Ph.D. Entrance Examination 2024 – Faculty and Subject Code

Faculty Code	Name of the Faculty	Title of the Subject	Subject Code
A	**Faculty of Ocean Science and Technology**	Marine Biology	**A 2401**
		Physical Oceanography	**A 2402**
		Applied Geology	**A 2403**
		Food Science and Technology	**A 2404**
		Biotechnology	**A 2405**
		Marine Chemistry	**A 2406**
		Marine Microbiology	**A 2407**
		Environmental Science	**A 2408**
		Remote Sensing and GIS	**A 2409**
		Climate Science	**A 2410**
B	**Faculty of Fisheries Engineering**	Ocean Engineering and Underwater Technology	**B 2411**
C	**Faculty of Fisheries Management**	Business Administration & Management	**C 2412**
		Economics & Statistics	**C 2413**
		Legal Studies	**C 2414**

Faculty of Ocean Science and Technology
Subject Code: A 2401
Marine Biology

Module. 1	**Research Methodology and Bio-statistics:** Types and significance of research; research approaches–objectives of research- important concepts relating to research design. Research ethics–plagiarism. Patents - Intellectual property Rights (IPR)- Patent laws - Copy right. Citation index - impact factor, H index. Databases - Inflibnet, Shodh Ganga, ShodhSindhu, - Biological databases. Reference management and publishing softwaresMendeley, Endnote, Latex. Chromatographic techniques – Ion-exchange chromatography – affinity chromatography – HPLC – Electrophoretic techniques - PAGE and SDS PAGE – Blotting techniques – Western Blotting and Southern Blotting – Centrifugation techniques - PCR techniques – microscopic techniques – Immuno- fluorecence, SEM and TEM. Sampling methods for biological studies. Measures of central tendency – Mean, median, mode. Measures of dispersion – range, mean deviation, standard deviation, skewness, kurtosis.
Module. 2	**Taxonomy and Phylogeny:** Principles of taxonomy and techniques of taxonomy. Systematic and general description of marine faunal groups. General features of the following Kingdom: Monera, Protista, Chromista, Fungi and Metazoa. Description of various phyla of marine organisms with examples.
Module .3	**Marine Biology:** early scientific investigations History of marine biological investigations in India. Equipments used for sampling water, sediment, plankton and benthos. Salient features of world oceans. Physico-chemical features of marine environment – tides, currents, waves, upwelling and monsoon cycles. Mudbanks.Plankton, Nekton and benthos.Primary and secondary productivity - estimation methods.
Module. 4	**Marine Ecology:** Zonation in marine environments. Marine Habitats – Types and divisions of marine habitats – Basic concepts about estuaries, coastal, oceanic and deep-sea ecosystems.Marine biodiversity hotspots and MPAs in India.Conservation status of marine organisms.Red list and its categories.Biotic factors in relation to individuals.Species interactions – Competition, predation and grazing.Population characteristics – natality, mortality, emigration and immigration.
Module. 5	**Fish & Fisheries:** Marine Fisheries of India - Fishery resources of India– Present status and trends - Important species contributing to the fishery - Exploitation, seasonal trends, production and demands. Deep Sea Fishery Resources – Major species – present status of exploitation – Explorative surveys in Indian EEZ. Deep Sea fishing policy - Oceanographic factors affecting deep sea fishery.
Module .6	**Mariculture:** Various methods of mariculture, culture of seaweeds, mussels, pearl oyster and finfish.
Module. 7	**Climate Change and Fisheries:** Marine ecosystems and global change – climate forcing on marine ecosystem, human impact on marine ecosystem, socioecological aspects of global change on marine ecosystem and marine resource management in the changing scenario.

Module. 1	**Physical Properties of Sea Water**- Pressure-Temperature-Salinity and Conductivity-Density of sea water-Effects of temperature and salinity on density- Potential density- Specific volume and specific volume anomaly - Sound in the sea- Light in the sea- Color of sea water. T-S diagram-Water type and water mass – Formation and classification of water masses- Major water masses- Bottom-Deep-Intermediate and surface water masses in the world oceans- Indian Ocean water masses.
Module. 2	**Ocean Circulation**- Thermohaline and Wind-driven Circulation- General Circulation of World Oceans- Equatorial Currents, Undercurrents. Indian Ocean circulation- geographical features-wind pattern- Surface and sub-surface currents of the Indian Ocean- Monsoon circulation. Upwelling and Sinking -Major upwelling regions of world oceans and Indian Ocean- Meso-scale Eddies and oceanic fronts. Southern Ocean Fronts and zones-Sea Ice. Large scale Oceanic variability-El Nino/La Nina-Southern Oscillation –Indian Ocean Dipole.
Module .3	**Ocean Dynamics**- Total derivative- Equation of continuity- equation of motion - Navier Stokes equation- Reynolds number- Reynolds stresses and eddy viscosity- Rossby number- Ekman number- Stability and double diffusion-Richardson Number- Buoyancy frequency. Inertial motion – Geostrophy- Ekman Current – Westward intensification - Sverdrup – Stommel – Munk solutions.Vorticity- Conservation of potential vorticity - Ekman pumping- Rossby radius of deformation-Barotrpic and baroclinic instability. Conservation of mass and salt-conservation equations.
Module. 4	**Eustrine and Coastal processes** - Classification of Estuaries- Circulation, mixing and stratification- Tidal asymmetry and flushing- Estuarine sedimentation. Ocean wave classification - Wave generation- wave dispersion - Wave transformations-shoaling, refraction, diffraction, reflection, wave run up, long-shore currents and rip currents.Wave breaking –Wave statistics and wave spectra. Internal waves- Planetary Waves - Rossby, Kelvin, Poincare and Yanai waves- Tsunamis- Seiches. Tides- Tide producing forces - Tide generation theories - Tidal currents- Internal tides -Tidal Bores- Amphidromic points- Co-tidal lines.
Module. 5	**Infrared Remote Sensing** thermal emission – atmospheric absorption – IR sensors – SST retrieval – atmospheric correction – effect of clouds. Microwave Remote Sensing: theory of microwave radiometry – microwave emission of sea surface – atmospheric effects – retrieval of salinity and wind vector – passive and active microwave radiometers – Altimetry – Scatterometry, Different types of satellite data products.
Module .6	**Air Sea Interaction:** fluxes of mass, momentum and heat - Estimation and measurement of fluxes - eddy correlation method - bulk aerodynamic method- scales of air-sea interaction - Reynolds's Number - turbulence- characteristics of turbulent flow - Kolmogorov length scale - Atmospheric boundary layer - wind stress - wind profile in the atmospheric boundary layer. Heat budget of the ocean.
Module. 7	Ocean Modeling- Mechanistic and Simulation models- Global Ocean Modelling- Hydrostatic Primitive Equations- Boussinesq approximation- Initial and Kinematic Boundary conditions. Numerical Schemes- Finite Differences- Forward, Backward and Central differences-Explicit and Implicit schemes. Horizontal and vertical grid types-finite difference and finite element-lateral boundary conditions-bathymetry- Model forcing - Model Initialization. Convergence- Consistency - Stability- Different types of Errors.

Faculty of Ocean Science and Technology
Subject Code: A 2403
Applied Geology

Module. 1	Physical and chemical weathering, Geological action of wind, streams, glaciers and ocean. Morphometric analysis of drainage basin. Coastal and shoreline landform features.
Module. 2	Silicate structure and classification. Concepts of symmetry, space lattice and point groups.32 crystal classes; its structure and common mineral in each systems.Common rock forming minerals and its distinguishing properties.Physical, optical and chemical properties of minerals.
Module .3	Partial melting and crystallization of magma. Bowen's reaction series.Intrusive and extrusive igneous bodies.Mineralogy, texture and structure of common felsic, mafic and ultramafic rocks.Metamorphism and its types; mineralogy, texture and structure of common metamorphic rocks.Grade of metamorphism and metamorphic facies.Role of fluids in metamorphic reactions.Sedimentary rocks and its texture and structure.Classification of Sandstone, limestone and conglomerate.Placer minerals and its provenance.
Module. 4	Principles of Stratigraphy: History and Development of Stratigraphy. Concepts of Magnetostratigraphy, Chemostratigraphy, Event stratigraphy, and Sequence stratigraphy; Nomenclature and the modern stratigraphic code.Radioisotopes and measuring geological time. Precambrian stratigraphy of India: Achaean stratigraphy - tectonic frame-work, geological history and evolution of Dharwar, and their equivalents; Easternghats mobile belt; Proterozoic stratigraphy -tectonic framework, geological history and evolution of Cuddapahs and their equivalents. Paleozoic, Mesozoic and cenozoic stratigraphy of India. Evolution of Himalaya.
Module. 5	Stress-strain relationships for elastic, plastic and viscous materials. Measurement of strain in deformed rocks. Behaviour of minerals and rocks under deformation conditions.Structural analysis of folds, cleavages, lineation, joints and faults.Superposed deformation.Mechanism of folding, faulting and progressive deformation. Shear Zones: Brittle and ductile shear zones, geometry and products of shear zones; Mylonites and cataclasites, their origin and significance. Unconformities and basement-cover relations.
Module .6	Concepts of ore genesis; spatial and temporal distribution of ore deposits. Mode of occurrence of ore bodies; texture, paragenesis and zoning of ore and their significance.Ore bearing fluids; their origin and migration, wall rock alteration. Coal and its properties: Different varieties and ranks of coal. Origin of coal.Coalification process and its causes.Fundamentals of coal petrology, concept of coal maturity, peat, lignite, bituminous and anthracite coal.Application of coal geology in hydrocarbon exploration.Origin, migration and entrapment of natural hydrocarbons.Characters of source and reservoir rocks.Structural, stratigraphic and mixed traps.Techniques of exploration.Geographical and geological distributions of onshore and offshore petroliferous basins of India.Mineralogy and geochemistry of radioactive minerals.Instrumental techniques of detection and measurement of radioactivity.Radioactive methods for prospecting and assaying of mineral deposits.Distribution of radioactive minerals in India.

Module. 7	General and exploration geophysics: Seismology, Structure of the Earth and Heat Flow studies. Gravity, magnetic, electrical, electromagnetic and seismic prospecting methods.Surface geophysical prospecting for groundwater exploration.Surface and underground mining methods.Sea floor mineral resources and its exploration.Continental drift theory and its evidences.Sea floor spreading and plate tectonics.Geophysical offshore exploration techniques.

Faculty of Ocean Science and Technology
Subject Code: A 2404
Food Science and Technology

Module. 1	**Food Chemistry:** Water activity and food stability; Chemistry of carbohydrates, proteins, fats, vitamins, minerals; Lipids: Major classes; Fatty acids, biosynthesis of fatty acids, essential fatty acids, omega-3 fatty acids, eicosanoids. Principles of colorimetry, spectrophotometry, fluorometry, atomic absorption spectroscopy and chromatographic methods.
Module. 2	**Food Microbiology:** Microorganisms of importance in foods; Food borne pathogens; Preservation and spoilage of different food items; Food borne infections and intoxications; Fermented food products.
Module .3	**Food Processing and Preservation:** Cereal, legume and oil seed products; Fruit and vegetable products; Meat, Poultry and Dairy products; Food Additives; Value addition and by-product utilization. Technology of freezing preservation of food: Different types of freezers, IQF and Block freezing, Freeze drying. Thermal preservation; Canning: Methods, canned products, D-value, F-value; Preservation by curing and drying: Food Irradiation; Membrane filtration techniques, high pressure processing, high intensity light, pulsed electric field, ultra sound, MAP as preservation technologies.
Module. 4	**Quality Control and Food Safety:** Food quality assurance and food quality management; Good manufacturing/ management practices (GMP), good hygienic practices (GHP), good laboratory practices (GLP), food safety and HACCP principles; Methods of determining quality- objective and subjective methods; Instrumental and sensory methods of evaluation. Food laws and standards: FDA regulations, USDA regulations, EPA regulations, *Codex Alimentarius*Commission,Role of national and international regulatory agencies- Bureau of Indian Standards (BIS), AGMARK, Food Safety and Standards Authority of India (FSSAI).
Module. 5	**Fish Processing:** Chilled products; Frozen products; Salt cured and dried products; Marinades; Smoking and smoked products; Thermally processed products; Battered and breaded products; Technology of processing and preservation of gel forming fish flour; fish analogue products; Fish protein concentrate; Fish hydrolysates; seaweed products- agar, algin, carrageenan- use in foods; By-products from underutilized fish or fish processing waste: Fish meal, fish silage; Chitin, chitosan and glucosamine preparation from crustacean shell waste; shark fin rays; Fish sauce, fish sausage and fermented fish products.
Module .6	**Waste Management and Utilization:** Waste Water Treatment; measurement of organic content in waste water; physical unit operations in waste water treatment; Utilization of waste: Methods of utilizing wastes to make value added products; Pectin, food colourants, antioxidants from fruit peels, lycopene from tomato peel, vegetable seed oils, biomolecules and enzymes from meat processing; Generation of biogas, SCP, microalgae, animal feeds.

Module. 7	**Food Packaging and Transportation:** Packaging materials and containers; Protective lacquers and coatings for metal containers; Plastic films, inomers, copolymers, laminates; Packaging material testing. Recent trends in food packaging: vacuum packaging, modified atmospheric packaging, shrink packaging, retort pouch packaging, aseptic packing, active packaging, intelligent packaging, smart packaging; Packaging laws and regulations.

Faculty of Ocean Science and Technology
Subject Code: A 2405
Biotechnology

Module. 1	**Biochemistry:** Biomolecules: Carbohydrates- structure, classification- monosaccharaides disaccharides and polysaccharides. Lipids- classification- biological functions of lipids. Proteins- structure and classification of proteins, biological functions of Proteins.Lipid metabolism, beta oxidation alpha and omega oxidation of fatty acids.Carbohydrate metabolism- glycogenesis, glycogenolysis, hexose monophosphate shunt, metabolic pathway of glucose- glycolysis, Kreb's cycle, electron transport cycles.
Module. 2	**Molecular Biology:** DNA replication, enzymology of DNA replication. Gene mutation, molecular mechanism of mutations, DNA repair. Transcription and Transcriptional control: Transcription events, Promoter elements, TATA box, Hogness Box, CAAT box, Enhancers and Silencers, RNA processing in prokaryotes and eukaryotes.
Module .3	Genetic code and wobble hypothesis, mechanisms of initiation, elongation and termination and regulation of translation. Post-translational modifications, proteins transport and trafficking. Control of gene expression in prokaryotes and eukaryotes.Operon model- lac and trp operon.Lytic cascades and lysogenic repression. Stress proteins-heat and cold shock protein, molecular chaperones, Molecular Biology of cancer.
Module. 4	**CellBiology:**Cell and its components: Plasma membrane- structure- structure and functions. Mitochondria- structure and functions. Endoplasmic reticulum - types and functions. Golgi bodies - functions. Lysosomes- polymorphism and functions.Microbodies - peroxisomes and glyoxisomes. Ribosomes-structure and functions.Centrioles and basal bodies.Cytoskeleton- microtubules, microfilaments and intermediate filaments.Nucleolus, euchromatin and heterochromatin, Chromosome, Cell cycle and regulation, Mitosis and Meiosis.Characteristics of cancer cells, carcinogenesis, oncogenes and tumour suppressor genes.
Module. 5	**Genetics:** Mendel and his experiments, Allelic and non-allelic interactions, Linkage, crossing over and recombination, Chromosome mapping. Sex linked inheritance of man (colour blindness and haemophilia), sex determination in man, barr bodies, dosage compensation and Lyon hypothesis. Mutation, mutagens- types and mechanism Bacterial Genetics: Bacterial growth kinetics: Bacterial chromosome. Extra-chromosomal genetic elements: F-factor, Plasmid, Transposons. Mechanism of gene transfer - transformation, transduction and conjugation.
Module .6	**Basic Biotechnology:** Biotechnology history, Microorganisms and applied Biotechnology, Biomass strategy- byproducts and raw materials. Protoplast and cell fusion technologies.Polymerase chain reactions and nucleic acid probes.Biosafety and biohazards in biotechnology industries. Bioreactor technology: Fermentation and types- scale up and downstream processing. Enzyme Technology and Immobilized enzymes.Biofuels- sources and process.

Module. 7	Environmental Biotechnology-waste water, sewage treatment and bio-composting. Bioremediation and environmental monitoring of pollution. Clean technology using microbes. Animal biotechnology and Genetic engineering: production of hormones, proteins and organs. Food biotechnology-microorganisms and food processing.Biopharmaceuticals and disease diagnostics.

Faculty of Ocean Science and Technology
Subject Code: A 2406
Marine Chemistry

Module. 1	**Inorganic Chemistry:** Chemical periodicity Structure and bonding in homo- and heteronuclear molecules, including shapes of molecules (VSEPR Theory). Concepts of acids and bases, Hard-Soft acid base concept, Non-aqueous solvents. Main group elements and their compounds: Allotropy, synthesis, structure and bonding, industrial importance of the compounds. Transition elements and coordination compounds: structure, bonding theories, spectral and magnetic properties, reaction mechanisms. Inner transition elements: spectral and magnetic properties, redox chemistry, analytical applications. Organometallic compounds: synthesis, bonding and structure, and reactivity. Organometallics in homogeneous catalysis. Nuclear chemistry: nuclear reactions, fission and fusion, radio-analytical techniques and activation analysis
Module. 2	**Physical Chemistry:** Basic principles of quantum mechanics: Postulates; operator algebra; exactly-solvable systems: particle-in-a-box, harmonic oscillator and the hydrogen atom, including shapes of atomic orbitals; orbital and spin angular momenta; tunneling. Atomic structure and spectroscopy; term symbols; many-electron systems and antisymmetry principle.Chemical bonding in diatomics; elementary concepts of MO and VB theories; Huckel theory for conjugated π-electron systems. Chemical thermodynamics: Laws, state and path functions and their applications; thermodynamic description of various types of processes; Maxwell's relations; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities; Le Chatelier principle; elementary description of phase transitions; phase equilibria and phase rule,thermodynamics of ideal and non-ideal gases, and solutions. Statistical thermodynamics: Boltzmann distribution; kinetic theory of gases; partition functions and their relation to thermodynamic quantities – calculations for model systems.
Module .3	**Chemical kinetics:**Electrochemistry: Nernst equation, redox systems, electrochemical cells; Debye Huckel theory; electrolytic conductance – Kohlrausch's law and its applications; ionic equilibria; conductometric and potentiometric titrations. Chemical kinetics: Empirical rate laws and temperature dependence; complex reactions; steady state approximation; determination of reaction mechanisms; collision and transition state theories of rate constants; unimolecular reactions; enzyme kinetics; salt effects; homogeneous catalysis; photochemical reactions. Colloids and surfaces: Stability and properties of colloids; isotherms and surface area; heterogeneous catalysis.

Module. 4	**Organic Chemistry:** IUPAC nomenclature of organic molecules including regio- and stereoisomers. Principles of stereochemistry: Configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction. Aromaticity: Benzenoid and non-benzenoid compounds – generation and reactions. Organic reactive intermediates: Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes. Organic reaction mechanisms involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways. Common named reactions and rearrangements – applications in organic synthesis. Chemistry of natural products: Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids. Biogenesis of terpenoids and alkaloids.
Module. 5	**Analytical Chemistry:** Spectrophotometry: Fundamental laws of photometry, interference and photometric error, instrumentation of photometers. Basic instrumentation for UV-Vis, IR and Fluorescence spectrophotometers. Atomic absorption Spectrophotometry – general principles and instrumentation. Atomic fluorescence spectrometry, Inductively coupled Plasma analysis. Chromatographic Techniques: Classification of chromatographic techniques. Experimental techniques and applications of Ion exchange, Column, Thin Layer and Paper chromatography. HPLC and Gas Chromatography – Principle, Instrumentation and Detectors. Methods and applications. NMR and Mass Spectrometry: NMR – Basic Principles and Instrumentation of Continuous Wave and Pulsed Fourier Transform NMR Spectrophotometers, Mass Spectrometry – Basic Principles and Instrumentation.
Module .6	**Introduction to Marine Environment :** General Introduction: Dimensions of ocean, Physical properties of Seawater, Sea Water Density, Compressibility Effects, T-S Diagrams, Horizontal, Vertical and Seasonal Temperature and Salinity Distributions, tides and tidal currents in shallow seas, estuaries and rivers. Estuaries: Classification and nomenclature; tides in estuaries; estuarine circulation and mixing; sedimentation in estuaries; salinity intrusion in estuaries; coastal pollution. The Ocean floor: General topography of the ocean floor, continental shelves, slopes, submarine canyons, submarine ridges and trenches. Structure and composition of oceanic crust-hydrothermal vents. Ocean margins and their significance, Mineral resources. Sea as a Biological Environment: Classification of the marine environment and marine organisms – plankton, nekton, benthos – marine ecosystems, marine food web, trophic structure - primary and secondary production and factors influencing them. Physico-chemical factors affecting marine life: light, temperature, salinity, pressure, nutrients, dissolved gases; adaptation and biological processes.
Module.7	**Marine Chemistry**: Ocean as a Chemical System: Origin of seawater, structure of water, ion-water interactions, the polarized water molecule, colligative properties of seawater, comparison of river and sea water. Composition of sea water, salinity and chlorinity concepts, the major and minor constituents, constancy of relative composition, Residence time, geochemical balance of oceans. Dissolved gases in sea water, Factors affecting the concentration of gases in seawater, pH, alkalinity, specific alkalinity, buffer capacity, sea water - carbon dioxide equilibria, precipitation and dissolution of carbonates, global carbon cycle. Biological pump and controls on atmospheric composition - emission of greenhouse gases. Micronutrients: Nitrogen, phosphorus and silicon, their cycles, distribution profiles and their effect on phytoplankton growth, N/P ratio. Organic matter in the sea: Dissolved and particulate Organic matter, Nature, origin and distribution, Photosynthesis and Primary production.

Module. 1	**Microbiology:** Characteristics of bacteria; prokaryotes and eukaryotes; Fungi- molds and yeasts, viruses, Microscopy- general principles, different types of microscope; Cultivation of microbes; growth of bacteria; types of media; Bacterial modifications, mutation and genetics; microbial metabolism, Bacteriophages, Control of microorganisms, sterilization, sterilization methods, antimicrobial activity, antibiotic and therapeutic agents.Microbial diseases, Immunology.
Module. 2	**Biochemistry:** Biomolecules and their conformation -protein, Lipid, Carbohydrates, Aerobic and Anaerobic degradation, metabolism, principle of bioenergetics, Biological oxidation and reduction, classification and mode of actionof proteins: proteins and amino acids, Biosynthesis, Enzymes: Classification, structure, activity, kinetics and inhibition. Hormone action, regulation and biosynthesis.Lipids, Biosynthesis of fatty acids. Inter relation of carbohydrates, lipids and proteins. Bioenergetics, Cell cycle and cell growth control; Cell signaling and signal transduction
Module .3	**MarineEnvironment:**Oceanography, Coastal Ecosystems, Importance of Oceans, Ecological Divisions of the Sea, Physical and chemical properties of seawater, Eutrophication and its impact, effects of physical and chemical factors on organisms, aquatic microbial food webs, microbial loop, adaptation and survival of microorganisms, Importance of extreme environments, ecology and diversity of extremophiles, Drugs from the sea, Biomaterials from the sea.
Module. 4	**Marine Drugs:** Concepts of drugs and their classification, Drugs from microorganisms, Modern methods of drug discovery-High throughput screening technology, natural products for lead identification, medicinal compounds from marine flora and fauna, Drug design, Docking, Classification, synthesis, mode of action, structure-activity relationship, biosynthesis, Methods of biological evaluation of drugs,.
Module. 5	**Biotechnology:**Molecular structure of genes and chromosomes; DNA: Replication, Transcription, Translation, Protein synthesis, Gene expression, Regulation of gene expression, Proteomics, Genomics (Genome & Human genome project), Genetic engineering, Cloning, Transgenics, DNA Fingerprinting, Regulatory controls in prokaryotes and eukaryotes; Molecular basis of genetic disease and applications, Genetic improvement and disease control, Diagnostic aids.
Module .6	**Statistics:**Basic Concepts, Biological data, Collection, Classification, Measures of location: Mean (arithmetic, geometric, harmonic) quartiles, quintiles, measures of dispersion: range, Variance, Standard Deviation, Coefficient of variation; Discrete probability distributions: Introduction to the concept of correlation: Pearson correlation coefficient, and its properties; Spearman ranks correlation coefficient, regression coefficients, fitting of regression lines to bi-variate data. Discrete probability distributions: Binomial, Geometric, Negative Binomial and Poisson distributions. Continuous probability distribution: Normal distribution and its properties, applications of normal distribution
Module .7	**Marine Microbial Ecology:**Microbial ecosystem, Marine microbial diversity, Microbial communities and ecosystems, species diversity indices, genetic/molecular diversity indices, Microbial interactions and associations, culture-based and culture independent methods, epiflourescent microscopy, biomarkers, PCR, real-time PCR, molecular fingerprints, FISH, DNA sequencing, pyrosequencing, Phylogenetic analysis, Biogeochemical cycling.

Module. 1	**Basic Environmental Science** Earth man Environment, The ecosystem concept, Abiotic and biotic components. Biomes and Habitats.Natural resources, Conservation and sustainable development. Autecology, synecology, tolerance range and limiting factors. Functional role and niche, key stone species, dominant species, ecotone, edge effect. Population properties and dynamics, prey predation and mutualism. Wetland systems of India, flora and fauna; marine habitats.Ecological succession, primary and secondary processes in successions, models of successions, endangered and threatened species, Biodiversity and conservation Heat budget of the earth.Energy resources and their exploitation. Conventional and non-conventional energy sources: Environmental implications of energy use, CO2 emission in atmosphere, Land use and land cover, land use change, drivers of land use change, impact of land use change on environment. Global water balance, impact of climate change on freshwater resources, Management and conservation of water resources. Important estuarine fishery resources- Important finfish and shellfish resources. Sustainability: Principles, social, economic, ecological, biological and legal issues. Bioenergy - Biofuel and biodiesel: biogas, butanol, biodiesel, ethanol,biohydrogen; bioenergy from wastes; Ecofriendly products: Biopolymers and bioplastics.
Module. 2	**Environmental Geoscience** Earth systems and Biosphere- Conservation of matter in various geospheres. Earth Processes-Primary differentiation and formation of core, mantle, crust, atmosphere, hydrosphere.Weathering processes and soil formation. Soil profile development, Chemical mineralogical composition of soil, Soil classification.Mineral resources and Environment. Geological hazards-Earthquakes,Volcanism, Tropical cyclones Principles of remotesensing and its applications Weather and climate - Elements of weather and climate: solar radiation, air temperature, atmospheric pressure, wind, humidity, clouds, precipitation and visibility - units of measurement of weather elements. Composition of the atmosphere - ozone in the atmosphere, aerosols, carbon compounds in the atmosphere and Green House Effect (GHE) Indian monsoon: onset, progress and withdrawal south west monsoon over India, north east monsoon - seasons of India - rainfall patterns over India - Influence of El Nino and La Nina on Indian monsoon. Climate change - preliminary concepts - global warming - anthropogenic causes. Consequences of global warming - sea level rise, changes in rainfall pattern and amount- impact on agriculture, fisheries, industries, human comfort etc. 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. Land observation satellites, Maps and Spatial information – Computer Assisted Mapping and Map Analysis. Components of Geographical Information System – Introduction – GPS satellites

Module .3	**Environmental Chemistry** Atmospheric chemistry, reactions in the lower and upper atmosphere, radioactivity in the atmosphere and air pollution chemistry. Structure and Physico-chemical properties of water and their environmental significance, chemistry of marine and fresh water, role Titrimetry, gravimetry, colourimetry, spectrophotometry, gas chromatography, atomic absorption spectrophotometry, GLC, HPLC, electrophoresis, X-ray fluorescence, X-ray diffraction, flame-photometry.UV- Visible Absorption Spectrometry, Fluorescence spectrometry, Atomic Spectroscopic Techniques, Flame Emission Spectrometry, Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) and ICP/MS. Chromatographic Techniques in Environmental Analyses. Gas– Liquid Chromatography (GLC), Instrumentations for GLC- columns, stationery phases, detectors, applications. Gas – Solid Chromatography (GSC), Liquid chromatography (LC): High-Pressure Liquid Chromatography (HPLC), column efficiency in Liquid Chromatography (LC).
Module. 4	**Environmental pollution** Water pollution- Sources and consequences.Characteristics of domestic, industrial, agricultural wastes, plastics.water quality parameters; criteria and standards, sewage and industrial waste water treatment methods. Atmospheric pollution – definition, primary and secondary pollutants, sources and classification of air pollutants global implication of air pollution effect of meteorological and topographical factors, Air pollution control equipments, national air monitoring programme, effects of air pollutants on humans, animals, plants and properties Basic properties of sound waves-plane and spherical waves, sound pressure and intensity levels, decibel, effect of meteorological parameters on sound propagation, Noise pollution levels. Soil pollution-Industrial andmining wastes, and human activities, plants and animals in degraded soil; soil pollution. Noise pollution- Basic properties of sound waves, intensity levels, decibel, effect of meteorological parameters on sound propagation. Measurement and analysis of sound. Environmental problems associated with noise pollution. Radiation, Mechanism of radiation on living system-Atmospheric, Aquatic and biological pathways and transport. Carbon and Tritium dating

Module. 5	**Environmental management** Biodegradation of organic pollutants: aerobic, anaerobic, co-metabolic; Biofertilizers and biopesticides : types; production and role in IPM; genetically engineered organisms – Bt toxin gene.acidic, alkaline and saline soils – reclamation techniques. Biotechnology for solid waste management: sanitary landfilling; Biocomposting– aerobic, anaerobic; vermicomposting; Biomethanation. Biotechnology for wastewater treatment: Microbial processes in wastewater treatment; Biodegradation of persistent organic pollutants: microbial adaptations; enzymes catalyzing biodegradation; Biosensors, biochips, biosurfactants – microbial production and their role in bioremediation. Principles in toxicology; Animal management in toxicological evaluation; Animal toxicity tests; Bio-absorption of heavy metals. Principles and methods of occupational health.The relationship of occupation of hygiene and safety and disease.Health and safety problems in the working and living environment. Coastal Zone Management: Integrated Coastal Zone Management (ICZM): Boundaries of the coastal zone, policies and planning for coastal resource management. Basic elements and tools of statistical analysis.Measures of central tendency and graphical representation of data, contingency tables and chi-square test, difference between sample means: t-test, range tests, correlation measurements and regression analysis, Approaches to development of models
Module .6	**Environmental Law** Stockholm Conference, Nairobi Declaration, Rio Conference, Rio+5 and the Rio+10, etc. Global environmental issues and International laws to control Global warming, Ozone depletion Acid rains, CITES etc. National Environmental Protection Legislations: The Water (Prevention and control of Pollution) Act 1974; The Air (Prevention and Control of Pollution) Act 1981; The Environment (Protection) Act 1986; Forest Act 1927; Forest Conservation Act 1980; The Wild life Protection Act 1972(2002 Amendment); Biodiversity Act 2002; The Noise Pollution (Regulation) 2000. Kerala State Environmental Regulations and Legislations: Public Health Act, Kerala Forest (Amendment Act), 2010, The Kerala ground water (control and regulation) Act, 2002, The Kerala Forest (Vesting and Management of Ecologically Fragile Lands) Act, 2003, Kerala Municipality Building (Amendment) Rules, 2004 - Rainwater harvesting, The Kerala Land Reforms (Amendment) Act, 2005,
Module. 7	**Environmental Impact Assessment** EIA and project planning and implementation; EIA and building rules in India. Classification of projects for EIA. Impact Identification, Establishing the Environmental base line.Impact prediction, evaluation and mitigation.Criteria and standards for assessing significant impact.Environmental Impact statement, Environmental Management plan. Cost- Benefit Analysis and valuation of Environmental Impacts. Public Participation, presentation and review.EIA monitoring and Guidelines for environmental auditing. Mitigation measures: Restoration and rehabilitation technologies, comparison of alternatives: review and decision making: compensatory actions: green belts: review of procedures, practices and guidelines in India.

Faculty of Ocean Science and Technology
Subject Code: A 2409
Remote Sensing & GIS

Module. 1	EMR-Electromagnetic Spectrum Energy sources and Radiation principles, Energy equation, EMR and Spectrum – EMR interaction with Atmosphere – Scattering, Absorption – EMR interaction with Earth surface features reflection, absorption, emission and transmission, - Microwave Band Designation Microwave interaction with atmospheric constituents, Earth's surface, vegetation, and ocean. – Spectral response pattern – Vegetation, Rocks, Soil, Water bodies – Spectral properties and characteristics.
Module. 2	Active, Passive, Optical Remote sensing, Visible, Infrared, thermal, Sensors and characters. Microwave Remote sensing sensors, Concept of Microwave Remote sensing, – Characters of real and successful remote sensing system- Platforms and sensors- orbit types– Resolutions in Remote Sensing, Types of Scanners in Remote Sensing, LIDAR, SONAR, Land observation satellites, characters and applications, , High resolution satellites, character and applications, Weather/Meteorological satellites and, Marine observation satellites and Applications
Module .3	Terrestrial and Aerial photographs - vertical and oblique photographs - height determination contouring - photographic interpretations- stereo- pair generation – parallax bar- Flight Planning- Photo Interpretation, Applications of aerial Photos, Orth photo generation, Aero- triangulation Internal Orientation Parameters, External orientation Parameters.
Module. 4	Geographical Information Systems: Maps and Spatial information – Computer Assisted Mapping and Map Analysis. Components of Geographical Information System, Map projections in GIS – Coordinate System – Georeferencing – Data Structures for Geographic Information Systems – GIS Entities – Point, Lines and Polygon. Definition of a map, Data input, verification, storage and output: Data input - Data verification, Correction and Storage. Data output – Data output format – Thematic maps, Charts and Graph, Data structures for thematic maps – Difference of Raster and Vector model. Digital Elevation Models: TIN – DEM Proximity analysis, Overlay Analysis, Network analysis
Module. 5	Geodesy: Definition and classification - geometry of ellipsoid – various co-ordinate systems – spherical excess – geoid and deflection of vertical, various height systems – rectangular and polar coordinates. Geodetic computation. GPS satellites – Components – Satellite Ranging – Codes - GPS – DGPS - GPS Receiver and its Features – Receiver selection – Enhancement of receiver - GPS processor Software – GPS Data Processing of GPS data and types. GPS Field Survey Techniques – Advantages – Characteristics Positioning modes – Static surveying – Kinematics surveying. Doppler Effect and basic positioning concept – Dilution of Precision – Types – Multipath Effect – Field practices.

Module .6	Image enhancement **-** Satellite image statistics, Uni-variate and multi-variate statistics. Basics of Histogram, noise models, image quality, contrast manipulation, grey level thresholding, level slicing, contrast stretching- Spatial feature manipulations, spatial filtering, convolution Low pass, high pass, edge enhancement, edge detection, Fourier analysis. Image classification - Introduction, Classification techniques, feature extraction, Supervised, training stage, classification stage, scatterogram, minimum distance to mean classifier, Parallelepiped classifier, Gaussian maximum Likelihood classifier, unsupervised classification, Hybrid classifier, classification of mixed pixel-fuzzy classification, output stage, classification accuracy, error matrix. Expert system, Artificial Neural Network; Integration with GIS
Module. 7	Definition, scope and concepts of cartography. Characteristics of Map. Categories of maps. Methods of mapping, relief maps, thematic maps. Trends in Cartography. Map projection, classification principles of construction of common projections, cylindrical, conical, azimuthal and globular projections. Properties & uses of projection. The spheroid, Map scale, and co-ordinate system. Plane co-ordinates in UTM system, projection used in Survey of India topographic sheets. Computer assisted cartographic processes, symbolization, mapping with point, line and area Symbols-Portraying the land surface form. Map Compilation – Analog and Digital Compilation. Map reproduction. Methods of Few Copies and Many Copies. Map production: Form of Art Work-Construction Method-Output option - Digital cartography.

Faculty of Ocean Science and Technology
Subject Code: A 2410
Climate Science

Module. 1	Weather and Climate-Climatic data and normals-World weather watch and Global observation system- -El Nino - Southern Oscillation-Indian Ocean Dipole-Stratosphere and Climate-Ozone depletion- Air pollution problems- Global warming and Climate Change. Composition and Vertical structure- troposphere and stratosphere- - surface pressure and winds – Moisture in the Atmosphere- Clouds and their classification - Inter Tropical Convergence Zone – Subtropical anticyclones – Trade Winds – Upper level winds and jet streams- Atmospheric thermodynamics- General circulation of the Atmosphere - Heat balance of the Atmosphere and Ocean system.
Module. 2	Weather systems: Thunderstorm, dust storm, hail and tornado – Tropical Cyclones – Cyclone structure, Genesis, growth and decay- Cyclones in North Indian Ocean basin- associated strong winds- heavy rain and storm surges - their life cycle. Southwest Monsoon – intra-seasonal and interannual variability of rainfall – monsoon onset - droughts and floods in monsoon – heavy rainfall – monsoon depressions and midtropospheric cyclones - short, medium and long range forecasting of monsoon – Global factors affecting monsoon - northeast monsoon, Other weather systems- Western disturbance and associated weather – Fog – Heat and Cold waves– Fronts and Depressions of middle latitudes and associated weather – Waves in westerlies – western disturbances affecting India.

Module .3	Weather and Climate-Climatic data and normals-World weather watch and Global observation system - El Nino - Southern Oscillation-Indian Ocean Dipole-Stratosphere and Climate-Ozone depletion- Air pollution problems- Global warming and Climate Change- IMD-WMO-IPCC- WCRP- National Action Plan for Climate Change-State Action Plan on Climate Change. Introduction to Hydrosphere- Hydrological cycle- Properties of sea water and their distribution, mixed layer, thermocline, heat budget –introduction to the Energy Budget of the Atmosphere and Oceans- Coastal Processes: Effects of climate change on coastal processes, coastal erosion- Hydrology of Lakes, Rivers and wetlands-river runoff-floods and flood plains- ground water-mangroves-dams and reservoirs-wetland functions and values.The Radiative Balance, carbon cycle of the ocean-Ocean acidification and marine calcifiers - climate sensitivity to oceans – indicators of past climates in ocean- lake sediment cores, ice cores, corals, and other geologic records. Global Ocean Circulation - Indian ocean Circulation- Equatorial processes - thermohaline circulation- salt transport in the ocean- global conveyor belt-Ekman layer- El Niño and the Southern Oscillation -El Niño and its Effects – coastal and open ocean Upwelling.
Module. 4	The biosphere - land and the oceans- Marine and coastal environment – biological zonation, inter-tidal ecosystem - sea as a biological environment – comparison among marine and terrestrial environment. Albedo of the Earth's surface- biosphere influences on fluxes of greenhouse gases - Plankton in the surface oceans and photosynthesis - influences of biosphere in the amount of aerosols in the atmosphere- mechanisms and processes which couple the biosphere with the rest of the climate system .Integrated approach in addressing biodiversity and climate change challenges - The Man and the Biosphere (MAB) Programme
Module. 5	Effects of global warming - Danger for Earth's biome by Global warming spells - The dramatic effects at high latitudes - multiple processes contribution to decreased surface reflectivity- assessment of ecosystem feedbacks to the climate system - carbon sequestration - projected climatic and ecological changes as informed basis for community and regional planning.
Module .6	Components of GIS – Hardware, Software and Organizational Context – Data – Spatial and Non-Spatial– Projection – Types of Projection – Data Input Raster and Vector data structures – Comparison of Raster and Vector data structure – Analysis using Raster and Vector data – Retrieval, Reclassification, Overlaying, Buffering – Data Output – Printers and Plotters – History of development. Essential Goal of Marine GIS, GIS technique and technology, Relating information from different sources, GIS uncertainties, Data representation, Data capture, Raster-to-vector translation, Projections, coordinate systems, and registration, Spatial analysis with GIS
Module. 7	Introduction to digital computer-functional units of a computer – storage – primary storage – secondary storage. Generation of computers, Introduction to programming languages –types of programming languages – high level languages – assembly language – machine language. Climate Models and Climate Data from ICT perspective; OpenClimateGIS – GIS for climate data; Climate Translator; NetCDF — the most commonly used format for climate simulation data; CIM (Common Information Model) — the most commonly used metadata standard for climate models and simulation data, Climate Data sources and analysis tools.

Module. 1	**Coastal Engineering** Different types of ocean structures and systems (fixed, floating, semi-submersibles, submersibles, pipelines, etc.,) for exploitation and production of oil and gas, minerals and energy. Brief outline of planning, design and construction.Towing, launching and installation. Waves in shallow waters – Shoaling, refraction, diffraction and breaking– Interaction currents and waves- near shore currents-wave run-up and overtopping and earth material – platforms – Airborne, space borne – satellites Ocean sat. Optical sensors and thermal sensors – Thermal detectors, thermal radiometer – thermal infrared Satellites - types and sensor & scanner.
Module. 2	**GIS & Ocean Engineering Sensors** Remote sensing: Introduction, principles of remote sensing, EMR interaction with atmosphere and earth material – platforms – Airborne, space borne – satellites Ocean sat. Optical sensors and thermal sensors – Thermal detectors, thermal radiometer – thermal infrared Satellites - types and sensors…. scanner. Introduction to GIS; Basics of ArcGIS; Geographic Coordinates Systems; Data creation (including geo-referencing images and on screen digitization), metadata; Addition of attributes; Geometrical calculations (e.g. calculation of area, perimeters)
Module .3	**Engineering Mathematics** Partial Differentiation, Multiple Integrals - Solutions of Ordinary Differential Equations, Solutions of partial Differential Equations, Fourier series - Rank, Eigen Values and Eigen Vectors, Solution of system of linear equations - Vector Differentiation, Unit Normal, Unit Tangent, Gradient, Directional Derivative Curl, Divergence, Green's Theorem, Stoke's Theorem, Divergence Theore - Random Variables, Probability Distributions-Binomial, Poisson and Normal Distributions-Mean and Variance - Newtons'sRaphson Method, Euler's Method, RungeKutta Method (IVth order).
Module. 4	**Computer Programming** **Operating Systems – Processes, Threads, IPC, Concurrency, dead lock, CPU scheduling, memory management, file systems, protection and security.Computer Organization -** Evolution of Computer arithmetic, Instruction Format, Control Unit, I/O Organization, Memory Organization, addressing modes, Parallel Programming, cache and main memory.**Databases -** Database Models, Overview and concepts of Relational Database Model, normalization, Transaction management in Relational Model, Concurrency Techniques, Recovery in Databases **Computer Networks -** Reference Models: OSI, TCP/IP, Data Link Layer, MAC layer, Network Layer, Transport Layer, Presentation Layer, Session Layer, Application Layer, basic concepts of hubs, switches, gateways and routers.**Programming and Data structure** – Programming in C, identifiers, data types, operators, stacks, queues, arrays, linked lists, trees.
Module. 5	**Electronics& Electrical** Electronics-Electronic circuits - Analog Circuits& Digital circuits- Communication Systems & network – Signals & System-Signal Processing-AC Fundamentals - laws of magnetic circuits, Phase relations and vector representation. Transformer - D.C. Machine - generator and motor - Measuring Equipment's: Classification, Characteristics of different electrical measuring systems and equipment's.
Module .6	**Basic mechanical and civil engineering** Strength of materials, Mechanics of fluids, Thermodynamics, Materials engineering, Thermal engineering, Manufacturing Technology, Geotechnical engineering, Design of structures,IC Engines, Refrigeration and air conditioning system.
Module. 7	**Basics of Research methodology** Foundations of Research,Research Design, Measurement and Scaling Techniques, Methods of Data Collection and Analysis, Techniques of Hypotheses, Parametric or Standard Tests, Analysis of Variance and Co-variance

Faculty of Fisheries Management
Subject Code: C 2412
Business Administration and Management

Module. 1	Principles of Management – Nature and scope of Management, Meaning and Definition; evolution of management- Schools of management-thought; F.W. Taylor and Henry Fayol; principles of management- management process. Functions of Management
Module. 2	Financial Management - Financial management – Meaning, Importance and Functions- Introduction to Financial Markets -Capital Markets - Primary Market - Basics of capital market mechanism, instruments, financing and rating institutions, and legal environment related to this. Secondary Market -Basics of stock exchanges and their role, regulatory framework, and transactions on stock exchange. Cost of Capital- Over capitalization- Under Capitalisation Dividend Policies.
Module .3	Research Methodology – Types of research- Research design- Research process- Formulation of Hypothesis- Types of hypotheses- testing of hypotheses- Report writing- referencing, bibliography- annexure Vs. appendix. Sampling methods - Measures of central tendancy – mean, median and mode – calculation of percentages and trend – variance – meaning and types of variance.
Module. 4	Marketing Management- Introduction to marketing management--Concept, nature and importance of marketing; Evolution of marketing concept; Marketing environment—Micro environment of marketing and macro environment of marketing -Domestic marketing and international marketing. Marketing research - Scope and types of marketing research – methods of market research.
Module. 5	General English – Grammar – parts of speech – direct and indirect speech- Sentence construction- components of sentence - noun, pronoun, verb, adjective, adverb, preposition, conjunction, and interjection- comprehension test.
Module .6	Elementary mathematics and logical reasoning- calculation of ratios- integration - number relationships and operations. problems containing whole numbers, decimals, fractions, percents, ratios, and proportions. Measurements- international units of measurements.
Module. 7	General knowledge- Indian History- Political environment of India- Cultural environment of India- Recent changes in Indian and International Economy - Current Affairs relating to education, science, literature, politics and sports.

Faculty of Fisheries Management
Subject Code: C 2413
Economics & Statistics

Module I: Demand Analysis, Marshallian, Hicksian and Revealed Preference Approaches Consumer Behaviour,Theory of Production and Costs, Pricing and output under different forms of market structure, Collusive and non- Collusive oligopolies, Different models of objectives of the firm – Baumol, Morris & Williamson, Cournot, Sweezy, Factory-Pricing, General Equilibrium & Welfare Economics.

Module II: Consumption function, investment function, demand for money and supply of money. Keynesian approach – Determinants of Effective Demand – Relevance – Economic Fluctuations-Hicks &Samuelson Approaches. Theories of inflation and unemployment. Measures to minimize economic fluctuations – Phillips curve-Concepts – Trade off – Implications- New classical Macroeconomics: Propositions and Policy conclusions of Supply Side Economics and Rational Expectations Analysis – Macroeconomic policies

Module III: National Income accounting: Trends and major issues – performance of different sectors – problems of poverty, unemployment, migration, inflation & environment – Economic reforms in India – India on the eve of economic reforms-objectives, nature & structures of economic reforms -Agriculture and Economic Development -India & WTO-WTO and Indian Agriculture.

Module IV:Basic concepts of statistics- Types of Data- Primary and Secondary – Data collection- Methods of Data Collection - Measures of Central Tendency- Measures of Dispersion, Skewness and Kurtosis- Correlation and Regression. Two variable regression model – assumptions – method of least squares – properties – BLUE – R-square – maximum likelihood method, Violation of classical assumptions – multicollinearity – autocorrelation – heteroscedasticity – problems – causes – consequences – remedial measures

Module V: Sampling – Random and non-random sampling, Sampling and Non sampling errors- definitions of sampling with and without replacement – type-I and Type-II errors – level of significance – rules of hypotheses testing – one-tailed and two - tailed test – sampling distributions of means and variances– Testing of Hypothesis- Parametric tests – Z test, F test and t test, ANOVA- One way and Two way classification- Non Parametric Tests – Chi-square test, Introduction to Multivariate Analysis Elementary theory of probability

Module. 1

Constitutional Law of India

Module. 2

Commercial Law (Law of contracts and special contracts)

Module .3

Criminal Law (I.P.C. and Cr.P.C.)

Module. 4

Tort Law

Module. 5

Public International Law including Law of the Sea (UNCLOS)

Module .6

Environmental Law

Module. 7

Maritime Law

In addition to the above modules, questions will also be asked covering the following syllabus.

Research methodology – relevance of sociological, social science, doctrinal, nondoctrinal and empirical research-identification of the research problem- preparation of research design- different research tools and techniques- collection of data – primary and secondary materials for research- observation, questionnaire, interview methods – sampling method- scaling techniques – classification and analysis of data- report writing