REGULATIONS & SYLLABUS

MASTER OF SCIENCE
IN
GEOLOGY

P.G. Department of Geology
Fakir Mohan University
Vyasa Vihar, Balasore – 756089
2020-21

FAKIR MOHAN UNIVERSITY M.Sc. GEOLOGY EXAMINATION

CHOICE BASED CREDIT SEMESTERSYSTEM

Examination Schedule: 1st Semester-December/January
2nd Semester-May/June
3rd Semester- December/January
4th Semester-May/June

1. Candidates with at least 2nd class honours in Geology are eligible to apply for admission in to the course. The course is of two years duration comprising four Semesters of Theory and practical. Each theory paper carries 100 marks out of which the internal marks will be 20% of the total that is 20 marks. The duration of the theory examination will be 3 hours. Practical papers will be of 70 marks and the duration of examination will be 6 hours. Rest 30 marks will be for seminar presentation in each semester (up to 3rd semester). There will be a dissertation/ project of 30 marks in 4th semester.
2. The First Semester will start with the beginning of the academic session after the admission into the said course as per the University schedule.
3. Normally examination for First and Third Semesters will be completed between December- January and Examinations for Second and Fourth Semesters will be completed between May- June of the academic session. If for any reason(s) Semester Examinations could not be conducted as per schedule, both Semester (Theory and Practical) examinations of the session will be conducted at the end of the academic session of that year.
4. The Semester system of Examination will have internal valuation for theory papers. Practical papers will be examined by one internal examiner and one external examiner. If necessary, the practical examination may be extended to the next day.
5. In order to be eligible to appear the University Examination, attendance will be taken into account as per University Rules. The attendance will be calculated every month by the Department and the students are to collect information from the office.
6. A candidate, if so desires, will get one chance only to repeat in one or more paper(s) of any Semester with in a period of one year of the said Semester examination.
7. In the fourth Semester there will be elective papers (Special papers) out of which the students may choose any one.
8. The paper GL405 will carry 70 marks of practical corresponds to four theory papers and Project/ Dissertation work of 30 marks.
9. In each Semester , the students are required to undergo a Field Training programme for a period of 15 days. The students need to deposit a requisite fee towards the field training programme at the time of admission.

M.Sc. GEOLOGY

SEMESTER I

PAPER CODE	PAPER NAME	MARKS			Credit
		External Mark	Internal Mark	TOTAL	
GL101	Crystallography and Mineralogy	80	20	100	04
GL102	Geochemistry and Isotope Geology	80	20	100	04
GL103	Structural Geology	80	20	100	04
GL104	Geomorphology & Global Tectonics	80	20	100	04
GL105	**Geology Lab-I**				
	(a) Practical related to Papers GL 101, GL 102	35	-	100	03
	(b) Practical related to Papers GL 103, GL 104	35	-		03
	Seminar	-	30		02
TOTAL				**500**	**24**

SEMESTER II

PAPER CODE	PAPER NAME	MARKS			Credit
		External Mark .	Internal Mark	TOTAL	
GL201	Igneous Petrology	80	20	100	04
GL202	Sedimentology and Fuel geology	80	20	100	04
GL203	Metamorphic Petrology	80	20	100	04
GL204	Oceanography, Atmospheric Science and Disaster Management	80	20	100	04
GL205	**Geology Lab-II**				
	a) Practical related to Papers GL 201, GL 202	35	-	100	03
	b) Practical related to Papers GL 203, GL 204	35	-		03
	Seminar	-	30		02
TOTAL				**500**	**24**

SEMESTER III

PAPER CODE	PAPER NAME	MARKS			Credit
		External Mark	Internal Mark	Total	
GL301	Palaeontology and Quaternary Geology	80	20	100	04
GL302	Stratigraphy	80	20	100	04
GL303	Economic geology	80	20	100	04
GL304	General Geology & Mineral resources of Odisha (CBCS paper for other P.G. departments)	80	20	100	04
GL305	**Geology Lab-III**				
	a) Practical related to Papers GL 301, GL 302	35	-	100	03
	b) Practical related to Paper GL 303	35	-		03
	Seminar	-	30		02
TOTAL				**500**	**24**

SEMESTER IV

PAPER CODE	PAPER NAME	Marks			Credit
		External Mark	Internal Mark	Total	
GL401	Groundwater & Engineering Geology	80	20	100	04
GL402	Remote Sensing, GIS and Geostatistics	80	20	100	04
GL403	Special Paper A/B/C/D	80	20	100	04
GL404	Special Paper A/B/C/D	80	20	100	04
GL-405	**Geology Lab-IV**				
	a) Practical related to Papers GL 401, GL 402	35	-	100	03
	b) Practical related to Papers GL 403, GL 404	35	-		03
	Project / Dissertation Work	30	-		02
TOTAL				**500**	**24**

ELECTIVES (Special papers)

A. Ore geology

B. Remote sensing and GIS

C. Applied Micropalaeontology

D. Applied Hydrogeology

Semester I

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL101	Crystallography and Mineralogy	4	20	80

Objectives	The basic objective of this course is to introduce students the ideas and techniques of analyzing crystal models to unearth the minerals with respect to its several properties and classes.
Pre-Requisites	Knowledge related to basics of crystals and minerals
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with focus on problem solving and practical activities.

Detailed Syllabus

Unit	Topics	Hours
I	Crystallography, Unit cells, Concept of lattice network, Bravais lattices, X-ray study of crystals, Crystal projection, Hermann Mauguin system of crystal notation, Pauling's rules and coordination polyhedra; Zone and zonal laws; Crystal imperfection, Twinning.	14
II	Polarisation, pleochroism, pleochroic scheme, isotropism and anisotropism, double refraction, birefringence, behavior of isotropic and anisotropic minerals under polarized light, interference colour, uniaxial and biaxial interference figures; optic axial angle, extinction angle.	10
III	Structural classification of silicates, Physico-chemical and optical properties and occurrence of Silicate Mineral groups- Felsdpar, Olivine, Garnet, Pyroxene, Amphibole, Mica, Silica.	12
IV	Physical, chemical, optical properties and occurrence of Non-silicate mineral groups- Native elements, Oxides, Carbonates, Sulphides, Phosphates and Halides.	12
	Total	48

Reference Books:

R1. Berry, L.G., Mason, B. and Dietrich, R.V. (1985) Mineralogy: Concepts, Descriptions and determinations. CBS Publishers

R2. Bloss, F.D. (1971): Crystallography and Crystal Chemistry, Holt, Rinehart, and Winston, New York

R3. Dana, E.S. and Ford, W.E. (2002) A text book of Mineralogy (Reprint) Deer, W.A., Howie, R.A. & Zussman, J. (2013): An Introduction to the rock forming minerals, ELBS and Longman

R4. Gribble C.D. (2005) Rutley's elements of Mineralogy, Springer.

R5. Kerr, P.F (1977): Optical Mineralogy McGrew Hill

R6. Nesse, D.W (1986): Optical Mineralogy, McGraw Hill

R7 Perkins, D. (2013) Mineralogy, Prentice Hall

R8. Phillips, F.C (1971) Introduction to Crystallography. Longman Group Publication.

Course Outcome	At the end of the course, the students will be able to: i) Explore different tasks related to crystal models ii) Differentiate the mineral properties and classes

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL102	GEOCHEMISTRY AND ISOTOPE GEOLOGY	4	20	80

Objectives	The basic objective of this course is to bring together the ideas of geochemistry and isotope geology for unraveling the earth layers and the elements present
Pre-Requisites	Knowledge of chemical elements
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with several models

Detailed Syllabus

Unit	Topics	Hours
I	Origin of chemical elements, solar system and earth, abundance of elements in cosmos, Distribution of elements in core, mantle, crust, hydrosphere and atmosphere, Internal structure of the earth, Geochemical cycle, Geochemical differertiation, Geochemical classification of elements. Isomorphism, Polymorphism, Atomic substitution	14
II	Geochemistry of igneous and metamorphic processes. Distribution coefficients and determination of Pressure and Temperature conditions. Trace element geochemistry. Geochemistry of weathering, transportation and deposition. Study of Eh-pH diagram. Petrography of lunar rocks and meteorites	10
III	Radioactivity. stable and radiogenic isotopes, Dating Methods, Interpretation and geological significance of ages. Isotope systematics of K-Ar, Rb-Sr, Sm-Nd, U-Th-Pb in igneous, metamorphic and sedimentary rocks and in evolution of ocean, crust and mantle	12
IV	Stable isotopes of oxygen and hydrogen, carbon, nitrogen and sulphur. Fractionation of stable isotopes in lithosphere, hydrosphere and atmosphere. Stable isotope geothrermometry and geobarometry	12
	Total	48

Reference Books:

R1. Alan P. Dickins (2005) Radiogenic Isotope Geology, Cambridge University Press.
R2. Hoefs, J. (1980): Stable Isotope Geochemistry, Springer and Verlag.
R3 Hugh R. Rollinson (2007) Early Earth Systems: A Geochemical Approach by Blackwell Publishing Ltd.
R4. Gunter Faure (1977) Principles of Isotope Geology by John Wiley & Sons Ltd.
R5. Hugh R. Rollinson (1993) Using Geochemical Data: Evaluation, Presentation and Interpretation, Pearson Prentice Hall.
R6. Albarde Francis (2003): Geochemistry- Introduction. Cambridge University Press.
R7. Kula C Misra (2012) Introduction to Geochemistry: Principles and Applications, Wiley-Blackwell.

Course Outcome	At the end of the course, the students will be able to: i) Elementary idea related to different layers of earth with respect to its chemical constituents ii) Establish knowledge on radioactivity iii) Explore the different isotopes

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL103	STRUCTURAL GEOLOGY	4	20	80

Objectives	The basic objective of this course is to introduce students the concepts of rock structure and its significance
Pre-Requisites	Knowledge of different types of rocks and its formation
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with presentation of related models followed by field studies

Detailed Syllabus

Unit	Topics	Hours
I	Concept of stress and strain. Two-dimensional stress and strain analyses. Mohrs circle. Types of strain ellipsoids and their geological significance. Strain analysis of naturally deformed rocks. Classification of joints. Joint related structures. Analysis of joints and their tectonic significance.	14
II	Geometry and classification of folds. Mechanics and dynamics of folding. Evidence of buckling. Superposed folding and interference patteren. Distribution of strains in folds, Salt dome.	10
III	Fault and Shear zone: Classification of faults. Features associated with normal faults, strike-slip faults, overthrusts and nappes. Causes and dynamics of faulting. Recognition criteria of faulting. Classification and geometry of different types of shear zones. Strain variation in shear zones. Shear sense indicators. Time relationship between crystallization and deformation	12
IV	Foliation and Lineation: Morphology and types of foliations and lineations. Significance of linear structures. Geometry and development of boudinage structures. Tectonites. Types of unconformity, their recognition criteria. Importance of unconformity	12
	Total	48

Reference Books:

R1. Turner, F.J. and Weiss, L.E. (1963): Structural analysis of Metamorphic Tectonites McGraw Hill.

R2. Ghosh, S.K. (1993): Structural Geology: Fundamental and Modern Developments. Pergamon Press.

R3 Ramsay, J.G. and Huber, M.I. (1983): Techniques of Modern Structural Geology. Vol. I. Strain Analysis. Academic Press.

R4. Ramsay, J.G. and Huber, M.I. (1987): Techniques of Modern Structural Geology. Vol. II. Folds and Fractures. Academic Press.

R5. Twiss, R.J. and Moores, E.M. (2006): Structural Geology Second Edition, W. H. Freeman

R6. Fossen, H. 2010: Structural Geology, Cambridge University Press:

R7. Marshak S and Mitra, G (1988): Basic Methods of Structural Geology, Prentice Hall

Course Outcome	At the end of the course, the students will be able to: i) Explore different rock structures and its fame ii) Explore the different skills to identify the rock structure

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL104	GEOMORPHOLOGY & GLOBAL TECTONICS	4	20	80

Objectives	The basic objective of this course is to introduce different landforms and its formation mechanism with significance and also present the ideas related to tectonics.
Pre-Requisites	Knowledge of several agents of transportation and deposition and tectonic plates
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with focus on model presentation

Detailed Syllabus

Unit	Topics	Hours
I	Geomorphic principles and processes, Weathering and associated landforms, erosion, Karst topography, soil profile, classification of soils, Geomorphic sub-divisions of India and Odisha.	14
II	Fluvial processes and landforms, regime concept, Drainage Analysis, Aeolian processes and landforms, Glacial processes and landforms, Coastal processes and landforms.	10
III	Theory of isostasy, Concept of plate tectonics. mechanism of plate tectonics, Types of plate boundaries. Characteristic features of accretionary, conservative and destructive boundaries. Mid-oceanic ridges. Sea-floor spreading. Continental rifting, transform faults, Island arcs	12
IV	Origin and composition of Archaean crusts. Proterozoic orogenic belts. Geosynclines and mountain building activity, Configuration of Indian plate. Evolution of the Himalaya and Himalayan tectonics.	12
	Total	48

Reference Books:

R1. Thornbury, W.D. 2004: Principles of Geomorphology. 2nd edition CBS Publication.
R2. Summerfield M.A 2011: Geomorphology and Global Tectonics, Wiley India Pvt Ltd.
R3 Gautam, A. 2015 : Geomorphology 5th Edition. Sharda Pustak Bhavan Allahabad.
R4. Siddhardha, K. 2016 : The Earth's Dynamic Surface- A book of Geomorphology, Kitab Mahal
R5. Singh Savindra 2016 : Geomorphology. Pravalika Publication Allahabad
R6. Condie, Kent. C. 1989. Plate Tectonics and Crustal Evolution. 3rd Edition. Butterworth-Heinemann Ltd.
R7 Windlley B. 1995: The Evolving Continents. 3 rd Edition Wiley-Blackwell.
R8 Davies, G.F. 1999: Dynamic Earth: Plates, Plumes and Mantle Convection. Cambridge University Press.
R9. Kearey P, Klepeis, K A and Vine, F.J 2009: Global Tectonics 3rd Edition. Wiley-Blackwell.

Course Outcome	At the end of the course, the students will be able to: i) Differentiate different landforms and its origin of formation ii) Signify the importance of each landform iii) Unravel the significance and mechanism of plate movement

Sub. Code	Subject Name	Marks	Total	Credit
GL105	GEOLOGY LAB I		70	6
	(a).Practical related to Papers GL 101, GL102	35		
	(b).Practical related to Papers GL 103, GL 104	35		
	Seminar	30	30	2

Detailed Syllabus

Unit	Topics	Hours
I	Identification of crystal models as per theory, Stereographic Projection of crystals, Axial ratio determination. Megascopic and Microscopic identification of rock forming minerals. Determination of sign of elongation, Extinction angle, scheme of pleochroism, Order of interference colours, Optic sign. Calculation of mineral formulae from chemical data.	54
II	Completion of outcrops. Interpretation of geological maps. Structural problems – thickness and depth of strata, three-point problem, determination of true and apparent dips. Stereographic projection – π and β diagrams. Plotting of line and planes, problems relating to true and apparent dips, plunge and pitch, angle between planes and lines. Completion of outcrop; Study and interpretation of structural maps. Contouring of land forms, Toposheet studies, Slope and drainage analysis, Morphotectonic analysis.	54
III	*Laboratory records and viva voce.*	
	Total	108

SEMESTER II

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL201	Igneous Petrology	4	20	80

Objectives	The basic objective of this course is to introduce students the detail idea related to igneous rocks formation, texture, structure and its types
Pre-Requisites	Knowledge of igneous rock analysis
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with focus on field based knowledge

Detailed Syllabus

Unit	Topics	Hours
I	Viscosity, temperature and pressure relationships in magmas; Classification of igneous rocks; nucleation and growth of minerals in magmatic rocks, development of igneous textures; structure.	14
II	Magmatic differentiation, assimilation, mixing and mingling; types of mantle melting (batch, fractional and dynamic); binary phase diagramand ternary (diopside-forsterite-silica, diopside-forsterite-anorthite and nepheline-kalsilite-silica) phase diagrams and relevance to magmatic crystallization;	10
III	Petrology and petrogenesis of granites, basalts, ophiolite suite, komatiites, syenites, boninites, anorthosites and layered complexes, and alkaline rocks (carbonatite, kimberlite, lamproite, lamprophyre);	12
IV	Mantle metasomatism, hotspot magmatism and large igneous provinces of India: Deccan trap, Singhbhum Granite. Inter-relation between tectonic setting and igneous rock suits.	12
	Total	48

Reference Books:

R1. J.D. Winter (2010) Principles of Igneous and Metamorphic Petrology, Pearson Prentice Hall.

R2. Robin Gill (2010) Igneous Rocks and Processes: a practical guide. John Wiley & Sons.

R3 Gautam Sen (2014) Petrology: Principles and Practice, Springer-Verlag publisher.

R4. A. Philpotts and J. Ague (2009) Principles of Igneous and Metamorphic Petrology, Cambridge University Press.

R5. K.G. Cox, J.D. Bell and R.J. Pankhurst (1979) . The Interpretation of Igneous Rocks Chapman and Hall publishing

R6. M. Wilson (1989) Igneous Petrogenesis: A Global Tectonic Approach. Chapman and Hall publishing

R7 B.R. Frost and C.D. Frost (2014) Essentials of Igneous and Metamorphic Petrology Cambridge University Press.

Course Outcome	At the end of the course, the students will be able to: i) Explore different igneous rocks ii) Composition, temperature and pressure condition of igneous rocks iii) Differentiate between igneous rocks of several era

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL202	Sedimentology and Fuel Geology	4	20	80

Objectives	The basic objective of this course is to introduce students the ideas of formation, texture and structure of sedimentary rocks and its analysis with study of fuel geology
Pre-Requisites	Knowledge of sedimentary rock types
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with focus on field based studies

Detailed Syllabus

Unit	Topics	Hours
I	Sedimentary textures, sedimentary structures; Sedimentation processes, principles and application of paleocurrent analysis, bed load and suspension load transport; Element of Hydraulics, Classification of sedimentary rocks. Composition, classification and significance of different types of sandstone, limestone, banded iron formation, mudstone, conglomerate; carbonate diagenesis and dolomitisation, Sedimentary Provenance	14
II	Study of heavy minerals and their significance, sedimentary environments and facies, sedimentation in major tectonic settings; Sequence stratigraphy, Basin Analysis : Concepts, Methods and Applications, Sedimentary basins of India	10
III	Origin and classification of coal, Rank of coal, Proximate and ultimate analyses of coal, Microscopic constituents of coal, Coal carbonization, Hydrogenation, Liquification and gasification, Environmental impact of coal mining, Coal bed Methane. coal deposits of India.	12
IV	Origin, migration and entrapment of natural hydrocarbons, mode of occurrence of petroleum, seepages, oil shale or kerogen shale, structural, stratigraphic and mixed traps; Reservoir rocks, pore space, Methods of Petroleum Exploration. Petroleum deposits of India. Gas Hydrate.	12
	Total	48

Reference Books:

R1. Boggs, S. (2001): Principles of Sedimentology and Stratigraphy, Prentice Hall.

R2. Blatt, H., Middleton, G.V. and Murray, R.C. (1980): Origin of Sedimentary Rocks,Prentice-Hall Inc.

R3 Collins, J.D., and Thompson, D.B. (1982): Sedimentary Structures. George Allen & Unwin, London.

R4. Lindholm, R.C. (1987) A Practical Approach to Sedimentology. Allen & Unwin, London.

R5. Pettijohn;, F.J. (1975): Sedimentary Rocks. 3 rd Edn. Harper and Row Publ., New Delhi.

R6. Reading, H.G. (1997): Sedimentary Environments and facies, Blackwell Scientific Publication.

R7 Selley, R. C. (2000) Applied Sedimentology, Academic Press.

R8 Tucker, M.E. (1981): Sedimentary Petrology: An Introduction, Wiley & Sons, New York.

R9 Tucker, M.E. (1990): Carbonate Sedimentolgy, Blackwell Scientific Publication.

Course Outcome	At the end of the course, the students will be able to: i) Explore types of sedimentary rocks ii) Analyze sedimentary rocks and its significance iii) Importance of coal and petroleum with respect to mode of formation

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL203	Metamorphic Petrology	4	20	80

Objectives	The basic objective of this course is to represent the process and tectonism of formation of metamorphic rocks related to several attributes
Pre-Requisites	Knowledge of types of metamorphic rocks
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with focus on field-based studies

Detailed Syllabus

Unit	Topics	Hours
I	Limits and physico-chemical controls (pressure, temperature, fluids and bulk rock composition) of metamorphism; Types of metamorphism, equilibrium concept in thermodynamics; laws of thermodynamics, enthalpy, entropy, Gibb's free energy, chemical potential, fugacity and activity; tracing the chemical reactions in P-T space, phase rule and mineralogical phase rule in multi-component system.	14
II	Concept of zones, facies, isograds and facies series, geothermal gradients and tectonics of orogenic belts; structures, micro-structures and textures of regional and contact metamorphic rocks; representation of metamorphic assemblages (ACF, AKF and AFM diagrams).	10
III	metamorphic reactions; geothermobarometry; mass and energy change during fluid-rock interactions; Metasomatism, Granitisation, charnockite problem, formation of skarns, progressive and retrogressive metamorphism of pelitic, calcareous and basic rocks; P-T-t path and tectonic setting.	12
IV	Ocean floor metamorphism, Cataclastic metamorphism, Paired metamorphic belts., Petrology of important metamorphic rocks – Khondalites, Charnockites, Leptynite, quartzite, slate, marble, migmatites, schist and gneiss.	12
	Total	48

Reference Books:

R1. Bhaskar Rao, B. 1986. Metamorphic Petrology. Oxford & IBH.

R2. Philpotts, A.R. 1994 Principles of Igneous and Metamorphic Petrology, Prentice Hall.

R3 Winter, J.D. 2001, An introduction to Igneous and Metamorphic Petrology, Prentice Hall.

R4. Wood, B.J. and Fraser, D.G. 1976: Elementary Thermodynamics for Geologists, Oxford University Press, London.

R5. Yardlley, B.W.D. 1989, An introduction to Metamorphic Petrology, Longman Scientific & Technical, New York

Course Outcome	At the end of the course, the students will be able to: i) Explore different tasks of data mining. ii) Explore the different techniques of soft computing. iii) Differentiate between supervised and unsupervised learning.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL204	Oceanography, Atmospheric Science & Disaster Management	4	20	80

Objectives	The basic objective of this course is to introduce students the ideas of ocean floor and its significance related to several geographic region and climatic condition
Pre-Requisites	Knowledge of world oceans
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with focus on model presentation

Detailed Syllabus

Unit	Topics	Hours
I	Relief and Morphology of ocean floor, Marine sediments and their classification, Sea floor mineral resources, Physical and chemical properties of sea water and their spatial variations. Residence times of elements in sea water.	14
II	Fundamental principles of climatology. Earth's radiation balance; latitudinal and seasonal variation of insolation, temperature, pressure, wind belts, humidity, cloud formation and precipitation, water balance. Air masses, The global wind system, monsoon, Jet streams, tropical cyclones, and ENSO. Classification of climates – Koppen's and Thornthwaite's scheme of classification. Climate change.	10
III	Ocean currents; Formation of subtropical gyres; western boundary currents; equatorial current systems, Ekman's theory; upwelling and sinking, Geostrophic motion; Characteristics of the global conveyor belt circulation and its causes.; El Niño, Monsoonal winds and currents over the North Indian Ocean, waves and tides.	12
IV	Climate change, global warming, Concept of disaster management; Management of earthquake, cyclone, tsunami, flood and landslide hazards; Hazards related to mining	12
	Total	48

Reference Books:

R1. Alan P. Trujjilo and Harold V. Thurman: Essentials of Oceanography (tenth edition).
R2. P. R. Pinet (1992): Oceanography: An introduction to the Planet Oceanus, West Pub,Co
R3. J.Weisberg & H. Parish (1974). Introductory Oceanograpghy. McGraw Hill
R4.. C. Donald Ahrens: Meteorology Today: An introduction to weather, climate and environment.
R5. Lal,D.S.,- Climatology, Chaitanya Publication, Allahabad.1986
R6. Valdiya, K.S. (1987) Environmental Geology – Indian Context. Tata McGraw Hill
R7. Bryant, E. (1985) Natural Hazards, Cambridge University Press
R8. Patwardhan, A.M. (1999) The Dynamic Earth System. Prentice Hall
R9. Subramaniam, V. (2001) Textbook in Environmental Science, Narosa International
R10. Bell, F.G. (1999) Geological Hazards, Routledge, London
R11. Smith, K. (1992) Environmental Hazards. Routledge, London

Course Outcome	At the end of the course, the students will be able to: i) Explore different tasks of data mining. ii) Explore the different techniques of soft computing. iii) Differentiate between supervised and unsupervised learning.

Sub. Code	Subject Name	Marks	Total	Credit
GL205	GEOLOGY LAB II		70	6
	(a).Practical related to Papers GL 201, GL 202	35		
	(b).Practical related to Papers GL 203, GL 204	35		
	Seminar	30	30	2

Detailed Syllabus

Unit	Topics	Hours
I	Megascopic and microscopic petrography of igneous rocks, calculation of norm and Niggli values. Megascopic and microscopic petrography of metamorphic rocks. ACF, AKF and AFM diagrams.	54
II	Megascopic and microscopic petrography of sedimentary rocks. Drawing of histogram, frequency curve and cumulative frequency curve. Determination of mean, standard deviation, skewness, kurtosis by graphical methods. Determination of resultant palaeocurrent vector and drawing of rose diagram.	54
II	Field Report, Laboratory records and viva voce.	
	Total	108

SEMESTER III

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL301	Paleontology and Quaternary Geology	4	20	80

Objectives	The basic objectives of this units is to know about the characteristic properties, origin and classification of fossils.
Pre-Requisites	Knowledge of fossilization and age of strata
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with focus on hands on practices.

Detailed Syllabus

Unit	Topics	Hours
I	Fossilization Processes (Taphonomy), Modes of preservation. Study of morphology, classification, evolution and extinction of Trilobites, Brachiopods. Lamellibranchs, Gastropods, Cephalopods and Graptolite.	12
II	Study of morphology, Classification and evolution of Echinoids and Corals. Concept of evolution. Evolution of horse, elephant and man. Evolution and extinction of Dinosaurs; General study of fossil plants, Gondwana flora and its significance.	10
III	Types of microfossils, their separation and preparation for study. Application of microfossil study in different fields with special reference to study of biostratigraphy and petroleum exploration. Study of morphology and ecology of foraminifers. Morphology and importance of Ostracods, Coccolithophores and Diatoms and conodonts, Palynology.	14
IV	Global sea level rise – past and future, Pleistocene glaciations – Causes and effects, Climate changes in Quaternary, Quaternary deposits and land forms of India. Quaternary dating methods; Radiocarbon, Uranium Series, argon isotope; OSL dating.	12
	Total	48

Text Books:

T1. Prothero, D.R. (2004): Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill

T2. R. C. Moore, C. G. lalicker and A. G. Fischer (2004) Invertebrate fossils, CBS Pub. & Dist., New Delhi

T3. Stowe, K.: Exploring Ocean Science: John Wiley, New York

Reference Books:

R1. B.U. Hag and A. Boersma (1978). Introduction to marine micropaleontology. Elsevier, Netherlands, 376p.

R2. M.D. Brasier (1980). Microfossils. George Allen & Unwin, London, 193p

R3. Wadia et al: Quaternary environments and geoarchaeology of India. Geol. Soc. India, Bangalore.

R4. Vaidyanathan, R. (ed): Quaternary Deltas of India: Geol. Soc. India, Bangalore.

R5. S. K. Shah (2013) Elements of Paleontology, Geological Society of India, Bangalore

Course Outcome	At the end of the course, the students will be able to: i) find out the age of various strata ii) interpret the paleoenvironment.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL 302	Stratigraphy	4	20	80

Objectives	The main objectives of studying stratigraphy is to know the logical deposition of strata according to geological time.
Pre-Requisites	Knowledge of deposition, bedding, strata
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive.

Detailed Syllabus

Unit	Topics	Hours
I	Principles of Stratigraphy, Stratigraphic correlation. Standard stratigraphic time scale and their Indian equivalence, Code of stratigraphic nomenclature, Concepts of Sequence-, magneto-, seismic- and chemo-stratigraphy.	10
II	Physiographic divisions of India, General character, stratigraphy, structure, lithology and economic resources of Dharwar, Singhbhum, Eastern Ghats, Aravalli. Detailed study of type areas of Cuddapah and Vindhyan Supergroups and other important groups (Delhi, Chhatisgarh and Kurnool).	14
III	Distribution and detailed study of the type areas of Palaeozoic (Spiti and Kashmir), Mesozoic (Triassic of Spiti, Jurassic of Kutch and Cretaceous of Trichinopolly), Concept of palaeogeographic reconstruction. Paleogeography of India during Permo-carboniferous period, Triassic, Jurassic and Cretaceous Periods.	14
IV	General character, stratigraphy, structure, lithology, economic resources and fossil contents of Gondwana Supergroup; Paleogene of Assam, Siwalik Group, Deccantraps, Palaeoclimatic reconstruction., Structure and Stratigraphy of Odisha.	10
	Total	48

Text Books:

T1. M.S. Krishnan 1982. Geology of India and Burma. CBS Publ. & Distributors, New Delhi.
T2. C.O. Dunbar & J. Rodgers 1957 Principles of stratigraphy. John Wiley and Sons, New York.
T3. Ravindra Kumar 1978. Historical Geology and Stratigraphy of India.

Reference Books:

R1. Naqvi, S.M. and Rogers, J.J.W. (1987): Precambrian Geology of India, Oxford University Press.
R2. Pascoe, E.H. (1968): A Manual of the Geology of India and Burma (Vols.I-IV), Govt. of India Press, Delhi

Course Outcome	At the end of the course, the students will be able to: i) find out the age, ii) lithological constitution and iii) economic importance of various strata.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL303	Economic Geology	4	20	80

Objectives	The main objective of studying Economic Geology is to know about the characteristic properties, origin and distribution of various ore and minerals of India.
Pre-Requisites	Basic knowledge of ore, mineral, mining, prospecting, exploration
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with special focus on Indian minerals.

Detailed Syllabus

Unit	Topics	Hours
I	Ore and gangue minerals, tenor, grade and loads, Processes of formation of Ore deposits: Controls of ore localization, Metallogenic epoch and provinces of India. Mineralogy, mode of occurrence, genesis, uses and Indian distribution of Iron, Manganese, Chromium, Copper, Lead and Zinc, Gold, and Aluminium ores. Important ore deposits of India	12
II	UNFC classification of ore reserves, Methods of prospecting, regional exploration and detailed exploration; geological, geochemical and geobotanical methods, geophysical methods (gravity, magnetic, electrical and seismic methods), Sampling, assaying, ore evaluation and reserve estimation.	10
III	Drilling, Mining, Ore beneficiation: Comminution, Crushing, Grinding, Different techniques of beneficiation: gravity separation, jigging, dense media separation; Tabling, froth floatation, magnetic and electrostatic separation. Ore beneficiation practices adopted in Fe, Mn, Al, Cr ore deposits.	13
IV	National mineral policy, strategic, critical and essential minerals, India's status in mineral production, Sustainable mineral development. Industrial minerals: Minerals/Rocks used in cement, refractories, ceramics and fertilizer industries. Mode of occurrence, genesis and Indian distribution of Mica, Asbestos, Graphite, Gypsum, limestone and barites. Gem stones of Odisha.	13
	Total	48

Text Books:

T1. G.B. Mohapatra (2010) Text book of Geology; CBS Pub. & Dist., New Delhi

Reference Books:

R1. Chandra, D., Singh, R.M. Singh, M.P., 2000: Textbook of Coal (Indian context). Tara Book Agency, Varanasi.

R2. Evans, A.M. (1993): Ore Geology and Industrial Minerals, Blackwell.

R3. James R. Craig and David J.Vaughan (1994): Ore Microscopy and Petrography.

R4. Klemm, D.D. and Schnieder, H.J. (1977): Time and Strata Bound Ore Deposits, Springer-Verlag.

R5. Levorson, A.I. Geology of Petroleum.

R6. Mookherjee, A. (2000): Ore Genesis-A Holistic Approach, Allied Publisher.

R7. Selley, R.C., 1998: Elements of Petroleum Geology. Academic press.

R8. Singh, M.P. (Ed.) 1998: Coal and organic Petrology. Hindustan Publishing Corporation, New Delhi.

Course Outcome	At the end of the course, the students will be able to: i) find out the properties and uses of minerals, ii) distribution of economic minerals iii) economic importance of various minerals. iv) conservation and management

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL304	General Geology and Mineral Resources of Odisha	4	20	80

(CBCS for other departmental students)

Objectives	The main objective of studying General Geology and Mineral Resources of Odisha is to get elementary idea about the General Geology of the earth, various Geological activities and too aware about the mineral resources available in Odisha.
Pre-Requisites	Knowledge of Geologic agents, ore, rock, mineral, mining
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with special focus on Orissa mineral resources.

Detailed Syllabus

Unit	Topics	Hours
I	Origin of the earth, internal structure of the earth, volcano, earthquake, concept of plate tectonics	10
II	Principles of geomorphology, Different geomorphic agents, Landforms developed by Wind, River, Glacier, Ground water, Sea	12
III	Introduction to mineralogy, Study of different mineral groups, Formation and classification of rocks (Igneous, Sedimentary and Metamorphic rocks) and petrography of different rocks	13
IV	Introduction to economic geology, Economic mineral resources of Odisha- Iron, Manganese, Chromite, Bauxite, Coal., Graphite and beach placer deposit	13
	Total	48

Text Books:

T1. G.B. Mohapatra (2010) Text book of Geology; CBS Pub. & Dist., New Delhi
T2. G.B. Mohapatra (2010) Text book of Physical Geology; CBS Pub.
T3. V. Radhakrishnan (1987) General Geology, V.V.P. Publishers, Tuticorin

Reference Books:

R1. Holmes, A. 1992: Holmes Principles of Physical Geology Edited by P. McL. D. Duff. Chapman and Hall, London.
R2. Mineral Resources of Odisha (2006), SGAT, Bhubaneswar
R3. Sharma, H.S. 1990: Indian Geomorphology. Concept Publishing Co. New Delhi.
R4. Siddhardha, K. 2016: The Earth's Dynamic Surface- A book of Geomorphology, Kitab Mahal

Course Outcome	At the end of the course, the students will be able to: i) Aware about the various geological activities undergoing in the earth system. ii) Describe various types of rocks/minerals etc. iii) Describe distribution of economic minerals of Odisha

Sub. Code	Subject Name	Marks	Total	Credit
GL305	GEOLOGY LAB III			
	(a).Practical related to Papers GL 301, GL 302	35	70	6
	(b).Practical related to Papers GL 303	35		
	Seminar	30	30	2

(PRACTICAL RELATED TO PAPERS GL 301, GL 302 & GL 303)

Detailed Syllabus

Unit	Topics	Hours
I	Identification of animal and plant fossils as stated in theory. Graphic representation of their stratigraphic intervals. Arrangement of fossils in chronological order. Drawing and labeling of fossils. Stratigraphic assemblages – Identification and interpretation.	27
II	Megascopic identification of metallic and nonmetallic minerals, Microscopic identification of ore minerals and their textures.	27
III	Calculation of assay value and reserve.	54
	Laboratory records and viva voce.	
	Total	108

SEMESTER IV

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL401	Groundwater & Engineering Geology	4	20	80

Objectives	The main objective of studying Groundwater & Engineering Geology is to know the characteristic properties, origin and types of groundwater and to know the requirement of geology for the construction of various engineering structures such as bridge, tunnel etc.
Pre-Requisites	Knowledge of Geologic deformations, engineering properties of rocks.
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with special focus on Indian context.

Detailed Syllabus

Unit	Topics	Hours
I	Global distribution of water, hydrologic cycle Vertical distribution of Ground water, Hydrologic properties of water bearing materials- porosity, permeability, specific yield and specific retention, hydraulic conductivity and transmissivity. Types of water bearing formations- Aquifiers, Aquicludes, Aquitards and Aquifuge. Classification of aquifers. Ground water movement storage co-efficient, cone of depression. Darcy's Law in isotropic and anisotropic media, Design and construction of tube well.	12
II	Ground water exploration- Geological, Geophysical and remote sensing methods. Well drilling techniques. Quality of groundwater and quality criteria for different uses. Groundwater provinces of Odisha and India, saline water intrusion, Waste water reuse systems, Organic and inorganic contamination of groundwater and their remedial measures, Artificial Recharge of Groundwater.	12
III	Engineering properties of rocks and soil; geological investigations in construction of tunnels, bridges, highways and coastal protection structures; geologic considerations of construction.	11
IV	Building materials (road metals, building stones, concrete aggregate). Landslides and stability of slopes. Earthquake resistant structure, Geotechnical considerations in dams and reservoirs and their environmental impact. case studies of major dam projects- Bhakra, Koyna, Hirakud and Balimela	13
	Total	48

Reference Books:

R1. Beavis, F.C. 1985. Engineering geology
R2. Bell, F.G. 1983. Fundamentals of engineering geology.
R3. Davies, S.N. and Dc-West, R.J.N. (1966): Hydrogeology, John Villey & Sons, New York.
R4. Davis, S.N. & De Wiest, R.J.N. 1966. Hydrogeology. John Wiley & Sons, New York.
R5. Ground Water and Wells (1977): UOP, Johnson, Div. St. Paul. Min. USA
R6. Raghunath, H.M. 1983. Groundwater. Willey Eastern, Calcutta.
R7. Todd, D.K. 1988. Groundwater Hydrology. John Willey and Sons.

Course Outcome	At the end of the course, the students will be able to: i) enable the students to use groundwater properly and will have the knowledge to install various types of wells. ii) know the requirement of geology for the construction of various engineering structures such as bridge, tunnel etc.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL402	Remote Sensing, GIS and Geostatistics	4	20	80

Objectives	The main objective of studying this course is to understand the aerial photography and its types with uses, remote sensing techniques and its application at several aspects of geological study and apply the knowledge of statistics in analyzing geological sample records
Pre-Requisites	Knowledge of photograph analysis and computer operation.
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with special focus on Indian satellites

Detailed Syllabus

Unit	Topics	Hours
I	Air-borne remote sensing: Concepts and principles of aerial photography, Aerial photographs - Types, Scale, Stereoscopy, Photo mosaics, Photo elements and photo interpretation.	12
II	Principles of Remote sensing, Types of platforms and sensors; Sensor resolution Remote sensing satellites Thermal radiation, Black body radiation, Interaction of EMR with terrain elements, Fundamentals of Microwave remote sensing, False colour composite, Interpretation of satellite imagery, Applications of remote sensing in landform and land use mapping, Structural mapping, Mineral and Groundwater exploration.	12
III	Concept and Objectives of Geographical Information Systems (GIS), conceptual models of spatial information- raster and vector data models, Digital Image processing, Digital Elevation Model	11
IV	Probability – concept, laws and application. Sampling methods; Frequency distribution and frequency tables. Graphical representation of frequency data - histogram, frequency curve and cumulative frequency curve. Normal frequency distribution. Degrees of freedom and level of significance. Correlation coefficient. The t-test – equality of sample means and significance of correlation coefficient. Chi-square test – goodness of fit. F-test and analysis variance. Least square method and regression analysis. Application of computer in solving statistical problems in geology.	13
	Total	48

Reference Books:

R1. Bhatta B, 2011: Remote Sensing and GIS 2nd Edition, Oxford University Press
R2. Davis, J.C. (1984) Statistics and data analysis in geology. John Wiley, New York
R3. Gupta, R.P. (1991) Remote Sensing Geology. Springer-Verlag. 356pp.
R4. Lilles T.M., Kiefer, R.W. and Chipman, J. 2008: Remote Sensing and Image Interpretation. 6th Edition, John Wiley and Sons
R5. Miller, V.C. & Miller, C.F. 1961. Photogeology. McGraw Hill, New York.
R6. Pandey, S.N. 1987. Principles and applications of photogeology. Wiley Eastern, New Delhi.
R7. Ray, R.G. 1969 Aerial photographs in geologic interpretation. USGS Professional Paper 373.

Course Outcome	At the end of the course, the students will be able to: i) Analyze aerial photograph ii) Apply remote sensing techniques in geological study iii) Geological field data analysis using statistics tools

ELECTIVES

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL403	(Special Paper – A) Ore Geology- I	4	20	80

Objectives	The main objective of studying Ore Geology is to gain understanding of the genesis and localization of ore deposits and the minerals associated with ore deposits.
Pre-Requisites	Knowledge of mineralogy, optics etc.
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with special focus on Indian context.

Detailed Syllabus

Unit	Topics	Hours
I	Concept of mineral equilibria- homogenous and inhomogeneous; Thermodynamic principles in mineral formation. Phase rule and its application, phase diagrams of binary (Fe- S and Cu-S) and ternary (Cu-Fe-S & Fe-Zn-s) systems. Eh – pH in natural environment; Eh-pH relationship with respect to iron and manganese in aqueous solution.	12
II	Concepts of ore genesis: genesis related to magmatic, hydrothermal activity, volcanic exhalation, residual, sedimentation, metamorphism, bacteriogenic activity, porphyry; ore deposits associated with plate boundaries. Mineralization associated with ultramafic, mafic and acidic rocks, greenstone belts, komatites, anorthosites, kimberlites and submarine volcanic exhalations.	12
III	Ore bearing fluids- nature, source, transportation, depositional environment in terms of ion potential and Fugacity. Chloride and sulphides complexes. Geological thermometry, Fluid inclusion studies. Ore textures and industrial application of ore microscopy. Properties of ore minerals under ore microscope, paragenesis and zoning.	12
IV	Mineralogy, mode of occurrence, uses, genesis and Indian distribution of Fe, Mn, Cr and tungsten ores with special reference to Indian occurrences. Mineralogy, mode of occurrence, uses, genesis and Indian distribution of Al, Cu, Pb & Zn, Sn, Au, Ni and Ag ores with special reference to Indian occurrences and growth of industries.	12
	Total	48

Reference Books:

R1. Borroah , S.K. (1963) Economic Mineral deposits of India. Sewali Prakash Bhawan.
R2. Evans, A.M. (1993): Ore Geology and Industrial Minerals, Blackwell.
R3. Gokhale, KVGK and Rao TC (1982) Ore Deposits of India. Affiliated East-West Press.
R4. James R. Craig and David J.Vaughan (1994): Ore Microscopy and Petrography.
R5. Klemm, D.D. and Schnieder, H.J. (1977): Time and Strata Bound Ore Deposits, Springer-Verlag.
R6. Mookherjee, A. (2000): Ore Genesis-A Holistic Approach, Allied Publisher.
R7. Prasad, U. (1996) Economic Geology, CBS publishers.
R8. Publications of the Geological Society of India on Mineral Resources of various states of India
R9. Sarkar, S.C. and Gupta, A. (2013) Crustal evolution and metallogeny in India. Cambridge University Press.
R10. Stanton, R.L. (1972): Ore Petrology, McGraw Hill.
R11. Wolf, K.H. (1976-1981): Hand Book of Stratabound and Stratiform Ore Deposits, Elsevier Publ

Course Outcome	At the end of the course, the students will be able to: i) understand the genesis and localization of ore deposits ii) understand the minerals associated with ore deposits

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL404	(Special Paper – A) Ore Geology- II	4	20	80

Objectives	The main objective of studying these Units is to gain understanding of the various laws associated with Mining, exploration methods and use of various Instruments for mineral characterization.
Pre-Requisites	Knowledge of mineralogy, optics etc.
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with special focus on Indian context.

Detailed Syllabus

Unit	Topics	Hours
I	Concept of mineral economics and its importance in national development, Mineral legislation; national mineral policy; mineral taxation, preservation of environment, Mineral conservation. The mines and minerals (regulation and development), Sustainable mineral development, Marine mineral resources and laws of the sea.	12
II	UNFC classification of reserves, Stages of exploration; scope, objectives and methods of prospecting, regional exploration and detailed exploration; geological, geochemical and geobotanical methods, geophysical methods (gravity, magnetic, electrical and seismic methods).	12
III	Sampling, assaying, ore evaluation and reserve estimation, Drilling, Mining, Ore beneficiation: Comminution, Crushing, Grinding, Different techniques of beneficiation: gravity separation, jigging, dense media separation; Tabling, froth floatation, magnetic and electrostatic separation. Ore beneficiation practices adopted in Fe, Mn, Al, Cr ore deposits.	12
IV	Physical and microscopic properties of ore minerals; Sample preparation techniques of ore sample for microscopic study. Use of XRD, SEM and EPMA in mineral characterization. Mineral paragenesis and zoning. Fluid inclusion study.	12
	Total	48

Reference Books:

R1. Arogyaswami, R.P.N. (1996) Courses in Mining Geology, IV Ed. Oxford IBH
R2. Bagchi, T.C., Sengupta, D.K., Rao, S.V.L.N. (1979): Elements of Prospecting and Exploration. Blackwell Publishing House.
R3. Clark, G.B. (1967) Elements of Mining, III ed. John Wiley
R4. Dorbin, M.B. Introduction to geophysical prospecting.
R5. Gaudin, A.M. Principles of Mineral Dressing. McGaw Hill Pub. Co. Ltd. Bombay
R6. Moon, CJ, Micheal, KG, Whateley and Evans AM. 2006. Introduction to Mineral Exploration.
R7. Parasnis, D.S. Principles of applied geophysics.
R8. Ramachandra Rao. Geophysical prospecting for geologists.
R9. Sinha, R.K. and Sharma, N.L. (1976) Mineral Economics.
R10. Wills, BA. 1988. Mineral Processing Technology. Pergamon Press. Oxford.

Course Outcome	At the end of the course, the students will be able to: i) understand the Mineral legislations ii) understand the Management and conservation of minerals iii) Use the instruments like XRD, SEM, EPMA etc

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL403	(Special Paper – B) Remote Sensing and GIS - I	4	20	80

Objectives	The basic objective of this course is to introduce students the ideas and concepts of aerial photography and remote sensing techniques
Pre-Requisites	Knowledge of photograph analysis and fundamentals of computer operation
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with special focus on Indian context.

Detailed Syllabus

Unit	Topics	Hours
I	Principles of aerial photography, types of aerial photographs, characteristics features of aerial photography- scale, vertical exaggeration, drift and crab. Photo elements, Photo mosaics, visual image interpretation- general procedure, interpretation of aerial photograph and satellite imagery, false color composite (FCC), stereoscopes.	11
II	Concepts of remote sensing, components of remote sensing system, Electromagnetic radiation (EMR), Spectral bands, Atmospheric interactions with EMR, Interactions of EMR with Earth's surface materials, Remote sensing platforms- types and uses. Sensors: fundamental properties and functions. Resolution: spatial, spectral, temporal and radiometric, Sensor characteristics of remote sensing satellites: Landsat, IRS, ASTER, Quickbird	13
III	Visual Image Interpretation, Interpretation keys; Digital Image Processing: Concepts, Preprocessing, Image Enhancement, transformation and classification; Multispectral, Hyperspectral Thermal and Microwave Remote Sensing	10
IV	Earth Model: Geoid, Authalic sphere and ellipsoid and their uses in GIS; Concept of datum: geocentric and local geodetic, horizontal and vertical; Co-ordinate systems: Geographic and planar; Concept of Map projections: Principal scale and scale factor, Concept of cylindrical, conical and planar map projections; Brief idea about commonly used map projections: Mercator, Transverse Mercator, Universal Transverse Mercator (UTM), Lambert Conformal, Conic and Polyconic; Digital Image Processing: Geometric and radiometric Corrections of satellite images; Image enhancement and classification.	14
	Total	48

Reference Books:

R1. Drury, S.A. 1987: Image Interpretation in Geology. Springer
R2. Pandey, S. N. 1987: Principles and Applications of Photogeology, Wiley Eastern limited.
R3. Ravi P Gupta 2003: Remote Sensing Geology 2nd Edition- Springer
R4. George Joseph 2005: Fundamentals of Remote Sensing 2nd edition: Universities Press
R5. Gopi, S, Sathikumar, R and Madhu, N 2006: Advanced Surveying total station GIS and Remote
R6. Sensing Pearson Education
R7. Sabins, F.F. 2007: Remote Sensing Principles and Interpretations 3rd Edition, Waveland Pr Inc.

Course Outcome	At the end of the course, the students will be able to: i) Analyze aerial photographs ii) Apply remote sensing techniques in geological study iii) Geological field data analysis using statistics tools

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL404	(Special Paper – B) Remote Sensing and GIS - II	4	20	80

Objectives	The basic objective of this course is to introduce students the concepts of GIS, GPS and application of remote sensing
Pre-Requisites	Knowledge related to fundamentals of computer operation
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with special focus on GIS software

Detailed Syllabus

Unit	Topics	Hours
I	Concept of GIS: Definition and components of GIS; Object based and field based GIS data model; Raster, vector, Spatial and non spatial data structures; Data Based Management Systems and Model; Spatial Analysis: Spatial elements and analysis, local, focal, zonal and global operations; GIS query and output, Digital Elevation Model (DEM) and its derivative.	14
II	Introduction to Global Navigation Positioning System, Various Global/Regional Satellite constellations, NAVSTAR GPS signals, Augmentation Systems (IRNSS, GAGAN, WAAS, LAAS etc.) – basic concepts and applications	10
III	Application of remote sensing techniques in geological and geomorphological mapping, land use and land cover studies, terrain evaluation, mineral exploration and groundwater resources evaluation, petroleum exploration. engineering site evaluation for dam, reservoir, tunnel and highways.	11
IV	Application of remote sensing techniques in agricultural management, forest mapping and management, irrigation and watershed management, Application of remote sensing in environmental hazard managements- floods, landslide and coastal erosion, soil mapping, waste land mapping, sustainable development studies.	13
	Total	48

Reference Books:

R1. Drury, S.A. 1987: Image Interpretation in Geology. Springer
R2. Pandey, S. N. 1987: Principles and Applications of Photogeology, Wiley Eastern limited.
R3. Ravi P Gupta 2003: Remote Sensing Geology 2nd Edition- Springer
R4. George Joseph 2005: Fundamentals of Remote Sensing 2nd edition: Universities Press
R5. Gopi, S, Sathikumar, R and Madhu, N 2006: Advanced Surveying total station GIS and Remote
R6. Sensing Pearson Education
R7. Sabins, F.F. 2007: Remote Sensing Principles and Interpretations 3rd Edition, Waveland Pr Inc.

Course Outcome	At the end of the course, the students will be able to: i) Spatial and non spatial data analysis using GIS ii) Global Navigation Positioning System data study iii) Interpret the satellite image using GIS software

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL403	(Special Paper – C) Applied Micropaleontology, Palaeobotany and Palynology - I	4	20	80

Objectives	The main objective of studying these Units is to gain understanding of the various micro fossils and their applications in Geology
Pre-Requisites	Basic knowledge on micro fossils and paleontology
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with special focus on Indian context.

Detailed Syllabus

Unit	Topics	Hours
I	Fundamentals of Micropalaeontology: Applications of palaeontology, objective of micropalaeontology, microfossil groups and their importance, processing of samples, marine environment, Historical review, Commercial importance.	10
II	Foraminifera: Test morphology, life style, food, symbiosis, life cycle, wall structure and composition, Chamber growth and development, Evolution of Foraminifera, General classification, Foraminiferal bioenvironmental indicators, Palaeoecological significance of Foraminifera, Distribution of planktonic foraminifera.	15
III	Ostracods: Morphology of the ostracod carapace, ontogeny, articulation, distribution and ecology of ostracods, ecological variables, applications of ostracods; classification, geological history of Ostracod.	11
IV	Coccolithophores: Introduction; Coccolith morphology; Coccolith Life-Style, Ecology and Reproduction; Coccoliths and Sedimentation; Geologic history of coccoliths.	12
	Total	48

Reference Books:

R1. Arnold (2002): Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford
R2. B. U. Haq and A. Boersma (1998). Introduction to Marine Micropaleontology, Elsvier.
R3. Bignot, G., Grahm and Trottman (1985): Elements of Micropaleontoogy, London.
R4. G. Bignot (1985). Elements of Micropaleontology. Graham & Trotman, London, 212p.
R5. Grant Gross, M. (1977): Oceanography; A view of the Earth, Prentice Hall.
R6. J.P. Kennet & M.S. Srinivasan (1983). Neogene-Planktonic Foraminifera. Hutchison Ross
R7. Jones, T.P. and Rowe, T.P. (1999): Fossil plants and spores, Modern Techniques, Geological Soc. of London
R8. M.D. Brasier (1980). Microfossils. George Allen & Unwin, London, 193p.
R9. P.K. Saraswati and M. S. Srinivasan (2016): Micropaleontology: Principles and Applications, Springer
R10. P. R. Pinet (1992): Oceanography: An introduction to the Planet Oceanus, West Pub, Co Publ. Co., U.S.A., 263p.

Course Outcome	At the end of the course, the students will be able to: i) Gain knowledge about composition of micro fossils ii) Describe the applications of microfossils in different aspects.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL404	(Special Paper – C) Applied Micropaleontology, Palaeobotany and Palynology - II	4	20	80

Objectives	The main objective of studying these Units is to gain understanding of the various micro fossils and their applications in Geology
Pre-Requisites	Basic knowledge on micro fossils and paleontology
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with special focus on Indian context.

Detailed Syllabus

Unit	Topics	Hours
I	Diatoms: Introduction; living diatom, Cell contents of living diatom; Structure and morphology of a diatom (Diatom frustule; diatom symmetry planes; diatom ornamentation); Taxonomy; Growth and reproduction; Diatom distribution and ecology; Geologic record and evolution; Applications and importance of diatoms.	12
II	Radiolaria: Introduction; Cell contents Structure and morphology; their food, reproduction; Classifications, Groups: Polycystines, Phaeodarians, Geologic record, palaeoecology, geologic importance, and evolution, Radiolaria in Petroleum Exploration.	10
III	Palynology: Introduction, history of Palynology; mode of preservation, palynofossils through geological time, Groups of palynofossils, Morphology, Acritarchs, method of study (Collection of samples, Processing of samples, Laboratory processing, Chemical Extraction, Mounting, Photomicrography) applications: (Environmental Interpretation, Biostratigraphic Correlation, Hydrocarbon Exploration, Archeology, Medical Science, Criminology, Melissopalynology, Taxonomy, Pollen morphology, Agriculture)	16
IV	Gondwana flora (Glossopteris flora, Dicroidium flora, Ptillophyllum flora) and their significance, important Gondwana plant fossils of Lycopodiales, Equisetales, Sphenophyllales, Filicales, Glossopteridales, Cycadales, Coniferales etc. plant groups)	10
	Total	48

Reference Books:

R1. Bignot, G., Grahm and Trottman (1985): Elements of Micropaleontoogy, London.
R2. Grant Gross, M. (1977): Oceanography; A view of the Earth, Prentice Hall.
R3. J.P. Kennet & M.S. Srinivasan (1983). Neogene-Planktonic Foraminifera. Hutchison Ross
R4. Jones, T.P. and Rowe, T.P. (1999): Fossil plants and spores, Modern Techniques, Geological Soc. of London
R5. M.D. Brasier (1980). Microfossils. George Allen & Unwin, London, 193p.
R6. P. R. Pinet (1992): Oceanography: An introduction to the Planet Oceanus, West Pub,Co
R7. Publ. Co., U.S.A., 263p.

Course Outcome	At the end of the course, the students will be able to: i) Gain knowledge about composition of micro fossils ii) Describe the applications of microfossils in different aspects.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL403	(Special Paper – D) Applied Hydrogeology and Water Management - I	4	20	80

Objectives	The main objective of studying Applied Hydrogeology and Water Management is to know the characteristic properties, origin, types of groundwater, application of hydrogeology and management of ground water.
Pre-Requisites	Knowledge of Hydrologic cycle, groundwater movement
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with special focus on Indian context.

Detailed Syllabus

Unit	Topics	Hours
I	Occurrence of groundwater-vertical zonation Geological formations, Aquifers, springs and Thermal springs. Origin of groundwater, Groundwater basins; Aquifer types components of hydrologic Cycle, Hydrometeorology, Hydrographs.	10
II	Groundwater properties based on storage and movement, porosity and permeability, Darcy's law, Transmissibility, specific yield, specific retention, storage coefficient, specific capacity of wells. Field and laboratory determination of porosity and hydraulic conductivity.Quality of groundwater, saline water intrusion.	12
III	Groundwater condition in rock types crystalline - volcanic, Carbonate, lithified sediments, fluvial deposits, coastal and aeolian deposits. Groundwater levels and its fluctuation, water table contour maps. Elementary idea on barometric and tidal efficiencies. Groundwater in different rocks and geomorphic terrain. Groundwater provinces of India and Odisha. Thermal springs of Odisha. Hydrology of arid zone and coastal zones of India.	16
IV	Design and construction of wells, yield tests and selection of pumpsets. Maintenance and development of wells. Unidirectional and radial flow of groundwater, general groundwater flow equations, pumping test, steady and unsteady flow, Theis, Theim, Jacobs and Walton's equations.	10
	Total	48

Reference Books:

R1. Davies, S.N. and Dc-West, R.J.N. (1966): Hydrogeology,John Villey & Sons, New York.
R2. Driscoll, F.G.(1988): Ground Water and Wells, UOP, Johnson Div. St. Paul. Min. USA
R3. Ground Water and Wells (1977): UOP,Johnson,Div. St. Paul. Min.USA
R4. Hiscock, K.M. and Bense, V.F., 2014. Hydrogeology: Principles and Practice 2nd Edition, Wiley-Blackwell
R5. Raghunath,H.M. (1983): Ground Water, Viley Eastern Ltd., Calcutta
R6. Todd, D.K. (1988): Ground Water Hydrology, John Viley & Sons,New York.

Course Outcome	At the end of the course, the students will be able to: i) Describe the characteristic properties ii) Describe the application of hydrogeology and management of ground water.

Sub. Code	Subject Name	Credit	Int. Mark	Ext. Mark
GL403	(Special Paper – D) Applied Hydrogeology and Water Management - II	4	20	80

Objectives	The main objective of studying Applied Hydrogeology and Water Management is to know the characteristic properties, origin, types of groundwater, application of hydrogeology and management of ground water.
Pre-Requisites	Knowledge of Hydrologic cycle, groundwater movement
Teaching Scheme	Regular classroom lectures with use of ICT tools as and when required, sessions are planned to be interactive with special focus on Indian context.

Detailed Syllabus

Unit	Topics	Hours
I	Groundwater problems related to foundation work, canals, Mining and tunnels. Problems of over-exploitation, artificial recharge and rain water harvesting. Groundwater estimation, Groundwater budgeting, groundwater balance, groundwater Legislation. Management of coastal aquifers of Odisha.	10
II	Quality of groundwater, Reporting of groundwater quality data, Maps and diagrams, Groundwater pollution, Suitability of groundwater for various uses, Fluoride problem in Odisha. Fluoride and Arsenic problems in India.	12
III	Groundwater basin management and conjuctive use, saline water intrusion into coastal aquifers. Groundwater exploration:- Geological, Geophysical and remote sensing methods, preparation of hydrogeomophic and lineament maps and their role in interpretation of groundwater.	16
IV	Surface water and ground water pollution and their treatment, Environmental impact of groundwater pollution and extraction of groundwater. Diseases due to various chemical constituents & trace metals in groundwater and their mitigation measures.	10
	Total	48

Reference Books:

R1. Davies, S.N. and Dc-West, R.J.N. (1966): Hydrogeology,John Villey & Sons, New York.
R2. Driscoll, F.G.(1988): Ground Water and Wells, UOP, Johnson Div. St. Paul. Min. USA
R3. Ground Water and Wells (1977): UOP,Johnson,Div. St. Paul. Min.USA
R4. Hiscock, K.M. and Bense, V.F., 2014. Hydrogeology: Principles and Practice 2nd Edition, Wiley-Blackwell
R5. Raghunath,H.M. (1983): Ground Water, Viley Eastern Ltd., Calcutta
R6. Todd, D.K. (1988): Ground Water Hydrology, John Viley & Sons,New York.

Course Outcome	At the end of the course, the students will be able to: i) Describe the characteristic properties ii) Describe the application of hydrogeology and management of ground water.

Sub. Code	Subject Name	Marks	Total	Credit
GL405	GEOLOGY LAB IV		70	6
	(a).Practical related to Papers GL 401, GL 402	35		
	(b).Practical related to Papers GL 403, GL 404	35		
	Dissertation/ project	30	30	2

(PRACTICAL RELATED TO PAPERS GL 401, GL 402, GL 403, GL 404)
Detailed Syllabus

Unit	Topics	Hours
I	**Practical relating to papers 401- 402** Analysis of Seismic Refraction, and Resistivity survey data, analysis and interpretation of bore hole logs. Water table contour maps, Determination of pH, conductance, total hardness of water samples. Soil study, Geological problems in dams, Tunnels and Bridges. Engineering properties of rocks. Practical relating to Special papers. Laboratory records and viva voce.	54
II	**Practical related to Special Papers 403-404**	54
	Practical (SPECIAL PAPER – A): Chemical analysis of ores- Fe, Mn, Cu. Mineralographic examination of ore minerals and etch test. Megascopic identification of ore bodies. Genetic and paragenetic interpretation from megascopic examination of ore assemblages. Reserve calculation and assay problems. Study of X-raydiffractogram for mineral identification. Lab. Record, Field report and Viva voce.	
	Practical (SPECIAL PAPER – B): Marking of principal points. Determination of scale. Tracing of details from aerial photos and imageries. Stereoscopic test, Use of pocket and mirror stereoscopes, use of parallax bar. Measurement of heights and determination of slopes from photos. Estimation of dip of beds. Study of topographic maps to identify typical landforms. Preparation of geologic, geomorphic and land use maps from aerial photos and imageries. Characterization of typical geologic formations of Odisha i.e. alluvial deposits, laterite deposits, Eastern Ghats, Gondwana rocks etc. Lab. Records, Field reports/Project report and viva-voce.	
	Practical (SPECIAL PAPER – C): Separation and processing of microfossils; identification of fossils as mentioned in theory. Laboratory records and viva voce.	
	Practical (SPECIAL PAPER – D): Determination of pH, conductance, turbidity, IDS, D.O., acidity alkalinity, Ca, Mg, Fluoride, bicarbonate, TH., Determination of porosity and permeability. Data interpretation of resistivity survey. Chemical data plotting, water table contour maps. Numerical problems related to various hydrologic properties. Hydrogeological interpretation by Remote Sensing method.	
	Total	108