

Faculty of Ocean Science and Technology

Subject Code: B1708

Biotechnology

Module. 1	<p>Biochemistry: Biomolecules: Carbohydrates- structure, classification- monosaccharides 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, Krebs's cycle, electron transport cycles.</p>
Module. 2	<p>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.</p>
Module .3	<p>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.</p>
Module. 4	<p>Cell Biology: 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.</p>
Module. 5	<p>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.</p>
Module .6	<p>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.</p>
Module. 7	<p>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.</p>

Faculty of Ocean Science and Technology**Subject Code: B1706****Earth Sciences**

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; Eastern ghats 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: B1707

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, <i>Codex Alimentarius</i> 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: B1704

Marine Biology

Module. 1	<p>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.</p>
Module. 2	<p>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.</p>
Module .3	<p>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.</p>
Module. 4	<p>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.</p>
Module. 5	<p>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.</p>
Module .6	<p>Mariculture: Various methods of mariculture, culture of seaweeds, mussels, pearl oyster and finfish.</p>
Module. 7	<p>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.</p>

Faculty of Ocean Science and Technology

Subject Code: B1709

Marine Chemistry

Module. 1	<p>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</p>
Module. 2	<p>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.</p>
Module. 3	<p>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.</p>
Module. 4	<p>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, benzyne 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.</p>

Module. 5	<p>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.</p>
Module. 6	<p>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.</p>
Module. 7	<p>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.</p>

Faculty of Ocean Science and Technology

Subject Code: B1710

Marine Microbiology

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 action of 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	Marine Environment: 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, epifluorescent microscopy, biomarkers, PCR, real-time PCR, molecular fingerprints, FISH, DNA sequencing, pyrosequencing, Phylogenetic analysis, Biogeochemical cycling.

Faculty of Ocean Science and Technology

Subject Code: B1705

Physical Oceanography

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 watermasses in the world oceans- Indian Ocean watermasses.
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-Barotropic 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.