structure of water and the chemistry of the hydrosphere.

6) R.A. Horne: Marine Chemistry (p.444).
7) Carol M. Lalli and Timothy R. Parsons (1997) Biological Oceanography: An Introduction.
8) Miller, C.B. (2004) Biological Oceanography. Blackwell Publishers. 416pp.
9) George Karleskint, Richard Turner, James Small, (2012) Introduction to Marine Biology Publisher: Brooks Cole, 512 p.

MGS 503: EXPLORATION AND ENGINEERING GEOLOGY

Skills, employability and entrepreneurship: These are similar to the above mentioned subjects with an emphasis on exploration techniques of earth resources processes taking place in the oceans, and their exploration. Students have chance to go on geological field work, visiting mining sites as well as ocean expedition. Students exit with course have skills to work as an exploration/mining geologists in organizations related to water resources, geological/ marine surveys, seismological stations and mining including the R & D labs. and educational institutions.

EXPLORATION GEOLOGY

Unit 1	Introduction: scope and objectives of exploration geology. General principles and applications of airborne, onshore and offshore exploration methods for understanding the structure of earth and in the exploration of water, fossil fuels and mineral deposits.	6 hrs
Unit 2	Geophysical Exploration: Principles, instrumentation, methodology and applications of onshore and offshore geophysical explorations - Gravity, magnetic, seismic, electrical and radioactive techniques. Well Logging Techniques: Electrical, Radioactive, Sonic and Miscellaneous. Echosounder and its uses.	6 hrs
Unit 3	Geological Exploration/Prospecting: Importance of geological and different types of maps. Various geological criteria for the identification of mineral deposits. Indications of ore body. Different methods of geological prospecting/exploration.	6 hrs
Unit 4	Geochemical and bio-geobotanical methods exploration:Geochemical and biogeochemical indicators of economically important ore deposits. Techniques of mineral exploration.Geobotanical prospecting: Importance of plants in identifying the ore deposits. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	8 hrs

ENGINEERING GEOLOGY

Unit 5	Geological studies and evaluation in planning, design and construction of major civil structures. Engineering properties of rocks. Concepts of rock mechanics and soil mechanics. Physical characteristics of building materials.	6 hrs
Unit 6	Resource evaluation of construction materials. Geological investingati- ons for dams, reservoirs and spillways, tunnels, underground caverns, bridges, highways and tunnels. Problems of groundwater in engg. projects. Remedial measures.	8 hrs

	Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	

List of References:

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2. Principles of Engineering Geology - McGraw Hill – Krynine, D.P. Judd, W.P. (1957)
3. Fundamentals of Engineering Geology - Butterworths – Bell F.G. (1983) Principles.
4. Engineering Hydrology – K. Subramaniam – Tata McGraw Hill Publishing Co. Ltd.
5. Anthony M. Evans (2006). Introduction to Mineral Exploration Blackwell II edition. (available in net)
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7. Burk, C.A. and Drake, C.L. The Geology of Continental Margins-SpringlerVerlag, NY (1974).
8. Condie, K.C. Plate tectonics and Crustal Evolution, Pergamon Press, 288p. (1989)
9. Christopherson, R. W. (1995). Elemental Geosystems A foundation in Physical Geography. Printice Hall Inc., 580p.
10. Vine, F. J., and Matthews, P. M. (1963). Magnetic anomalies over ocean ridges. Nature, 199, 947-949.
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12. Khan, M. A., (1975). The Afro-Arabian Rift System.Sci. Prog.62, 207-236.
13. McElhinny, (1973). Palaeomagnetism and Plate Tectonics. Cambridge Univ. Press, 358p.
14. Ramachandra Rao, M. B (1975). Outlines of Geophysical Prospecting: A manual for Geologist E.B.D. Educational Pvt. Ltd., Dehra Dun.403p.
15. Parasnis, D. S. (1979). Principles of applied Geophysics. Chapman and Hall, - 275 p.
16. Dobrin, M.B. (1976). Introduction to Geophysical Prospecting. New York McGraw-Hill, 630p.
17. Introduction to Geophysical Prospecting - Milton B Dobrin (1981).
18. Exploration geophysics – Jakaosku J. J.
19. Outlines of geophysical prospecting - A manual for geologists – M B Ramachandra Rao.
20. Exploration Geophysics for Geologist and Engineers – Bhimasanakaran and Gaur
21. Geochemistry in mineral exploration Rose, A.W Hawkes, H.E and Webb J.S. 1979. Academic press.
22. Engineering and General Geology: P T Sawant- New India Publishers.

MGS 504: ECONOMIC GEOLOGY AND MINING GEOLOGY

Skills, employability and entrepreneurship: These are most important subjects for the national development in terms of attaining sustainability of water and mineral resources. Similar to the above mentioned subjects with an emphasis on mining techniques are taught in this course. Students have chance to visit mining sites as well as ocean expedition related to ocean mining. Students exit with course have skills to work as an exploration/mining geologists in organizations related to water resources, geological/ marine surveys, seismological stations and mining including the R & D labs. and educational institutions.

Economic Geology

Unit 1	Ore genesis. Classification of ore deposits – renewable and non-renewable, metallogenic provinces and epochs.	4 hrs
Unit 2	Metallic deposits: origin, occurrence, and geology of iron, manganese, copper, gold, aluminium and chromite deposits in India with particular reference to Karnataka.	6 hrs
Unit 3	Non-metallic deposits: origin, occurrence, of minerals used in refractory, abrasives, chemicals, fertilizer, cement and electrical industries, building materials. National mineral policy.	6 hrs
Unit 4	Precious stones: diamonds including gem and industrial varieties. Semiprecious stones: garnet, corundum, beryl etc.	4 hrs
Unit 5	Hydrocarbons: Classification, origin, migration and accumulation of petroleum and natural gas; properties of source and reservoir rocks; structural, stratigraphic and combination traps. Methods of petroleum exploration. Petroliferous basins with special reference to India. Gas hydrates.	6 hrs
Unit 6	Coal: Definition, origin, rank and grading. Peat, lignite, bituminous coal and anthracite. Coal petrology. Gondwana and Tertiary coal resources of India. Coal bed methane. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	4 hrs

Mining Geology

Unit 7	Introduction, definition, aim, and scope of mining of natural resources. Methods of mining / quarrying: alluvial mining, open cast mining, loading, glory hole, kaoline mining, quarrying.	6 hrs

Unit 8	Underground mining methods - stopping and caving, coal and metallic mineral mining. Ventilation and mine supports. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	4 hrs

List of References:

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2) Bateman, Economic Mineral Deposits (1979).
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4) Kirshnaswamy, Indian Mineral Resources
5) Skinner, Earth Resources (1995).
6) Deb, S., Industrial Minerals and Rocks of India (1987) - Allied Publishers.
7) W.H. Freeman and Park C.F. Ore Deposits (1975).
8) Sinha and Sharma. Mineral Economics (1980).
9) An Open University Course Team (1989): Seawater: Its composition, properties and behaviour (p. 33)
10) Bhandari, L. L. and Venkatachala, B.S. (Ed.): Petroliferous basins of India.
11) Bjorlykke K. (1984): Sedimentology and Petroleum Geology.
12) Abdulin, F.: Petroleum of Oil and Gas (1985).
13) Sidorov, N. A.: Drilling Oil and Gas wells (1985).
14) G.S. Roonwal: The Indian Ocean: Exploitable Mineral and Petroleum Resources (1986).
15) G.S. Roonwal (1989): Marine minerals in the Ocean. JGSI, 34:182-192.
16) Dictionary of Oil and Gas Production: Clifford Jones.
17) The Myth of the Oil Crisis: Robin M. Mills.
18) Petroleum Geochemistry: Satyanarayana- Daya Publishers.
19) A hand book of minerals, rocks and ores: Alexander. P.O (2009) - New India Publishing Agency.

MGS 505: GIS AND GPS

Skills, employability and entrepreneurship: These are advanced as well applied subjects in terms of not only studying the entire earth science, but also all aspects of spatio-temporal data of any discipline. With the help of computers, and allied systems with advanced software's and programs, huge data collected over time can be analyzed find out the complex trends in the future. Data There is good scope of this subject in terms of almost absolute employability in different organizations related to human resource development as well as private firms and MNCs. Students can start their entrepreneurship.

Geographical Information System

Unit 1	Introduction:Data and information: Types of data - spatial and time variant. Geographical Information System (GIS): Introduction, fundamentals and functions of GIS. Components of GIS. Generation of database, Database Management System (DBMS), DBMS Architecture and Model. Map Concept: Map features, scale, resolution and accuracy. Map Projection: Earth's size and shape in time and space. Spherical coordinates, Properties of map projections, Types of basic projections classification - Cylindrical, Conical and Azimuthal projections. UTM Coordinates.	8 hrs
Unit 2	Spatial Data Models:Raster and Vector models. Advantages and Disadvantages of Raster and Vector Models. Digitization, editing, topology creation and structuring of map data. Data quality and errors: Importance of Errors, Accuracy and Precision, Types of Errors, Sources of Inaccuracy and Impression, Problems of Propagation and Cascading, False precision and false accuracy, and dangers of undocumented data.	8 hrs
Unit 3	Spatial Analysis:Introduction, significance of spatial Analysis, spatial analysis tools in GIS. Vector Based - Various types of overlay analysis operations: Topological overlays, Polygon-in-polygon overlay, line-in-polygon overlay, Point-in-polygon overlay, Logical operations (Boolean operations), Conditional operations, Buffer analysis, Steps for performing Geographic analysis. Raster Based - Introduction, Advantages and disadvantages of raster analysis, Grid operations used in map algebra, important raster analysis operations, Grid based spatial analysis. Digital Elevation and Terrain Models (DEM and DTM): Generation and structure of DEM/DTM and their applications. Geospatial Triangulated Irregular Network (TIN) model. Introduction to network analysis and its Applications.	16 hrs
Unit 4	Global Positioning System (GPS): GPS system segments, GPS satellites and receivers. GPS-Error sources, Measurements, Accuracy and estimates of user position and time. Applicationand limitations of GPS.	8 hrs

	Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	

List of References:

1) Remote Sensing and Image Interpretation – T. M. Lillesand and R. W. Kiefer – John Wiley and Sons.
2) Remote Sensing and Photogrammetry, vol. 1 and vol. 2 – M. L. Jhanwar and T. S. Chouhan – VignanPrakasan, Jaipur
3) Applied Remote Sensing and Photo Interpretation – T. S. Chouhan and K. N. Joshi – VignanPrakasan, Jaipur
4) Remote Sensing in Geology – P. S. Siegal and A. R. Gillespie – John Wiley
5) Remote Sensing and its applications to Geology - Drury, John Wiley and Sons
6) Remote Sensing – Sabins, John Wiley and Sons
7) Manual of Remote Sensing - American Society of Photogrammetry
8) Geographical Information System: A Guide to Technology – John C. Antenucci – Van Norstrand Reinhold Publications
9) Principles of Geographical Information System for Land Resource Assessment – P. A. Burrough – Oxford University Press
10) Computers: Concepts and Uses – Mary Summer - Prentice Hall
11) The Hardware Bible – Winn L. Roseh – BPB Publications, New Delhi.
12) Computer Fundamentals - P K Sinha BPB
13) Introduction to computers - N Subramanian TMH
14) Understanding computers - R Rajagopalan TMH
15) Multi-media bible Indianapolis - Winn L Rosch 1995
16) Multimedia making it work - Osbome McGraw - Tay Vaughan Hill, 1998
17) Digital computer fundamentals Sixth Ed. McGraw Hill, 1991 - Thomas C Bartee
18) Computers today - Donald Sanders MGH
19) Computers today - Suresh K BasandraGalgotia
20) Computer concepts and applications, McGraw - Donald H Sanders Hill, (1987).
21) Outline of theory and problems of data processing - Martin M Schaum's
22) McGraw Hill international book company - Lipschutz and Seymour Lipschutz (1998).
23) Manual of Photo Interpretation – American Society of Photogrammetry
24) Photogeology and Image Interpretation – Shiv N. Pandey – Wiley Eastern, New Delhi
25) Fundamentals of Photogeology, Geomorphology – Verstappen – TTC Holland.
26) Elements of GPS: Nand Kishore Agrawal.
27) Geographic Information Analysis:Darid O, Sur - John Willey.
28) A Primer of GIS: Fundamental Geographic and Cartographic concept: Francis Harvey - Rawath Publisher.
29) Geoinformatics: G. Randy Keller and Chaithanya Bara - CUP
30) Remote Sensing in Geomorphology: Patrick Simon-Oxford Book Company.
31) Remote Sensing Techniques for Regional Development: Banarjee R. K- Concept Publishers.
32) Principles of Map Design: Tyner Judith A. - The Guil Ford Press.
33) Spatial Statistics and Spatio-Temporal Data: Covariance Functions and Directional Properties :Sheman Michael - John Velly and sons .
34) Remote Sensing in Geomorphology: S.M. Ramaswamy- New India.

MGP 506: Remote Sensing and GIS (Lab, Soft Core)

Skills, employability and entrepreneurship: These subjects are practical experiences of the advanced subjects and details are provided in the **MGS 505: GIS AND GPS** Students have employability in different organizations related to human resource development as well as private firms and MNCs. Students can start their entrepreneurship.

Remote Sensing (Lab)

1) Numerical problems on aerial photographs.
2) Mosaic compilation, annotation, scaling and preparation of photo Index
3) Interpretation of Aerial photographs
4) Satellite Image Interpretation: Visual interpretation of Black and White and FCC images.
5) Plotting of spectral reflectance curves for vegetation, soil and water
6) Generation of Thematic maps like geology, geomorphology, Land use / land cover. Hydro-geomorphology etc.
7) Photo-base determination
8) Digital Image processing – Importing and exporting, Image enhancement and Image classification of satellite images using ERDAS Imagine software.
9) Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises of the Gt. Aide (Academy Software), Google Earth and Topo maps for structural geological and geomporhicappplications in the recent advancement of the subject related to the curriculum.

GIS (Lab)

1) Georeferencing – image rectification based on co-ordinate system.
2) Onscreen digitization
3) GIS and Remote Sensing data integration. Integration of vector and raster data (linking of spatial and non - spatial data)
4) Extraction of Thematic maps: Road, Settlement, Drainage
5) Overlay analysis and proximity analysis.
6) Edge matching/ spatial adjustment
7) Calculation of slope in degrees and percentages.
8) Calculation of area, perimeter and distance using ArcGIS
9) Map composition and presentation of results
10) Creation of 3D maps: TIN, Hillshade, Aspect with ArcGIS
11) Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.

MGP 507: Physical Oceanography and surveying (Lab, Soft Core)

MGH 501: Oceanography – I

Skills, employability and entrepreneurship: These are similar to the above mentioned ones (**MGH 501**) with an emphasis on the practical related to the physical oceanography and land survey. Students have chance to go on ocean expedition and exit with course have skills to work in organizations related to National Institute of Oceanography and sister departments, research institutes, Navy, geological survey, mining and ocean related R & D Labs. and educational institutions.

Physical Oceanography (Lab)

1) Representation of annual wave period percentage frequency of the given region
2) in the form of bar-diagram/histogram and its study.
3) Representation of wave direction data in the form of rose diagram and their study.
4) Interpretation of wave climate for the given data.
5) T-S diagrams
6) CSS diagram and study of waves.
7) Wave forecasting and Wave refraction study.
8) Observation and study of different wave breaker types.
9) Study of waves during rough and fair weather seasons.
10) Preparation and study of tidal curves (mean tidal range, spring and neap tidal range - for different months).
11) Calculation of velocity of sound using Nomograph.
12) Study of major surface current patterns of the Indian Ocean.
13) Study of major surface current patterns of the Atlantic Ocean
14) Study of major surface current patterns of the Pacific Ocean
15) Deep ocean circulation in the Atlantic Ocean.
16) Littoral drift study in the field and lab using dye and tracer techniques.
17) Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.

Surveying (Lab)

1) Chain survey
2) Plane table survey
3) Leveling survey
4) Compass survey
5) Total station survey
6) Sextant
7) Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.

MGE 508: Ocean and Atmospheric Science (Open Elective)

MGE 457: GEOSCIENCES (Open Elective Paper)

Skills, employability and entrepreneurship: This paper is useful to the sister department students of the Earth Science, such as chemistry, physics, life sciences, statistics, computer as well as computing sciences. Usually science students other than earth science qualify NET exams/interviews in the institutes join earth science related organizations, and they have to learn earth, atmosphere and ocean science in their area of research. However, with the knowledge of this subject (earth science), students can perform better in their career thereby utilizing the intension of studying the interdisciplinary science. Students have employability in many branches of science in different government organizations and MNCs.

Oceanography

Unit 1	Physical Oceanography - Physical properties of sea water. Waves, tides and currents. Coastal protection and management.	6 hrs
Unit 2	Chemical Oceanography - Composition of seawater: Constancy of composition of seawater and its limitations. Distribution of elements in seawater and biogeochemical processes regulating the composition and climate change. Residence times of elements in the ocean and its importance. Tracers for understanding the present and past oceanographic processes.	6 hrs
Unit 3	Biological and Geological Oceanography - Introduction, classification of marine life. Primary, secondary and tertiary production. Planktonic and benthic life in the ocean. Diversity index and its use in biological oceanography, food-web. Geological oceanography: Origin and evolution of the ocean floor. Continental drift, sea-floor spreading and plate tectonics. Ocean morphological features, development and significance.	6 hrs
Unit 4	Marine mineral resources: Distribution and classification of minerals of economic importance in different oceanographic settings: Seawater as a source of elements/minerals. Placer and heavy mineral deposits, petroleum and coal, phosphorites, gas hydrates, poly-metalic nodules, metals enriched crusts, hydrothermal and metalliferous sediments. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	6 hrs

Atmospheric Science

Unit 5	Introduction to atmospheric Science - Structure and composition of the atmosphere. Processes regulating the composition of the atmosphere, and human interference - Greenhouse effect, ozone hole and global warming. Introduction to meteorology and elements of the weather system.	8 hrs

Unit 6	Climatology and Paleoclimatology: Difference between weather and climate. Climate and its principles of classification. Climate change, climate cycles and tools/proxies for studying paleoclimatology. Interactive sessions of teaching to enhance students-teacher interactions through hands-on demonstrations and exercises in the recent advancement of the subject related to the curriculum.	8 hrs

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2) Physical Geology - A. N. Strahler.
3) Meteorology - William L. Donn (1975) - McGraw-Hill Book Co., New York.
4) An introduction to Dynamic Meteorology - J. R. Holton (1992) - III Ed, Academic Press.
5) Carol M. Lalli and Timothy R. Parsons. Biological Oceanography: An
6) Introduction (1997).
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9) Thruman, H. V. (1994) Introductory Oceanography. 7th Ed. Macmillian Pub., Co.
10) George Karleskint, Richard Turner, James Small, (2012) Introduction to Marine Biology Publisher: Brooks Cole, 512 pp.
11) Fasham, Michael J.R. (2003) Ocean Biogeochemistry. The Role of the Ocean Carbon Cycle in Global Change Series.
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13) Komar, P. D., (1976) Beach Processes and Sedimentation, Prentice-Hall. 429p.
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20) Sidorov, N. A.: Drilling Oil and Gas wells (1985).
21) G.S. Roonwal: The Indian Ocean: Exploitable Mineral and Petroleum Resources (1986).

Fourth Semester

Skills, employability and entrepreneurship: This semester is devoted for field work and dissertation related to all branches of earth, atmosphere, ocean and space science, including subjects related to societal aspects. Students learn skills to work with the public, private sectors, universities and research institutions generally outside the university to provide better exposure related to earth, atmosphere and ocean science to compete at national (and international) levels. Students who qualify MSc in Marine Geology with dissertation will have ample opportunities in terms of developing skills, employability in research organizations, both in public, private sectors, universities and research institutions, and overseas fellowships/employment. They can develop skills to start their own **entrepreneurship**

MGP 551: Project Work

Dissertation: Each student is required to undertake a project work under the supervision of faculty members during the entire tenure of the fourth semester. The project may be experimental, field investigation, laboratory studies, a theoretical investigation accompanied by computational work, data processing and analysis or a combination of these. After the dissertation work is completed, students shall submit dissertation/thesis based on the above mentioned work. The dissertation is evaluated by internal and external examiners.	300 marks
Viva –Voce: Each student has to present the dissertation work carried out by him/her in front of the examination committee that comprising of Guide, Chairman of the department and the External Examiner(s).	100 marks
Field Work: All students must do detailed geological field work / participate in the ocean expedition under the guidance of faculty members immediately after the third semester. The faculty members will continuously evaluate the performance of the students during field work / ocean expedition.	50 marks
Field Report: A detailed report must be submitted immediately after the field work / ocean expedition to facilitate the students to devote the fourth semester time exclusively for dissertation. The report will be evaluated by the accompanied faculty member(s).	50 marks
Total	500 marks