KERALA UNIVERSITY OF FISHERIES AND OCEAN STUDIES

Panangad, Kochi- 682506, Kerala

M.Sc. Applied Geology

SYLLABUS

2024

REGULATIONS, ELIGIBILITY, SCHEME AND SYLLABUS FOR M. Sc. APPLIED GEOLOGY, DEPT. OF EARTH SCIENCES (Effective from 2020 Admission onwards)

All the general rules and regulations laid down by the Kerala University of Fisheries and Ocean Studies PG Curriculum shall be applicable.

SCOPE OF THE PRORGAMME

M.Sc. Applied Geology programme deals basically with subjects such as geology, geophysics, oceanography, remote sensing, climate change and polar science and concerned with the study of the earth, its composition or any of its changing aspects. Applied Geology plays a significant role in various spheres from measuring the physical properties of the Earth and understanding the history and modifications of our planet to studying, assessing and predicting natural/man-made disasters (volcanoes, earthquakes, hurricanes, floods, landslides, tsunamis) to studying past climates, current global warming and future climate change to discovering and exploring precious and valuable natural resources (oil, natural gas, fuels, metals, minerals, ground water). They are also at the forefront of resource mapping, remote sensing, recycling technology and computer simulations. Candidates with M.Sc. Applied Geology have excellent career prospects as they are trained professionals with excellent international opportunities. Within India, they can work in national scientific organizations like ONGC, NGRI, GSI, IIG, NIO, NIOT, NCAOR, INCOIS, NGRI, AMD, NCESS and other State Departments like CWRDM, State Groundwater Department, Mining and Geology Department etc. They can also join for Ph.D and pursue their research.

ELIGIBILITY CRITERIA

Those students who possess B.Sc.Geology as Main or Subsidiary/B.Sc. Physics as main or subsidiary with not less than 55% Marks.

Duration : Two Academic Years (4-Semester Programme)
No. of Seats : 15

I. PROGRAMME AND SCHEME OF EXAMINATIONS

1. M.Sc. Applied Geology Programme shall have four semesters. In the first semester, there will be 4 core courses plus two practical courses. In the second and third semesters, there will be 5 core courses and 2 practical courses. Besides, there will be one elective course in the first, second and third semesters and one open elective course in second and third semesters. There will be ship board/industries/institution training/field work during the third semester. The fourth semester is devoted exclusively for dissertation/project work.
2. There shall be external university examination of 3 hour duration for each theory course at the end of the each semester, to be conducted after the completion of 90 working days.
3. Each practical examination is of 3 hour duration .
4. Project/Dissertation evaluation shall be conducted at the end of the programme only.
5. Project/Dissertation shall carry 18 credits.

II. EVALUATION AND GRADING

The evaluation scheme for each course shall contain two parts (a) Internal evaluation and (b) external evaluation. 50% marks shall be given to internal evaluation and the remaining 50% to external evaluation.

Internal Evaluation:

The internal evaluation shall be based on predetermined transparent system involving periodic written tests, assignments, seminars and attendance. In respect of theory courses, they are evaluated based on written test where as the practical courses are evaluated In respect of theory courses and based on written tests, lab skill/records/viva and attendance in respect of practical courses. The weightage assigned to each component for internal evaluation is as follows:

Components of Internal Evaluation

	Component	Weightage
A	Assignment	20%
B	Seminar	10%
C	Attendance	10%
D	Classroom Participation	10%
E	Internal Examination	50%

To ensure transparency of the evaluation process, the internal assessment grade awarded to the students in each course in a semester shall be published on the notice board at least one week before the commencement of external examination. There shall not be any chance for improvement for internal grade.

The course teacher shall maintain the academic record of each student registered for the course, which shall be forwarded to the University.

External Evaluation:

The external Examination in theory courses is to be conducted by the University with question papers set by external experts. The evaluation of the answer scripts shall be done by examiners based on a well-defined scheme of valuation. The external evaluation shall be done immediately after the examination preferably in a Centralized Valuation Camp.

III. Grievance Redressal Mechanism for Internal Evaluation

There is provision to redress grievance at four levels- first at the level of teacher concerned; second, at the level of Department committee consisting of the Head of the Department, Departmental

Coordinator and the teacher concerned; third, at the level of the Director of the School. HOD and a senior faculty member of the School nominated by the Director each year, and also a student member of that class nominated by the HOD. And fourth, at University level committee consisting of the Pro-Vice Chancellor, Director of the School and a subject expert nominated by the Vice-Chancellor, Controller of the Examination and the Convener of the Examination Standing Committee.

Department and School level complaints will be filed within one week of the publication of the results and the decision is taken within the next two weeks. Appeals, if any, on such decision shall be filed in the University level committee within a period of one week and decision taken within one month for the date of the submission of complaints. The time schedule for grievance redressal will be announced by the colleges concerned and the University in advance.

Normalization of continuous internal evaluation may be done by the university when there is inflation of grades in internal evaluation. The grades will be scaled down proportionately if the variation between the internal and external evaluation exceeds 40%.

IV. Evaluation of Project Report/Dissertation

Dissertation will be valued by two examiners (one Internal and One External) who conduct the practical examination (External) at the time of 4th semester. Distribution of marks allotted for dissertation will be as follows:

Methodology	20% Marks
Content	40% Marks
Presentation	10% Marks
Answering Questions	10% Marks
Originality or Overall Outlook	20% Marks

KERALA UNIVERSITY OF FISHERIES AND OCEAN STUDIES
DEPARTMENT OF EARTH SCIENCES, SOST
SYLLABUS FOR M.Sc. APPLIED GEOLOGY (2020 - 21 ACADEMIC YEAR ONWARDS)
SCHEME OF EXAMINATION

SEMESTER I

COURSE CODE	CREDIT	COURSE	Marks		
			Internal	External	Total
ESC 2101	3	Mineralogy	50	50	100
ESC 2102	3	Crystallography and Petrology	50	50	100
ESC 2103	3	Stratigraphy and Palaeontology	50	50	100
ESC 2104	4	Geophysics I			
		(Gravity, Magnetic, Electrical and Electromagnetic prospecting)	50	50	100
Elective IESC 2105	3	Physical Geology and Geomorphology	50	50	100
Elective IIESC 2106	3	Geodynamics	50	50	100
ESC 2107	2	Practical -1Mineralogy, Petrology and Paleontology	50	50	100
ESC 2108	2	Practical - 2 Geophysics - 1	50	50	100
Total	**20**		**350**	**350**	**700**

Choose any one of the Elective papers

SEMESTER II

COURSE CODE	CREDIT	COURSE	Marks		
			Internal	External	Total
ESC 2201	4	Hydrogeology	50	50	100
ESC 2202	4	Economic Geology	50	50	100
ESC 2203	3	Structural Geology	50	50	100
ESC 2204	4	Geophysics II (Seismic Prospecting and Well Logging)	50	50	100
ESC 2205	3	Geochemistry	50	50	100
Elective IIIESC 2206	3	Mining & Engineering Geology	50	50	100
Elective IVESC 2207	3	Climate Change and Polar Sciences (II Semester Open Elective)	50	50	100
ESC 2208	2	Practical-1Structural Geology/			
		Economic Geology/ Hydrogeology	50	50	100
ESC 2209	2	Practical - 2 Geophysics - 2	50	50	100
Total	**25**		**400**	**400**	**800**

Choose any one of the Elective papers

SEMESTER III

COURSE CODE	CREDIT	COURSE	Marks		
			Internal	External	Total
ESC 2301	3	Remote Sensing & GIS	50	50	100
ESC 2302	4	Oceanography	50	50	100
ESC 2303	4	Marine Geology	50	50	100
ESC 2304	4	Marine Geophysics	50	50	100
ESC 2305	3	Quantitative Geology	50	50	100
Elective VESC 2306	3	Marine Geochemistry	50	50	100
Elective VIESC 2307	3	Integrated Coastal Zone Management (III Semester Open Elective)	50	50	100
ESC 2308	2	Practical - 1Remote Sensing & GIS, Oceanography and Marine Geology	50	50	100
ESC 2309	2	Practical - 2 Marine Geophysics and Quantitative Geology	50	50	100
ESC 2310	2	Ship Board Training/ Industries/			
		Institutions/Field work	50	-	50
Total	**27**		**450**	**400**	**850**

Choose any one of the Elective papers

SEMESTER IV

COURSE CODE	CREDIT	COURSE		Marks	
			Internal	External	Total
ESC 2401	18	Dissertation	50	100	150
Total	18		50	100	150

Total Credits for 4 Semesters = 90

Total Marks for 4 Semesters = 2500

THE COURSE ENVISIONS GEOLOGICAL & GEOPHYSICAL TRAININGS, INTERNSHIPS IN INDUSTRIES/NATIONAL LABORATORIES/LABORATORIES OF HIGH REPUTATION/ACCREDITATION BY NAAC.

SYLLABUS

CORE SUBJECTS **SEMESTER I**

ESC 2101	CRYSTALLOGRAPHY AND MINERALOGY	CREDIT 3

Unit I

Crystallography: Concept of symmetry of crystals, space lattice and point group. Derivation of 32 crystal classes. Stereographic projections. X-Ray diffraction methods – basic principles, powder method – Bragg's law and its applications.

Unit II

Crystral notation – Schoenflies notation – Herman Maugin symbols. Calculation of crystal elements to test the knowledge of the application of Tangent relations, Anharmonic ratios, Napier's theorem.

Unit III

Optical mineralogy: Refractive index, Isotropic and anisotropic minerals. Interference of light waves passage of light through doubly refracting minerals. Birefringence. Plane polarized and cross polarized light.Orientations of nicol prisms of a Petrological Microscope Pleochroism and schemeof pleochroism. Uniaxial & biaxial minerals; uniaxial & biaxial indicatrices. Generation of interference colours. Determination of order of interference colours.

Unit IV

Optical accessories –construction and uses of Gypsum Plate, Mica Plate quartz wedge. Conoscopic study – Formation of interference figures. Uniaxial and biaxial interference figures. Determination of the Optic sign of uniaxial and biaxial minerals. Vibration directions and sign of elongation in minerals. Extinction and extinction angle. Determination of Optic axial angle (2V).Dispersion and types of dispersion.

Unit V

Isomorphism, Polymorphism and the types. Different types of bonding minerals and their significance. Solid solution and exsolution. Mineralogical expression of radioactivity:Metamictisation and pleochroic haloes. Structure and classification of Silicates.Distinctive physical, chemical &optical characters of the following mineral groups: Olivine, garnet, aluminosilicates, pyroxenes, amphiboles, mica, clay minerals, feldspars, feldspathoids, zeolites and silica group.

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
CORE	ESC 2101	**CRYSTALLOGRAPHY AND MINERALOGY**	3	3	1

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Distinguish the elements of symmetry in different minerals using axial relationships and symmetry operations	U/S
2	Apply the concepts of mathematics to calculate crystal elements	A/E
3	Demonstrate the use of petrological microscope in understanding the optical properties of minerals	Ap/A
4	Develop skills in the usage of optical accessories in the identification of mineral groups	E/A/S
5	Distinguish the important silicate minerals based on their physical and optical properties	An/S/A
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

References:

1. Burger, M.J., Elements of Crystallography, Wiley, 1963
2. De Jong,W.F., General Crystallography, Freeman ,1955
3. Battey, M. H., Mineralogy for students, Oliver and Boyd, Edinburgh, 1972
4. Berry, L.G, Mason,B and Deitrich Mineralogy, 1976
5. Berry, L.G., Brian Mason, Mineralogy, Freeman, 1959
6. Dana, E. S., Text Book of Mineralogy Revised by Ford, Wiley, 1962
7. Deer, W. A., Howie, R. A., and Zussman, J., Rock forming minerals. Vol. 15, Longman, London, 1962
8. Hurbut, C. S., Dana's Manual of Mineralogy, John Wiley, I8"1 Edition, 1971
9. Kerr,P.F., Optical mineralogy, Me Graw Hill,1959.
10. Naidu, P. R. J., Johansen, Optical Mineralogy, Allied Publishers, 1967
11. Naidu, P.R.J., Four axes.universal stage, Commercial printing and Publishing house, Madras, 1985
12. Philips, F. C, Introduction to Crystallography, Thomas Nelson, 1963
13. Philips, W.R., Mineral Optics Principles and techniques, Freeman, 1971.
14. Sinkankas, J., Mineralogy, East West Edition, 1959.
15. Tutton. V I:. II., Crystallography and Practical crystal Measurements. Vol. 1, Today and tomorrow. 1965.
16. Wahlstrom, E E.. Optical Crystallography, Wiley. 1962.
17. Williams, K. L., Introduction to Xray spectrometry, CBS Publishers and distributors, New Del hi-1987.
18. Winchell, A.N., Elements of Optical mineralogy, Part I,Wiley, 1951.
19. Dexter Perkins (1998) Mineralogy, Prentice Hall Books

20. William H. Dennen (1960) Principles of Mineralogy, Ronald Press Co
21. William D. Nesse (1991) Introduction to optical mineralogy, Oxford University Press
22. Dexter Perkins, Kevin R. Henke (2004) Minerals in thin section, Pearson/Prentice Hall
23. James Dwight Dana (1855) Manual of Mineralogy, Durrie & Peck
24. William John Phillips, Nahid Phillips (1980) An introduction to mineralogy for geologists.Wiley
25. Keith Frye (1993) Mineral science: an introductory survey, Macmillan Pub. Co
26. Melinda Darby Dyar, Mickey E. GuntermMineralogical Society of America(2008)Mineralogy and Optical mineralogy

ESC 2102	PETROLOGY	CREDIT 3

Unit 1

Partial melting & generation of magmas. Crystallization of magma, Bowen's reaction series; Intrusive & extrusive igneous bodies; Mineralogy, textures and structure of common felsic, mafic & ultramafic rocks, magmatism in relation to tectonic settings, Radmiometric dating of rocks.

Unit 2

Petrogenetic provinces : Continental areas: Volcanic-Flood basalts- (Deccan Trap, Columbia River basalts); Layered gabbroic intrusions: The Bushveld complex, Skaergaard intrusion, Plutonic: Carbonatites and alkaline rock complexes of India; Oceanic Rift valleys: MORB- Tholeiites-Ophiolites. Plate tectonic settings of igneous rocks.

Unit 3

Metamorphism – diagenesis and metamorphism; factors of metamorphism – P, T, time, composition of the fluid phase; mineralogy, textures and structures of common metamorphic rocks; metamorphism of mafic rocks, metamorphism of carbonate rocks. Metasomatism. Metamorphic facies concept. Application of phase rule. Phase diagrams and graphic representation of mineral assemblages – ACF, AKF and AFM diagrams; Role of fluids in metamorphic reactions. Metamorphic rocks of Kerala

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Unit 4

Sediments & sedimentary rocks: phi scale, Udden – Wentworth scale; Goldich's stability series; composition, textures & structures of sedimentary rocks; origin & classification of conglomerate, sandstone & shale. Limestone classification in petroleum industry; Sedimentary environments & facies; characteristics of non-marine, transitional & marine environments. Evolution of sedimentary basins - tectonics and sedimentation.

Unit 5

Placer minerals – Heavy minerals in provenance studies. Deep sea basins; palaeoclimate and palaeoenvironment analysis. Major diagenetic processes; Porewater chemistry and importance; diagenetic environments; limestone diagenesis. Petrogenetic significance of textures and structures, Major carbonate minerals and environments.

Course	Course Code	Course Title	L	P	Credits
Core	**ESC 2102**	**Petrology**	3		3

Course Outcome No	Expected Course Outcome	Learning Domains
1	Understand various igneous processes, chemical and physical characteristics of magma and various rock types its geological settings.	U/R
2	Evaluate the different schemes of classification and nomenclature of igneous and metamorphic rocks and their tectonic associations.	U/E
3	Understand classification of metamorphic rocks and textures and structures of metamorphic rocks also understand limits, factors and types of metamorphism and applicationof Phase rule.	U/A
4	Study the composition, texture, structure and classification of clastic and non-clastic rocks, and determine the sedimentation processes. Understand the facies models and environments in sedimentary basin determination.	R/U/I
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I), and Appreciation (Ap).		

References:

1. Ehlers, E.G. & Blatt, H. 1987 Petrology: Igneous, Sedimentary and Metamorphic, CBS
2. Pettijohn, F.J. 1975 Sedimentary rocks, 3rd ed., Harper & Row
3. A.R. Philpotts and J. Ague. 2009 Principles of Igneous and Metamorphic Petrology. 2nd edition. Cambridge University Press
4. BR Frost and CD Frost. 2013. Essentials of Igneous and Metamorphic Petrology. Cambridge University Press.
5. Nichols, G. 2013. Sedimentology and Stratigraphy. John Wiley & Sons.
6. ME Tucker 2013. Sedimentary Petrology: an Introduction to the Origin of Sedimentary Rocks. John Wiley & Sons.
7. Miall, A.D. 2013 Principles of Sedimentary Basin Analysis. Springer
8. Sengupta, S.M. 1994 Introduction to Sedimentology. Oxford & IBH.
9. K Bucher and M Frey. 2008. Petrogenesis of Metamorphic Rocks. Springer.
10. Soman K 2010 Geology of Kerala 2nd ed. Geological Society of India.
11. Robin Gill 2010 Igneous Rocks and Processes: A Practical Guide. Wiley Blackwell.
12. C.W. Passchier, J.S. Myers, and A. Kroner 2012 Field Geology of High-Grade Gneiss Terrains. Springer.

Practicals:

Megascopic and microscopic study of different igneous rocks; Calculation of CIPW and molecular norms; Modal analysis; Preparation and description of variation diagrams. Exercises related to various igneous processes such as crystal fractionation, partial melting and magma mixing.

Study of metamorphic rocks of different metamorphic facies in hand specimens; Detailed study of textures in thin 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; Estimation of pressure and temperature from important models of geothermobarometry.

Detailed study of clastic and non-clastic rocks in hand specimens; Study of assemblages of sedimentary structures in context of their paleoenvironmental significance; Microscopic examination of important rock-types; Heavy mineral separation and their microscopic characters, graphic representation and interpretation; Grain-size analysis by sieving method; Plotting of size-distribution data as frequency and cumulative curves, computation of statistical parameters and interpretation.

ESC 2103	STRATIGRAPHYAND PALAEONTOLOGY	CREDIT 3

Unit 1

Introduction and scope of stratigraphy, Principles of stratigraphy; code of nomenclature of India, litho, bio Chrono and magnetostratigraphic units, principles of stratigraphic correlation, Walther's law.

Geological time scale. Geological, physical and biological events through geological time.

Unit 2

Precambrian stratigraphy- Archean Granite-Greenstone belts, evolution of Archean cratons of India, Proterozoic mobile belts-Eastern Ghats Mobile belt, Southern Granulite terrain, Central Indian Tectonic zone, Aravalli-Delhi belt, North Singhbhum Mobile belt. Mineral deposits of Precambrian rocks

Unit 3

Phanerozoic stratigraphy- Paleozoic; Spiti, Kashmir and Kumaon. Mesozoic; Spiti, Kutch, Narmada valley and Trichinopoly. Gondwana Super group. Cenozoic; Assam, Bengal basin, Garhwal-Shimla Himalayas. Siwaliks; Stratigraphic boundary problems in Indian stratigraphy.

Unit 4

Invertebrate and Vertebrate paleontology-Fossil record through geological time scale. Mode of preservation of fossils and concepts of taphonomy. Body and ichnofossils, species concept, organic evolution. Ediacara fauna; morphology and time range of Graptolites, Trilobites, Brachiopods, and Molluscans. Vertebrate life through ages. Evolution in Proscidea, Equidae and Hominidae. Mass extinctions.

Unit 5

Micropaleontology and Palynology-Organic and mineral walled microfossils. Methods ofseparation of microfossils from sedimentary matrix. Morphology of Foraminifera, Ostracod. Fossil spores, pollens and dinoflagellates. Gondwana plant fossils and their significance. Applications of paleontological data in stratigraphy, paleoecology and paleoclimatology

Course	Course Code	Course Title	L	P	Credits
Core	**ESC 2103**	**Stratigraphy and Paleontology**	3		3

Course Outcome No	Expected Course Outcome	Learning Domains
1	acquire knowledge in stratigraphic nomenclature and Understands about the stratigraphical applications.	U/A
2	Study the current geological time scale and apply it in various Geological, physical and biological events.	R/An
3	Understand the crustal evolution includes major cratons, basins and rift valleys with special reference to the Indian shield.	U
4	Examine the patterns of evolution of vertebrates and invertebrates to understand palaeoclimatic and palaeographic dispositions.	U/I
5	Understand microfossils, their morphology, palaeoecology and applications in petroleum exploration.	U/A/An
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I), and Appreciation (Ap).		

References:

1. Ramakrishnan, M and Vaidhyanathan Indian Geology Geological Society of India, Publication, Bangalore, 2007
2. Krishnan, M.S., Geology of India and Burma III Ed. IBH Publishers, New Delhi, 1984
3. Wadia
4. Ravindra Kumar, Fundamentals of historical Geology and stratigraphy of India, Wiley Eastern Ltd. New Delhi, 1985
5. Schrock and Twenhofel Principles of Invertebrate Paleontology, IBH New Delhi, 1983
6. Moore, Lalikar and Fisher
7. Pratul Sarwati and Srinivasan, M.S, Micropaleontology-Principles and applications. Springer International Switzerland, 2016
8. Gérard Bignot (1985)Elements of Micropaleontology, Springer
9. B.U. Haq, A. Boersma (1998) Introduction to Marine Micropaleontology, Elsevier
10. Martin Fritz Glaessner (1947) Principles of Micropaleontology, John Wiley & sons

ESC 2104	GRAVITY, MAGNETIC, ELECTRICAL AND ELECTROMAGNETIC PROSPECTING	CREDIT 4

Unit 1:

Principles of gravity prospecting: Properties of Newtonian potential; Geoid, Spheroid and normal gravity field. Instruments for measuring gravity: absolute gravity measurements – pendulum, stable and unstable type gravimeters; Adaption of gravity meters for marine areas; procedures for marine gravity surveys – various corrections including Eotvos correction in marine gravity surveys.

Unit 2:

Reduction of gravity data and various types of gravity anomaly; concept of isostasy and isostatic anomaly; study of gravity anomaly map; qualitative rules of interpretation; principle of equivalent stratum and ambiguity in gravity interpretation. Concept of regional residual anomalies – their separation using graphical and grid methods; second derivative method and its significance; upward and downward continuation of gravity anomalies and their interpretations. Gravity anomalies due to sphere, cylinder and fault. Depth rules and quantitative interpretation

Unit 3:

Earth's magnetism: anomaly field of the earth, distribution of magnetic materials in the earth's crust, magnetic properties of rocks and minerals, their determination and variation. Magnetic measurements, theory and working principles of measuring instruments: proton precession magnetometer, Rubidium-vapour magnetometer, Methods of magnetic explorations, Magnetometers for marine surveys; Air-borne magnetometers and surveys.

Unit 4:

Reduction of magnetic data, calculation of IGRF by spherical harmonic coefficients, magnetic anomalies, contour maps preparation. Interpretation of magnetic anomalies – Qualitative interpretation, ambiguity in magnetic interpretation, regional and residual separation; vertical derivative maps. Upward and downward interpretation techniques. Quantitative Interpretation - magnetic anomalies due to geological structures – dykes, faults, depth estimation; interpretation of anomalies over irregular bodies; frequency analysis of magnetic anomalies and inversion techniques; geological applications.

Unit 5:

Basic principles of transient electromagnetic methods, transient emf and magnetic field behaviour; concepts of toroidal and poloidal induction; geometric sounding, Airborne EM. Electrical properties of rocks - Current flow in a homogeneous media - Electrode arrays - Current flow across layers of differing resistivities. Field methods - Vertical Electrical Sounding (VES), Constant Spacing Traverse (CST) – Resistivity imaging, - Applications – Induced polarization (IP), Spectral IP (SIP) and Self-Potential (SP) methods -. Magneto Telluric (MT) theory, origin of the MT and telluric fields. Processing and interpretation of MT and Transient Electromagnetic (TEM) data. Applications. MT and TEM methods of geophysical exploration

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
CORE	ESC 2104	GRAVITY, MAGNETIC, ELECTRICAL & ELECTROMAGNETIC PROSPECTING	4		1

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Understand gravity and magnetic potential theories, units, instruments and survey methods	U/A
2	Data collection, correction, separation of regionals and residuals and interpretation techniques	A/An/S
3	Understand the basic principle of Electrical and Electromagnetic methods, data collection and interpretation techniques	U/A
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

References:

1. Parasnis, D.S., 1973. Mining Geophysics, Elsevier.
2. Keller, G.V. Electrical Methods in Geophysical Prospecting, Frischnett, Pergamon
3. Patra, H.P. and Mallick, K. Principles of Geoelectric Soundings
4. Telford, W. K and Geldart, L.P., Sheriff, R. F and Keys D.A Applied Geophysics Cambridge University Press
5. Kalyan Kumar Roy, K. Mallick (1999) Deep electromagnetic exploration, Springer
6. W. J. Botha (1992)Evaluation of Electromagnetic Exploration Techniques in GroundwaterExploration, Water Research Commission
7. Edwin S. Robinson, Cahit Çoruh (1988)Basic exploration geophysics, Wiley
8. M. E. Best, Geological Association of Canada (1992)Resistivity mapping and electromagnetic imaging, Geological Association of Canada
9. Mikhail Semenovich Zhdanov, George Vernon Keller (1994) The geoelectrical methods in geophysical exploration, Elsevier
10. John D. Corbett (1991) Electromagnetic Methods in Applied Geophysics, Society of Exploration Geophysicists
11. Stanislav Mares et al., (1984) Introduction to Applied Geophysics, D. REidel Publishing Company, Dordrecht/Bostont
12. Telford, W.M., Goldart, L.P., Sheriff, R.E. and Keys, D.A., (1981) Applied Geophysics, Cambridge University Press, Cambridge.
13. B.S.R. Rao and I.V.R. Murthy. (1978) Gravity and Magnetic Methods of Prospecting, Arnold-Henninman Publishing Company, Delhi
14. S.H. Ward (Ed.). (1967) Mining Geophysics, Vol. I and Vol. II., SEG Publication, Tulso, Oklahoma, USA.
15. Grant, F.S. and West, G.F. (1964) Interpretation Theory in Applied Geophysics, Mc Graw Hill Publication, New York
16. D.S. Parasnis. (1973) Mining Geophysics, Amsterdam, Elsevier Publishers, The Netherlands
17. L.L. Nettleton. (1976) Gravity and Magnetics in Oil Prospecting, McGraw Hill Publication, New York
18. Edwin S. Robinson and Cahit Coruh. (1988) Basic Exploration Geophysics. John Wiley and Sons,

New York/Toronto/Brisbane/Singapore

ELECTIVE I ESC 2105	PHYSICAL GEOLOGY AND GEOMORPHOLOGY	CREDIT 3

Unit 1

Physical processes of the earth. Weathering - Physical weathering, Chemical weathering and Biological weathering, Factors affecting weathering. Rate of weathering. Soil profile, Climate and soil formation. Geological work of Wind, Erosional and depositional features. Geological work of rivers, Erosion and depositional features. Drainage patterns.

Unit 2

Geological work of glaciers, Types of glaciers, Movement of glaciers, Glacier erosion, features of glacier erosion, Sediment transport by glaciers and glacier deposits and structures. Work of sea, coastal land form features, Shoreline erosional features. Plate tectonic theory. Plate boundaries. Earthquakes and its causes. Volcanoes, types, eruption, lava flow, and its distribution. Volcanic land foam features.

Unit 3:

Geomorphic principles and processes. Theory of uniformitarianism. Control of geomorphological features by geologic structures, lithology, climate and time. Geomorphologic cycles. Streams-stream hydraulics- Drainage basin, Morphometric analysis of drainage basins. Fluvial -denudational and erosional landforms. Concept of rejuvenation and interruptions in the evolution of land. Coastal Geomorphology. Landforms of wave erosion and deposition. Geologic work of glaciers and the land form structures formed by Glacier action.

Unit 4:

Wetlands- Geological significance, classification and mode of formation. The Indian scenario – conservation and management in India. Backwaters (Kayals) of Kerala. Soils- formation, classification, soil profile, soils of Kerala. Geomorphology of Kerala- classification, relief features, geological Significance, rivers of Kerala. Geomorphic features of the I n d i a n subcontinent.

Unit 5:

Hill slopes- forms in relation to lithology and structural weakness in rocks; control and mass movement, modification by overland flow of hill slopes. Slope stability. Application of Geomorphology in Hydrogeology, and Environmental Studies

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
ELECTIVE 1	ESC 2105	**PHYSICAL GEOLOGY AND GEOMORPHOLOGY**	3	3	

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Understand various types of weathering, factors influencing weathering, and their resultant products.	U/Ap
2	Understand the various geomorphic agents such as rivers, glaciers, wind, and gravity, and their respective roles in shaping landforms.	U
3	Analyze the processes related to plate tectonics	An/ Ap
4	Identify the major geomorphic theories and principles and its influence in the concept of landform evolution	U/Ap
5	Appreciate the formation of geomorphologic features in Kerala and Indian context	U/Ap
6	Apply morphometric analysis techniques to interpret mass movements, slope stability	A
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

References:

1. Carlson, Plummer & McGeary. Physical Geology: Earth Revealed. McGraw-Hill, 2006.
2. Holmes, A. Principles of Physical Geology. Ronald Press, 1993.
3. Thornbury, W. D. Principles of Geomorphology. Wiley. 2004.
4. Mahapatra, S. Basics of Geology. Anmol Publications Pvt Ltd, New Delhi,
5. Marshak, S. Essentials of Geology. W.W. Norton & Company, 2003. New York.
6. Huggett, R. J. Fundamentals of Geomorphology. Routledge Taylor & Francis Group, 2003. London, New York.
7. Duff, P. and Holms, A. Principles of Physical geology, Nelson Thornes Ltd,1993.
8. Thompson and Turk “Physical Geology”.Saunders College Publication, 1998.
9. John Bridge and Robert Demicco "Earth Surface Processes, Landforms and Sediment Deposits".Cambridge University Press,2008.
10. Burbank, Douglas West"Tectonic geomorphology" Blackwell Publishing,2008.

ELECTIVE II ESC 2106	GEODYNAMICS	CREDIT 3

Unit 1

Thermal regime over continents and oceans; Importance of heat flow studies; nature of heat sources in the crust and mantle; heat flow continents and oceans; areas of anomalies heat flow.

Unit 2

Composition of the upper and lower continental crust; oceanic crustal structure and different layering;

deep seismic sounding for crustal structure with reference to India. Geophysical studies and crustal structure with reference to Indian Ocean.

Unit 3

Geological applications: (i) modelling and simulation of hydrocarbon maturation and migration in sedimentary basins; (ii) Thermal structure of the Mantle; mantle convection models, thermal perturbation in subduction zones; (iii) reactive flow modelling and simulation of mineralization in hydrothermal systems; (iv) modeling and simulation of folding in multilayer rocks.

Unit 4

Geodynamic models: Sea floor spreading and Plate Tectonics, Oceanic magnetic anomalies and their interpretation, magneto-stratigraphic time scale, paleomagnetic evidences of continental drift, Apparent Polar Wandering Path (APWP) for different continents and their main results,

Unit 5

Seismological evidences for lithospheric deformation, Plate margins and processes at plate margins, Triple Junction, Break-up of Gondwana, Movement of Indian Plate and formation of the Himalayas.

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
CORE	ESC 2106	GEODYNAMICS	3		1

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Explain the thermal structure of Earth and the heat flow pattern and heat flow anomalies on the continents and oceans	U/A
2	Learn Deep Seismic Sounding to grasp the composition of continental and oceanic crusts	U/A
3	Understand modelling studies pertaining to hydrocarbons, thermal structure of the mantle and folding multilayer rocks	U/E
4	Learn marine magnetic anomalies leading to seafloor spreading and plate tectonic theory	U/A
5	Summarise the break-up of Gondwana, formation of Himalayas and subsequent deformation processes	U/E
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

References:

1. D. L. Turcotte, G Schubert (2002) Geodynamics, Cambridge University Press
2. D.L. Turcotte, G Schubert (1982) Geodynamics – applications of continuum physics to geological problems, Wiley
3. C. M. R. Fowler (2005) The Solid Earth: An Introduction to Global Geophysics, Cambridge University Press
4. Frank D. Stacey, Paul M. Davis (2008) Physics of the Earth, Cambridge University Press
5. Kurt Stüwe (2007) Geodynamics of the Lithosphere: An Introduction, Springer
6. Laurent Jolivet, H. C. Nataf, Jean Aubouin (2001) Geodynamics, Taylor & Francis

7. K.S. Valdiya (2010) The Making of India: Geodynamic Evolution, Macmillan, New Delhi
8. K.S. Valdiya (2001) Himalaya: Emergence and Evolution. Universities Press, Hyderabad
9. K.S. Valdiya (1984) Aspects of Tectonics: Focus on Southcentral Asia. Tata-McGraw Hill, New Delhi
10. W. Frisch, M. Meschede and R. C. Blakey 2011 Plate Tectonics: Continental Drift and Mountain Building. Springer
11. B.K. Chakrabarti 2013 Geology of the Himalayan Belt: Deformation, Metamorphism, Stratigraphy. Elsevier

ESC 2107	CORE PRACTICAL - 1	CREDIT 2

Crystallography:

Spherical projection of Cube, Octahedron and Dodecahedron. Stereographic projection of holohedral classes of all the systems, pyritohedral, tetrahedral, plagiohcdral classes of Isometric system and Rhombohedral classes of Hexagonal system. Calculations of Axial ratios, Zone symbols Napier's rule, Laws of anharmonic ratio.

Mineralogy: Identification of mineral specimens based on physical properties. Determination of the optical characters by classical methods .

Identification of thin sections of important rock forming minerals

Petrology

Hand specimen study of rocks: Ideintification of typical igneous, metamorphic and sedimentary rocks, based on textures, structures and mineralogy (at least three from each type to be described in record book).

Thin-section studies of rocks: Identification of the rock texture and structure, mineralogy of typical igneous, metamorphic and sedimentary rocks (at least three from each type to be described in record book).

Stratigraphy and Paleontology

Exercises on stratigraphicclassification and correlation, sequence, magneto and seismic stratigraphic interpretations; Study and understanding of plate-movements through important periods during Phanerozoic eon; Evolution of ocean systems during Phanerozoic.

Study of modes of preservation of fossils; Study of morphological characters of important invertebrate fossils belonging to Brachiopoda, Bivalvia, Gastropoda, Nautiloidea, Ammonoidea, Belemnoidea, Trilobita, Echinoidea, Graptoloidea and Corals; Study of important trace fossils and microfossils; Study of important Indian Gondwana and Paleogene flora; Paleogeographic maps.

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
PRACTICAL 1	ESC 2107	**CORE PRACTICAL - 1**	2		1

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Differentiate the symmetry elements of crystals of different systems	S/A/U
2	Plot spherical projections of crystals	A/S
3	Identify common rock-forming minerals in thin sections and in hand specimens to appreciate their chemistry, optical and physical properties, paragenesis etc.	A/U/S
4	Develop skills in mineral optics in understanding the genesis and identification of minerals.	S/A/U
5	Differentiate minerals based on their optical properties	An/U
6	differentiate rock types include igneous, metamorphic and sedimentary rocks by microscopic and megascopic identification	U/Ap
7	Learn stratigraphic classification and correlation, sequence, magneto and seismic stratigraphic interpretations.	S/I
8	It provides Skill development on accurate identification of fossils for systematic palaeontology and functional morphology.	C/I
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

References:

AR Philpotts 2015 Petrography of Igneous And Metamorphic Rocks: with CD-ROM. CBSPD.

W. S. Mackenzie 1994 Colour Atlas of Rocks and Minerals in Thin Section. Wiley Blackwell

M Prinz, G Harlow and J Peters 1978 Simon & Schuster's Guide to Rocks & Minerals. Simon & Schuster, Inc.

ESC 2108	GEOPHYSICS - CORE PRACTICAL - 2	CREDIT 2

Practicals:

Reduction of gravity data to base station; To calculate Free air and Bouguer anomaly at given station; Interpretation of Bouguer anomaly map.

Elements of Earth Magnetic Field; Reduction magnetic data to base station; Interpretation of Magnetic anomaly map

Magnetic Methods - Computations

Gravity Methods - Computations

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
CORE	ESC 2108	GEOPHYSICS – CORE, PRACTICAL - 2	2		1

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Explain the gravity and magnetic survey methods in the field	U/A/S
2	Compulsory record work to recheck the level of grasping	A/S
3	Learners acquire skill to work in a survey team	A/S
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

CORE SUBJECTS **SEMESTER II**

ESC 2201	HYDROGEOLOGY	CREDIT 4

Unit 1

Origin, occurrence and distribution of water. Water on earth; Types of water — meteoric, juvenile, magmatic and sea water; Hydrological Cycle and its components; Water balance; Water-bearing properties of rocks — porosity, permeability, specific yield and specific retention; Vertical distribution of water; Zone of aeration and zone of saturation; Aquifers; Classification of aquifers; Concepts of drainage basins and groundwater basins; Aquifer parameters- transmissivity and storage coefficient; Water table and piezometric surface; Fluctuations of water table and piezometric surface; Water table contour maps; Groundwater provinces of India

.

Unit 2

Groundwater Hydraulics Theory of groundwater flow; Darcy's law and its applications; Determination of permeability in laboratory and in field; Flow through aquifers; steady, unsteady and radial flow conditions; Evaluation of aquifer parameters of confined, semi-confined and unconfined aquifers - Thiem, Thies, Jacob and Walton's methods; Groundwater modelling.

Unit 3

Groundwater Exploration: hydrogeologic methods of exploration; Role of remote sensing in groundwater exploration; Surface geophysical methods — seismic, gravity, geo-electrical and magnetic methods; Sub-surface geophysical methods; Yield characteristics of wells; Pumping tests-methods, data analysis and interpretation;

Unit 4

Groundwater Quality Physical and chemical properties of water; Quality criteria for different uses; Graphical presentation of groundwater quality data; Groundwater quality in different provinces in India; Groundwater contamination; natural (geogenic) and anthropogenic contaminants; Saline water intrusion.

Unit 5

Over-exploitation of groundwater and groundwater mining; Groundwater problems in urban areas; Ground water management in arid and semi-arid areas; Climate change impact on groundwater resources; Concept of sustainable development of groundwater resources; Rainwater harvesting and managed aquifer recharge.

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
CORE	ESC 2201	**HYDROGEOLOGY**	4	4	1

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Understand the fundamentals of hydrological cycle with its components, and distribution of groundwater	U
2	Evaluate aquifer parameters of confined, semi-confined and unconfined aquifers	E/A/U
3	Recognize groundwater exploration techniques and type of wells	U/Ap
4	Realize the physical and chemical properties of water, saline water intrusion and water quality for house hold and irrigation purposes	An/A/U
5	Exemplify ground water problems in urban areas along with mitigation measures	A/An/U
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

References:

1. Handbook of Applied Hydrology — Ven te Chow
2. Concepts and models in Ground water Hydrology — Domenica P.A.
3. Modern Hydrology — Rapheal A.G.
4. Geophysical Exploration — Heiland C.A.
5. Geophysical Prospecting — Dobrin M.B.
6. Applied Geophysics — Telford W.M.
7. Electrical methods in Geophysical Prospecting — Keller G.V.
8. Ground Water Hydrology — Todd, David Keith

Practical:

Delineation of hydrological boundaries on water-table contour maps and estimation of permeability; Determination of groundwater flow direction; Problems in calculating transmisivity, specific retention and specific yield; Interpretation of well inventory data; Analysis of hydrographs and estimation of infiltration capacity; Pumping test: time-drawdown and time-recovery tests and evaluation of aquifer parameters; Step drawdown tests, Electric resistivity sounding for delineation of fresh aquifers; Study of geophysical well logs; Estimation of TDS using resistivity and SP logs; Exercises on groundwater exploration using remote sensing techniques; Water budgeting problems.

ESC 2202	ECONOMIC GEOLOGY	CREDIT 4

Unit 1

Concepts of ore genesis; Spatial and temporal distribution of ore deposits - a global perspective; processes of formation; Metallogenic deposits and plate tectonics; Mode of occurrence of ore bodies - morphology and relation to host rocks; Texture, Paragenesis and Zoning of ores and their significance; Concept of ore-bearing fluids, their origin and migration; Wall-rock alteration. Structural, Physiochemical and Stratigraphic controls. Ore microscopy – indentation hardness – reflected light microscopy.

Unit 2

Geothermometry and geobarometry of ore assemblage. Chemical composition of ores - bulk chemistry, trace elements; REE and isotopes (stable and radiogenic); Ore petrology of the Indian deposits. : Orthomagmatic ores of mafic-ultramafic associations - diamond in kimberlite; REE in carbonatites; Ti-V ores; chromite and PGE; Ni ores; Kuroko and Cyprus type Cu-Zn ores of silicic igneous rocks - Kiruna type Fe-P pegmatites; greisens; skarn.

Unit 3

Stratiform and Stratabound ore deposits (Mn, Fe, non-ferrous ores); Residual deposits - laterite, bauxite, Ni/Au laterite; Placers – elluvial, alluvial and colluvial; Ores of metamorphic affinity - metamorphism of ores;. Study of following Indian ore deposits with reference to their mineralogy, mode of occurrence, origin, geological association and geographical distribution: iron, manganese, gold, aluminum, chromium, copper, lead, zinc, nickel, PGE, uranium; **Fuels:** coal, petroleum and radioactive minerals.

Unit 4

Coal: Definition and origin l. Sedimentology of coal bearing strata – Rank, grade and type of coal – Indian and International classifications, Chemical characterization: Proximate and ultimate analyses – Macroscopic ingredients and microscopic constituents, concept of 'maceral' and microlithotypes. Coal Petrology, and its applications in solving industrial and geological problems – Preparation of coal for industrial purposes – coal carbonization (Coke manufacture), coal gasification and coal hydrogenation. Coal-bed methane - maturation of coal and generation of methane in coal beds – coal as reservoir – fundamentals of coal bed methane exploration and production. Coal forming epochs in the geologic past geological and geographical distribution of coal deposits in India – Geology of coalfields of India.

Unit 5

Petroleum: - its composition and different fractions - Origin, nature and migration (primary and secondary) of oil and gas – Transformation of organic matter into kerogen, organic maturation, thermal cracking of kerogen - characteristics of reservoir rocks and traps (structural, stratigraphic and combination) – Prospecting for oil and gas, drilling and logging procedures – Oil bearing basins of India and the world. Geology of the productive oilfields of India – Status of oil and natural gas in India.

Course	Course Code	Course Title	L	P	Credits
Core	**ESC 2202**	**Economic Geology**	4		4

Course Outcome No	Expected Course Outcome	Learning Domains
1	The students acquire knowledge on how, where, and when earth's most important ore deposits have formed.	I
2	It offers a detailed study of origin of valuable economic mineral deposits and its distribution in India.	R/U
3	Understand how global tectonics influences ore mineralization and understand ore microscopy to analyze ore textures and genesis.	U/I
4	Understand the National Mineral Policy and the origin and properties of radioactive minerals especially U and Th bearing mineral deposits of India.	U
5	Understand the physico-chemical properties, origin and distribution of fossil fuels (Coal and Petroleum) in India.	R/U
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I), and Appreciation (Ap).		

References:

1. L Thomas 2002 Coal Geology, John Wiley & Sons
2. L Thomas 1992 Handbook of practical coal geology, Wiley
3. I Suárez-Ruiz and JC Crelling 2008 Applied Coal Petrology: The Role of Petrology in Coal Utilization, Academic Press
4. RE. Chapman 2000 Petroleum Geology, Elsevier
5. RC. Selley and SA Sonnenberg 2014 Elements of Petroleum Geology, Academic Press
6. Evans A M 1993 Ore Geology and Industrial Minerals: an introduction. Blackwell Scientific Publications
7. JR Craig and DJ Vaughan 1981 Ore microscopy and ore petrography, Wiley
8. AM Bateman 1950 Economic mineral deposits, John Wiley & Sons
9. Arndt N, Kesler S and Ganino C 2015 Metals and Society: an Introduction to Economic Geology 2nd Edition. Springer.
10. Misra K C 1999 Understanding Mineral Deposits. Kluwer Academic Publishers
11. Robb L 2005 Introduction to Ore-forming Processes. Blackwell Scientific Publications
12. Sarkar SC and Gupta A 2012 Crustal Evolution and Metallogeny in India. Cambridge University Press.
13. Taylor R 2009 Ore Textures: Recognition and Interpretation. Springer
14. Valdiya KS 2017 The Making of India: Geodynamic Evolution 2nd edition. Springer.
15. EN Cameron 1961 Ore Microscopy. Wiley

ESC 2203	STRUCTURAL GEOLOGY	CREDIT 3

Unit 1

Mechanical principles and properties of rocks and their controlling factors; theory of rock failure;

concept of stress and strain; two dimensional strain and stress analysis; types of stress and strain ellipses and ellipsoids, their properties and geological significance; strain marks in naturally deformed rocks.

Unit 2

Folds - Geometric classification of folds; mechanics of folding and buckling; folding in shear zones; distribution of strains in folds; structural analysis in terrain with multiple deformation.

Unit 3

Faults - Causes and dynamics of faulting; strike- slip faults; normal faults; overthrust and nappe Fractures and joints- their nomenclature; age relationship; origin and significance, introduction to petrofabric analysis. Stress and strain ellipsoids and their use in the study of faults and joints. Stereographic and equal area projections in structural geology.

Unit 4

Tectonites - classification, tectonic fabric, Axial-plane foliation and its origin, Fracture cleavage, crenulation cleavage and transposed foliation. Use of axial plane foliation and fracture cleavage in the determination of major structures. Lineation - types, classification and origin.

Unit 5

Fundamental concepts of geotectonics; tectonics of Precambrian orogenic belts of India; tectonic framework of India; Seismicity in India

Course	Course Code	Course Title	L	P	Credits
Core	**ESC 2203**	**Structural Geology**	3		3

Course Outcome No	Expected Course Outcome	Learning Domains
1	Students able to identify the structures in rocks with respect to change in stress-strain, which includes analysis of faults, folds, and structural signatures, and tectonic setups	An
2	Understand the mechanical and engineering properties of rocks and their use in locating engineering structures**.**	U/An
3	Understand Structural and geometric analysis. Application of stereographic and equal area projections in the representation of structures and geometric analysis of folds and lineations.	U/I
4	Acquire clear knowledge on tectonic framework of India and seismicity in India from available seismic data.	A/An/I
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I), and Appreciation (Ap).		

RECOMMENDED BOOKS

1. J G. Ramsay and M I Huber 1987 The Techniques of Modern Structural Geology: Folds and Fractures 1st Edition. Academic Press.

2. GH Davis, SJ Reynolds and CF Kluth 2011 Structural Geology of Rocks and Regions 3rd Edition Wiley
3. Price, N.J. and Cosgrove, J.W. (1990) Analysis of Geological Structures 1st Edition Cambridge University Press
4. P Kearey, K A Klepels, F J Vine 2009 Global Tectonics 3rd Edition Wiley Blackwell
5. B.K. Chakrabarti 2013 Geology of the Himalayan Belt: Deformation, Metamorphism, Stratigraphy. Elsevier
6. M P Billings (1972) Structural Geology, Prentice-Hall
7. Hobbs, B.E., Means, W.D. and William, P.F. (1976), An Outline of Structural Geology, John Wiley and Sons.
8. Park, R.G. (1989), Foundation of Structural Geology, Blackie.
9. Ragan, D.M. 2009 Structural Geology: an Introduction to Geometrical Techniques. ed 4thCambridge University Press Turner, E.J. and Weiss, L.E. (1963), Structural Analysis of Metamorphic Tectonites, Mc. GrawHill, 545p.
10. Twiss, R.J and Moores, E.M. (2007). Structural Geology, W.H.Freeman and Company, 695p.
11. H Fossen 2016 Structural Geology 2nd Edition Cambridge University Press

ESC 2204	GEOPHYSICS II (SEISMIC PROSPECTING & WELL LOGGING)	CREDIT 4

Unit 1

Theory of elasticity, Equation of motion and its solution in terms of displacement for an elastic isotropic body. Body waves and surface waves, their characters and passage through the earth, Reflection and refraction of elastic waves, Principles of seismographs; chief types, construction and standardization,damping, Interpretation of seismograms; Travel time curves.

Unit 2

Seismic wave propagation in different type of rocks, various forms of waves and their characteristic,Travel times of direct refracted, reflected and head waves over multi-layered earth. Marine seismic data acquisition – Energy sources, bubble oscillations, hydrophones and streamer, analog and digital recording, dynamic range. Seismic reflection and refraction surveys – single andmultichannel reflection profiling.

Unit 3

Seismic data processing and interpretation – Seismic signal, sampling theorem and digital representation, multiplexing and demultiplexing, correlation, convolution and filtering operations, deconvolution. Isochron and isopach maps, seismic sections of anticlines and faults, migration and application of seismic confirmation to stratigraphic interpretation.

Unit 4

Fundamental concepts in borehole geophysics - formation factor, porosity, permeability, formation water resistivity, water saturation, irreducible water saturation, hydrocarbon saturation, residual hydrocarbon saturation, Archies and Humbles equations. Principles, techniques and interpretation of SP, Resistivity and Microresistivity logs, Nuclear logs, Acoustic impedance and propagation logs, Temperature log, Caliper log, Dip and Directional logs. Evaluation of different parameters, Applications in groundwater, metallic and non-metallic exploration.

Unit 5

Subsurface Formation evaluation, Oil well technology; Drilling fluids; Logging techniques Imagescanning methods; Data acquisition and interpretation; M-N plots; Estimation of physical parameters of rock formations; case studies.

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
CORE	ESC 2204	GEOPHYSICS II SEISMIC PROSPECTING & WELL LOGGING	4		1

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Explain the principles of seismic prospecting. Types of elastic waves and their propagation within the earth, seismographs and seismograms	U/A
2	Understand seismic sources and receivers used on land and ocean Multi channel seismic surveys including 2D, 3D and 4D surveys in the ocean	U/A/S
3	Apply the reflection survey methods and study the seismographs in oil prospection to know the geology of the sedimentary formation precisely.	U/A/S
4	Understand the physical properties of subsurface rocks and fluids from empty bore-holes through different techniques and apply to derive better subsurface geological information	U/A/S
5		
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

References:

1. Elementary seismology — C.F. Richter
2. An introduction to theory of seismology — K.E. Bullen
3. Seismology — M. Bath
4. Applied Geophysics — Telford, Geldart et. al
5. Exploration seismology — Sheriff & Geldart
6. Introduction to geophysical prospecting — M.B. Dobrin.

ESC 2205	GEOCHEMISTRY	CREDIT 3

Unit 1

Introduction of Geochemistry and Cosmochemistry. Origin of elements; Chemical composition and properties of Earth's layers. Atmosphere: layers, chemical composition and evolution. Goldschmidt's geochemical classification. Isotope Geochemistry - stable and radiogenic isotopes.

Unit 2

Concept of enthalpy, free energy; chemical potential; fugacity, Structure and types of atoms. Internal structure of atoms, atomic weights. Types of chemical bonding. Ionic radii. Coordination number. Lattice energy. Ionization potential. Electronegativity. Pauling's rule. Cosmochemistry; Meteorites – chondritic, achondritic; cosmic dust, tektites.

Unit 3

Ionic substitution in minerals. Eh and pH diagrams, limits of Eh and pH in nature; oxidation and reduction in sedimentation. Geochemical cycles.. Geochemical classification of elements. Distribution of elements in igneous, metamorphic and sedimentary rocks. Rare-earth and transition element geochemistry.

Unit 4

Unstable isotopes - decay scheme of K-Ar, U-Pb, Sm-Nd, Rb-Sr; Lu-Hf, ^{14}C. Radiometric dating of single minerals and whole rocks; Stable isotope geochemistry and its application in Geology. Instrumentation – AAS, ICP-OES, ICP-MS, XRF, EPMA, NMR, XRD, SEM-EDS, IRMS, MC-ICP-MS, TIMS

Unit 5

Concept of geochemical-biogeochemical cycling and global climate; Hydrosphere: the hydrological cycle, composition of natural waters, river waters and ground water. Biosphere.-Introduction, mass and composition. Biogenic deposits. Geochemical evolution of the Earth.

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
CORE	ESC 2205	**GEOCHEMISTRY**	3	3	

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Understand the basics of geochemistry governing the origin and distribution of elements as well as origin and evolution of Earth	U/Ap
2	Apply crystal chemistry, thermodynamics, geothermo-barometry for geological analysis.	A/U
3	Analyse the distribution of elements in igneous, sedimentary and metamorphic rocks to interpret geological processes.	An/U
4	Realize the applications of radiogenic isotopes for geochronological age determinations	A/S

5	Use stable isotope systematics for their geological applications	E/A/U
6	Apply modern analytical techniques, including flame photometer, spectrophotometer, AAS, XRF, ICP-MS, TIMS, NMR, EPMA	A/S
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

References:

1. K. H. Wedepohl (1971) Geochemistry, Holt, Rinehart and Winston
2. F. Albarède (2003) Geochemistry: An Introduction, CAMBRIDGE PRESS
3. John Victor Walther (2005)Essentials Of Geochemistry, Jones & Bartlett Learning
4. Konrad Bates Krauskopf, Dennis K. Bird (1995) Introduction to geochemistry, McGraw-Hill
5. Brian Harold Mason, Carleton B. Moore (1982)Principles of geochemistry, Wiley
6. Gunter Faure, Teresa M. Mensing (2005) Isotopes: principles and applications, Wiley
7. Kula C. Misra (2012) Introduction to Geochemistry: Principles and Applications, John Wiley & Sons
8. Giulio Ottonello (1997)Principles of Geochemistry, Columbia University Press

ELECTIVE III ESC 2206	MINING AND ENGINEERING GEOLOGY	CREDIT 3

Unit 1

Mineral exploration-Triangulation-Establishment of Local Base from National Grid Base-Review of Surface Mapping and Underground Mapping-Different Plans and Sections-Search for ore–Surface and Concealed Guides to ore - Persistence of ore in depth– Preliminary Investigations–Trenching, pitting, Data Interpretation – Drilling from pits

.

Unit 2

Ore reserve estimation- Reserves and Resource – Types and Classification -Geological / Techno economic Considerations in Reserve Classification-Reserve Estimation Methods – Surface and Underground Deposits. Mineral prospecting-Macro/Micro Economic Considerations-Sampling – Types-Sampling Quantity-Spacing, Sampling error of Mean-Sample Data Processing-Interpretation-Surface/underground mining terms and definition-Drilling – Core, Diamond Drilling arrangement-Core logging.

Unit 3

Elements of mining: mining methods; various types of surface and underground mining methods; factors involving in selection of open cast and underground mining methods; salient features of bench-mining, shrinkage stopping, sub-level stopping and sub-level top slicing; coal mining methods: room and pillar method, long wall method. Explosives: types, storage and precautions in handling; blasting: various patterns of blast holes and methods of their charging and blasting. National mineral policy. Environmental issues. EIA and EMP in mining

.

Unit 4

Engineering properties of rocks- Rock description and engineering classification of rocks – weathering

and its significance in engineering site- Engineering properties of rocks and soils, RMR, RQD methods- determination of engineering properties in field and laboratory. Geological investigations for coastal development- Coastal erosion and accretion process and its impact-Geological investigations for harbor construction-Coastal protection structures-Sea walls, bulk heads, groins, jetties.

Unit 5

Geological investigations for construction of Dam and Tunnels- Dams -geological investigations- suitability of site, geological profile from catchment area to Dam site- lithology, structures, topography, slope, drainage system- groundwater studies in reservoir sites-reservoir site investigations, siltation analysis-Geological investigations for soft rock and hard rock tunnels construction. Geotechnical studies and land subsidence- Landslide - Classification, causative factors, and control measures. Land subsidence, factors, causes and remedial measures. Geological considerations for monitoring of landslides.

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
ELECTIVE III	ESC 2206	**MINING AND ENGINEERING GEOLOGY**	3	3	

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Understand and apply the fundamental principles of exploration geology, including the stages of exploration, ore reserve estimation methods, and criteria for exploration guidance	U/A
2	Analyse the significance of resource and reserve classification systems, such as UNFC, in the context of exploration geology	An/Ap/U
3	Appraise different types of mining methods including coal mining techniques	U/Ap/An
4	Integrate the knowledge of environmental management plans, mining legislation, and the economic impact of the mineral industry.	An/A
5	Evaluate the engineering properties of rocks using appropriate testing methods.	E/A/U
6	Evaluate the geological and geotechnical considerations for dam construction, reservoirs, tunnels, and bridges.	E/A/U
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

.References:

1. William C. Peters (1978) Exploration and mining geology, Wiley
2. Willard C. Lacy (1983) Mining geology, Hutchinson Ross Pub. Co
3. Roger W. Majoribanks (1997) Geological Methods in Mineral Exploration and Mining, Springer
4. James Park (1906)A text-book of mining geology for the use of mining students and miners,

J.B.Lippincott company

5. Hugh Exton McKinstry (1948)Mining geology, Prentice-Hall
6. Vasudev Kanithi (2012) Engineering Geology, University press
7. Parbeen singh, Engineering Geology
8. Bangar K.M (2011) Principles of Engineering Geology
9. Courses in Mining Geology**,** Arogyaswamy, Oxford & IBH Pvt. Ltd.3rd Ed. 1999
10. Beth Thorpe, Mining Geology-Exploration and Management, Syrawood Publishing House, 2016.
11. Robert Stevens, Mineral Exploration and Mining Essentials, Pakawau GeoManagement Inc, Reprinted, 2012.

ELECTIVE IV ESC 2207 (OPEN ELECTIVE)	CLIMATE CHANGE AND POLAR SCIENCES	CREDIT 3

Unit 1

Introduction to Climate : The Earth's Climate Machine Definitions,Climate and Weather, Clouds, Storms and Climate-Cloud Formation,, Tropical Cyclones Anticyclones- Global Warming Climate in the Spotlight; the Spectra of Scientific Opinion. The Earth's Natural Greenhouse Effect-General Overview, the radiative balance, greenhouse gases - An Overview, The role of carbon dioxide, methane, nitrous oxide, and water vapour on climate change, Major Uncertainties.

Unit 2

Polar regions as an indicator of climate change, CO_2 Emissions, Human Emissions of CO_2. Carbon Cycling: Some Examples, the Physical Carbon Pump, the Biological Carbon Pump, the Marine Carbon Cycle, and the Terrestrial Carbon CycleGlobal Ocean Circulation: Introduction and Overview; El Niño and the Southern Oscillation; El Niño and its Effects; Indian Ocean Dipole; Upwelling and Climate. Outlook for the Future: IPCC projections;; Computer Modeling.

Unit 3

Description of the climate system Ggreenhouse effect and the effect of trace gases and aerosols, Ffeedbacks in the climate system, climate change in the past, ice ages, proxy records, abrupt climate change, Instrumental record of climate, Climate variability on various time-scales, simple models of climate, General Circulation Models, natural and anthropogenic climate change: detection and attribution, impacts and mitigation

Unit 4

Overview of Polar Geology & Geography and Climate;; Physical characteristics; weather and climate, ice coring in Antarctica for paleo-environment studies, logistics operational aspects of Antarctic Science, opportunities, Governance and protection of Antarctic environment, International linkages. Ice characteristics and physical oceanography of polar seas; Sea ice: types, physical and mechanical properties, heat flux, temporal and spatial distribution, melting and freezing processes, forecasting models, and remote sensing of ice/snow covered surfaces. Microbial geochemistry of ice. Currents and water masses, deep and bottom water formation, fronts and eddies, polynya processes, and underwater acoustics.

Unit 5

Arctic; Operational aspects of Arctic meteorology, including polar lows, boundary layer and marginal

ice zone influences. Polar oceanography: Sea ice amount, seasonal distribution, melting and freezing processes, physical and mechanical properties, drift and predictions. Currents and water masses, deep and bottom water formation, fronts and eddies. Indian Polar programme: History and status.

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
ELECTIVE IV	ESC 2207	**CLIMATE CHANGES AND POLAR SCIENCES**	3	3	

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Study the climate history of the earth on geological time scales, and differentiate between various internal and external drivers, and feedbacks	U/Ap
2	Analyse the importance of polar regions in regulating climatic patterns across the globe	An/U
3	comprehend the role of natural and anthropogenic drivers into climate	A/An/Ap
4	gain perspective of varying spatial and temporal scales of climate change and variability and its projected changes	A/An/U
5	Apply the basic knowledge of climatology to understand the climatic variation	A/U
6	Understand polar geology of the artic and Antarctic regions and importance of governance and protection of polar environment	U/Ap/An
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

References:

1. Kendal McGuffie, Ann Henderson-Sellers (2005) AClimate Modelling Primer, John Wiley & Sons
2. Dennis L. Hartmann (1994) Global Physical Climatology, Academic Press
3. Lee R. Kump, James F. Kasting, Robert G. Crane (2004) The Earth System, Pearson Prentice Hall
4. Leslie Daryl Danny Harvey (2000) Global warming: the hard science, Prentice Hall
5. John E. Harries (1990) Earthwatch: the Climate from space, Wiley
6. Barrie Pittock (2009) Climate Change: The Science, Impacts and Solutions, CSIRO Pub
7. Matthias Ruth, Mari Eugenia Ibarrara (2009) Distributional Impacts of Climate Change and Disasters: Concepts and Cases, Edward Elgar Publishing
8. William Kininmonth (2004) Climate Change: A Natural Hazard, multi-science publishing
9. Bettina Kaiser; Becky Allen; Sandra Zicus. (2010) Polar Science and Global Climate: An international resource for education and outreach, Pearson Custom Publishing
10. Walker O. Smith (1990) Polar oceanography: chemistry, biology and geology, Academic Press
11. Walker O. Smith, Jr., David Barber (2007) Polynyas: Windows to the World: Windows to the World, Elsevier

12. W. R. Siegfried, Patrick Richard Condy, Richard M. Laws (1985) Antarctic nutrient cycles and afood webs, Springer-Verlag
13. Lance Tufnell (1984) Glacier hazards, Longman
14. Michael P. Lizotte, Kevin R. Arrigo (1998)Antarctic sea ice: biological processes, interactions and variability, American Geophysical Union
15. Norbert Untersteiner (1986)The Geophysics of sea ice, Plenum Press
16. Matti Leppäranta (1998)Physics of ice-covered seas, Dept. of Geophysics, University of Helsinki
17. Matti Leppr̃anta (2005)The Drift Of Sea Ice, Springer
18. Ola M. Johannessen, Robin D. Muench (1994) The polar oceans and their role in shaping the global environment, American Geophysical Union
19. Jen Green (2005) Arctic Ocean, World Almanac Library

ESC 2208	CORE – PRACTICAL - 1	CREDIT 2

Structural Geology

1. Description and interpretation of topographic features in geological maps
2. Interpretation of geological maps and identification of unconformities, folds, faults
3. Stereographic projection in solving structural problems involving folds
4. Preparation of Rose, Beta and Pi diagrams and interpretations.

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
PRACTICAL 1	ESC 2208	PRACTICAL 1	2		1

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Understand the interpretation of geologic maps and identification of topographic features, unconformities, folds and faults.	U/An
2	Application of stereographic and equal area projections in the representation of structures, include foliation, folds, fault and lineations.	A/An/I
3	Interpretations of Joint and foliation data from the field by using Rose and Pi diagrams.	A/An/I
4	learn different techniques of groundwater exploration such as drilling methods	A/E/S
5	assess the groundwater quality for specific uses and identify sources of pollution	E/A/S
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Ref:
RJ Lisle 2003 Geological Structures and Maps: A Practical Guide, 3rd Edition. Butterworth Heinemann
AL Coe 2010 Geological Field Techniques 1st Edition. Wiley-Blackwell
PR Leyshon and RJ Lisle 1996 Stereographic Projection Techniques in Structural Geology. Butterworth-Heinemann

ESC 2209	CORE - PRACTICAL -2	CREDIT 2

Seismic Prospecting: Computations, study of seismic reflection and refraction seismograms

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
CORE	ESC 2209	GEOPHYSICS – CORE, PRACTICAL - 2	2		1

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Summarise calculation of seismic velocities and travel times of seismic waves	U/A
2	Hands on training on seismic data processing	A/An/S
3	Interpretation of seismograms	A/S
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

CORE SUBJECTS **SEMESTER III**

ESC 2301	REMOTE SENSING AND GIS	CREDIT 3

Unit – 1

Introduction to Remote Sensing – Energy sources and Radiation principles, Energy equation, EMR and Spectrum – EMR interaction with Atmosphere – Atmospheric Windows - Scattering, Absorption – EMR interaction with Earth surface features; reflection, absorption, emission and transmission – Spectral response pattern –Vegetation, Rocks, Soil, Water bodies – Spectral properties and characteristics.

Unit – 2

Introduction- Active, Passive, Optical Remote sensing, Visible, Infrared, thermal, Platforms and sensors- orbit types– Resolution. Microwave Remote sensing sensors, Concept of Microwave Remote sensing, SLAR, SAR Scattro meter – Altimeter, Characteristics, Image interpretation characters.

Unit – 3

Land observation satellites, characters and applications, IRS series, LANDSAT series, SPOT series, High resolution satellites, character and applications, CARTOSAT series, IKONOS Series, QUICKBIRD series, Weather/Meteorological satellites, INSAT series, NOAA, GOES, NIMBUS Applications, Marine observation satellites; OCEANSAT

Unit – 4

Introduction to Geographical Information Systems: Maps and Spatial information – Computer Assisted Mapping and Map Analysis. Components of Geographical Information System –Introduction – GPS satellites – Components – Satellite Ranging – Codes - Basics of Geodesy – Branches, Applications and Observations of Geodesy. Digital Elevation Models: TIN – DEM.

Unit – 5

Map projections in GIS – Coordinate System – Georeferencing – Data Structures for Geographic Information Systems – GIS Entities – Point, Lines and Polygon.Data Quality, Errors and Natural Variation: Sources of error – Errors resulting from natural variation and original measurements. Errors arise through processing – Problems and Errors arising from overlay and boundary intersections – raster and vector maps; Errors resulting in raster and vector maps – Errors associated with overlaying two or more polygon networks.

Course	Course Code	Course Title	L	P	Credits
Core	ESC 2301	Remote Sensing and GIS	3		3

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand the theory and physical principles associated with remote sensing technique and illustrate the spectral response patterns of various surface features of earth.	R/U/A
2	Demonstrate the applications of optical/thermal/microwave/ SAR remote sensing techniques and understand the concepts of image interpretation.	U/A

3	Understand the characteristics and demonstrate the applications of Land/Marine/Weather observation satellite series.	U/A
4	Identify the various aspects and the components of Geographical Information System as well as differentiate GIS data structure and entities.	U/A/An
5	Compare various data formats and satellite imageries in GIS, and analyse various problems and errors arising from overlay and boundary intersections.	A/An
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

References:

1. Principles of Geographical Information System for Land Resource Assessment, P.A. Burrough, Clarendon Press, Oxford, 1986.
2. Geographic Information Systems, T.R. Smith &Piqent, London Press, 1985.
3. Principles of data base systems, J.D. Ullman, Computer Science Press.
4. Paul Jude Gibson, Introductory Remote Sensing: Principles and Concepts, Routledge, 11 New Fetter Lane, Landon, UK. 2000. ISBN: 0-415-17024-9
5. M. Anji Reddy, Textbook of Remote Sensing and Geographical Information systems, BS Publications, Hyderabad. 2011. ISBN: 81-7800-112-8
6. A.M.Chandra and S.K. Gosh. Remote Sensing and GIS, Narosa Publishing Home, New Delhi 2009.
7. Thomas M. Lillesand, Ralph W. Kiefer, Jonathan W. Chipman, Remote sensing and image interpretation John Wiley & Sons, 2008

ESC 2302	OCEANOGRAPHY	CREDIT: 4

Unit 1

History and development of Marine Sciences; general characteristics of oceans, exploration, survey tools and methods, Navigation and positioning systems.

Unit 2

Physical Oceanography: Physical properties of seawaters; temperature, salinity, density, T-S diagram, stability, acoustics, optics. Waves-generation, wave transformation, shoreline transformation energy. Currents-Wave generated, thermohaline, turbidity currents (gravity), Coriolis force, large-scale (gyres) oceanic circulation, . Dimensions of Oceans. Water masses. Currents: General characteristics, effects of fields of pressure, gravity and mass. Relative currents, wind currents, upwelling and sinking. Tides: tide-producing forces and tide characteristics. Circulation patterns and currents in the India Ocean. Major currents of the world oceans. Ocean-land-atmospheric interactions: Monsoons, cyclones, anticyclones, Oceanography – Remote sensing techniques.

Unit 3

Chemical Oceanography: Water and Salts in the Sea, Major Constituents, Simple Gases & CO2 System, Trace Elements, Nutrients, Colloid and Particulate chemistry; Marine Biogeochemistry; Dissolved and

Particulate Carbon, Radioactive & Stable Isotopes, Organic Molecules, Drugs from Sea, Anoxic Environments, Exchange at Boundaries, Chemical Evolution of oceans

Unit 4

Biological Oceanography: The sea as a Biological environment: classification of marine environment; general characters of the populations of the primary biotic divisions (plankton, nekton and benthos). Introduction of plankton; general classification and composition of plankton; floating mechanism of plankton. Collection of plankton; general account of instruments and nets employed; methods of fixation and preservation of plankton; analysis of samples, methods of estimating standing crop of plankton. Plankton in relation to fisheries; general account. Distribution of plankton in space and time; horizontal distribution; neritic and oceanic plankton; geographical distribution; indicator species. distribution of plankton, vertical migration ; seasonal changes in plankton.

Unit 5

Marine Pollution: Definition by GESAMP, major sources of pollution, dynamics, transport paths and agents. Toxicology: Lethal and sub lethal effects of pollutants on marine organisms, evaluation of toxicity tolerance, bioassay. Enzymatic removal of hazardous organic substances from aqueous effluents. Sewage: composition and fate in the marine environment, toxicity and treatment methods, sewage disposal system. Environmental Impact Assessment Methods of aquaculture activities. Oil pollution: Sources and fate of oil, composition and toxicity of oil, biological effects treatment procedures. Thermal and radioactive pollutants: Source and characteristics, strategies for disposal of RNA and Heated effluents, biological effects and alternative uses of waste dumping, mining and dredging operations, their effects on the organisms and marine environment.

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
CORE	ESC 2302	**OCEANOGRAPHY**	4	4	1

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Know and understand the history and development of marine sciences, oceanographic expeditions, general features of oceans, Ocean survey and positioning tools	U/A
2	Provide a good understanding of physical properties of sea water and physical process occurring in the ocean.	U/E
3.	Discuss the chemical aspects of ocean- inorganic and organic components in dissolved, particulate and sedimentary environments of the oceans.	U/An
4.	Gain general idea about biology of oceans- classification, distribution, sampling and analysis of primary biotic population of oceans	U/An
5	Gives an idea about different type of marine pollution, composition and Fate pollutants, treatments and disposal methods methods, EIA methods of aqua cultural activities, biological effects of waste dumping, mining and dredging.	U/An

References:

1. Svedrup H.U, Johnson, M.W. & R.H. Fleming (1942)The Oceans, Prentice Hall,
2. Tait, R.V (1972) Elements of Marine Ecology, 2nd edition, Butterworths
3 Pickard. G.L (1963) Descriptive physical – Oceanography, Pergamon Press,
4. King, C.A.H., (1975) Introduction to Physical and Biological oceanography, ELBS Ltd., London
5. Angel, M.V (1975) Biological Oceanography, Methuen
6. Nair, N.B. & D.M. Thampy (1980) AText Book of Marine Biology, Macmillan
7. Ryamont, J.E.G., (1980) Plankton and productivity in Oceans. Vel. 1: Phytoplankton, Vol.II, Zooplankton, Pergamon Press.
8. Parsons, T.R. Takahashi, M. and B. Hargrave (1977) Biological Oceanographic processes, Pergamon
9. Broecker W.S., (1974) Chemical Oceanography. 2nd edition Harcout Brace, Jovanovich,
10. Riley O.P. & G.S.Skirrow (1975) Chemical Oceanography, 2nd edition, Vols. I-IV, Academic Press,
11. A.M.Chakravarthy (1928) Biodegradation and detoxification of Environmental pollutants, CRC Press,
12. O.Kinne: (1984) Marine Ecology, Vol.V. Ocean Management 3&4, John Wiley & Sons,
13. Johnston R. (Ed.) : (1976).Marine Pollution, Academic Press
14. Patin. S.A (1982) Pollution and Biological resources of the Oceans Butterworth & Co. Ltd.
15. Venugopalan, V.K. (1991) Pollution and Toxicology, CAS in Marine Biology
16. Hilary B. Moore (1958) Marine Ecology, John Wiley & Sons

ESC 2303	MARINE GEOLOGY	CREDIT 4

Unit 1

Introduction and scope of Marine Geology; history of oceanography, voyages and expeditions, ocean profile, oceanic features; beaches, coastal classification, erosion and accretion; waves, currents and tides, coastal protection structures. Ocean floor topography – Shelf, slope, rise, abyssal plains, submarine canyons, mid oceanic ridges, plateaus, abyssal hills and plains, sea mounts, guyot, fracture zones, trenches. Seafloor spreading – concepts, hypothesis and mechanisms, evidences of seafloor spreading. Plate tectonics – theories and concepts, major plates and plate motions.

Unit 2

Origin and ages of ocean basins. Structure and evolution of Pacific, Atlantic and Indian Oceans, Red Sea and Mediterranean Sea. Morphologic and tectonic domains of the ocean floor. Ocean tectonics, Structure, composition and mechanism of the formation of oceanic crust. Ocean sediments, classification, and digenesis

Unit 3

Origin and depositional system of marine resources; Classification of marine mineral deposits; beach placers, shelf deposits, deep ocean Phosphatic, Polymetallic nodules, sulfate deposits, hydrocarbon deposits Sea water as a resource. Oceanic sediments – Processes and patterns of sedimentation; Sediment distribution in Pacific, Atlantic and Indian Oceans, Arabian Sea and Bay of Bengal. Gas charged sediments- special reference to North Indian Ocean. Offshore oil and gas and oil and gas fields of India

Unit 4

Concept of sea level changes, physical and chemical properties of seawater. Marine pollution-pathways, residence time, pollutants in the marine environment. Law of the sea, EEZ. Fundamentals of Remote sensing applications to ocean science.

Unit 5

Descriptions of research vessels, cruise, position fixing in the sea; sampling devices – Grab samplers, bottom samplers, dredges, sediment traps, boomerang samplers, water samplers, Winches, temperature measurement instruments, tools for studying ocean floor topography. POD, COD, GOD and BOD tools kit. .Prospects of ocean mining; Environmental aspects of ocean mining.

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
CORE	ESC 2303	**MARINE GEOLOGY**	4	4	1

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Understand the fundamental concepts in marine geology including expeditions, ocean floor structure and features on the ocean floor	U/Ap
2	Understand the origin and the dynamic evolution of ocean basins and the role of plate tectonics	U/An/A
3	Demonstrate the sediment types found in different oceanic settings and understand the sedimentary processes leading to their deposition	An/E/A
4	Illustrate marine pollution pathways and its remedial measures	An/E/Ap
5	Apply modern oceanographic tools and techniques, including research vessels and samplers for oceanographic research	A/Ap/U
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

RECOMMENDED BOOKS:

1. Marine Geology — J. Kennet
2. Geotectonics — Belonssov V.V.
3. Plate tectonics and crustal evolution — Condia K.C.
4. The Geology of Continental margins — C.A. Burk & C.L. Drake
5. Sea levels, land levels and tide ganges — Emery & Aubrey
6. Marine Manganese nodules — Wallace
7. J.J. Bhatt. Oceanography – Exploring the Planet Ocean. D. Van. Nostrand Company, New York, 1994.
8. Shepard, F. P. Submarine Geology, Harper and Row Publ. New York, 1994.
9. Kerth. S, Ocean Science, John Wiley and Sons. Inc. New York. 1996.

10. James, K, Marine geology Prentice Hall, Inc. Englewood Clifs. N. J. 07632. 1981.
11. Eric. C. Bird Coasts: An Introduction to Coastal Geomorphology, III ed. Basil Black well Publ. 1984.
12. Suzy Bullock, Marine Geology,2017
13. Jon Erickson, Marine Geology: Exploring the New Frontiers of the Ocean, Facts On File Inc; Revised edition , 2002

ESC 2304	MARINE GEOPHYSICS	CREDIT 4

Unit 1:

Techniques of echo-sounding, sound ranging side scan sonar, sparker and pneumatic pulsar profiling. Gravity and magnetic survey over the oceans, marine magnetic and gravity instruments,

Unit 2:

Position fixing at sea, underwater photography and television, underwater navigation system. Sediment samplers – grab - van veen, free-fall; corers – vibro-, gravity, spade, piston. Drilling techniques and vessels – Glomar Challenger, JOIDES Resolution, Chikyu ; DSDP, ODP, IODP programs.

Unit 3:

Seismic energy sources- Airgun, water guns, Seismic reflection receivers- geophones, hydrophones. Array configuration and advantages. Single channel and multi-channel seismic reflections, Sonobuoys, ocean bottom seismometers (OBH) – Data acquisition.

Unit 4:

Application of geophysical methods for placer deposits; oil and natural gas and other minerals of the continental margin. Survey and exploration of different types of sediments and minerals of the deep ocean floor.

Unit 5:

Offshore mining – exploration technology; tunneling, solution mining, dredge mining etc. Resource management. Different offshore structures.

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
CORE	ESC 2304	MARINE GEOPHYSICS	4		1

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Summarise data acquisition and survey procedures in marine surveys such as bathymetry, gravity and magnetics.	U/A
2	Understand land-based and satellite position fixing systems	U/A
3	Summarise different marine seismic survey methods	U/A
4	Application of geophysical methods for offshore minerals	U/A

	Exploration.	
5	Understand different offshore mineral mining technologies	U/A
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

RECOMMENDED BOOKS:

1. Geophysical Exploration — C.A. Heiland
2. Offshore Exploration — R.K. Verma
3. The Sea Vol.3 — M.N. Hill
4. Bathymetric navigation and charting — Cohen P.M
5. Marine Geophysics — E.J.W. Jones

ESC 2305	QUANTITATIVE GEOLOGY	CREDIT 3

Unit 1

Introduction to statistics, geostatistics; population and sample; variables, frequency distribution, histogram, frequency polygon, ogive; statistics and parameters, sampling, geological population. Measures of central tendency, measures of dispersion, skewness and kurtosis, moments. Probability : Empirical and theoretical / statistical probability, addition law, conditional probability, product law, Bayes' theorem, expectation, expected variance. Binomial distribution, Poission distribution and Normal Distribution. Standardization of normal distribution, Joint distribution. Examples of the distribution in geological population. Correlation and regression, variance and covariance, standard and probable error of correlation coefficient, linear curve fitting. Geological data analysis.

Unit 2

Sampling distributions: Estimators, sampling distribution of mean, confidence limits, Student t-distribution. Test of significance, setting up a hypothesis, null and alternative hypothesis, t-test, z-test, Chi-square test. Geological data analysis. Factor and principal component analysis, eigen vactors – there uses in geological data analysis. Q and R techniques, ramifying linkage method of cluster analysis. Some statistical approaches to mapping problems. Moving average, Gumbel and Log-pearson distributions - their applications.

Unit 3

Programming ability in C++, FORTRAN, MATLAB or an equivalent. Programming: Scalars, vectors, variables, functions, Plotting, Numerical errors - Matrices and linear algebra; Matrix algebra, determinants, Statistical analysis; Probability distributions, mean and variance, Fitting models and distributions to data

Unit 4

Exploratory data analysis, surface modeling and contouring, Kriging, analysis of point patterns and directional data. Multivariate statistics - regression, principal components, factor analysis, cluster and time series analysis.

Unit 5

Stochastic processes, Linear systems with stochastic input, Nonparametric spectral analysis, Signal

detection: matched filters, Signal estimation: stacking, Frequency response estimation for multiple-input systems, Wiener filtering, Predictive deconvolution, Parametric spectral analysis, State variables, Kalman filtering.

Course	Course Code	Course Title	L	P	Credits
Core	ESC 2305	Quantitative Geology	3		3

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Recognize and calculate various statistical measures and describe its applications in geological data.	R/U/A
2	Understand the basic theorems of empirical and theoretical probability and explain Binomial distribution, Poisson distribution and Normal distribution and demonstrate the same with geological data.	U/A
3	Understand the concepts of sampling distribution, factor and principal component analysis, as well as understand and perform hypothesis test.	U/A
4	Describe the aspects of Exploratory data analysis and Surface modelling (gridding and contouring), as well as analyse various gridding methods using geological data.	U/A/An
5	Develop computer programming skills and apply the skills to create codes for statistical analysis.	U/A/C
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

ELECTIVE V ESC 2306	MARINE GEOCHEMISTRY	CREDIT 3

Unit 1

Introduction to Marine Biogeochemistry, Geochemical history of the ocean, Carbon cycle, Organic matter in the ocean, Organic biogeochemistry, , Fate of terrestrial organic matter reaching the sea, organic matter in the ocean, settling fluxes of organic matter; sediment traps. Biogeochemistry of coral reefs, Biogeochemistry of coastal, continental margin and deep-sea abyssal plains. Human influences on ecosystem cycling – CO_2 sequestration

Unit 2

Oxidation-Reduction Reactions - Oxic/hypoxic/suboxic/anoxic environments. Oxygen minimum zones in today's ocean, Coastal anoxia. Case studies of low oxygen environments - the Arabian Sea, Bay of Bengal, and Indian Ocean, Benthic biogeochemistry: Interstitial water chemistry, bioturbation, benthic mixing, diagenetic sequence of organic matter mineralization; chemical fluxes across sediment-water interface.–Climate Change and redox change, redox-sensitive elements, Redox Evolution of the Ocean, paleo-redox Proxies, Redox responding elements and isotopes; Biomarkers.

Unit 3

Salinity, Major elements, Minor elements, Nutrients, Trace elements, dissolved gases in the Ocean, CO_2 and the carbonate system, Optical properties and photochemistry in the surface ocean -, Measurements and Methods in Chemical Oceanography, Stable isotopes of C, N, O and S in

Biogeochemistry. Isotope Ratio Mass Spectrometer (IRMS), GC-MS, HPLC.

Unit 4

Introduction to thermodynamics, Sediment decomposition & modeling, Basic N cycle – processes and overview, Aquatic nutrient limitation: definitions and evidence - driving mechanisms, N fixation in aquatic ecosystems, Acid rain: terrestrial and aquatic ecosystems, Human alteration of the N cycle at global and regional scales

Unit 5

New frontiers in biogeochemistry, Human alteration of the global C cycle: Climate change feedbacks on C-cycle; mechanisms; sources & sinks, Circulation, Ocean Structure, Currents, Si, P, and Fe cycles, Air-sea CO_2 fluxes, Biogeochemical time series, Moorings, profiling floats, gliders,in-situ sampling using trace-element and trace-organic clean sampling techniques - supported by advanced analytical procedures.

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
ELECTIVE V	ESC 2306	**MARINE GEOCHEMISTRY**	3	3	

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	understand geochemical processes involved in the transfer of material from land to sea.	U/Ap
2	Evaluate case studies of low oxygen environments in the Arabian Sea,Bay of Bengal, and Indian Ocean	E/An/Ap
3	Apply analytical techniques to measure marine sediment chemistry	A/U/S
4	Illustrate the importance of N cycle in aquatic ecosystems	A/Ap/U
5	Correlate biogeochemical cycles and its impact on ocean circulation	A/An/E
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

RECOMMENDED BOOKS

1. Susan Libes (2011) Introduction to Marine Biogeochemistry, Academic Press
2. Jorge Louis Sarmiento, Nicolas Gruber (2006) Ocean biogeochemical dynamics, Princeton University Press
3. Michael E. Q. Pilson (1998) An introduction to the chemistry of the sea, Prentice Hall
4. M. J. R. Fasham (2003) Ocean Biogeochemistry, Springer
5. David Jay Burdige (2006) Geochemistry of marine sediments, Princeton University Press
6. David R. Schink, James T. Corless (1965) Marine Geochemistry, Narragansett Marine

Laboratory, University of Rhode Island
7. Wallace S. Broecker (1974)Chemical oceanography, Harcourt Brace Jovanovich
8. John Price Riley, Roy Chester (1971) Introduction to marine chemistry, Academic Press
9. Roy Chester Marine Geochemistry
10. Schultz.....Marine Geochemistry
11. D. Satyanarayana (2007) Marine Chemistry, Daya Books
12. R.E. Zeebe, D. Wolf-Gladrow (2001) CO_2 in Seawater: Equilibrium, Kinetics, Isotopes, Elsevier

ELECTIVE VI ESC 2307	INTEGRATED COASTAL ZONE MANAGEMENT (OPEN ELECTIVE)	CREDIT 3

Unit 1

Introduction to Coastal Zone – The need for Integrated Coastal Management (ICM) – Fundamental concepts –Interactions between coastal and ocean uses and conflicts – Definitions used in ICM – Glossary of terms in ICM, Tools and techniques for ICM – ICM, Processes – Stakeholder analysis – Environmental assessment – Problem tree analysis – Conflict resolution – Risk evaluation – Cost Benefit Analysis – Traditional management

Unit 2

Case studies (including field work) – Resource survey – Transect walks – learning through observation – Observing in practice – Participatory observation – Focus group discussions – Group ordering – Interpreting observations, Social science insights – Natural science insights – Horizontal integration – Vertical integration – Problem and objective analysis – Monitoring and evaluating management, National and International regulations; Coastal Zone Regulation Notification of India; Law of the Sea – Ocean Governance – Coastal Regulation Zones including small islands – Environmental policies – Spatial planning – Administrative and legal measures Coastal erosion

Unit 3

Types and functions of coastal and marine resources – Coastal zone as an integrated resource area – Marine resources: biotic, mineral and energy resources, Environmental variability on marine fisheriesresources – Interactions between fisheries and the ecosystem – Marine Protected Areas (MPA) – Large marine Ecosystems (LMEs) – Climate effects on living marine resources – Biological monitoring of marine ecosystems, Marine geophysical methods – Sea floor resource exploitation – Exploitation of the oceans by human activities – overfishing – mining – ocean dumping – oil spills – coral reef bleaching – Marine archaeology, Resources as common property – Defining resource management – Conflicting interests with other Marine Resources: Food and Recreation/Tourism – Management tools – Ecosystem health and protection of biological diversity – Coastal hygiene - Ecotourism – Future uses of the oceans

Unit 4

Introduction to Natural hazards – earthquakes, tsunamis, volcanoes, landslides, avalanches, floods, cyclones, mine fire and blow out; Causes, risk and mitigation of natural hazards; Mechanics of recent and historical earthquakes, seismic risk and hazard, earthquake prediction, types of volcanism, styles of eruption, forecasting and mitigation of volcano hazard,

Unit 5

Coastal erosion and deposition-causes and forces, monitoring,; coastal protection, natural (bioshields) and engineering measures Tsunami – causes and prediction, landslides - prediction and prevention, landslide zonation and risk assessment, coastal flooding-causes and possible preventive measures, vulnerability and risk assessment using GIS, Environmental hazards biological, chemical, nuclear waste ground water pollution-Important case studies of natural hazards

Course	Course Code	Course Title	L	P	Credits
Elective VI	**ESC 2307**	**Integrated Coastal Zone Management (Open Elective)**	3		3

Course Outcome No	Expected Course Outcome	Learning Domains
1	Understand and apply the tools and techniques of Integrated Coastal Management.	U/A
	Application of environmental assessment and risk evaluation in ICM	I
2	Understand the national and international regulations and coastal zone regulation notification of India.	R/U
3	Evaluate the climate effects on living marine resources and biological monitoring of marine ecosystems.	E/I

*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I), and Appreciation (Ap).

RECOMMENDED BOOKS

1. Cicin-Sain, B and Knecht, R.W., (1998) Integrated Coastal and Ocean Management:Concepts and Practices. Washington, DC, Island Press,
2. Clark, J.R. (1995) Coastal Zone Management Handbook, CRC Press Environmental Studies
3. Holder, S., Bearley, T., Brower, D.J. and. Schwab, A.K., (2002) An Introduction to Coastal Zone Management, 2nd edition. Island Press, Washington, DC,
4. Le Tissier, M.D.A., Ireland, M., Hills, J.M., McGregor, J.A., Ramesh, R. and Hazra, S. (eds). (2003) A Trainers' Manual for Integrated Coastal Management Capacity Development. Integrated Coastal Zone Management and Training (ICZOMAT) Project. The University of Newcastle upon Tyne, Newcastle upon Tyne, U.K.
5. Le Tissier, M.D.A., S. Coulthard, D. Rath and H.A.Y. Whyte (eds), (2008) Integrated Coastal Management – From post-graduate to professional Coastal Manager – a teaching manual. www.coastalprofs.eu,
6. Ramesh, R. and Purvaja, R., (2006) E-learning module on ICZM for UNESCO-IHE, The Netherlands,
7. Donald W. Hyndman, David W. Hyndman (2010) Natural Hazards and Disasters, Cengage Learning
8. Patrick L. Abbott (2004)Natural disasters, McGraw-Hill Higer Education
9. Edward A. Keller, Robert H. Blodgett (2006)Natural hazards: earth's processes as hazards, disasters, and catastrophes, Pearson/Prentice Hall
10. Beer, T., (1997) Environmental Oceanography: Second Edition (Marine Science Series), CRC

Press
11. Kennish, M.J., (1998) Pollution Impacts on Marine Biotic Communities, CRC Press, New York,
12. Alongi, D.M., (1998) Coastal Ecosystem Processes, CRC Press, New York,
13. Eisma, D., (1998) Intertidal deposits, River Mouths, Tidal flats and Coastal Lagoons, CRC Press, New York,
14. Newman, M.C., Roberts Jr. M.H. and Male, R.C. (Eds.), (2002) Coastal and Estuarine Risk Assessment, Lewis Publishers, Washington D.C.

ESC 2308	CORE - PRACTICAL - 1	CREDIT 2

Practicals: Remote Sensing & GIS, Oceanography and Marine Geology

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
PRACTICAL 1	ESC 2308	**PRACTICAL - 1**	2		1

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Identify physical and optical properties of metallic and non-metallic marine mineral resources.	A/Ap/S
2	Preparation of maps showing distribution of important marine mineral resources across various ocean basins	E/A/Ap
3	Marine Geological equipment handling and bathymetry preparation	An/S/A
4	Demonstrate proficiency in Geographical Information System software for geospatial data visualization and analysis, and seek help from software/website help menus and the GIS community to solve problems.	U/A
5	Demonstrate various colour composites and evaluate its applications, and differentiate raster and vector maps.	A/An
6	Operate georeferencing tool for image georeferencing, and calculate and evaluate the importance of various indices using satellite imagery data.	A/E
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

ESC 2309	CORE- PRACTICAL -2	CREDIT 2

Practicals: Marine Geophysics and Quantitative Geology

Course	Course Code	Course Title	L	P	Credits
Core	ESC 2309	Marine Geophysics and Quantitative Geology		4	2

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Apply gridding methods to open source bathymetric data and prepare image and contour maps using standard software like SURFER and analyse the maps.	A/An
2	Apply gridding methods to open source marine gravity data and prepare image and contour maps using standard software like SURFER and analyse the results.	A/An
3	Analyse single channel and multichannel seismic sections using open source data.	A/An
4	Use graphical representation tools of statistical data such as Bar charts, Histograms, Frequency polygon, Pie chart, Ogives and interpret the graphs.	A/An/E
5	Develop programming ability in relation to various statistical measures and create codes for statistical analysis.	A/C
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

ESC 2310	SHIP BOARD/INDUSTRY/ INSTITUTE TRAINING/FIELD WORK	CREDIT 2

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
FIELD WORK	ESC 2310	**SHIP BOARD TRAINING/ INDUSTRIES/INSTITUTIONS/FIELD WORK**	2		

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	Develop skills in the field techniques for various geological data collection.	A/Ap/S
2	Identify the economic minerals, mineral deposits and various fossils, and analyse the significance of their occurrences.	An/A/Ap
3	Identify various types of rocks in the field with various structural features associated with them, and analyse the geological processes involved with the formation and deformation of the rocks.	An/S/A
4	Generate teamwork, communication, and problem-solving skills through collaborative field work, and interpretation of the geological data, for the presentation of the field report.	E
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

SEMESTER IV

COURSE CODE	CREDIT	COURSE	Marks		
			Internal	External	Total
ESC 2401	18	Dissertation/Project	50	100	150
Total	18		50	100	150

COURSE	COURSE CODE	COURSE TITLE	CREDIT	L	P
DISSERTATION	ESC 2401	**DISSERTATION / PROJECT**	18		

COURSE OUTCOME NO.	EXPECTED COURSE OUTCOME	LEARNING DOMAINS
1	develop research interest, communication skills, analytical skills, including the ability to understand information, and interpret data required for research	S/A/Ap
2	develop effective work habits, including time management, punctuality, and personal accountability	S/A
3	identify a science problem, develop methods to address it, and draw accurate and precise conclusions	E/A/An
4	write a focused scientific dissertation on the research findings	S/A/Ap
*Remember (K), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

TOTAL CREDITS FOR 4 SEMESTERS = 90

TOTAL MARKS FOR 4 SEMESTERS = 2500

THE COURSE ENVISIONS GEOLOGICAL AND GEOPHYSICAL TRAININGS,INTERNSHIPS IN INDUSTRIES/NATIONAL LABORATORIES OF HIGH REPUTATION/ACCREDITATION BY NAAC