KERALA UNIVERSITY OF FISHERIES AND OCEAN STUDIES

Panangad, Kochi- 682506, Kerala

M. Sc. Physical Oceanography

Syllabus

2024

M. Sc. Physical Oceanography

Covering more than 70% of the earth surface, oceans play a major role in regulating the climate and the distribution of food resources. Further, the human society is faced with severe challenges from rising sea levels, extreme storm events, warming oceanic waters, altered ecosystems and increasing ocean acidification. Realizing the significance of oceans and its physical processes, the Department of Physical Oceanography, KUFOS offers a unique post-graduate course in Physical Oceanography integrating observational, theoretical and modelling aspects of oceans.

The goal of physical Oceanography is to provide a systematic understanding oceanic process, its interaction with atmosphere and quantitative description of the oceanic movements using observations and modelling. Basic knowledge of Physical Oceanography is crucial to understanding of many biological, geological and chemical processes in the Oceans. Besides, the physical processes of the ocean influence the distribution of rainfall, droughts and the development of storms, cyclones.

Basically, Physical Oceanography involves the application of physics and mathematics to study oceans. In addition to the descriptive learning of oceans, hands on training also be given in observing, data analysis and interpretation of oceanic phenomena. Modern techniques like remote sensing, satellite oceanography and computer applications in oceanography for data analysis and numerical modelling of the oceanic processes are appropriately incorporated in the course of study. The curriculum includes field visits, Institutional visits and dissertation work at the final semester of the course.

This course will equip students with the skills they need to join the workforce as ocean scientist as well as provide strong foundation for students to pursue doctoral research in Oceanography. The successful completion of the course will offer opportunities to join with National Institutes and private companies which are working on ocean related fields.

Course offered: M. Sc. Physical Oceanography

Course duration: Two years

No. of seats: 10

List of Contents

I. ELIGIBILITY CRITERIA

Those students who possess B.Sc. with 50% or 5.5/10.0 or 2.2/4.0 marks in any of the following subject combinations are eligible for admission to this Programme.

1. Physics main with Mathematics and Chemistry as subsidiaries
2. Physics main with Mathematics and Statistics -as subsidiaries
3. Physics main with Mathematics and Computer Science/Computer applications as subsidiaries.
4. Physics main with Mathematics and Electronics as subsidiaries
5. Physics main with Mathematics and Geography as subsidiaries
6. Mathematics with Physics and Statistics as subsidiaries
7. Mathematics main with Physics and Computer Science / Computer Applications as subsidiaries.
8. Three main with Physics, Mathematics and Chemistry
9. Three main with Physics, Mathematics and Statistics
10. Three main with Mathematics, Physics and Computer Science/Computer application
11. Bachelor of Science in Nautical Science

Candidates awaiting their final results of the qualifying degree examination can also apply but they should produce their qualifying degree/mark up to the semester preceding the last semester at the time of interview. All the general rules and regulations laid down by the Kerala University of Fisheries and Ocean Studies PG Curriculum shall be applicable.

II. PROGRAMME AND SCHEME OF EXAMINATIONS

1. M.Sc. Physical Oceanography, programme shall have 4 core courses, 1 elective course and 2 core practical course in First semester. Second semester have 4 core courses, 2 elective courses and 2 core practical courses. Third semester have 4 core courses, 2 elective courses and 2 core practical courses. Whole IV Semester comprises Dissertation work. Students are allowed to carry out the dissertation work at the University departments/National Research Institutes/ other University recognized Research Institutes. Viva-voce, evaluation of project work/ dissertation will be conducted at the end of 4th semester.

2. There shall be external university examination of 3-hour duration for each theory courses at the end of each semester, to be conducted after the completion of 80 working days.

3. Each practical examination is internal and is of 3-hour duration
4. Project / dissertation evaluation and viva-voce shall be conducted at the end of the programme only.
5. Each theory question paper may contain 10 short answer types, of weightage 1, 4 short essays out of 6 questions of weightage 5. Two long essays out of 2 questions (each have two options) of weightage 10.

III. EVALUATION AND GRADING

The evaluation scheme for each course shall contain two parts

(a) Internal evaluation and

(b) external evaluation. 50% marks shall be given to internal evaluation and the remaining 50% to external evaluation.

Internal evaluation: The internal evaluation of theory courses shall be based on predetermined transparent system involving periodic written tests, assignments, seminars and attendance. For practical courses, the internal evaluation based on written tests, labskill/records/viva and attendance in respect of practical courses. The weightage assigned to various components for internal evaluation is a follows.

Components of Internal Evaluation

	Component	Weightage
A	Assignment	10
B	Seminar	5
C	Attendance	5
D	Overall Performance	5
E	Test paper	25

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

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

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

IV. Grievance Redress Mechanism for internal evaluation

There is provision for grievance redresses at four levels- first at the level of teacher concerned; second, at the level of Department committee consisting of the Head of the Department, Departmental Coordinator and the teacher concerned; third, at the level of the School committee consisting of the Director, HOD and member of the School council nominated by the Director each year, and also a student member of that class nominated by the HOD. And fourth, at University level committee consisting of the Pro- vice chancellor, chairman-PG board of studies of subject expert nominated by the Vice- Chancellor, Controller of the Examination and the Convener of the Examination standing Committee.

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

For university level complaints, a fee, as fixed by the Syndicate from time to time, will be levied from the students.

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

V. Evaluation of Project Report/ Dissertation

Dissertation will be valued by two examiners who conduct the Viva-Voce examination (external) at the time of 4th semester. Distribution of 20 weightage allotted for dissertation will be as follows

Methodology	4 Weightage
Content	5 Weightage
Presentation	4 Weightage
Answering question	3 Weightage
Originality/Overall Quality	4 Weightage
Total	**20 Weightage**

OUTCOMES-BASED CURRICULUM

A high priority task in the context of future education development agenda in India is fostering quality higher education enabling effective participation of young people in knowledge production and participation in the knowledge economy, improving national competitiveness in a globalized world and for equipping young people with skills relevant for global and national standards and enhancing the opportunities or social mobility. Sustained initiatives are required for institutionalizing an outcome-oriented higher education system and enhancing employability through learning outcomes-based curriculum framework, improving/upgrading academic resources and learning environment, raising the quality of teaching and research across all higher education institutions; technology use and integration to improve teaching-learning processes and reach a larger body of students through alternative learning modes such as open and distance learning modes and use of MOOCs.

Other priority areas of action of fostering quality education include translation of academic research into innovations for practical use in society and economy, promoting efficient and transparent governance and management of higher education system, enhancing the capacity of the higher education system to govern itself through coordinated regulatory reform and increasing both public and private sector investment in higher education, with special emphasis on targeted and effective equity-related initiatives.

The overall **OBJECTIVES OF THE LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK** are to:

- help formulate graduate attributes, qualification descriptors, programme learning outcomes and course learning outcomes that are expected to be demonstrated by the holder of a qualification;
- enable prospective students, parents, employers and others to understand the nature and level of learming outcomes (knowledge, skills, attitudes and values) or attributes a graduate of a programme should be capable of demonstrating on successful completion of the programme of study;
- maintain national standards and international comparability of learning outcomes and academic standards to ensure global competitiveness, and to facilitate student/graduate mobility; and
- provide higher education institutions an important point of reference for designing teaching-learning strategies, assessing student learning levels, and periodic review of programmes and academic standards

Programme Specific Outcomes (PSOs):

1. Demonstrate the ability to apply fundamental concepts and techniques of oceanography, including physical, chemical, biological, and geological processes, to analyze and understand the complex marine environment.

2. Utilize advanced oceanographic instruments, data collection methods, and data analysis techniques to monitor, assess, and model various ocean parameters and phenomena.

3. Develop the skills to interpret and integrate oceanographic data from multiple sources, including in-situ measurements, remote sensing, and numerical models, to address real-world problems in coastal and marine environments.
4. Critically evaluate the impact of natural and anthropogenic factors on ocean-atmosphere interactions, climate dynamics, and marine ecosystems, and propose sustainable management strategies.
5. Demonstrate the ability to conduct independent research, apply theoretical knowledge and practical skills, and effectively communicate oceanographic findings to diverse stakeholders.

VI. COURSE STRUCTURE, SCHEME & SYLLABUS

(Credit Semester System – 2021 Admission onwards)

SEMESTER I

Course	**Course Code**	**Course Title**	**L**	**P**	**Exam Duration**	**Internal (%)**	**External (%)**	**Credits**
Core	POM 2101	Mathematics and statistics	4		3 hrs.	50	50	**4**
Core	POM 2102	Introduction to Oceanography	4		3 hrs.	50	50	**4**
Core	POM 2103	Descriptive Physical Oceanography	4		3 hrs.	50	50	**4**
Core	SME 531	General Meteorology	4		3 hrs.	50	50	**4**
Elective (Choose Anyone)	POM 2105	Geophysical Fluid Dynamics	3		3 hrs.	50	50	**3**
	POM 2106	Calculus						
Practical	POM 2107	Fortran Computer Programming and MATLAB		6+2 tutorial	3hrs	100		**3**
Practical	POM 2108	Meteorological data Analysis		2	3hrs	100		**1**
							Total Credits	**23**

SEMESTER II

Course	Course Code	Course Title	L	P	Exam Duration	Internal (%)	External (%)	Credits
Core	POM 2201	Dynamical Oceanography	5		3 hrs.	50	50	**4**
Core	POM 2202	Ocean Waves and Tides	4		3 hrs.	50	50	**4**
Core	POM 2203	Remote Sensing of Oceans	4		3 hrs.	50	50	**4**
Core	POM 2204	Oceans and Climate	3		3 hrs.	50	50	**3**
Elective (Choose anyone)	POM2205 POM2206	Oceanographic Instruments Marine bio-geochemical processes	3		3hrs	50	50	**3**
Open Elective (Choose Any One)	OST 2202	Environment and Bio-diversity	3		3 hrs.	50	50	**3**
	OST 2203	Marine Biotechnology						
	OST 2204	Marine Drugs						
	OST 2205	Climate Change and Polar Science						
	OST 2206	IPR and GI						
	OST 2207	Analytical Methods in Marine Environment						
Open Course offered by Department	OST 2201	General Oceanography						
Practical	POM 2207	Dynamical Oceanography		4+1 tutorial	3 hrs.	100		**2**
Practical	POM 2208	Oceanographic Data Analysis		4+2 tutorial	3 hrs.	100		**2**
Total Credits								**25**

SEMESTER III

Course	Course Code	Course Title	L	P	Exam Duration	Internal (%)	External (%)	Credits
Core	POM 2301	Air-Sea interaction	4		3 hrs.	50	50	**4**
Core	POM 2302	Ocean Modelling	4		3 hrs.	50	50	**4**
Core	POM 2303	Coastal and Estuarine Process	4		3 hrs.	50	50	**4**
Elective (Anyone)	POM 2304	Coastal Hazards and Management	3		3 hrs.	50	50	**3**
	POM 2305	Coastal Ocean Modelling						
	POM 2306	Coastal Engineering						
	POM 2307	Ocean State Forecasting						
Open Elective (Choose Anyone)	OST 2302	Ornamental Fishes and Aquarium Management	3		3 hrs.	50	50	**3**
	OST 2303	Fundamentals of Molecular Biology						
	OST 2304	Instrumentation Techniques						
	OST 2305	Marine Geology						
	OST 2306	Food Safety and Quality Control						
	OST 2307	Marine Chemistry						
Open Course offered by Department	OST 2301	Coastal Oceanography						
Practicals	2308	Ocean Modelling		8+2 tuto r ial	3 hrs	100		4
Total Credits								**22**

SEMESTER IV

CORE	Dissertation	20	20
Total credits (Combining all semesters)			**90**

SEMESTER –I (Theory)

POM 2101	Mathematics and Statistics	C	Credits 4

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand and apply linear algebra concepts, including matrices, eigenvalues, and matrix decomposition.	R, U, A
2	Apply vector operations, coordinate systems, and vector calculus to solve physical problems.	U, A
3	Analyze statistical data using measures of central tendency, correlation, and regression methods.	A, An
4	Understand and apply probability distributions to model real-world scenarios.	U, A
5	Perform hypothesis testing and use non-parametric tests for data analysis.	An, E
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

Linear algebra-Matrices - Types of matrices and its operations - Linear equations and their solutions - Eigen vectors & Eigen values-Properties of Eigen values - Nonlinear equations and their solutions - Matrix decomposition -Lower triangular matrix & upper triangular matrix-Interpolation and Extrapolation.

Unit 2

Review of vector analysis: Vector operations-vector addition - Laws of vector addition-dot product -cross product- Cartesian, Cylindrical and Spherical co-ordinates systems-. Vector operators: Gradient, Divergence and curl- Line integral-surface integral- volume integral Divergence theorem- Stokes theorem.

Unit 3

Descriptive Statistics: Basic concepts of Statistics. Methods of summarization of statistical data-Averages, Dispersion, Skewness and Kurtosis. Correlation and Regression- Linear, Partial and Multiple Correlation, Rank Correlation, Curve fitting, Method of Least Squares, Linear and Multiple Regression.

Unit 4

Probability and Distributions: Probability – Random variables and Probability Distributions. Expectations and moments. Binomial, Poission, Normal, Exponential, Weibull, Extreme value, Rayleigh and Log-normal Distributions (Definitions and properties only).

Unit 5

Sampling distributions, Standard Error, Chi-square, Students t and F distributions. Confidence interval for the mean and proportions. Tests of Significance concerning Mean, Proportion and Variance. Non-parametric procedures- Chi-square tests, Kolmogorov-Smirnov test and Run test.

References:

1. Emery and Thomson, (2001): Data Analysis Methods in physical oceanography, Permagon Press
2. Zar, J.H. (2003): Bio-statistical Analysis. 4th edition. Pearson Education.
3. Gupta and Kapoor (2000): Fundamentals of Mathematical Statistics.
4. Croxton F.E. and Cowden D.J.(2000): Applied General Statistics. Prentice Hall.
5. Kendall M.G and Stuart A.: The advanced theory of statistics. Vol. I & I

Reference Books:

1. Sumitabha Das: UNIX Concepts and Applications (English), 4th Edition, McGraw Hill Education

2. V. Rajaraman: Computer Programming in FORTRAN 90 and 95, PHI Learning Pvt. Ltd.
3. Use web link ftp://ftp.pmel.noaa.gov/ferret/pub/docs/ferret_installation_example.pdf for FERRET
4. S.N. Alam& S.S. Alam: Understanding MATLAB: A Text Book for Beginners, I.K. International Publishing House
5. Babu Ram and Pearson (2009) Engineering Mathematics
   6**.** RavindraB (2012) Linear Algebra and Linear models
6. Gilbert Strang (2012) Linear Algebra and its applications 4th Edition

POM 2102	Introduction to Oceanography	C	Credits 4

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand the fundamental concepts of ocean and sea, including major ocean dimensions and seafloor features.	R, U
2	Analyze Earth's composition, plate tectonics, and oceanic processes such as turbidity currents and bottom topography mapping.	An, U
3	Classify marine sediments based on sources, types, and grain size.	R, U, E
4	Apply knowledge of the physical and chemical properties of seawater, including density, sound, and light in marine environments.	A, U
5	Evaluate key concepts in biological oceanography, including food chains, primary productivity, and marine ecosystems.	E, U
6	Appreciate the historical development of oceanography through major expeditions and global ocean experiments.	Ap, S, I
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

General Introduction-Ocean and Sea-Major Oceans and its dimensions -seafloor features-shoreline-Continental Shelf-Continental slope-Continental Rise-Mid ocean Ridges-Seamounts-Guyots-Trenches-Island Arc-Atolls- Hydrothermal Vents and Cold Seeps-Geoid.

Unit 2

Composition of Earth- Crust, Mantle and ore- Continental and oceanic crust- Ocean basins and bottom materials- Turbidity currents- Submarine Canyons- Plate tectonics- Continental drift and sea floor spreading-Pangea-Gondwana-Evolution of the Indian Coast- Methods for mapping bottom topography- Paleo oceanography.

Unit 3

Marine sediments-sources and types- Lithogenous, biogenous, hydrogenous and cosmogenous sediments-classification of sediments based on grain size

Unit 4

Physical properties of sea water-Molecular properties of 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- Chemical composition of sea water, Major nutrients and dissolved gases.

Unit 5

Introduction to biological oceanography-Food chain-Primary productivity-Phytoplankton and zooplankton- Nekton and Benthos -Biological pump-Fishes, Marine mammals - Algal blooms and HAB.

Unit 6 (Assignment)

Of Oceanography-History Exploring Oceans- Major Expeditions in oceanography-Challenger Expedition-METEOR and DISCOVERY Expeditions-International Geophysical Year (IGY)-International Indian Ocean Expedition (IIOE)-Monsoon Experiments in Indian Ocean- MONEX-BOBMEX-ARMEX- Tropical Ocean Global Atmosphere (TOGA) World Ocean Circulation Experiment (WOCE) - Joint Global Ocean Flux Studies (JGOFS)

Reference Books:-

1. Pickard G.L. and W.J. Emery (1995): Descriptive Physical Oceanography- Pergamon press, (1995or latest edition).
2. Lynne D. Talley, G.L. Pickard, W.J. Emery and James Swift (2011): Descriptive Physical Oceanography: An Introduction- Elsevier (6th edition, 2011).
3. Robert H. Stewart (2003): Introduction to Physical Oceanography- online edition (public domain), Aug 2003.
4. Open University Course team and Butterworth-Heinemann (1997): Sea water, its composition, properties and behavior; Open University team, 2nd Edition, 1997, jointly published by Oxford, UK, ISBN 0-7506-3715-3
5. Alan P. T and Harold V. T. (2014) Essentials of Oceanography, Eleventh Edition 6.Tomczak M. &J.S.Godfrey (2003) Regional Oceanography an Introduction second edition

POM 2103	**Descriptive Physical Oceanography**	**C**	**Credits 4**

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand the spatial and temporal distribution and variability of oceanic properties.	R, U
2	Explain the formation and classification of water masses.	R, U, An
3	Analyze global and regional ocean circulation patterns.	An, U
4	Examine Indian Ocean circulation, currents, and their seasonal variations.	An, U
5	Identify oceanic processes such as upwelling, eddies, and large-scale variability (e.g., El Niño/La Niña).	R, An, U
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

Space and time scales of physical oceanographic phenomena- Temperature and Salinity distribution in Oceans- Horizontal and Vertical structures and time variation of temperature-salinity -density-Sea level. Ocean mixed layer- barrier layer and thermal inversion- Thermocline, Halocline and Pycnocline- Seasonal and permanent thermocline- distribution of dissolved Oxygen-Oxygen minimum layer- Nutrients and other tracers and age of ocean water and turnover time.

Unit 2

Conservation of salt and heat-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-Red Sea-Persian Gulf and Mediterranian watermasses.

Unit 3

Ocean Circulation- Thermohaline and Wind driven Circulation- Importance of deep ocean circulation –Heat and fresh water transports - General circulation of World Oceans- Equatorial Currents, Undercurrent, Antarctic Circumpolar Current and Western and Eastern Boundary Currents, Langmuir Circulation.

Unit 4

Indian Ocean circulation- geographical features-wind pattern- Surface and sub-surface currents of the Indian Ocean- Seasonal cycle of currents in the north Indian Ocean-Currents in the Arabian Sea and Bay of Bengal- Currents off the east and west coasts of India- Somali current-Equatorial jet – Agulhas Current and retroflection. Lakshadweep High and Low-Intermediate and Deep Ocean circulation.

Unit 5

Convergence and Divergence in Oceans- 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 and Indian Ocean Dipole (Definitions only).

Reference Books:-

1. Pickard G.L. and W.J. Emery- Descriptive Physical Oceanography (1995): Pergamon press, (1995or latest edition).
2. Lynne D. Talley, G.L. Pickard, W.J. Emery and James Swift (2011): Descriptive Physical Oceanography: An Introduction- Elsevier (6th edition, 2011).
3. Sverdrup H.U., Johnson M.W. and Fleming R.H (1958): The Oceans: their physics, chemistry and general biology, Prentice Hall Inc., New Jersey, 1958.
4. Robert H. Stewart- Introduction to Physical Oceanography (2003) : online edition (public domain).
5.Tomczak M. &J.S.Godfrey (2003) Regional Oceanography an Introduction second edition
6. G. Neumann & WJ Pierson, Jr.(1966) Principles of Physical Oceanography (1966)

POM 2104	General Meteorology	C	Credit 4

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand basic meteorological concepts, including weather, climate, and atmospheric structure.	R, U
2	Analyze atmospheric circulation patterns like the Hadley and Walker Circulations, ITCZ, and jet streams.	U, An
3	Understand the monsoon system, its dynamics, and factors influencing monsoon variability.	U, An
4	Explain the formation and classification of tropical and extratropical cyclones, thunderstorms, and related phenomena.	U, An
5	Apply weather forecasting techniques, including surface weather map analysis and special forecasting methods.	U, A, S
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

Introduction to Meteorology - Definition of Weather and Climate - Weather Elements- - Horizontal and Vertical distribution of air temperature and atmospheric pressure-Atmospheric Stability - Structure and composition of Atmosphere- Scales of weather systems – micro, meso, synoptic and planetary scales – Classification of Clouds.

Unit 2

General circulation of the atmosphere – Hadley and Walker Circulation – Trade winds – ITCZ, Doldrums, Polar front – Coriolis Force- Geostrophic and Gradient winds – Jet Streams-Quasi Biennial Oscillations.

Unit 3

Definition of monsoon- Monsoon regions of the World – Southwest (summer) and Northeast (winter) monsoons over India – Monsoon onset and withdrawal – Monsoon Trough – Active and Break monsoons – Monsoon depressions – Low level Jet – Factors affecting monsoon –Intra-seasonal Variability – Madden-Julian Oscillations- Monsoon and Indian Ocean.

Unit 4

Thunderstorms-Hailstorm-Tropical Cyclones – classification – T-number – Genesis, intensification, movement and landfall– vertical structure – Tropical Cyclones in Arabian Sea and Bay of Bengal. Extratropical cyclones – Anticyclones – Western disturbances – Airmass and Fronts – Squall-Tropical cyclones in the Bay of Bengal- blizzards- Dust storms-Norwesters.

Unit 5

Fundamentals of Weather Forecasting- observation of weather elements-Preparation of surface weather maps- analysis and interpretation- different types of forecasting (general, statistical, numerical)- Special weather forecasting (agricultural, route forecasting, cyclone warning, etc.)

References

1. Battan L.J. (1979) Fundamentals of Meteorology, Prentice Hall Inc., N.J.
2. Donn W.L. (1975) Meteorology, McGraw Hill book company, New York.
3. Petterson S. (1969) Introduction to Meteorology, McGraw Hill book company, New York.
4. Monsoon (2- volumes) (2012) India Meteorological Department
5. James R. Holton (2004) An Introduction to Dynamic Meteorology. 4th edition
6. Seymour L. Hess (1959) Introduction to theoretical meteorology.
7. Chandrasekar A. (2010) Basics of Atmospheric Science.

POM 2105	Geophysical fluid dynamics	E	3 Credits

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand fundamental fluid properties and flow types, applying fluid statics to both compressible and incompressible fluids.	R, U, A
2	Analyze fluid flow using Lagrangian and Eulerian descriptions, incorporating streamlines, deformation, and vorticity.	U, A, An
3	Apply the continuity equation and Euler's equations of motion to non-viscous flow, understanding Bernoulli's theorem and rotational forces.	U, A, An
4	Understand viscous fluid dynamics, Forces acting in the geophysical fluid motion, Navier-Stokes equations, and the significance of Reynold's number in flow regimes.	U, A, An
5	Evaluate circulation and vorticity concepts using theorems like Kelvin's and Bjerknes', understanding barotropic and baroclinic fluids.	U, E, An
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

Basic concepts- fluids: fluid continuum, fluid properties, ideal fluid, actual fluids, types of flow; statics: pressure surface and body forces on a fluid element; fundamental equation of fluid statics: application to compressible and incompressible fluids, perfect gas equation, hydrostatic equation

Unit 2

Kinematics: Lagrangian and Eulerian methods of description of fluid flow- stream lines- streak lines and trajectories- steady and non-steady flow- decomposition of the field of motion in the vicinity of a point- translation, rotation- divergence and deformation- stream function, divergence and vorticity- local and convective derivatives.

Unit 3

Dynamics: equation of continuity and its applications- non-viscous incompressible flow- Eulerian equations of motion- inertial and rotational frames of reference- Coriolis force, irrotational flow- velocity potential- integration of the equations of motion- Bernoulli's theorem and its applications.

Unit 4

Viscous fluids- coefficient of viscosity- Navier-Stoke's equations of motion for a viscous Newtonian fluid- laminar flow of viscous incompressible fluids- Reynold's number and dynamic similarity of flows- physical significance of Reynold's number, low and high Reynold's number.

Unit 5

Circulation and vorticity- Stoke's theorem- Kelvin's theorem- barotropic and baroclinic fluids- absolute and relative circulation- Bjerknes circulation theorem and interpretation.

Reference Books:

1. S.W.Yuan (1967) :Foundations of Fluid Mechanics
2. J. Pedlosky (1987): Geophysical Fluid Dynamics
3. G.K. Batchelor (1967) An introduction to Fluid Mechanics
4. S.L.Hess (1959) An introduction to Theoretical Meteorology
5. Samual A. Elder and J. Williams (1989) Fluid Physics for Oceanographers and Physicists.
6. Benoit Cushman-Roisin and Jean-Marie Beckers (2009): Introduction to Geophysical Fluid Dynamics. Physical and Numerical Aspects

POM 2106	Calculus	E	Credit 3

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand and apply fundamental calculus in solving physical problems.	R, U, A
2	Solve first and second-order differential equations and understand special functions.	U, A, An
3	Classify and solve partial differential equations with real-world applications.	U, A, An
4	Apply numerical methods to solve differential equations with error analysis.	A, An, E
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1 - **Differentiation, integration and its applications**

Rate of change problems, formation of equations involving derivatives, mean value theorems, series expansion of functions, partial derivatives, area under a curve, double and triple integrals, volume bounded by a surface, change of variables, spherical and cylindrical co-ordinate system.

Unit 2 - **Ordinary Differential equations**

First and second order equations, simple harmonic motion, linear differential equation with constant coefficients, series solutions, special functions - Legendre, Bessel, Hermite and Airy functions.

Unit 3 - **Partial differential equation**

Hyperbolic Parabolic and Elliptic classification, Wave and Diffusion equations, general and particular solutions withexamples, separation of variables method, integral transform method.

Unit 4 - **Numerical solution**

Finitedifference schemes, consistency stability and convergence, error analysis, examples - numerical solution to advection equation, wave equation, diffusion equation.

References

1. Erwin Kreyszig., Advanced Engineering Mathematics, Tenth edition, Wiley, 2015
2. Riley, K. F., M. P. Hobson, & S. J. Bence, Mathematical methods for physics and engineering, Cambridge University Press, 2006.
3. Hassani, S., Mathematical physics, Springer, 2002.
4. Greenberg, M. D., Advanced engineering mathematics, Pearson Education, 2002.
5. Croft, A., R. Davidson and M. Hargreaves, Engineering Mathematics, Pearson education, 2001.
6. Ian N. Sneddon., Elements of partial differential equations, Dover Publications, 2006.

7. LeVeque, Randall J., Finite Difference Methods for Ordinary and Partial Differential Equations: Steady-State and Time-Dependent Problems, Philadelphia, PA: Society for Industrial and Applied Mathematics, 2007.
8. Fletcher, C. A. J., Computational Techniques for Fluid Dynamics. Fundamental and General Techniques Volume I, Springer series in computational physics, New York, NY: Springer-Verlag, 1996.

Semester 1 Practical

POM 2107	Fortran computer programming and MATLAB (Practical)	C	Credits 3

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand the basics of signal analysis using MATLAB	U, A
2	Perform FFT/IFFT for spectral analysis	A, An
3	Apply Butterworth filters for data smoothing	A, S
4	Use Hanning/Hamming windows in signal processing	A, S
5	Conduct statistical analysis on oceanographic data	An, E
6	Analyze oceanographic station data using Fortran	A, An
7	Format and grid oceanographic observations for modeling	A, S, Ap
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

1. Signal analysis using Matlab
2. FFT/IFFT analysis
3. Data Filtering- Butterworth
4. Hanning / Hamming Windows
5. Statistical Analysis
6. Oceanographic station data analysis using Fortran
7. Formatting and gridding oceanographic observations

SEMESTER-I (Practical)

POM 2108	Meteorological Data Analysis (Practical)	C	Credits 1

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Plot and interpret various weather parameters.	U, A, S
2	Perform synoptic analysis and interpret data.	U, An, S
3	Analyze cyclonic and anti-cyclonic weather patterns.	A, An, E, S
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

1. Plotting of different weather parameters on a weather chart.
2. Synoptic analysis and Interpretation of weather parameters.
3. Analysis of cyclonic and anti-cyclonic conditions for some typical weather scenarios

SEMESTER-II (Theory)

POM 2201	**Dynamical Oceanography**	**C**	**Credits 4**

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand the basic conservation laws, forces, and coordinate systems in dynamical oceanography	R, U
2	Apply equations of motion and understand the effects of Coriolis force, pressure gradient, and gravity in ocean dynamics	A, An
3	Analyze geostrophic and frictionless ocean currents, including their computation and assumptions	An, E
4	Evaluate the impact of friction in ocean circulation, including Ekman transport, upwelling, and western boundary currents	E, An
5	Understand and apply concepts of vorticity, potential vorticity conservation, and their role in oceanic phenomena	U, A, An
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

The basic conservation laws in dynamical oceanography-Dominant forces-Primary and secondary forces- Coriolis force-Co-ordinate systems-f palne, B plane and spherical coordinates-Types of flows in ocean- Conservation of mass and salt- barotropic and baroclinic fields- quasi static conditions, sigma-t surfaces-Specific volume and specific volume anomaly-thermosteric anomaly- Equation of continuity- Total derivative-Equation of continuity-application- Stability and double diffusion-Richardson Number-Buoyancy frequency-Boussinesq approximation.

Unit 2

The equation of motion –with reference to Rotating frame – Coriolis force - gravity and Pressure gradient force. Nonlinear terms-Equation of motion with friction- Navier Stokes equation-Scaling the equations of motion- Reynolds number- Reynolds stresses and eddy viscosity-Rossby number- Ekman number-Dynamic stability.

Unit 3

Currents without friction- Inertial motion - Geopotential surfaces- Geostrophic flow-. Computation of geostrophic currents- Level of no motion-Advantages and limitations of geostrophic assumption. Relative currents and slope currents.

Unit 4

Currents with friction-Equation of motion with friction-Ekman's solution to wind driven flow-Ekman Spiral-Ekman transport - Ekman pumping – Upwelling and Sinking- Bottom friction and shallow water effects. Sverdrup's theory of ocean circulation-mass transport stream function-general form of Sverdrup's equation. Stommel's theory of western boundary currents- Munk's solution for wind driven circulation.

Unit 5

Vorticity-Relative Vorticity-Planetary Vorticity–-Potential Vorticity- Conservation of potential vorticity and its applications- westward intensification-Equatorial undercurrent. Ekman pumping-Taylor proudman theorem- Rossby radius of deformation-Barotropic and baroclinic instability.

Reference Books:-

1. Pond and Pickard (1983): Introductory Dynamical Oceanography
2. Robert H. Stewart (2003): Introduction to Physical Oceanography- online edition (public domain).
3. Benoit Cushman-Roisin and Jean-Marie Beckers (2009): Introduction to Geophysical Fluid Dynamics. Physical and Numerical Aspects
4. Gill, A. E., (1982): Atmosphere-Ocean Dynamics
5. John A. Knauss (1997) Introduction to Physical Oceanography
6. Henk A. Dijkstra (2008) Dynamical Oceanography

POM 2202	Ocean Waves and Tides	C	Credits 4

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand ocean wave classifications, generation, and properties of linear waves.	U, R
2	Analyze finite amplitude and nonlinear waves, and wave transformations in shallow water.	An, A
3	Understand internal and planetary waves and their causes.	U, R
4	Explain tidal phenomena, generating forces, and predict tidal behaviors.	U, An
5	Apply Newton's, Equilibrium, and Dynamic tidal theories to real-world observations.	A, E
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

Introduction to Waves- Ocean wave classification - capillary and gravity waves – Wave generation- Sea and swell- Linear waves- wave dispersion- Phase and Group velocity- Classification of deep and shallow water waves.

Unit 2

Finite amplitude waves- Stokes theory- Shallow water waves- Nonlinear waves- Cnoidal and Solitary waves- Wave transformations- shoaling, refraction, diffraction, reflection, wave run up, long-shore currents and rip currents. Orbital motions in deep and shallow water waves – Wave breaking – Types of wave barkers- Wave-height and period distributions- Rayleigh distribution- Wave statistics and wave spectra.

Unit 3

Internal waves-two-layer ocean- normal modes of internal waves – causes of internal waves. Planetary Waves- Poincare, Rossby, Kelvin, and Yanai waves- Tsunamis- Seiches

Unit 4

Introduction and history of tides- tide Generating forces in ocean - lunar and solar components- types of tides- spring and neap tides- typical tidal ranges at coast, estuaries, bays and open ocean- tidal currents- internal tides - phase, amplitude and cycle time- amphidromic points- cotidal lines- tidal bores

Unit 5

Tide generating forces- Newton’s theory- Equilibrium theory - Dynamic theory- Observations and prediction of tides- Harmonic analysis

Reference Books:

1. Pond and Pickard :(1983) Introductory Dynamical Oceanography
2. Sverdrup H.U., Johnson M.W. and Fleming R.H: (1958) The Oceans: their physics, chemistry and general biology, Prentice Hall Inc., New Jersey.
3. Open University Course team and Butterworth-Heinemann (1999): Waves, Tides and Shallow Water Processes; Open University team, 2nd Edition, 1999, Oxford, UK
4. Philips O. M. (1966) The Dynamics of the upper ocean.
5. Pierson W. J., G. Neumann and R. W. James (1955) Practical methods for observing and forecasting Ocean waves.

POM 2203	Remote Sensing of Oceans	C	Credit 4

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand the basic principles of remote sensing, including aerial photography, electromagnetic radiation, and atmospheric effects.	R, U
2	Classify satellites and sensors, interpret oceanographic data from visible and infrared wavelengths, and apply atmospheric correction methods.	R, U, A
3	Explain microwave remote sensing, including radiometry, sea surface interaction, and data retrieval for oceanographic parameters like salinity and wind.	U, A, An
4	Apply remote sensing techniques using AVHRR, Altimeters, and SAR for ocean monitoring (SST, currents, eddies, sea ice), and utilize various satellite data products.	A, An, S
5	Understand GIS components and data types, apply spatial analysis in marine GIS, and address data acquisition, errors, and geo-referencing.	R, U, A, S
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1
Introduction to Remote Sensing - Basic concepts – principles of aerial photography - electromagnetic radiation – solar and terrestrial radiation - atmospheric effects – absorption, transmission and scattering – spectral response of earth's surface features – atmospheric windows – concept of signature.

Unit 2
Satellites-classification based on orbits and purpose-different types of sensors-Optical Remote Sensing-optical pathways in atmosphere-strategies for atmospheric correction of visible wave length data-scattering and absorption of light in sea water-oceanographic interpretation of ocean colour-light scattering at sea surface-important ocean colour sensors. Infrared Remote Sensing: thermal emission – atmospheric absorption – IR sensors – SST retrieval – atmospheric correction – effect of cloud – thermal skin layer – skin and bulk SST.

Unit 3
Microwave Remote Sensing: theory of microwave radiometry – microwave emission of sea surface – atmospheric effects – retrieval of salinity and wind vector – passive microwave radiometers: SMMR, SSM/I, TRMM/TMI and AMSR – active microwave radiometers: microwave interaction with the sea surface – NSCAT, Sea Winds -– Altimetry: principles – sea surface height anomaly – ERS, T/P, Jason-1 – observing planetary waves and eddy energy.

Unit 4
Applications of AVHRR, Altimeters, SAR- Monitoring of SST, geostrophic currents, mesoscale

variability, eddies, fronts, upwelling, Sea ice Satellite capabilities-Global scale coverage-Different types of satellite data products available SeaWiFS, MODIS, OCM-1& 2, SARAL-Altika, TOPEX-Poseidon, ERS 1 & 2, JASON, QuikScat, etc.

Unit 5

Definition of GIS – components of GIS – Geographical concepts – Input data for GIS – Types of output products, Application of GIS – GIS Data types – Data representation – Data sources – Data acquisition – Geo referencing of GIS data – Spatial data errors – Spatial data structures. Essential Goal of Marine GIS, Spatial Thinking and GIS Analysis in the Marine Context, Conceptual Model of a Marine GIS.

Digital image processing technique-image enhancement-unsupervised and supervised classification methods (Assignment)

Reference Books:

1. I.S. Robinson: (1985) Satellite Oceanography- An Introduction for Oceanographers and Remote Sensing Scientists.

2. Seelye Martin (2014): An Introduction to Ocean Remote Sensing, 2nd Edition, Cambridge Press

3. Motoyoshi Ikeda and Frederic W. Dobson (1995). Oceanographic Applications of Remote Sensing, CRC Press, USA.

4. Robert H.Stewart (1985) Methods of Satellite Oceanography

5. T.D. Allan (1983) Satellite Microwave Remote Sensing

6. G.A. Maul (1985) Introduction to Satellite Oceanography

7. I. S. Robinson (2004) Measuring the Oceans from space: *The principles and methods of satellite Oceanography*

POM 2204	**Oceans and climate**	C	**Credits 3**

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand the natural factors, including Milankovich cycles, that influence climate changes.	U, R
2	Analyze methods to study past climates and recognize major climate events like Ice Ages and abrupt changes.	An, U, R
3	Explain the role of ocean circulation in climate, including deep-water circulation and its impact in global climate.	U, A, An
4	Evaluate the effects of anthropogenic activities on global warming, climate change, and ocean-related consequences like acidification, coral bleaching, sea level change etc.	E, An, U
5	Apply climate mitigation strategies and understand global and Indian policies addressing climate change.	A, E, U
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1
Weather and Climate - Natural factors affecting climate - Milankovich cycles-other natural factors affecting climate change

Unit 2
Paleo climate - Methods to study Paleo climate - Ice ages - Bond cycle - Abrupt climate changes - Dansgaard-Oescheger events - Heinrich events

Unit 3
Effects of ocean on climate - formation and spreading of deep water masses in the ocean – Deep water circulation - meridional heat transport - ocean circulation and climate - Gulf Stream - effect of breakdown of thermohaline circulation on climate.

Unit 4
Anthropogenic causes of climate change - green-house effect - green-house gases - global warming - Recent changes in temperature over atmosphere and ocean. Projected changes in earth's temperature. Effects of global warming - weather and climate - sea level changes – Ozone Hole-Biological effects – Effect on agriculture- Ocean Acidification- Oxygen depletion-Role of ocean in global carbon cycle.

Unit 5
Climate mitigation and adaptation – green technologies-reduction in emissions-increasing green cover- sustainable agriculture-renewable energy- Climate change policies-IPCC-International treaties/Protocols- Indian Climate change policies and planning.

Reference Books:

1. Dorothée Herr and Grantly R. Galland (2009): The Ocean and Climate Change
2. Dan Seidov, Bernd J. Haupt, Mark Maslin (2013) The Oceans and Rapid Climate Change: Past, Present, and Future
3. Gerold Siedler, Stephen M. Griffies, John Gould and John A. Church (Eds.) (2001) Ocean Circulation and Climate_a 21st Century Perspective
4. Climate Change 2001 : Synthesis Report – IPCC, 2002
5. E Bryant (1997) Climate Process and Change
6. K KJurekian (1996) Global Environmental Change – Past, Present and future
7. Grant R. Bigg (2004) The Oceans and Climate.

POM 2205	Oceanographic instruments	E	Credits 3

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand and apply ship-based ocean observation techniques.	U, A
2	Analyze current measurement methods and instruments to measure temperature and salinity.	An, E
3	Evaluate wave and tide measurement devices and their applications.	E, An
4	Create and utilize advanced oceanographic data collection tools.	C, A
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

Ocean Observation Platforms- Ship-based Measurements- Oceanographic Data collection- Spatial and Time-series stations- Winches, wire ropes, messengers- Nansen water bottles and Reversing thermometers- Collection of salinity and oxygen samples- Thermo-salinograph- Autosal and salinity calibration- SST bucket thermometer- Seichi disk and Radio meter - Mechanical Bathy Thermograph (MBT) and Expendable Bathy Thermograph (XBT) system- Conductivity, Temperature and Depth (CTD) with Rosette sampler- XCTD - Automatic Weather Station (AWS)

Unit 2

Current measurements- Eulerian and Lagrangian methods- Swallow Floats- Types of Current meters- Propeller and Acoustic Devices- Speed and Direction measurements- Mooring of Current meters- Shallow and Deep water moorings- Acoustic Doppler Current Profilers (ADCP)- Ship hull mounted and bottom mounted ADCP systems.

Unit 3

Wave Measuring Devices- Bottom mounted pressure sensors- Ship-Borne Wave Recorder (SBWR) systems (Tucker’s device)- Accelerometer and pressure sensors- Waverider Buoys- Directional Wave buoys- Tide Staff and Tide Gauges- Acoustic Tide Gauges- Mooring of Wave buoys and Tide sensors- Coastal and ship-borne Radars for measuring waves.

Unit 4

Argo floats and Gliders for Oceanographic data collection- Towed Oceanographic Data Collection systems and AUVs- AXBT systems- Meteorological Instruments- Echosounder

References:

1. Pickard G.L. and W.J. Emery (1995): Descriptive Physical Oceanography- Pergamon press.
2. Sverdrup H.U., Johnson M.W. and Fleming R.H- The Oceans: their physics, chemistry and general biology, Prentice Hall Inc., New Jersey, 1958.
3. William J. Emery and R. E. Thomson (2001): Data Analysis and methods in Physical Oceanography, Elsevier

POM 2206	Marine Bio-geochemical Processes	E	Credits 3

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Describe major ocean biogeochemical cycles and the role of organic matter in marine ecosystems.	R, U
2	Analyze phytoplankton dynamics, primary productivity, and their relationships with environmental factors in the Arabian Sea and Bay of Bengal.	A, An
3	Evaluate the influence of physical processes on primary productivity and marine ecosystems, including responses to climatic changes.	E
4	Examine zooplankton communities, their role in secondary production, and indicators of fishery health within different marine environments.	U, An
5	Assess the implications of plankton on fisheries and understand the effects of climate change on coastal and pelagic ecosystems.	E, A
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

Major ocean biogeochemical cycles – carbon, nitrogen, silicon and phosphorus cycles, micro-nutrient dynamics and cycling- Organic matter- dissolved, particulate and colloidal species, sources, classification, composition, distribution, seasonal variations- Ecological significance-Growth promoting and growth inhibiting effects- Biogeochemical cycles.

Unit 2

Phytoplankton and primary productivity - pigments, photosynthesis – net and gross primary productivity- rate of primary production in inshore and offshore regions of Arabian Sea and Bay of Bengal- Latitudinal and Seasonal variations in primary productivity- Factors affecting primary production, methods of estimation- Relationship of phytoplankton productivity to light and nutrients- Role of phytoplankton in global carbon cycle – Impacts of climate change- Algal blooms – HABs and TABs- Ocean Colour Monitoring and estimation of primary productivity.

Unit 3

Influence of Physical processes on primary productivity- Hydrodynamic forcing- Upwelling, stratification, mixed layer depth, turbulent mixing, monsoon driven biogeochemical processes in the Arabian Sea and Bay of Bengal – Spatial and Temporal variations in the nutrient concentrations- Response of marine pelagic ecosystems to climatic forcing, OMZ, HNLC-Ocean currents and their impact on marine life- Phytoplankton distribution ad patchiness.

Unit 4

Zooplankton communities in estuarine, neritic and oceanic systems. Secondary production-Linkages to higher trophic level, Plankton as indicators of fisheries. Indicator species of water masses. Benthic ecosystem processes, benthic environment and community structure, Organism sediment relations. Benthic pelagic coupling, CDOM.

Unit 5
Plankton in relation to fisheries –Plankton as indicators of fisheries- Potential Fishery Zones- SST variations and pelagic fisheries- Influence of upwelling on oil sardine fishery in Arabian Sea, Larval transport and recruitment- Effects of climate change on Coastal upwelling systems- Fish migrations.

Reference Books:

1. John H Simpson and Jonathan Sharples (2012): Introduction to the Physical and Biological Oceanography of Shelf Seas; Cambridge University Press.
2. Tom Beer (1996): Environmental oceanography (CRC Marine Science), 2nd Edition, CRC Press
3. J P Riley & Chester Introduction to Marine Chemistry. Academic Press London and New York
5 Biological Oceanography an Introduction. Carol M. Lalli& Timothy R. Parsons. Elsevier, Butterworth-Heinemann
6 Marine biology. Peter Castro & Michel E Huber. The Mc-Graw companies.

SEMESTER-II (Practical)

POM 2207	**Dynamical Oceanography (Practical)**	**C**	**Credits 2**

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Analyze vertical sections of temperature, salinity, and density data.	An, U
2	Create horizontal sections of physical properties and chlorophyll concentrations.	C, A
3	Compute specific volume anomalies and potential temperature from sample datasets.	A, An
4	Compute geostrophic currents using hydrography or sea level anomaly data.	A, An
5	Perform stability analysis of oceanographic data.	An, E
6	Estimate vertical velocity from given data.	A, E
7	Estimate Ekman currents and analyze the Ekman spiral.	A, An
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

1. Plotting of Vertical sections of temperature, salinity and density data and Interpretation of oceanographic features.
2. Preparation of horizontal sections of physical properties and Chlorophyll
3. Computations of specific volume anomalies and potential temperature from sample data Sets.
4. Computations of geostrophic currents using hydrography data or sea level anomaly data.
5. Stability Analysis
6. Estimation vertical velocity
7. Estimation of Ekman current and Ekman Spiral

POM 2208	Oceanographic Data Analysis (Practical)	C	Credit 2

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Analyze standard oceanographic data and interpret results	An, U
2	Create vertical and horizontal sections of temperature, salinity, and density; Plot T-S diagrams to identify water mass characteristics.	C, A, E
3	Construct Hovmoller diagrams and interpret their significance	A, U
4	Perform time series analysis of oceanographic data	A, An
5	Apply FFT and wavelet analysis to oceanographic datasets	A, C
6	Implement low pass and high pass filters for data processing	A, S
7	Conduct EOF analysis and interpret its results	An, E
8	Analyze wave data and extract meaningful insights	An, U
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

1. Standard Oceanographic data analysis and interpretation of results
2. Vertical and horizontal sections of temperature salinity density and other properties'
3. Hovmoller diagrams and interpretation
4. Time series analysis of data
5. FFT and wavelet analysis
6. Low pass and high pass filters
7. EOF analysis and interpretation
8. Wave data analysis.

OST 2201	General Oceanography	C	Credit 3

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand the multidisciplinary nature of Oceanography and identify major oceans, seas, and their geographical features.	U, R, I
2	Explain the physical properties and chemical composition of seawater and their effects on marine processes.	U, A, R
3	Analyze the horizontal and vertical distribution of temperature, salinity, and density in oceans using T-S diagrams.	An, U, A
4	Evaluate oceanic circulation, upwelling, and other coastal processes, and their significance to marine life and fisheries.	E, An, U, Ap
5	Apply oceanographic instruments and modern techniques like remote sensing for data collection, analysis, and modeling.	A, C, S, I
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1: Multidisciplinary nature of Oceanography- Ocean and Sea- Major Oceans, Seas and their dimensions- Shoreline, Continental Shelf and Slope- Mid-Oceanic Ridges, Sea mounts and Trenches- Sea bottom materials- Major Oceanographic Expeditions (both international and national).

Unit 2: Physical properties and Chemical composition of sea water- Temperature, Salinity, Pressure and its units- Density and Specific volume anomaly- Effects of temperature, salinity and pressure on density- Light in the sea- Colour of the sea- Sound in the sea.

Unit 3: Horizontal and Vertical distribution of temperature, salinity and density in oceans- T-S diagram- Water masses in World Oceans and in the Indian Ocean- Ocean Mixed Layer, Thermocline, Halocline and Pycnocline- Distributions of dissolved oxygen and nutrients.

Unit 4: Spatial and Temporal scales of variability in ocean- Currents and Circulation- Major circulation gyres and currents of World Oceans- Monsoonal circulation of the Indian Ocean- Upwelling and Sinking- Coastal Upwelling regions and its significance for Fisheries- Waves, Tides, Long-shore Currents and Coastal processes.

Unit 5: Oceanographic Instruments and Data Collection at sea- Methods of Data Processing, Analysis and Ocean Modelling- Remote Sensing of Oceanographic parameters- Oceanographic Satellites and their Sensors -Climate Change and Oceanic Perspectives.

<u>Reference Books</u>

1. Pickard G.L. and W.J. Emery- Descriptive Physical Oceanography- Pergamon press, (1995or latest edition).

2. Lynne D. Talley, G.L. Pickard, W.J. Emery and James Swift- Descriptive Physical Oceanography: An Introduction- Elsevier (6th edition, 2011).

3. Robert H. Stewart- Introduction to Physical Oceanography- online edition (public domain), Aug 2003.

4. Open University Course team and Butterworth-Heinemann: Sea water, its composition, properties and behavior; Open University team, 2nd Edition, 1997, jointly published by Oxford, UK, ISBN 0-7506-3715-3

SEMESTER- III (Theory)

POM 2301	Air - Sea interaction	C	Credits 4

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand the principles of air-sea interaction, including fluxes of mass, momentum, and heat, and their characteristics within the atmospheric boundary layer	U
2	Apply models of the atmospheric boundary layer and turbulent transport, including stability effects and Monin-Obukhov theory, to real-world scenarios.	A
3	Analyze and evaluate the methods for estimating and measuring surface fluxes, including the eddy correlation and bulk aerodynamic methods.	An, E
4	Examine the ocean's heat budget, understanding factors affecting heat fluxes and their annual and spatial variations.	U, An
5	Assess the role of oceans in climate dynamics, focusing on large-scale air-sea interaction processes and significant oscillation patterns like El Nino, Pacific Decadal Oscillation.	An, E
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

Air-sea interaction: Atmospheric boundary layer- fluxes of mass, momentum and heat -- wind stress - wind stress curl - friction velocity - eddy viscosity- Reynolds's Number - turbulence-characteristics of turbulent flow - scales of air-sea interaction Kolmogorov length scale - Taylor's micro scales.

Unit 2

Wind profile in the atmospheric boundary layer - mixing length - effect of stability on wind profile -turbulent transport of fluxes - Von Karman Constant - Modelling the atmospheric boundary layer-turbulence closure - K-theory - Prandtl's mixing length theory - Reynolds stress equation model - Monin-Obhukov length - Monin-Obhukov surface layer similarity theory for stratified atmosphere **-** air-sea interaction in coastal zone - sea and land breeze.

Unit 3

Estimation and measurement of fluxes - eddy correlation method - bulk aerodynamic method- Fluxes from Satellite observations and ocean weather stations - measurement of surface fluxes from ocean weather stations.

Unit 4

Heat budget of the ocean - Short wave and long wave heat fluxes - albedo -factors affecting short wave and long wave heat fluxes - sensible and latent heat flux - net heat flux- Bowen's ratio - annual cycle of heat fluxes - spatial and time variation of heat fluxes - meridional heat transport in the ocean.

Unit 5

Role of Oceans in climate - Large scale air-sea interaction processes - El Nino and La Nina-Southern Oscillation - El Nino-Modoki, - North Atlantic Oscillation - Atlantic Multi-decadal Oscillation – Pacific Decadal Oscillation -Arctic Oscillation - Antarctic Oscillation –Indian Ocean Basin Mode (IOBM) - Indian Ocean Dipole (IOD).

Reference Books:

1. Kraus, E. B. and J. A. Businger Atmosphere - Ocean Interaction, 2nd edition.
2. G T Csanady, Air-sea interaction: laws and mechanisms
3. Y. Toba (2004) Ocean-Atmosphere interactions
4. John Marshall and Alan Plumb (2007) Atmosphere, Ocean and climate Dynamics – An introductory text.
5. Adrian E. Gill (1982) Atmosphere-Ocean Dynamics
6. Neil Wells (1986) The atmosphere and Ocean – A physical Introduction

POM 2302	Ocean Modelling	C	Credit 4

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand the fundamentals of ocean general circulation modeling, including key equations.	R, U, A
2	Apply numerical schemes and boundary conditions in ocean simulations.	A, An
3	Analyze and compare various ocean and wave models.	An, E
4	Evaluate the performance and limitations of operational wave models.	E, Ap
5	Create and implement a basic ocean model using available data.	C, S, I
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

Introduction to Ocean Modelling- Mechanistic and Simulation models- Conservation of Mass and Momentum – Navier-Stokes equations and Ocean circulation modelling- Spherical coordinates - Conservation of angular momentum – Conservation of Mechanical Energy-Global Ocean Modelling- Hydrostatic Primitive Equations- Initial and Kinematic Boundary conditions- Shallow water equations- Geostrophic adjustment- Quasi-geostrophy.

Unit 2

Numerical Schemes- Finite Differences- Forward, Backward and Central differences- Explicit and Implicit schemes. Horizontal and vertical grid types-finite difference and finite element methods- lateral boundary conditions-bathymetry- Model forcing - Model Initialization and Spin up -ocean data assimilation-Time Differencing- Time Splitting.

Unit 3

Barotropic and Reduced gravity models. Basin scale models and Regional models- Cox's Model of Indian Ocean- O'Brien's model of North Pacific Ocean- Holland and Hirschman's Model of Atlantic Ocean - 3 Dimensional Ocean Models- GFDL Modular Ocean Model (MOM)- Princeton Ocean Model (POM)- ROMS and HYCOM.

Unit 4

Introduction to wave modelling- Kelvin-Helmholtz, Jeffrey's, Sverdrup-Munk, Phillips' and Miles wave generation theories- Non-linear wave-wave interactions and wave growth- Early wave prediction methods- Significant wave and wave spectrum approaches- 1D and 2D wave spectrum- Sverdrup-Munk- Bretschneider (SMB) and Pierson-Neumann-James (PNJ) methods of wave prediction.

Unit 5

Over view on numerical wave modelling- Evolution of spectral wave models- 1st, 2nd and 3rd generation wave models- Discrete spectral wave models- Parametric and Hybrid wave models-

Coupled discrete wave models- Deep and shallow water wave models-Source functions and examples of models of 1st and 2nd generations -DSA, MRI, VENICE, PTB, SOWM, GSOWM, GONO, TOHOKU, HYPA, SAIL. Third generation wave model (3G WAM) - Wave Watch III model- SWAN model- Operational wave models- Cold start and spin-up time of wave models- Data Assimilation techniques -Validation and inter-comparisons of models- Limitations of operational models.

Reference Books:

1. SWAMP Group 1985: Ocean Wave Modelling, Plenum Press, (pp.256).
2. M.L. Khandekar: Operational Analysis and Prediction of Ocean Wind Waves, Springer-Verlag, 1989.
3. Leo H. Holthuijsen (2010) Waves in Oceanic and Coastal Waters
4. Stanislaw R. Massel (1996) Ocean Surface Waves: Their Physics and Prediction
5. G. J. Komen, L. Cavaleri, M. Donelan (1994) Dynamics and Modelling of Ocean Waves
6. D.B. Haidvogel and A. Beckmann (1999) Numerical Ocean Circulation Modeling (Vol.2), Imperial College Press.
7. James J Obrien (1985) Advanced physical oceanographic numerical modeling (Nano science series).
8. Pond and Pickard (2013) Introductory Dynamical Oceanography, Butterworth-Heinemann
9. Kantha&Clayson: (2000) Numerical Models of Oceans and Oceanic Processes, Academic Press
10. Benoit Cushman-Roisin and Jean-Marie Beckers: (2009) Introduction to Geophysical Fluid Dynamics. Physical and Numerical Aspects
11. P. Muller H. von Storch (2004) Computer Modelling in Atmospheric and Oceanic Sciences

POM 2303	Coastal and Estuarine Process	C	Credit 3

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand coastal geomorphology and its evolution with sea level changes.	R, U, A
2	Analyze estuarine systems, including circulation, mixing, and sedimentation processes.	An, E, A
3	Apply knowledge of coastal oceanography, including wave dynamics and sediment transport.	A, U, S
4	Evaluate shoreline changes and the impact of engineering structures on coastal processes.	E, An, Ap
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

Coastal Geomorphology- Evolution of the coast in relation to sea level changes- Geomorphology of the coast-Shelf geological processes- Beach Definition, beach and surf zone morphology- Coastal Land forms- Depositional and Erosional environments- Mud banks- coastal erosion and accretion -Natural and anthropogenic - Coastal Protection methods.

Unit 2

Classification of Estuaries- Circulation, mixing and stratification- Flocculation-Tidal asymmetry and flushing- Estuarine sedimentation-Tidal Prism- Tidal inlets and creeks-Mangroves-Delta-Intertidal zone-Tidal Flats-Salt marshes-Estuaries in Kerala.

Unit 3

Coastal Oceanography- Shallow water wave transformation-wave shoaling - Wave breakers-Wave decay in surf zone- Infra Gravity waves- Edge waves- Littoral currents- Cross shore, long-shore and rip currents- coastal flooding-Kallakadal- tidal currents- sediment transport- Aeolian and littoral transport- Classification of sediments- Grain size analysis

Unit 4

Shoreline Changes- Beaches- Beach Cusps- Edge waves and rhythmic formations- beach profiles- Profile changes due to storms-Long-shore bars and troughs- barriers and barrier Islands-Classification of beaches- Beach processes – source, nature and character of the beach material- beach stability- Coastal response to Engineering structures- Remote sensing for shoreline mapping

References:

1. Paul D Komer (1997) Beach Processes and Sedimentation, Prentice Hall, 2nd Edition
2. Pethick J, (1984) An Introduction to Coastal Geomorphology (Arnold)
3. Horikawa, K. (1978). Coastal Engineering (University of Tokyo Press)
4. Dean, R G and Darlymple, R A, (2001). Coastal Processes with Engineering Applications (Cambridge University Press)
5. J.S. Mani (2012) Coastal Hydrodynamics
6. Dyer K.R (1973) Estuaries: A Physical Introduction, John Wiley
7. Dyer K.R (1986) Coastal and Estuarine Sediment Dynamics; In : Coastal and Estuarine Sediment Dynamics, John Wiley & Sons Ltd
8. CAM King (1961) Beaches and Coasts
9. U S Army CERC, (1984 or latest). Shore Protection Manual

POM 2304	**Coastal Hazards Management**	**E**	**Credit 3**

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Identify and describe coastal hazards and their impacts.	R, U
2	Analyze factors contributing to coastal erosion and propose management strategies.	An, A
3	Evaluate the effects of marine pollution and climate change on coastal ecosystems.	E, U
4	Develop and assess disaster risk management strategies and policies for coastal areas.	C, S
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

Coastal Hazards-Geological, oceanographic meteorological and anthropogenic hazards-Storms and storm surges-factors affecting storm surges-Tsunami-Causes-Tsunami transformation in shallow water-Case studies of most destructive Tsunami-Extreme waves-Coastal Flooding-Kallakadal-Rip currents

Unit 2

Coastal erosion-natural and man-made factors inducing coastal erosion- man made factors inducing coastal erosion-sediment budget-shoreline management plan-strategies for shoreline management-sediment cell-hard and soft solutions for coastal protection-sea level rise-causes and implications

Unit 3

Marine pollution-classes of pollutants-trace elements and other inorganic chemicals-Acidity and Alkalinity-sewage and effluent pollution-ocean acidification-oil spills-Biological Disasters-Harmful algal blooms-Coral bleaching-effects of global warming on ocean food chain-man made coastal hazards

Unit 4

Cases of hazards in Indian coasts-Coastal Disaster Risk Management (DRM) – Hazard monitoring and evaluation- Coastal hazard risk reduction-Establishment of Early Warning System (EWS) for DRM- Indigenous Knowledge Systems for EWS-Institutional and legal arrangements for disaster risk management-Integrated Coastal Zone Management (ICZM) - Local and International constraints/challenges of ICZM- Policy, legislation and institutional framework- Environmental Impact Assessment

Reference books:

1. Clark J R (1996) Coastal Zone Management Handbook (CRC Press (Lewis Publishers))
2. Klay R and Alder J(2005) Coastal Planning and Management (Taylor and Francis)2nd Edition
3. Shroder J F, Ellis T J and Sherman D J (editors)(2015) Coastal and Marine hazards, risks and disasters.
4. Van Dam J C (editor) (2005) Impacts of climate change and climate variability on Hydrological regimes (Cambridge University Press)
5. Houghton J(2009) Global warming – the complete briefing (second edition) (Cambridge University Press) IPCC 4th and 5th Reports

POM 2305	Coastal Ocean Modelling	E	Credit 3

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand key coastal and estuarine processes including waves, currents, and sediment transport in the nearshore and surf zones.	U, An, S
2	Apply coastal modeling approaches for profile, coastline, and area models, including input schematization and software tools like SBEACH, XBeach, and Delft 3D.	A, C, S
3	Develop and validate coastal models, including grid setup, calibration, and result interpretation.	A, An, E, S
4	Analyze and predict tidal dynamics using tide models and storm surge modeling techniques.	An, E, Ap
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

Review of coastal and estuarine process: Waves in the nearshore and surf zone, beach profiles, currents and sediment transport in the near-shore and surf zone; estuaries and tidal inlets, tidal currents, residual currents, tidal flushing

Unit 2

Coastal Ocean modelling approaches – Coastal profile, coastline models and coastal area models- Input schematization - Input parameters- General principles of schematization- Tidal schematization- Schematization wind/wave climate- Coastal profile models – Principles and approach, SBEACH- Coastal area models - One line models- Principles and approach- GENESIS- Coastal area models – Flow model- Sediment Transport model- XBeach- ROMS- Delft 3D-MIKE 21.

Unit 3

Modelling procedure - Data collection and analysis- Conceptual model- Setting up model grid and bathymetry- Boundary conditions- Calibration and Validation- Defining output- Running and post processing- Interpretation of results- Case studies

Unit 4

Introduction on Tide Models-tidal prediction for ports and shallow water-the harmonic method-the response method- Storm surge modelling

References Books:

1. Paul D Komer(1998) Beach Processes and Sedimentation, Prentice Hall, 2nd Edition
2. Roelvink D and Reniers A., (2012) A Guide to Modelling Coastal Morphology, World Scientific
3. Goda, Y., (2010) Random Seas and Design of Maritime Structures, World Scientific Publishing Ltd
4. Horikawa, K.(2010) Coastal shoreline change prediction models, Won Kisool (Korea) (2010)
5. Bowden, K. F. (1984) Physical Oceanography of Coastal Waters. Ellis Hot-wood Ser. Mar. Sci., John Wiley& Sons, Inc., Somerset, N.J. 302 p.

POM 2306	Coastal Engineering	E	Credit 3

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Analyze coastal engineering problems and propose alternative solutions.	An, E
2	Understand and apply small amplitude wave theory to coastal dynamics.	U, A
3	Evaluate finite-amplitude wave theories for wave prediction and analysis.	E, An
4	Develop principles for coastal defense and environmental assessment.	C, A
5	Model and simulate coastal processes and hazards for effective management.	A, C
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

Coastal Engineering Problems- coastal flooding, shoreline erosion, navigation sedimentation, water quality pollution, and coastal habitat evanescence. Physical processes on coastal environment.Equation and Solution.Sediment Transport. Breakwaters tip and entrance gap-Wave-Structure Interaction- Wave Run-up- beaches- structures and slopes- Wave Overtopping-structures and slopes. Offshore piles - Design of Seawalls & Breakwaters - Design of Coastal Structures, - Basic principles of coastal processes.

Unit 2

Small Amplitude Wave Theory- Wave properties: Profile, celerity, velocity - Pressure, Energy and Mass Transport. Standing Waves. Wave Transmission-Wave Breaking- Height and depth-wave Forces. Define and analyze coastal problems to conceive alternative solutions

Unit3

Finite-Amplitude Waves- Stokes Theory- Shallow Water Waves. Cnoidal& Solitary Wave Theory- Stream Function Theory- Long Waves: Wave Prediction, Wave Transformation, Shoaling, Refraction: Snell’s law- Diffraction.

Unit 4

Principles of Coastal Defence- Management and Environmental Assessment- Coastal Zone Metrics- Navigation and harbour design- Tools and procedures to plan, design, construct, and maintain coastal projects- Dredging and disposal- structure repair and rehabilitation- wetland and low-energy shore protection- risk analysis

Unit 5

Coastal Processes and Hazards - Coastal Geomorphology, Coastal planning and design parameters - coastal structures - coastal development/management-Numerical simulation of engineering process- Coastal Zone Modelling - hydraulic engineering works.

References:

1. Barnabe&Barnabe (2000) Ecology and management of coastal waters: The aquatic environment Springer-Praxis
2. Kamphuis, J W (2000) Introduction to Coastal Engineering and Management, World Scientific, 2000.
3. Coastal Engineering Manual Outline, USACE, 2006: http://chl.erdc.usace.army.mil/cemtoc

POM 2307	Ocean State Forecasting	E	Credit 3

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Identify traditional methods for locating fishing grounds, including visual observations and aerial surveys.	R, U, A
2	Utilize remote sensing techniques to analyze sea surface parameters and their impact on biological productivity.	U, A, An
3	Forecast ocean state parameters, including SST, wave height, and ocean currents, for maritime safety and navigation.	U, A, E
4	Implement ocean data assimilation methods and validate marine ecosystem models.	A, E, An
5	Understand the role of satellites in operational oceanography and the retrieval of geophysical parameters.	U, A, Ap
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

Potential fishing zone advisories and validation - Traditional methods of locating the fishing grounds- fish shoal based on their colour, behaviour and schooling patterns- Ariel surveys to locate the fishing grounds. Visual fish spotting from aircraft - Indirect detection by observing the associated sea surface.

Unit 2

Remote sensing of sea surface parameters - Chlorophyll – biological productivity - SST - thermal fronts, Eddies, meanders, upwelling, rings, filaments, etc. - Cost benefits, reduction in search time and fuel - Ocean Tuna fishing advisories

Unit 3

Ocean State Forecast - Numerical Models SST - Wave height and direction forecasts - Wave forecast for coastal states - Ocean State Forecast – ocean currents and temperature - Mixed layer and thermocline - Wind Speed and Direction- High wave alerts and Tsunamis warning- Forecasts along ship route- Cyclones and Storm surge forecasts.

Unit 4

Ocean Data Assimilation and Forecasting- Validation of ocean circulation and marine ecosystem models- Advanced data assimilation methods

Unit 5

Satellites for Operational Oceanography- Global Ocean Observing System (GOOS) and Operational oceanography- Passive & active Techniques- Retrieval of Geophysical Parameters- Microwave Radiometers, Altimetry, High Level Data Processing and Products

References:

1. Eric P. Chassignet and Jacques Verron (2006) Ocean Weather Forecasting: An Integrated View of Oceanography
2. MischaelHord, “Remote Sensing Methods and Applications”, John Wiley & Sons, New York, 1986.
3. Motoyoshi Ikeda and Frederic W. Dobson (1995). Oceanographic Applications of Remote Sensing, CRC Press, USA
4. Peter Michael Inness and Steve Dorling (1988) Operational Weather Forecasting
5. Kenneth E. Lilly (1981)An Introduction to Sea State Forecasting

SEMESTER -III (Practical)

POM 2308	Ocean Modelling (Practical)	C	Credits 4

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Analyze stability in implicit and explicit schemes.	An, E
2	Select appropriate numerical model parameters including coordinates, grid structure, and boundary conditions.	A, An
3	Understand oceanic convection and geostrophic adjustment processes.	U, A
4	Conduct wind-driven circulation simulations using a numerical ocean model.	A, C
5	Examine layered models to study abyssal circulation patterns.	U, An
6	Perform exercises with conventional wave prediction techniques using formulae and nomograms.	A, S
7	Simulate wave patterns using a numerical wave model.	C, A
8	Analyze wave records and estimate significant wave parameters using Tucker's method.	An, E
9	Analyze stability in implicit and explicit schemes.	An, E
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

1. Selection of Schemes-Implicit and Explicit – stability analysis
2. Selection of coordinates, grid structure, boundary conditions, vertical levels, horizontal resolution, etc.
3. Oceanic Convection-Geostrophic adjustment
4. Wind-driven circulation simulation experiments on computer using any one of the Numerical Ocean Model.
5. Layered Models - Abyssal Circulation
6. Exercises with conventional SMB and PNJ Wave Prediction techniques using formulae and nomograms.
7. Model simulation using numerical wave model
8. Analysis of sample wave record and estimation of significant wave parameters following Tucker's method.

OST 2301	Coastal Oceanography	C	Credit 3

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Understand coastal geomorphology, including shoreline features, beach dynamics, and the impact of wave action and human activities.	U, R, Ap
2	Explain the principles of tides, including lunar and solar components, tidal currents, and measurements.	U, A, R
3	Analyze ocean wave dynamics, including wave transformation, and assess their effects on coastal processes such as erosion and accretion.	An, U, E
4	Evaluate the characteristics, circulation, and sedimentation processes in estuaries.	E, An, U
5	Apply coastal zone management strategies, assessing environmental impacts and understanding the legal aspects of coastal protection.	A, C, E, I
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Unit 1

Coastal Geomorphology: sea coasts and shorelines, shoreline features, beaches, behavior of beach, wave action on beach sediments, movement of beach material, beach stability, effect of man on the beach, long shore currents - rip currents, types of sediment transport, equation governing sediment transport, long-shore sediment transport, cross-shore sediment transport, sediment transport calculations, sediment budgeting, Mud banks.

Unit 2

Introduction to Tides- Lunar and Solar components- Semi-diurnal and Diurnal tides- Spring and Neap tides - range differences- Tide generating forces- tidal currents and tide measurements.

Unit 3

Ocean waves- Sea –Swell- internal waves -Wave transformation in shallow waters, effect of bottom friction, phenomena of wave reflection, refraction and diffraction, breakers, littoral currents. Tsunamis- Seiches - Storm surges - measurement of waves. Wave erosion and accretion

Unit 4

Estuaries: General characteristics of estuaries, classification and nomenclature, stratification, estuarine circulation and mixing, tidal prism, entrainment, sedimentation in estuaries, flocculation and turbidity maxima.

Unit 5

Coastal zone management, environmental characteristics and conditions, oceanographic aspects in coastal zone protection, impact assessment for coastal environment, coastal zone of India, EEZ and is importance, law of the sea.

Reference Books

1. Estuary and Coastline Hydrodynamics: A T Ippen
2. Estuaries: A Physical Introduction: K R Dyer
3. Estuaries: G H Lauff
4. Beaches and Coasts: C A M King
5. Waves and Coast: R E Meyer
6. The Coast Line: R S K Barnes
7. Stability of Coastal Inlets: P Brunn and Gerritsen
8. Shelf Sediment Transport Processes: D J P Swift

SEMESTER - IV

Dissertation		**20 Credits**

Course Outcome No.	Expected Course Outcome	Learning Domains
1	Demonstrate the ability to conduct independent research, applying theoretical knowledge and practical skills to address specific oceanographic problems and forecasting/modelling.	R, U, A, An, E, C, S, I, Ap
*Remember (R), Understand (U), Apply (A), Analyze (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)		

Whole IV Semester involves Dissertation work. Students are allowed to carry out the dissertation work at the University departments/National Research Institutes/ other University recognized Research Institutes.