File Ref.No.Ac.A3/General/2023

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

(Abstract)

Department of Physical Oceanography - Modifications in the programme curriculum of M.Sc. Oceanography consequent to the introduction of mandatory MOOC courses - Resolution of the Academic Council - Communicated - Orders issued.

ACADEMIC A SECTION

No.CUSAT/AC(A).A3/4654/2024 Dated,KOCHI-22,31.10.2024

Read:-1. Item No.II (34) (2) of the minutes of the meeting of the Academic Council held on 07.09.2024

2. U.O.No:CUSAT/AC(A).A3/1208/2024 dated 13.03.2024

ORDER

The Academic Council meeting held on 07.09.2024, vide item referred as (1) above, considered along with the recommendations of it's standing committee and resolved to approve modifications in the programme curriculum of M.Sc. Oceanography, consequent to the introduction of mandatory MOOC programmes, with effect from 2024 admission onwards.

The modified curriculum is appended.

Orders are, therefore, issued accordingly.

Dr. Arun A U *
Registrar

To:

1. The Dean, Faculty of Marine Sciences
2. The Chairperson, BoS in Physical Oceanography
3. The Head, Department of Physical Oceanography
4. All AR/DR Examination wing - with a request to forward to concerned sections
5. The Director, IQAC/ DoA
6. CIRM/Conference Sections
7. PS To VC/PVC;PA To Registrar/CE.

* This is a computer generated document. Hence no signature is required.

CURRICULUM AND SYLLABUS FOR

M.Sc OCEANOGRAPHY

(With effect from Academic Year 2024-25)

Choice Based Credit System (CBCS) with
Outcome Based Education (OBE)

DEPARTMENT OF PHYSICAL OCEANOGRAPHY
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
KOCHI – 682022

2024

CONTENTS

1. Preamble

The M.Sc. program in Oceanography, spanning two years over four semesters, is a flagship offering of the Department of Physical Oceanography at Cochin University of Science and Technology. This meticulously crafted curriculum aims to equip students with both theoretical understanding and hands-on experience in the vast realm of oceanography. Specifically tailored to cultivate expertise in physical oceanography, the program is structured to meet the growing demand for skilled professionals in this field. Through practical coursework encompassing computer programming and data analytics, students gain proficient skills essential for analyzing oceanographic data and deriving meaningful interpretations.

The curriculum operates on a Choice Based Credit System (CBCS), where every course is allocated specific credits. To be eligible for the award of the degree, students must accumulate a minimum of 72 credits. Evaluation is conducted through grading for each course, adhering to Outcome Based Education (OBE) principles. Under OBE system, each course is structured around predefined Course Outcomes (CO), and students' performance is assessed based on their achievement of these outcomes.

2. Scope

This curriculum and syllabus are designed for the M.Sc. Oceanography program offered by the Department of Physical Oceanography at Cochin University of Science and Technology, starting from the 2024-25 academic year onwards. All academic procedures including admission, course registration, and assessment will adhere to the regulations set forth by Cochin University of Science and Technology for postgraduate courses. This document exclusively outlines the particulars of the M.Sc. Oceanography program, including OBE evaluation procedures and the scheme and syllabus.

3. Outcome Based Education (OBE)

Outcome-Based Education (OBE) is a student-centric teaching and learning methodology in which the course delivery and assessment are planned to achieve stated objectives and outcomes called as Course Outcomes (CO). Each CO is categorized according to its level of comprehension based on the Revised Bloom's Taxonomy Level (BL). OBE encompasses key concepts including Graduate Attributes, Program

Educational Objectives (PEO), Program Outcomes (PO), Program Specific Outcomes (PSO), and Course Outcomes (CO).

3.1 Graduate Attributes

This curriculum and syllabus incorporate the following graduate attributes outlining the key competencies and qualities students will acquire to excel in their academic pursuit and beyond.

1. Knowledge
2. Creativity
3. Digital skills
4. Teamwork
5. Communication
6. Leadership
7. Responsible decision making
8. Integrity

3.2 Programme Educational Objectives (PEO)

The Programme Educational Objectives (PEO) are statements that describe the expected achievements of graduates in their career, and also in particular, what the graduates are expected to perform and achieve during the first few years after graduation.

PEO1 Skill Acquisition

Students acquire various skills that are important to address research problems, writing reports and presentation of their work to audience. The course will also develop valuable life skills of students and transform them to a holistic personality so that they are enabled to think independently, argue critically, solve problems and communicate effectively at a level which reflects their competency.

PEO2 Creativity and Innovation.

Students will be motivated to bring out the best in them and foster creativity and innovation. Students will be able to formulate research problems and will have the potential to handle the project work.

PEO3 Employability

Students will develop professional and innovation skills that qualify them for immediate employment and life-long learning in advanced areas of oceanography and related fields. The students will be able to get employment from various research and academic institutions in India and abroad.

PEO4 Higher Studies and Research

The course curriculum is made up-to-date every four years and covers all branches in Physical Oceanography. Students will be able to carryout higher studies in the subject such as Master of Technology and Ph D. Students can also apply for research positions in various oceanographic organizations such as Project Assistant, Project Associate, Project Scientist etc.

PEO5 Well informed, Ethical and Socially committed professionals

Students are encouraged to participate in social organizations such as National Service Scheme (NSS) and other social gatherings in the campus. This makes the students more responsible towards the society. They also develops leadership roles to explore and develop social, legal and ethical responsibilities for a career with a respectful mind towards the society.

PEO6 Team Work

Students will be able to collaborate with others and achieve specific goals as teamwork when required. Students should also, able to function effectively as an individual, as a member or leader in diverse teams, and in multidisciplinary settings.

PEO7 Ethics

Students will be able to apply ethical principles and commit to professional ethics and responsibilities and norms in their career as researcher or academicians.

3.3 Programme Outcomes (PO)

Program outcomes (PO) are statements conveying the intent of a program of study. Specifically, program outcomes refer to what a student should know or be able to do at the end of a program. They are often seen as the knowledge and skills students will have obtained by the time they have received their intended degree.

PO1 Bridging the knowledge of basic sciences and technologies to understand various natural phenomena.

PO2 Identifying, formulating and analysing research problems.

PO3 Developing analytical and computational skills to address challenges in environmental issues

3.4 Programme Specific Outcomes (PSO)

Programme Specific Outcomes (PSO) are narrower statements that describe what students are expected to be able to do by the time of completion of the Programme.

PSO1 Attain knowledge in the areas of ocean dynamics, ocean remote sensing, air-sea interaction, coastal processes, ocean modelling and climate sciences

PSO2 Develop proficiency in data acquisition, analysis and visualisation using computer programming and data analytics softwares.

PSO3 Design and execute scientific projects in advanced multi-disciplinary topics of oceanography and publication of its output.

PSO4 Develop scientific skills to address ocean-related natural hazards and climate change.

3.5 PO-PSO mapping

Programme Outcomes (PO)	**Programme Specific Outcomes (PSO)**			
	PSO1	**PSO2**	**PSO3**	**PSO4**
PO1	3	2	-	3
PO2	2	2	3	2
PO3	1	3	2	2

Note: Correlation levels: 1 = Low, 2 = Medium, 3 = High

3.6 Course Outcome (CO)

Course (or Learning) outcomes are specific and measurable statements that define the knowledge skills and attitude the learners will demonstrate by the completion of the course. Course Outcomes are written with a verb phrase and declare a demonstrable action. Ideally, they should be observable, measurable, and achievable within a specified time period.

3.7 Bloom's Revised Taxonomy Levels (BL)

There are six levels of cognitive learning according to the revised version of Bloom's Taxonomy. Each level is conceptually different. The six levels starting from lowest are remembering, understanding, applying, analyzing, evaluating, and creating.

		BL
Remember	Retrieve, recall, or recognize basic concepts	1
Understand	Explain ideas and concepts	2
Apply	Use information in new situations	3
Analyze	Draw connections among ideas and concepts	4
Evaluate	Make decisions after evaluating information	5
Create	Use information to create something new	6

3.8 CO-PSO mapping

Each CO of a course is mapped with the PSO of the programme with weightages (correlation levels).

3.9 OBE based question paper

Question papers are prepared in the OBE format. Each question is linked with the Bloom's Taxonomy level (BL), Course Outcome (CO) and Programme Specific Outcome (PSO).

3.10 OBE Evaluation

The OBE evaluation is done to obtain the attainment levels of students. From the percentage of marks scored for each CO, the Level_of_Attainment (LA) is calculated for Continuous and End semester exam. The total weighted LA is then calculated which provides the information on how much each Course Outcome is achieved by the students in a class.

4 Scheme

SEMESTER - I

Course Code	Course Name	C/E	Credit	Marks		
				CA	EA	Total
24-319-0101	Introductory Physical Oceanography	C	4	50	50	100
24-319-0102	Geophysical Fluid Dynamics	C	4	50	50	100
24-319-0103	Ocean Instrumentation	C	3	50	50	100
24-319-0104	Ocean Observations (Practical)	C	1	100	--	100
24-319-0105	Oceanographic Computations – Python (Practical)	C	2	100	--	100
	Elective 1	E	2/3/4	50	50	100
	Elective 2	E	2/3/4	50	50	100
	MOOC	E	2/3	-	100	100

CA – Continuous Assessment, EA – End-Semester Assessment
C/E - Core/Elective
X – Credit will be decided based on the Elective course selected by the student

Total Core Credits : 14
Total minimum Elective Credits required : 4

SEMESTER – II

Course Code	Course Name	C/E	Credit	Marks		
				CA	EA	Total
24-319-0201	Ocean Dynamics	C	4	50	50	100
24-319-0202	Air-Sea Interaction	C	3	50	50	100
24-319-0203	Coastal and Estuarine Oceanography	C	3	50	50	100
24-319-0204	Dynamical Computations (Practical)	C	1	--	--	100
24-319-0205	Coastal Oceanography (Practical)	C	2	--	--	100
24-319-0206	Air-Sea Interaction (Practical)	C	1	--	--	100
24-319-0207	Oceanographic Computations - Fortran (Practical)	C	2	--	--	100
	Elective 1	E	2/3/4	50	50	100
	Elective 2	E	2/3/4	50	50	100
	MOOC	E	2/3	-	100	100

CA – Continuous Assessment, EA – End-Semester Assessment
C/E - Core/Elective
X – Credit will be decided based on the Elective course selected by the student

Total Core Credits : 16
Total minimum Elective Credits required : 4

SEMESTER – III

Course Code	Course Name	C/E	Credit	Marks		
				CA	EA	Total
24-319-0301	Ocean Remote Sensing	C	4	50	50	100
24-319-0302	Numerical Ocean Modelling	C	3	50	50	100
24-319-0303	Oceans and Climate	C	3	50	50	100
24-319-0304	Ocean Climate Data Analytics (Practical)	C	2	100	--	100
24-319-0305	Ocean Modelling (Practical)	C	2	100	--	100
	Elective 1	E	2/3/4	50	50	100
	Elective 2	E	2/3/4	50	50	100
	MOOC	E	2/3/4	-	100	100

CA – Continuous Assessment, EA – End-Semester Assessment
C/E - Core/Elective
X – Credit will be decided based on the Elective course selected by the student

Total Core Credits : 14
Total minimum Elective Credits required : 4

SEMESTER - IV

Course Code	Course Title	C/E	Credit	Marks		
				CA	EA	Total
24-319-0401	Project Dissertation	C	16	50	50	100
	MOOC	E	2/3/4	-	100	100

CA – Continuous Assessment mark awarded by the respective research supervisor.
C/E - Core/Elective
EA – End-Semester Assessment mark awarded by the examination committee on the presentation of dissertation work at the department.

Total Core Credits : 16

List of Elective Courses

Course Code	Course Title	Credit	Mark			Pre-requisites
			CA	EA	Total	
24-319-0001	General Oceanography	3	50	50	100	GS
24-319-0002	Marine Hazards and Management	2	50	50	100	GS
24-319-0003	Marine Pollution	3	50	50	100	GS
24-319-0004	Ocean Optics	2	50	50	100	24-319-0101
24-319-0005	Marine Acoustics	4	50	50	100	24-319-0101
24-319-0006	Integrated Coastal Zone Management	4	50	50	100	GS
24-319-0007	Beach Dynamics	2	50	50	100	24-319-0101 & 24-319-0203
24-319-0008	GIS in Oceanography	2	50	50	100	GS
24-319-0009	Advanced Ocean Dynamics	3	50	50	100	24-319-0102 & 24-319-0201
24-319-0010	Wave Dynamics	3	50	50	100	24-319-0102 & 24-319-0201
24-319-0011	Marine Biogeochemistry	3	50	50	100	GS
24-319-0012	Ocean Circulation	2	50	50	100	24-319-0102 & 24-319-0201
24-319-0013	Remote Sensing and GIS (Practical)	2	100	--	100	24-319-0301
24-319-0014	Marine Remote Sensing Applications	3	50	50	100	GS
24-319-0015	Regional Oceanography	3	50	50	100	24-319-0101
24-319-0016	Ocean Engineering	4	50	50	100	24-319-0101 & 24-319-0203
24-319-0017	Applied and Computational Mathematics	4	50	50	100	GM/GP

24-319-0018	Ocean Ecosystem Modelling	2	50	50	100	24-319-0101 & 24-319-0201
24-319-0019	Statistical Methods in Oceanography (Practical)	1	100	--	100	GM/GP
24-319-0020	Polar Oceanography	3	50	50	100	24-319-0101
24-319-0021	Oceanographic Computations-Matlab/ Octave (Practical)	1	100	--	100	GS
24-319-0022	Data Science & Artificial Intelligence in Oceanography	2	50	50	100	GS

5. Syllabus

5.1 Core Courses

SEMESTER – I

Course Code	Course Title	C/E	Credit
24-319-0101	**Introductory Physical Oceanography**	**Core**	**4**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Describe the spatial and temporal variability of physical properties of the ocean.	2
CO2	Classify different water masses of world oceans using T-S diagrams.	1
CO3	Describe the general characteristics of wind driven and thermohaline circulation of the world oceans.	2
CO4	Describe large scale oceanographic phenomena such as El-Nino, La-Nina, IOD, upwelling and downwelling.	2
CO5	Explain different heat budget terms.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	1	1
CO2	3	-	1	1
CO3	3	-	1	1
CO4	3	-	1	2
CO5	3	-	1	1

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Unit I

General introduction, major expeditions -Dimensions of the ocean, Geographical features of ocean - Physical properties of sea water-distribution of temperature, salinity, density and oxygen in space and time, Indo-Pacific warm pool, mixed layer and barrier layer, Acoustic properties of sea water- sound velocity profile- SOFAR channel and shadow zone- Optical characteristics of sea water – Color of the sea.

Unit II

Heat budget of ocean: Radiation laws, insolation-long wave radiation-factors controlling short wave and long wave radiation- sensible and latent heat transfer, bulk formula for heat fluxes- Bowen's ratio-ocean heat transport- spatio-temporal variability of heat budget terms and net heat balance.

Unit III

Circulation and Water masses: General circulation of the atmosphere – wind-driven currents in the world ocean – Equatorial current systems – Wyrtki Jet- Under currents- seasonal currents in the north Indian Ocean - Somali current – wind stress- Ekman spiral– Upwelling. Formation and classification of water masses- T-S diagram- water masses of the world ocean- – thermohaline circulation - Indian Ocean Dipole (IOD)- El Nino and La Nina

Unit IV

Waves and Tides: General aspects of ocean waves, wave characteristics, sea and swell, deep and shallow water waves, storm surges and tsunamis- Tides and tide generating forces; their causes, variation and types, Tidal currents.

References:

1. Descriptive Physical Oceanography, Reddy, M. P. M., 2000, New Delhi Oxford & IBH
2. Descriptive Physical Oceanography: An Introduction.Ed.6, Lynne D. Talley, George L. Pickard, William J. Emery and James H. Swift, Elsevier, 2011.
3. Introduction to Physical Oceanography: R. H. Stewart, E-book, 2005
4. The Oceans, their Physics, Chemistry and General Biology, H.U. Sverdrup, Prentice Hall, 1969.
5. Introduction to Physical Oceanography, Third edition, John A. Knauss and Newell Garfield, Waveland press, Inc., 2017.

Suggested Reading:

1. Descriptive Physical Oceanography: An Introduction: G.L.Pickard and W. J. Emery, Pergamon, Edns.,1982, 1992.

2. William J Emery, Why we study the Physics of the Ocean: What Physical Oceanographers Really Do. Cambridge Scholars Publishing. 2021.
3. Elements of Physical Oceanography, McLellan, Hugh J., Pergamon press (New York), 1965
4. Elements of Physical Oceanography: A Derivative of the Encyclopedia of Ocean Sciences, Steele, John H, Academic Press, 2010.
5. Essentials of oceanography, Trujillo, Alan P., Pearson, 2014.
6. Ocean Circulation & Climate: Siedler, Church & Gould, Academic Press, 1st Edn., 2001.
7. Ocean Circulation and Climate, Volume 103, Second Edition: A 21st century perspective, Siedler, Gerold, Academic Press, 2013.
8. Physical Oceanography (Vol. 2), Defant, Albert, 1961, New York Pergamon Press.
9. Physical Oceanography, A.S.N. Murty and V.S.N. Murty, A.P.H. Pub, viii, 430 p, 2010.
10. Principles of Physical Oceanography: G.Neumann & WJ Pierson, Jr., Prentice Hall,1st edn.,1966
11. Regional Oceanography: Tomczak M. & J.S.Godfrey, Daya Publishing House, New Delhi, 2004.
12. Oceanography Challenges to Future Earth, Komatsu, T., Ceccaldi, H., Yoshida, J, Prouzet, P., Henocque, Y. (Eds), Springer, ISBN 978-3-030-00137-7, 2019.
13. Ocean circulation in three dimensions, Barry A. Klinger and Thomas W.N. Haine, Cambridge University Press, 2019.

Course Code	Course Title	C/E	Credit
24-319-0102	**Geophysical Fluid Dynamics**	**Core**	**4**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	List out fundamental equations of the fluid dynamics.	1
CO2	Derive the different terms in the conservation equations of mass and momentum for oceans.	3
CO3	Discuss dimensional analysis and the importance of various dimensionless numbers.	2
CO4	Describe the fundamental concepts in fluid dynamics	2
CO5	Apply standard mathematical techniques to solve numerical problems relevant to fluid dynamics.	3

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	1	2	1
CO2	3	2	2	-
CO3	3	2	2	1
CO4	3	1	1	1
CO5	3	3	2	1

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Unit I

Fluid mechanics: Fluid properties – Newton's law of viscosity - Fluid statics - Pascal's law – equation of state– Thermodynamic variables Static stability of ocean– Continuum hypothesis- Distinguishing attributes of geophysical flows- stratification and rotation. Distinction between the atmosphere and ocean. Vector, tensor, gradient, divergence and curl. Stokes' theorem, Gauss' theorem.

Unit II

Lagrangian and Eulerian representation – streamline, pathline, streaklines – Conservation of mass (equation of continuity) – Incompressibility - vertically averaged continuity equation - convergence and divergence – conservation of momentum – Euler's equation – Navier-Stokes equation – plane Couette flow - Plane Poiseuille Flow.

Unit III

Rotating frame of references – Coriolis force – Turbulence -Reynolds averaged equations, closure problem, eddy coefficients, Rotation - vorticity and circulation – Kelvin's theorem – one, two and three dimensional flows – velocity potential – stream function - Laplace equation - Bernoulli equation and applications.

Unit IV

Dimensional analysis- Buckingham's Pi theorem - non-dimensional numbers, Reynolds, Richardson, Rossby, Ekman, Froude number – Scaling analysis, Approximations – geostrophic, hydrostatic and Boussinesq. Conservation of temperature and salinity – advection, diffusion. Stratification. Linear continuously stratified fluid, barotropic and baroclinic instabilities.

References:

1. Fluid Mechanics, Kundu, P.K., Cohen, I.M., Dowling, D.R., 6th Edition, Academic Press, Elsevier, 2015.
2. Introduction to geophysical fluid dynamics physical and numerical aspects, Benoit Cushman-Roisin, Jean-Marie Beckers, 2nd Edition, Academic press, Elsevier 2011.
3. Atmosphere-Ocean Dynamics, Gill, A. E., International Geophysics Series, Vol. 30, 1982.
4. Fluid Physics for Oceanographers and Physicists: An Introduction to Incompressible Flow, Samual
   A. Elder and J. Williams, 2nd Edn, Pergamon Pr, 1989.
5. An introduction to fluid dynamics, Batchelor, G. K., Cambridge University Press, 2000.

Suggested Reading:

1. Classical Mechanics in Geophysical Fluid Mechanics. Osamu Morita Second Edition. CRC Press, Taylor & Francis Group. DOI. 10.1201/9781003310068. 2023.

2. Geophysical Fluid Dynamics, J. Pedlosky, 2nd Edn, Springer, 1992.
3. Geophysical Fluid Dynamics: An Introduction to Atmosphere - Ocean Dynamics: Homogeneous Fluids, Özsoy, Emin, Springer 2020.
4. Geophysical Fluid Dynamics II. Stratified/Rotating Fluid Dynamics of the Atmosphere-Ocean. , Özsoy, Emin *Springer*.2021.
5. An Introduction to Theoretical Meteorology, S. L. Hess, Holt, Rinehart & Winston, 1966.
6. Atmospheric and oceanic fluid dynamics fundamentals and large-scale circulation, Geoffrey K. Vallis, Cambridge University Press, 2006.
7. Climate dynamics, Cook, Kerry H., Princeton University Press, 2013.
8. Environmental fluid dynamics, Imberger, Jorg, Academic Press, 2013.
9. Fluid dynamics: An introduction. Reutord, M. Springer, 508pp. 2015.
10. Foundations of Fluid Mechanics, S. W. Yuan, Student International Edition, Prentice Hall, 1970.
11. Fundamentals of Geophysical Fluid Dynamics, James C. McWilliams, Cambridge University Press, 2006.
12. Numerical Methods and Models in Earth Science, Ghosh, Parthasarathi, New Indian Publishing Agency, 2011.
13. Essentials of Atmospheric and Ocean Dynamics. Geoffrey K. Vallis, Cambridge University Press, 2019.

Course Code	Course Title	C/E	Credit
24-319-0103	**Ocean Instrumentation**	**Core**	**3**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	List out various platforms used in oceanographic measurements.	1
CO2	Describe the working principles of various oceanographic instruments.	2
CO3	Explain the basic sampling requirements for general oceanographic purposes	2
CO4	Explain the various navigational aids for obtaining positions at sea.	2
CO5	Describe the surface meteorological measurement techniques.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	2	1	-	-
CO2	2	3	-	-
CO3	2	3	-	-
CO4	2	3	-	-
CO5	3	3	-	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, “-” No correlation

Syllabus:

Unit I

Oceanographic platforms: research vessels and their facilities -Major Oceanographic expeditions, aircrafts and satellites – Shallow and deep water buoys - drifting buoys - research towers – submersibles – drifting platforms – mooring- moored buoys in major oceans- RAMA, PIRATA & TAO moored buoy arrays - FLIP – unmanned platforms and autonomous robotic vessels – smart ocean sensors. Principles of navigation – classical and modern navigational methods – GPS & DGPS – Projections, Sampling requirements – sampling duration, interval and accuracy.

Unit II

Measurement of ocean depth – Lead sounding - Echo sounder, SONAR – side scan, multibeam, sub-bottom profilers. Measurement of light – optical sensors - Secchi disc – Turbidity meter, Silt meter, Lux meter. Water sampling devices: NRWB – modifications - horizontal water sampler - Rosette sampler- special water sampling devices.

Unit III

Temperature measurement - SST measurements from ships, buoys and satellites –subsurface temperature measurements - reversing thermometers, temperature profiling using MBT, XBT. Salinity measurements - titration method – salinity from conductivity – induction method – Autosal – CTD, microstructure profiler, thermosalinograph.

Unit IV

Measurement of currents - Direct reading and Recording Current Meters - Acoustic Current Meters Electromagnetic Current Meters - profiling of currents using ADCP - surface and subsurface drifters – ARGO floats - oceanographic gliders. Measurement of waves - surface buoys – subsurface gauges-pressure gauges-resistant gauges. Measurement of Tides - Tide staff, Tide gauge and pressure gauge - Satellite altimetry - Inverted Echo Sounder - Surface meteorological measurement atmospheric temperature, pressure, humidity and wind.

References:

1. Data analysis methods in Physical oceanography, Thomson, Richard E., Elsevier, Edns.1997, 2014.
2. Principles of Physical Oceanography: W J Pierson and G Neumann, Prentice Hall, 1966.
3. The Oceans- Their physics, chemistry and general biology: Sverdrup, Prentice Hall, 1942.
4. Descriptive Physical Oceanography, Reddy, M. P. M., 2000, New Delhi Oxford & IBH
5. Descriptive Physical Oceanography: An Introduction.Ed.6, Lynne D. Talley, George L. Pickard, William J. Emery and James H. Swift, Elsevier, 2011.

Suggested Reading:

1. Modern Observational Physical Oceanography. Carl Wunsch, Princeton University Press, 2015.
2. A Pictorial History of Oceanography Submersibles: J B Sweeny, London Robert Hale Company, 1970.

3. A Practical Handbook of Seawater Analysis, Strickland and Parsons, 2nd Edn, Miscellaneous Special Publications-Fisheries Research Board of Canada, 1972.
4. Descriptive Physical Oceanography: An Introduction: G. L Pickard and W.J Emery, Oxford Pergamon Press, 2003.
5. Instruction Manual for Oceanic Observations: U S Naval Oceanographic Office, H.O. Pub. 607, 1955
6. Introduction to Physical Oceanography: Robert H. Stewart, e-book, 2005.
7. Introduction to Physical Oceanography: W. S. Von Arx, 1st Edn., 1962.
8. Marine Sciences Instrumentation: Vol.1 & 2; Gaul, Roy D.; Plenum Press, 1962.

Course Code	Course Title	C/E	Credit
24-319-0104	**Ocean Observations (Practical)**	**Core**	**1**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Apply practical skills for conducting high quality research.	3
CO2	Demonstrate and operate the modern oceanography/meteorology instruments on board.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	1	3	2	-
CO2	1	3	2	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Use and operation of instruments on board - GPS, Lead sounding - Echo Sounder, NRWB, Niskin and Horizontal water samplers, BT, XBT, CTD, Salinometer, Current meters, Tide gauge, Lux Meter, Turbidity meter, Silt meter, Anemometer and Psychrometer - Familiarization of hydrographic tools - Collection of environmental data – collection of sea water using oceanographic samplers. On board data collection.

Course Code	Course Title	C/E	Credit
24-319-0105	**Oceanographic Computations – Python (Practical)**	**Core**	**2**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Design programs in Python for general applications.	6
CO2	Process Oceanographic data and create graphical outputs.	4

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	-	3	-	-
CO2	-	3	-	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Features of Python programming language – print function - data types and variables - input function – mathematical operation using math module - string operations – control operations - list, tuple, set and dictionary sequences – loops – user-defined functions and modules – file operations

Data processing with statistics, random, datetime, numpy modules – plotting with matplotlib – oceanographic computations using netcdf, cartopy, seawater modules.

SEMESTER - II

Course Code	Course Title	C/E	Credit
24-319-0201	**Ocean Dynamics**	**Core**	**4**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Describe the governing equations of statics, kinematics and dynamics of the ocean.	2
CO2	Explain theories of wind driven ocean circulations.	2
CO3	Describe upwelling and downwelling mechanisms.	2
CO4	Describe frictionless currents such as inertial and geostrophic currents.	2
CO5	Explain barotropic and baroclinic instabilities.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	1	-
CO2	3	-	1	-
CO3	3	-	1	-
CO4	3	-	1	-
CO5	3	-	1	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Unit I
Statics of the ocean: fields of gravity, pressure and mass - barotropic and baroclinic fields - quasistatic conditions – sigma-t surfaces - static stability- Equation for static stability criteria, Brunt Vaisala - frequency, double diffusion. Richardson number, geopotential distance and

dynamic height – kinematics - conservation equations of mass - divergence and convergence – upwelling.

Unit II

Field of motion – forces – derivation of momentum equation – Navier-Stokes equation - non-linear terms - mean and turbulent flow - Reynold's decomposition – RANS equation - eddy viscosity - scaling equation of motion, dynamic stability - currents without friction- inertial motion - geostrophic currents - relative current and slope current - Helland-Hansen's formula - thermal wind equations, level of no motion and absolute currents - homogeneous geostrophic flows over an irregular bottom - quasi-Geostrophic dynamics – hydrostatic and Boussinesq assumptions

Unit III

Currents with friction- Ekman's solution to the equation of motion with friction - Ekman transport and upwelling - wind stress - bottom friction and shallow water effect - beta-plane and f-plane - Sverdrup's equation and its application - equatorial currents – vorticity - Stommel and Munk theory – western boundary currents

Unit IV

Barotropic Instability- Kelvin and Rossby waves - waves on a shear flow - baroclinic Instability – linearized equations – linear wave dynamics.

References:

1. Introductory Dynamic Oceanography: S Pond & G L Pickard, 2nd Edn. Pergamon, 1983.
2. Atmosphere-Ocean Dynamics, Adrian E. Gill, International Geophysics series, Academic Press, First Edition, 1982.
3. Atmospheric and Oceanic Fluid Dynamics: Fundamentals and large–scale circulation, Second edition, Geoffrey K. Vallis, Cambridge University Press, 2017.
4. Introduction to Geophysical Fluid Dynamics, Cushman Rosetin, 1st Edn, Prentice Hall, 1994.
5. Geophysical Fluid Dynamics, J. Pedlosky, 2nd Edn, Springer, 1992.

Suggested Reading:

1. Observations and Dynamics of Circulations in the North Indian Ocean McCreary, J. P., Shetye, S. R, Springer Nature Singapore. 2023.
2. Ocean Dynamics: Theory And Exercises (With Solutions), A.S.N.Murty, New India Publishing Agency – NIPA. 2023.

3. Geophysical Fluid Dynamics: An Introduction to Atmosphere- Ocean Dynamics: Homogeneous Fluids, Özsoy, Emin, Springer 2020.
4. Climate dynamics, Cook, Kerry H., Princeton University Press, 2013.
'Understanding weather and climate, Ed.7, Aguado, Edward, Pearson, 2013.
5. Dynamical Oceanography: J. Proudman, Methuen & Co. Ltd, 1963
6. Environmental fluid dynamics, Imberger, Jorg, Academic Press, 2013.
7. Introduction to Dynamic Meteorology, Ed.2 & 5 Holton, James R, Academic, 2013.
8. Infinite-dimensional dynamical systems in atmospheric and oceanic science, Boling, Guo, World Scientific, 2014.
9. Modelling atmospheric and oceanic flows, Larcher, Thomas von, American Geophysical Union, 2013.
10. Nonlinear climate dynamics, Dijkstra, Henk A, Cambridge University Press, 2013.
11. Ocean Currents, G Neumann, Elsevier Publishing Company, 1968.
12. Oceanography for Meteorologists, H U Sverdrup, Biotech Books, 2002.
13. Physics of the earth, 4th Edn.., Stacey, Frank D, Cambridge University Press, 2013.
14. Principles of Physical Oceanography, W J Pierson and G Neumann, Prentice-Hall and Englewood Cliffs, 1966.
15. The Dynamic Method in Oceanography, L M Fomin, Elsevier Applied Science, 1964.
16. Dynamics of the Equatorial Ocean, Boyd, John P., Springer, ISBN 978-3-662-55474, 2018
17. Relationships between Coastal Sea Level and Large Scale Ocean Circulation, Ponte, R.M., Meyssignac,B., Domingues, C., Stammer, D., Cazenave, A & Lopez, T. (Eds.), Springer, ISBN 978- 3-030-45633-7, 2020.
18. The Ocean in motion, Manuel G. Velarde, Roman yu. Tarakanov, Alexey V. Marchenko, Springer, 2018.
19. Essentials of Atmospheric and Oceanic Dynamics, Geoffrey K. Vallis, Cambridge University Press, 2019.
20. Ocean circulation in three dimensions, Barry A. Klinger and Thomas W.N. Haine, Cambridge University Press, 2019.

Course Code	Course Title	C/E	Credit
24-319-0202	**Air-Sea Interaction**	**Core**	**3**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Discuss the structure of atmospheric boundary layer and its role in air-sea interaction.	2
CO2	Describe the fundamental theories of atmospheric turbulence.	2
CO3	Explain similarity theory for formulating air-sea flux.	2
CO4	Estimate the large scale momentum, moisture and heat fluxes, and its budget.	5
CO5	Identify large scale anomalies in air-sea interactions leading to interannual variability.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	1	-
CO2	3	-	1	-
CO3	3	-	1	-
CO4	3	-	1	-
CO5	3	-	2	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, “-” No correlation

Syllabus:

Unit I

Introduction to air-sea interaction – - atmospheric boundary layer and divisions - momentum, heat and moisture fluxes – turbulence – static and dynamic instabilities – methods of study – general characteristics - statistical properties – fundamental theories and hypotheses – turbulent kinetic energy – Richardson number – dynamic and kinematic fluxes – Reynolds stresses – turbulence closure – K theory and mixing length theory.

Unit II

Dimensional analysis – similarity theory of neutral atmosphere – friction velocity - roughness length – Charnock's law - logarithmic wind profile - atmospheric stability – Monin-Obukhov similarity theory and flux-profile relationships – Monin-Obukhov Length - bulk-aerodynamic formulation of fluxes – methods of flux estimation: eddy correlation, gradient, profile methods and bulk methods – air-sea gas exchange

Unit III

Large scale air sea interactions – global wind stress distribution - shortwave and longwave radiation fluxes – sensible and latent heat fluxes – global data sets on fluxes – annual climatology of fluxes – heat budget and heat transport – evaporation, precipitation and freshwater budget - intra-seasonal air-sea interactions – inter-annual air-sea interactions - ENSO and IOD

References:

1. Introduction to Micrometeorology, S. Pal Arya, Academic Press, 2001.
2. Introduction to Boundary Layer Meteorology, R. B. Stull, Kluwer Academic Publishers, 1988.
3. Air-Sea Exchange: Physics, Chemistry and Dynamics, G. L. Geernaert, Kluwer Academic Publishers, 1999.
4. Small Scale Processes in Geophysical Fluid Flows, Authors: Lakshmi H. Kantha, Carol Anne Clayson, 2000. Hardback ISBN: 9780124340701, eBook ISBN: 9780080517292.
5. Physics of the Marine Atmosphere International Geophysics Series, Vol. 7 1st Edition, H. U. Roll, ISBN: 9781483222547, 1965.

Suggested Reading:

1. Observations and Dynamics of Circulations in the North Indian Ocean McCreary, J. P., Shetye, S. R, Springer Nature Singapore. 2023.
2. Ocean-Atmosphere Interactions, Yoshiaki Toba, Terra Scientific Publishing Company, 2003.
3. Atmosphere-Ocean Interaction, E. B. Kraus and J. A. Businger, Oxford University Press, 1994.

4. Recent Advances in the Study of Oceanic Whitecaps. Vlahos, P., & Monahan, E. C., Springer Nature. 2020.
5. Essentials of Oceanography, Trujillo, Alan P., Pearson, 2014.
6. Fundamentals of Tropical Climate Dynamics, Tim Li and Pang-chi Hsu, Springer International Publishing AG, 2017.
7. Indo-Pacific climate variability and predictability, Edited by Swadhin Kumar Behera and Toshio Yamagata, World Scientific Publishing Co. Ptc. Ltd, 2016.
8. Infinite-dimensional dynamical systems in atmospheric and oceanic science, Boling, Guo, World Scientific, 2014.
9. Mesoscale-convective Processes in the Atmosphere, Trapp, Robert J, Cambridge University Press, 2013.
10. Meteorology: understanding the atmosphere, Ackerman, Steven A, Jones & Bartlett Learning, 2015.
11. The Asian Monsoon, Clift, Peter D, Cambridge University Press, 2014.
12. The Oceans and Climate, Grant R. Bigg, Cambridge University Press, 1996.
13. Wind Stress over the Oceans, Ian S. F. Jones and Y. Toba, Cambridge University Press, 2009.
14. Intraseasonal Variability in the Atmosphere-Ocean Climate System. Lau, William K.-M., Waliser, Duane E. S. Springer. 2012.

Course Code	Course Title	C/E	Credit
24-319-0203	**Coastal and Estuarine Oceanography**	**Core**	**3**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Distinguish various coastal environments and processes.	2
CO2	List and explain different methods for coastal sediment transport estimation.	3
CO3	Explain the characteristics of different wave transformations.	2
CO4	Describe the generation of tides and perform harmonic analysis.	4
CO5	Describe the dynamics of Indian and global estuaries.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	1	-	-
CO2	3	3	1	-
CO3	3	2	1	-
CO4	3	3	1	-
CO5	3	1	-	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, “-” No correlation

Syllabus:

Unit I
Coasts and shorelines, coastal morphology, coastal land forms, types of coastal environment, coastal processes, factors influencing coastal processes. Beaches – classification and features, beach configuration & profiles, beach erosion & accretion, long shore bars, sand spits, atolls, mud banks- beach stability, coastal zone management, Coastal protection, coastal uses and resources, coastal pollution, coastal regulation zone of India, coastal hazards and mitigation measures.

Unit II

Wave transformation in shallow waters, effect of bottom friction, phenomena of wave reflection, refraction and diffraction, breakers, littoral currents. Wave action on sediments, alongshore and cross shore transport, rate of sediment transport, artificial nourishment - Sediment transport in coastal zone - characteristics of wind waves and swells - Significant wave height and period. Fetch limited and duration limited conditions.

Unit III

Major port cities of the world, tide gauges, Tidal forces, Moon-Earth-Sun system, Neap-Spring and Flood-ebb cycles, Newton's equilibrium theory, Laplace tidal equations. Tidal constituents-semidiurnal and diurnal constituents, Harmonic analysis of tides, Tidal prediction. Tides and tidal currents in shallow seas and estuaries, Tides along the coast of India.

Unit IV

Estuaries- classification and nomenclature, effect of river discharge and tides, salinity intrusion in estuaries, mixing and stratification, residual estuarine circulation, estuaries of India – monsoonal estuaries, Tidal prism, Pollution in estuaries.

References:

1. Beaches and Coasts: C A M King, Edward Arnold, 1961.
2. Beaches Processes and Sedimentation: P D Komar, Prentice Hall, 2nd Edn., 1997.
3. Contemporary issues in estuarine physics, Arnoldo-Valle Levinson, Cambridge University Press, 2010.
4. Estuaries: A Physical Introduction: K R Dyer, John Wiley, 1973.
5. Sea-level science : understanding tides, surges, tsunamis and mean sea-level changes, Pugh, David, Cambridge University Press, 2015.

Suggested Reading:

1. Environmental Oceanography and Coastal Dynamics: Current Scenario and Future Trends. N.p., Mukherjee, Swapna, et al., Springer International Publishing, 2023.
2. Climate Change and Estuaries. United States, CRC Press, 2023.
3. Proceedings of The Coastal Sediments 2023, The (In 5 Volumes). Singapore, World Scientific Publishing Company, 2023.Beaches and Coasts: R A Davis & D M Fitzgerald, Wiley Blackwell, 2004.
4. Relationships between Coastal Sea Level and Large Scale Ocean Circulation. Rui M. Ponte, Benoit Meyssignac, Catia M. Domingues, Detlef Stammer, Anny

Cazenave, Teodolina Lopez., Springer, 2020.Shore protection manual Vol. 1, 2, 3, Coastal Engineering Research Centre, University of Michigan Library, 1973.

5. Coastal Hydrodynamics, Mani.J.S, PHI Pvt Ltd. New Delhi, 2012.
6. Coastal Oceanography: Yanagi Tetsuo, Kulwer, 1999.
7. Coastal Zone Management: D R Green, Thomas Telford Pub., 2009.
8. Coastal Zones: Solutions for the 21st Century, Baztan, Juan, Elsevier, 2015.
9. Estuaries: G H Lauff, AAAS, 1967.
10. Estuarine Ecohydrology, Erik Wolanski, Elsevier, Second Edition, 2015.
11. Estuary and Coastline Hydrodynamics: A T Ippen, McGraw Hill, 1966.
12. Tides - a scientific history, Cartwright, D.E. Cambridge University Press. 292pp. 1999.
13. Waves, tides and shallow-water processes. Open University Oceanography Series Vol.4. Oxford: Pergamon Press in association with the Open University, 187 pp., 1989.
14. Coastal engineering processes, theory and design practice, Dominic Reeve, Andrew Chadwick & Christopher Fleming, CRC Press, 3rd Edition, 2018.
15. Sediment transport in coastal waters; Sylvian Quillon; MDPI Publishers; 2019
16. Coastal engineering theory and practice, Vallam Sundar & S.A Sannasiraj, Advanced series on Ocean engineering, Vol. 47, Publisher: WSPC, 2019.

Course Code	Course Title	C/E	Credit
24-319-0204	**Dynamical Computations (Practical)**	**Core**	**1**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Compute thermosteric anomaly, static stability and Brunt Vaisala frequency using temperature and salinity datasets.	4
CO2	Estimate relative currents, vertical velocity, geopotential anomaly, Ekman current and Ekman pumping.	4

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	1
CO2	3	3	2	2

Correlation levels: 1 = Low, 2 = Medium, 3 = High, “-” No correlation

Syllabus:

Thermal structure, Static Stability, Specific volume anomaly, Dynamic depth, Relative currents, Level of No motion, Absolute currents, Divergence and convergence, Ekman spiral, Mass transport, Upwelling.

Course Code	Course Title	C/E	Credit
24-319-0205	**Coastal Oceanography (Practical)**	**Core**	**2**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Estimate coastal accretion and erosion using insitu field observations.	5
CO2	Analyze the wave record data and estimate different wave parameters.	4

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	2	3	-	3
CO2	2	3	-	3

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Preparation and interpretation of Bathymetric charts, Beach Profiles, Analysis of wave records, Tuckers' method-Wave power computation, Littoral drift and sand budget, Wave spectrum, Tide data analysis-harmonic analysis.

Course Code	Course Title	C/E	Credit
24-319-0206	**Air-Sea Interaction (Practical)**	**Core**	**1**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Estimate air-sea fluxes from marine observational data.	5
CO2	Analyze Global Air-Sea Flux data.	4

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1	-
CO2	3	3	1	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Estimate statistical properties of turbulence – log wind profile – momentum flux from wind profile – fluxes and profiles under non-neutral stability condition – Richardson number – bulk, eddy correlation, gradient and profile methods of flux estimation.

Wind stress over global oceans – analysis of radiative and turbulent air-sea fluxes from moored buoy data – analysis of global heat flux data - heat budget analysis – heat transport – global freshwater fluxes and budget – inter-annual anomalies in fluxes during ENSO and IOD.

Course Code	Course Title	C/E	Credit
24-319-0207	**Oceanographic Computations – Fortran (Practical)**	**Core**	**2**

Course Outcomes:
At the end of the course, the students will be able to :

	Description of Course Outcome	BL
CO1	Explain the basic syntax involved in Fortran program coding for performing mathematical operations.	2
CO2	Calculate various physical properties of seawater using computer programs.	5

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	1	3	1	-
CO2	1	3	1	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Computer Programming in Fortran: Variables and data types – input and output - operators – built-in functions - control operations – loops – arrays – function and subroutine subprograms - file input and output – programming style and debugging.

Computation of density, potential temperature, specific volume anomaly, sound velocity, freezing point temperature – estimating salinity from conductivity – pressure to depth conversion – Brunt- Vaisala Frequency. Analysis of temperature and salinity profile data – interpolation – temperature gradient – Mixed Layer Depth – dynamic height.

SEMESTER – III

Course Code	Course Title	C/E	Credit
24-319-0301	**Ocean Remote Sensing**	**Core**	**4**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Describe the fundamentals of ocean remote sensing and its applications for the benefit of society.	2
CO2	Explain the algorithms and principles of optical, infrared and microwave remote sensing.	2
CO3	Explain the principles of computation of geostrophic current and eddy kinetic energy by using microwave altimeter data.	2
CO4	Identify internal waves, oil slicks and bottom topography from satellite microwave ocean data.	3
CO5	Describe satellite image processing techniques.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	2	2
CO2	3	-	-	-
CO3	3	-	2	-
CO4	3	-	3	1
CO5	3	-	-	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, “-” No correlation

Syllabus:

Unit I

Introduction to Remote Sensing: Basic concepts – Electromagnetic radiation – solar and terrestrial radiation, atmospheric effects absorption, transmission and scattering. Spectral response of Earth's surface features. – Atmospheric windows – spectral signature. Remote sensing platforms: – Satellites, orbits and missions, near polar, geostationary and sun synchronous satellites. Sensors: swath, Resolution concepts – types-spatial, temporal, spectral and radiometric resolution- Active and passive remote sensing– Remote Sensing in Indian perspective- Indian Satellites and sensors for oceanographic applications. Basics of satellite image processing.

Unit II

Visible remote sensing: theory of ocean colour remote sensing optical properties of pure water, natural waters and atmosphere – optical pathways in the atmosphere – – Scattering and absorption of light – colour of the sea: phytoplankton, yellow substance, suspended particulate matter principle of estimation and its applications– case 1 and case 2 waters – satellite sensors for ocean color data. Clouds in visible remote sensing.

Unit III

Infrared Remote Sensing: thermal emission – atmospheric absorption – SST retrieval – atmospheric correction – effect of cloud – thermal skin layer – skin and bulk SST.- effect of surface films – Infrared radiometers -NASA pathfinder, global SST data: SST – applications. Cloud altitude based on cloud top temperature. Satellite and sensors for measurement of SST. LIDAR & shallow bathymetry.

Unit IV

Microwave Remote Sensing: Microwave emission of sea surface - atmospheric effects – Microwave bands, sensors – Passive and active microwave radiometers- retrieval of SST and salinity. Microwave Radar-measurement of ocean waves, Sea ice, oil spills. Water vapor and rainfall, Scatterometers: SAR & RAR- wind and radar backscatter – wind speed and direction. Altimetry: principles – SSH & sea surface height anomaly- Geostrophic currents, eddy kinetic energy, Planetary waves- SARAL and recent altimeters.

References:

1. Satellite Oceanography: An Introduction for Oceanographers and Remote Sensing Scientists: I.S. Robinson, Ellis Horwood, 1985.
2. Oceanographic Applications of Remote Sensing: Motoyoshi Ikeda and W. Dobson CRC Press, 1995.
3. Discovering the Ocean from Space: The Unique Applications of Satellite Oceanography, I.S. Robinson, Springer, 2010.
4. An Introduction to Ocean Remote Sensing 2nd Edn., Seelve Martin, Cambridge Univ. Press. 2014.
5. Introduction to Satellite Remote Sensing Atmosphere, Ocean, Cryosphere and Land Applications, William Emery, Adriano Camps and Marc Rodriguez-Cassolac, Elsevier, 2017.

Suggested Reading:

1. Remote Sensing of Turbulence, Victor Raizer , ISBN 9780367469788 , CRC Press, 2021.
2. Advanced Remote Sensing, Liang, Shunlin, Academic Press, 2012.
3. Advances in SAR Remote Sensing of Oceans, Xiaofeng Li, Huadong Guo, Kun-Shan Chen and Xiaofeng Yang, 2018, eBook ISBN 9781351235822. CRC Press.
4. Application of Remote Sensing Technology to Marine Fisheries. An Introductory Manual: Fisheries, M.J.A.Butler, M.C.Mouchot, V.Barale and Lebanc.C, Technical Papers, FAO publications, Vol.295. 1988.
5. Measuring the Oceans from Space: The Principles and Methods of Satellite Oceanography: I. S. Robinson, Praxis Publishing, UK. 2004.
6. Introduction to Remote Sensing, James B. Campbell, Randolph H. Wynne**,** Guilford Press. **2011.**
7. Introduction to Satellite Oceanography, G.A. Maul, Springer, 1985.
8. Advances in Passive Microwave Remote Sensing of Oceans, 1st Edn., Victor Raizer, CRC Press, Taylor and Francis Group. 2017.
9. Fundamentals of satellite remote sensing, Chuvieco, Emilio, CRC Press, 2016.
10. Image Processing and GIS for Remote Sensing: Techniques and Applications-2nd Edn., Jian Guo Liu, Philippa J. Mason., Wiley Blackwell. 2016.
11. Methods of Satellite Oceanography: Robert H. Stewart, Publisher: Berkeley, California. 1985.
12. Observation of the system earth from space, Flechtner, Frank, Springer, 2014.
13. Remote Sensing of the Changing Oceans, Dan Ling Tang, Gad Levy, Malcolm Heron, James Gower, Kristina B. Katsaros and Ramesh Singh, Springer, 2011.
14. Satellite based applications on climate change, Qu, John J, Springer, 2013.

15. Satellite Microwave Remote Sensing: T.D. Allan, Ellis Horwood Series in Marine Science, Chichester. 1983.

16. Remote Sensing of the Asian Seas, Barale, Vittorio**,** Gade Martin (Eds.), Springer, ISBN 978-3- 319-94065-6, 2019.

17. Satellite Image Analysis: Clustering and Classification, Borra, S., Thanki, R., Dey, N**.**, Springer, ISBN 978-981-13-6423-5, E-book, 2019.

Course Code	Course Title	C/E	Credit
24-319-0302	**Numerical Ocean Modelling**	**Core**	**3**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Explain modelling concepts and its importance in Oceanography.	2
CO2	Explain the finite difference method for solving differential equations.	2
CO3	Explain various numerical schemes in modelling.	2
CO4	Explain the modelling of oceanographic processes such as advection, diffusion, Ekman currents, shallow water processes etc.	2
CO5	Describe the fundamentals of Ocean General Circulation Models	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	1	-
CO2	3	-	1	-
CO3	3	-	1	-
CO4	3	-	1	-
CO5	3	-	1	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Unit-I

Introduction – modelling in science – physical and mathematical models - numerical models - advantage and limitations of models - the modelling cycle – classification of PDEs - analytical and numerical solutions - initial and boundary value problems – Dirichlet and Neumann boundary conditions – numerical modelling of decay problem, Newton's law of cooling and population growth.

Unit-II

Taylor's series – finite difference approximations - forward, backward and centered difference methods – truncation error – numerical schemes: explicit, implicit, semi-implicit, Predictor-corrector and leapfrog – system of equations - matrix and iterative solutions - Laplace equation - consistency, convergence and stability of numerical schemes – Von Newmann stability analysis

Unit-III

Modelling buoyancy oscillation - inertial currents - advection model - FTFS, FTBS, FTCS, upwind, Lax and Lax-Wendroff schemes - CFL stability condition - diffusion model – stability analysis - advection-diffusion model – Peclet number – Ekman model - mixed layer models – shallow water equations - shallow water models – Ocean General Circulation Models - Arakawa grids – sigma coordinate system – model spin up – validation.

Reference Books

1. *Introductory dynamical oceanography by* Pond, S., & Pickard, G. L., Gulf Professional Publishing, 1983
2. *Ocean modelling for beginners: using open-source software*. By Kämpf, J., Springer Science & Business Media, 2009.
3. Advanced Ocean Modelling: Using Open-source Software by Kämpf, J. Springer Science & Business Media, 2010.
4. Numerical Modelling of Oceans and Oceanic Processes, Lakshmi H.Kantha & Carol A. Claysor, Academic Press, 2000.
5. Atmospheres and Oceans on Computers: Fundamental Numerical Methods for Geophysical Fluid Dynamics by Røed, Lars Pette, Springer, 2019.

Additional References

1. Introduction to Geophysical Fluid Dynamics – Physical and Numerical Aspects by Benoit Cushman-Roisin and Jean-Marie Beckers, Academic Press, 2010.
2. Computer Modelling in Atmospheric and Oceanic Sciences by Peter Muller and Hans Von Storch, Springer, 2004.
3. *Advanced physical oceanographic numerical modelling by* O'Brien, J. J. (Ed.), (Vol. 186). Springer Science & Business Media, 2013.
4. *Atmosphere-ocean modeling: coupling and couplers by* Mechoso, C. R., An, S. I., & Valcke, S. World Scientific, 2021.

Course Code	Course Title	C/E	Credit
24-319-0303	**Oceans and Climate**	**Core**	**3**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Describe the equations representing the climate of the ocean and atmosphere	2
CO2	Describe the different terms of heat balance in the climate system	2
CO3	Explain the ocean structure and circulation and its role in climate	2
CO4	Use simple greenhouse model to evaluate responses of varying greenhouse emissions on the Earth's temperature	5
CO5	Explain the climate change projections using climate models.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	1	-
CO2	3	-	1	-
CO3	3	-	1	-
CO4	3	-	1	2
CO5	3	-	1	2

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Unit I

Climate system: Planet earth – Radiative balance – Distribution of solar radiation – Simple radiation models. Greenhouse effect: Blackbody radiation – Greenhouse gases – Layer models of greenhouse effect. Ocean structure and circulation: Horizontal structure of the ocean currents – Meridional overturning circulation and vertical structure – Mixed layer –Thermocline –

Geostrophic flow – Western boundary and eastern boundary currents -Ocean stratification – Oxygen minimum zones.

Unit II

Ocean role in climate: Moderating influence of oceans – lag in the seasons – Ocean heat transport – Mixed layer heat budget. Climate variability in the tropics – El Nino and Southern Oscillation – Changing Oceans: Causes and implications of Global warming – Observed temperature records – Salinity variation –Sea level rise – Changing Ocean currents – Thermohaline slowdown – Ocean acidification – CO_2 sink and source, Ozone hole.

Unit III

Climate sensitivity and feedback mechanisms -Basic radiative feedback processes - Climate projections: Climate models – Projections of temperature, sea-level rise, ocean circulation, rainfall and acidification. Impacts of climate change: Future of nature – Food, water and health issues – Regional impacts. Climate change adaptations- Assessment reports of IPCC.

References:

1. Climate and the oceans, Geoffrey K Vallis, Princeton Primers in Climate, 2012.
2. Climate System Dynamics and modelling, Hugues Goosse, Cambridge, 2015.
3. Global Physical Climatology, Dennis L Hartmann, Elsevier, 2016
4. Climate Crisis: An introductory guide to Climate change, David Archer and Stefan Rahmstorf, Cambridge, 2010.
5. Global warming: Understanding the forecast, David Archer, John Wiley and Sons Inc., 2012.

Suggested reading:

1. The Oceans and Climate. Grant Bigg. Cambridge Press, 2003.
2. Atmosphere, Ocean and Climate Dynamics. John Marshall and R. Alan Plumb, Elsevier Academic Press, 2008.
3. Introduction to Physical Oceanography, Third edition, John A. Knauss and Newell Garfield, Waveland Press, Inc., 2017.
4. Descriptive Physical Oceanography: An Introduction. Ed.6, Lynne D. Talley, George L. Pickard, William J. Emery and James H. Swift, Elsevier, 2011.

5. Introduction to dynamic meteorology, Ed.2 & 5 Holton, James R, Academic, 2013.
6. The Earth system. Kump L. R. Kasting J.F and Crane R. G., Prentice Hall, 3rd Ed. 2009.
7. Atmospheric and Oceanic Fluid Dynamics: Fundamentals and Large-scale circulation, Geoffrey K. Vallis, Cambridge University Press, 2017.
8. Demystifying Climate Models: A user guide to earth system models, Andrew Gettelman Richard B. Rood, Springer, 2016.
9. Climate Change and Climate Modeling, David J. Neelin, Cambridge University Press, 2011.
10. Climate dynamics, Cook, Kerry H., Princeton University Press, 2013.
11. Essentials of Atmospheric and Oceanic Dynamics, Geoffrey K Vallis, Cambridge University Press, 2019.

Course Code	Course Title	C/E	Credit
24-319-0304	**Ocean Climate Data Analytics (Practical)**	**Core**	**2**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Use visualization software such as Ferret/Python/Grads to generate graphs and maps of ocean data (Salinity, temperature, current velocity, mixed layer depth, T-S diagram).	3
CO2	Use a software for oceanographic data analysis and computation	4

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	2
CO2	3	3	3	2

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Data and tools: NetCDF data – Ferret/Python/Grads – Climate Data Operator (CDO), Hydrography: World Ocean Atlas of temperature and salinity – estimation of global ocean mixed layer depth and climatology – T-S diagram and water mass analysis – Mixed layer heat budget.

Ocean circulation: seasonal wind pattern over Indian Ocean-wind stress distribution-ocean circulation using global data sets-Argo buoy data-geostrophic currents-Rossby and Kelvin waves using gridded sea level data- Analysis of climate model data. ENSO - Southern Oscillation Index – Indian Ocean Dipole Mode- long term trends in Indian Summer Monsoon rainfall. Time-series and spatial data analyses – FFT, Wavelet, EOF.

Course Code	Course Title	C/E	Credit
24-319-0305	**Ocean Modelling (Practical)**	**Core**	**2**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Apply finite difference methods for solving differential equations.	3
CO2	Develop and execute numerical ocean models for various oceanic processes.	6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	-
CO2	3	3	2	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Approximation of derivatives using Taylor's series-reducing truncation error - solution to ODE using Euler Method-solving 1 and 2 dimensional Laplace equation-matrix and iterative methods-solution to time-dependent equations using various numerical schemes.

Modeling oscillation of a buoyant object in a stratified fluid – modeling 1 and 2D advection and diffusion – advection plus diffusion problems – advanced numerical schemes – modeling inertial currents – Coriolis force - 1D Ekman model for wind-driven currents – ocean mixed layer models – shallow water process and modeling – hands-on training on global models.

SEMESTER – IV

Course Code	Course Title	C/E	Credit
24-319-0401	**Project Dissertation**	**Core**	**16**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Undertake independent research work pertaining to an earth science related topic of his/her expertise.	6
CO2	Propose a scientific problem, carry out field or laboratory experiments, analyse and communicate.	4

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	-	3	3	-
CO2	-	3	3	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

5.2 Elective Courses

Course Code	Course Title	C/E	Credit
24-319-XXXX	**General Oceanography**	**Elective**	**3**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Describe the spatial and temporal variability of physical properties of the ocean.	2
CO2	Sketch Ekman spiral and explain the theory.	2
CO3	Explain ocean upwelling process and identify areas of upwelling.	1
CO4	Explain different heat budget terms.	2
CO5	Describe Ocean circulations and interannual anomalies.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	1	1	1
CO2	3	1	1	-
CO3	3	1	-	-
CO4	3	1	2	1
CO5	3	1	2	1

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Unit I

General introduction - dimension of oceans - geographical features - physical properties of sea water and its measurement - distribution of temperature, salinity, density and oxygen in space and time.

Unit II

Water masses: formation and classification - T-S diagram – Stability of ocean, water masses of the world ocean with special reference to Indian Ocean – Mixed layer - Heat budget of Arabian sea and Bay of Bengal - insolation – long wave radiation – effect of clouds – sensible and latent heat transfer- Bowen's ratio.

Unit III

Circulation: general circulation of the atmosphere – trade winds – wind-driven and thermohaline circulation - major currents of the world oceans – seasonal currents in the Indian Ocean – Ekman current, Ekman transport, upwelling and sinking with special reference to the Indian Ocean. Geostrophic currents, Eddies in the ocean -El-Nino and La-Nina.

References:

1. Descriptive Physical Oceanography: An Introduction: G.L.Pickard and W. J. Emery, Pergamon, Edns., 1982, 1992.
2. Descriptive Physical Oceanography, Reddy, M. P. M., 2000, New Delhi Oxford & IBH
3. Descriptive Physical Oceanography: An Introduction.Ed.6, Lynne D. Talley, George L. Pickard, William J. Emery and James H. Swift, Elsevier, 2011.
4. Introduction to Physical Oceanography: R. H. Stewart, E-book, 2005
5. The Oceans, their Physics, Chemistry and General Biology, H.U. Sverdrup, Prentice Hall, 1969.

Suggested Reading:

1. Why we study the Physics of the Ocean: What Physical Oceanographers Really Do, William J Emery .Cambridge Scholars Publishing. 2021.
2. Elements of Physical Oceanography: A Derivative of the Encyclopedia of Ocean Sciences, Steele, John H, 2010, Academic Press.
3. Introduction to Physical Oceanography, Third edition, John A. Knauss and Newell Garfield, Waveland press, Inc., 2017
4. Ocean Currents: G. Neumann, Elsevier, 1st edn., 1968.
5. Oceanography: An Invitation to Marine Science, Garrison,Tom S., Brooks Cole, 2016
6. Physical Oceanography (Vol. 2), Defant, Albert, 1961, New York Pergamon Press.
7. Physical Oceanography, A.S.N. Murty and V.S.N. Murty, A.P.H. Pub, 2010, viii, 430 p.
8. Principles of Physical Oceanography: G.Neumann & WJ Pierson, Jr., Prentice Hall,1st edn.,1966.

9. Oceanography Challenges to Future Earth, Komatsu, T., Ceccaldi, H., Yoshida, J. , Prouzet, P., Henocque, Y. (Eds), Springer, ISBN 978-3-030-00137-7, 2019 .

10. Ocean circulation in three dimensions, Barry A. Klinger and Thomas W.N. Haine, Cambridge University Press, 2019.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Marine Hazards and Management**	**Elective**	**2**

Course Outcomes:

At the end of the course, the students will be able to :

	Course Outcome	BL
CO1	Learn at an introductory level, the various types of marine hazards	2
CO2	Closely understand the nature and severity of each of the marine hazard	2
CO3	Learn about the physics and physical forces bring about the cause and ill effects from such hazards	2
CO4	Discuss and appreciate the management tools, as available now to address each marine hazard.	2
CO5	The mitigation measures, action plans, early warning systems and post hazard management figure in the learning processes.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	-	3
CO2	3	-	-	3
CO3	3	-	-	3
CO4	3	-	-	3
CO5	3	-	-	3

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Unit I

General introduction- classification-overview of marine and atmospheric hazards-Tsunami-cyclones-storm surges-floods-coastal vulnerability-shore line changes-landslides-earthquakes-subsidence.

Unit II

Pollution - oil spills - chemical and other pollutants – toxic algal bloom - thermal pollution – radioactivity - remedial approaches – dredging – mining - sand excavation - structures and ship collision – fire on oil rigs.

Unit III

Winds, waves, currents as agencies bring about hazards - Hazard management -Mitigation measures long term planning – pre hazard action plans - hazard monitoring and early warning systems – active post hazard management plans.

References:

1. Global Warming-The Complete Briefing: H. John, 4th Edn, Cambridge University Press, 2009.
2. Ocean Environmental Management: E. G. Frankel, 1st Edn, Prentice Hall, 1995.
3. Encyclopedia of Disaster Management: P. C. Sinha, Anmol, India, 2002.
4. Environmental Hazards-Assessing Risk and Reducing Disasters: K. Smith, 5th Edn, Routledge, 2009.
5. Essentials of Oceanography, Trujillo, Alan P., Pearson, 2014.

Suggested Reading:

1. The climate crisis, Archer, David, Cambridge University Press, 2010.
2. Geomorphological impacts of extreme weather, Loczy, Denes, Springer, 2013.
3. Coastal environments and global change, Masselink, Gerd, Wiley-Blackwell, 2015.
4. Interactions of land, ocean and humans, Maser, Chris, CRC Press, 2015.
5. Climate change and environment, Sundaresan, J., Scientific Publishers, 2013.
6. Global Environmental Change: Past, Present and Future: Karl K. Turekian, Prentice Hall; 1st Edition, 1996.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Marine Pollution**	**Elective**	**3**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Explain the types of marine pollution and its impacts	2
CO2	Discuss the marine factors involved in polluting the oceanic environment	2
CO3	Understand the mechanisms in transport and disposal of marine pollutants	2
CO4	Learn the principles of control and abatement of marine pollution	2
CO5	Evaluate the monitoring strategies and study the prevalent laws related to this subject	5

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	-	3
CO2	3	-	-	2
CO3	3	-	-	2
CO4	3	-	-	2
CO5	3	-	-	2

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Unit I

Pollution of the marine environment, marine pollutants and their sources. Types of pollutants - inorganic, organic, biological, micro plastic, thermal, radioactive and non-point. Mitigation-source control.

Unit II

Marine factors involved in transport & dispersal of pollutants - the transport phenomenon, advective and diffusion aspects. Dispersal of pollutants in estuaries and near shore areas, physical oceanographic factors affecting marine pollution.

Unit III

Impacts of pollution on the oceans. Control and abatement of marine pollution, oil pollution, oil slicks and their management- chemical dispersants, containment of oil at sea- ecotoxicology-case studies. Coral bleaching. Indian scenarios and case studies. Monitoring strategies, water quality parameters and standards, hazardous material transport, Open Ocean dumping and incineration, monitoring and control, general laws on prevention on marine pollution.

References:

1. Coastal Pollution: C J Sindermann, CRC Press, 2005.
2. Oceanic Processes in Marine Pollution: JM Capuzzo & Kester,Krieger, 1987.
3. Marine Pollution: R B Clark, Oxford Uty Press, 2001.
4. Marine Environment Pollution: R A Geyer, Elsevier, 2000.
5. Ocean sustainability in the 21 st century, Arico, Salvatore, Cambridge University Press, 2015.

Suggested Reading:

1. Biodiversity in the marine environment, Goulletquer,Philippe et al., Springer, 2014.
2. Coastal zones, Baztan, Juan, ed., Elsevier, 2015.
3. Coastal Zones: Solutions for the 21st Century, Baztan, Juan, Elsevier, 2015.
4. Dispersion in Estuaries and Coastal Waters: R Lewis, Wiley, 1997.
5. Interactions of land, ocean and humans, Maser, Chris, CRC Press, 2015
6. Marine Pollution & Human Health: R E Hester, Royal Soc. Chem., 2011.
7. Marine Pollution: New Research: T N Hofer et al., Nova Science, 2008.

8. Oil Spill Response in the Marine Environment: J W Doerffer, Pergamon Press, 1992.
9. Remote Sensing for the control of Marine Pollution: Jean Marie Massin, Springer, 1984.
10. Water and Water Pollution: L L Ciaccio, Marcel Dekker, 1971.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Ocean Optics**	**Elective**	**2**

Course Outcomes:

At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Explain the penetration of daylight into the sea when the inherent optical properties of the sea are known.	2
CO2	Describe the method for estimating the optical properties from remote sensing.	2
CO3	Apply algorithm for ocean colour application.	3
CO4	Demonstrate various absorptive characteristics of sea water which leads to identifying various parameters.	2
CO5	Discuss the biogeochemistry of the ocean.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	-	-
CO2	3	-	-	-
CO3	3	2	-	-
CO4	3	-	-	-
CO5	3	-	-	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Unit I

Introduction – Characterization of light field in water, radiance, irradiance, diffuse attenuation coefficient, water leaving radiance – Inherent and Apparent optical properties of sea water – Light scattering by water molecules – Raman scattering by water – Rayleigh scattering Mie scattering.

Unit II

Absorption characteristics of water constituents - Backscattering characteristics of water constituents – Fluorescence by phytoplankton and Dissolved Organic matter – Impact of bottom refection on upwelling radiance and volume reflectance in water – Colour of the sea. Optical properties of Case I and Case II waters -Refractive index of sea water -Remote sensing reflectance, reflectance albedo, Photo-synthetically Active Radiation.

Unit III

Hydro optical models-Bio-optical models, Composition of natural water and its relation to hydro- optics, Ocean colour remote sensing – Ocean colour sensors, Algorithms for Ocean colour data processing, Ocean colour application studies - Underwater photography and Imaging instruments.

References:

1. Coastal Ocean Optics and Dynamics, Volume 17, Issue 2 of JARE data reports: Oceanography, Oceanography Society, 2009.
2. Colour of Inland and Coastal waters -A methodology for its interpretation: Dimitry Pozdnyakov and Hartmut, Springer with Praxis Publishing, UK, 2003.
3. Light Absorption in Sea Water, By Bogdian Wozniak, Jerzy Dera, Springer, 2014.
4. Marine Optics: N. G. Jerlov, Elsevier, 2nd edition, 1976.

Suggested Reading:

1. Optical Oceanography, N.G. Jerlov, Elsevier publishing company, 1968.
2. Physical Optics of Ocean Water, Shifrin, K.S., Springer, 1988.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Marine Acoustics**	**Elective**	**4**

Course Outcomes:

At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Describe the models of underwater sound wave propagation.	2
CO2	Explain the seasonal and spatial variability of ocean acoustic characteristics.	2
CO3	Discuss the application of acoustics on Marine habitat and ecosystem monitoring.	2
CO4	Describe source localization applications.	2
CO5	List and explain the passive and active acoustic sensors.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	-	-
CO2	3	-	-	-
CO3	3	-	-	-
CO4	3	-	-	-
CO5	3	-	-	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, “-” No correlation

Syllabus:

Unit I

Introduction to Ocean acoustics. Acoustic plane, spherical and cylindrical wave equations and their solutions. Sound velocity in fluids. Energy density. Acoustic intensity. Acoustic standards. The decibel scale.

Unit II

Reflection and transmission of plane waves: Normal incidence; fluid – fluid interface, fluid-solid interface, standing wave patterns, transmission through three media. Oblique incidence; fluid-fluid interface, angle of intromission, fluid-solid interface.

Unit III

Absorption of sound waves in fluids. Sound transmission loss in sea water. Sound velocity structure of the sea. Ray tracing. Refraction phenomenon. Sound channels. Surface and bottom reflections. Sound transmission in shallow water- ray and normal mode solutions. Attenuation in inhomogeneous fluids. Scattering from non-resonant bodies and bubbles. Bubble resonance. Scattering characteristics of marine life – non-resonant bodies.

Unit IV

Piezoelectric and magnetostrictive sonar transmitting and receiving transducers. Hydrophones. Radiation pattern of sonar transducers – array of discrete and continuously distributed source elements. Transmitting and receiving directivity factor and directivity index. Beam shaping for arrays.

Unit V

Active sonar signals, resolution and bandwidth: Source level, echo level. Masking by noise and reverberation. Improving signal-to-noise ratio. Additional parameters significant in active sonar. Echo sounding and sub bottom profiling. Diffraction of impulsive signal at rough surfaces. Average reflection coefficient for rough surfaces. Doppler effect of moving objects. Doppler navigation. Passive sonar: Fundamental characteristics. Acoustic output of ships. Passive detection range. Passive detection hydrophones. Array steering. Ocean acoustic tomography.

References:

1. Acoustical Oceanography- Principles and Applications: Clay and Medwin, Wiley, 1977.
2. Underwater Acoustics and Ocean Dynamics: Proceedings of the 4th Pacific Rim, Lisheng Zhou, Wen Xu, Qianliu Cheng, Springer, 2016.
3. Ocean Acoustics, Desanto, John (Ed.), Springer, 1979.
4. Underwater Acoustic Modeling and Simulation, Fourth Edition, Paul C. Etter, CRC Press, Taylor and Francis Group, 2013.
5. Fundamentals of Acoustics: L. E. Kinsler and A. R. Frey, Wiley; 4th edition, 1999.

Suggested Reading:

1. Ocean Acoustics, Kistovich, A., Pokazeev, K., & Chaplina, T. Springer. 2020.
2. A Demonstration of Ocean Acoustic Tomography- The Ocean Tomography Group Nature, 299, pp. 121-125, 1982.
3. Applied Underwater Acoustics: D. G. Tucker and B. K. Gazey, Pergamon Press, 1966.
4. Fundamentals of Ocean Acoustics, L. Brekhovskikh, Y. Lysanov, Springer-Verlag 1982.
5. Introduction to the Theory of Sound Transmission: C. B. Officer, McGraw-Hill, 1958.
6. Ocean Acoustic Tomography- A Scheme for Large Scale Monitoring: Munk, W. and C. Wunsch, Deep Sea Res., 26A, PP. 123-161, 1979.
7. Ocean Acoustics- Theory and Experiment in Underwater Sound: Tolstoy and Clay, Acoustical Society of Amer., 1987.
8. Principles of Underwater Sound for Engineers: R. J. Urik, McGraw-Hill Ryerson, 1983.
9. Sounds in the Sea: From Ocean Acoustics to Acoustical Oceanography, Herman Medwin, Cambridge University Press, 2005.
10. Underwater Acoustics: Leon Camp, Wiley- Interscience, 1970.
11. Underwater Observation Using Sonar: D. G. Tucker, Fishing News (Books), 1966.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Integrated Coastal Zone Management**	**Elective**	**4**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Conduct a scientific management exercise at an advanced level in ICZM.	3
CO2	Understand the coastal zone in detail and assess minute, underlying causes that control various processes in the coastal zone.	2
CO3	Appreciate the inter-linkages within the diverse coastal ecosystems.	2
CO4	Describe the sensitiveness of coastal habitats and their response to global climate change(s).	2
CO5	Apply tools to conduct integrated management of coastal zones and learn to perform and grow globally as an expert in coastal zone management.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	1	-
CO2	3	-	1	-
CO3	3	-	1	-
CO4	3	-	1	-
CO5	3	-	1	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Unit I

Concepts, definition and approach – general classification of coastal zones of the World – dominant natural processes - Asia –Pacific coastal zone - State of the environment – terrestrial and marine influence on coastal zone – catchment coast interactions - climate change and impacts on coastal zone – sea level changes and coastal responses – approaches to sustainable coastal zone management – adaptive management in contextual scenarios.

Unit II

Coastal resources and utilization – conservation measures – developmental activities – human pressures and responses - hotspot management- hazards and vulnerability analysis. Management options - DPSIR - Matrix approach - participatory dialogues and stakeholder roles-voluntary partnerships - Marine spatial planning and ICZM – coastal and marine spatial data – zoning and uses of coastal zone based on GIS and MSP.

Unit III

Coastal surveying methods – monitoring - approach to fieldwork - sampling techniques - RS/GIS applications – EIA within the framework of CZM. Coastal engineering works – structures – impacts- shore protection and maintenance. Coastal Management Risk Management (C-DRM)- PRA tools – Early warning systems for DRM -

Unit IV

Legal Regime – law of the sea - territorial sea and EEZ – International law in CZM – Treaties - Indian coastal policy – Indian laws: Coastal Regulation Zone Notifications, 1991, 2011 and 2019 – M S Swaminathan and Shailesh Nayak Committee Recommendations - implementation of policy – enforceability of laws in CZ – currents status of coastal zones.

References:

1. Challenges in Tropical Coastal Zone Management: Experiences and Lessons Learned, Matthias W, Sebastian C.A. F., Hugh G., Springer, 2023.
2. CZM handbook: R. J. Clark, CRC Press; 1 edition, 1995.
3. Coastal Zone Management: Ramakrishnan Korakandy, Kalpaz Publications, 1st Edn., 2005.
4. Coastal Zone Management: Global Perspectives, Regional Processes, Local Issues,Mu Ramkumar, Arthur J., David M., Kumaraswamy K., Elsevier, 2018.

5. Integrated CZM: Erland M, Wiley – Blackwell, 2009.

Suggested Reading:

1. Sustainable Coastal Management & Climate Adaptation: R Kenchington, CRC Press, 2012.
2. Interactions of land, ocean and humans, Maser, Chris, CRC Press, 2015.
3. Coastal environments and global change, Masselink, Gerd, Wiley-Blackwell, 2015.
4. Coastal Wetlands: an integrated ecosystem approach: Perillo G M E, Elsevier, 2009.
5. Coastal zones, Baztan, Juan, ed., Elsevier, 2015.
6. Coastal Zones: Solutions for the 21st Century, Baztan, Juan, Elsevier, 2015.
7. Geomorphological impacts of extreme weather, Loczy, Denes, Springer, 2013.
8. Sustainable Coastal Management & Climate Adaptation: R Kenchington, CRC Press, 2012.
9. Integrated CZM: Erland M, Wiley – Blackwell, 2009.
10. Global challenges in integrated coastal zone management, Moksness, Erlend, Wiley-Blackwell, 2014.
11. Perspectives on Integrated CZM: W. Salomons, R. K. Turner, Lacerda, L.D. de, S. Ramachandran, Springer, 1999.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Beach Dynamics**	**Elective**	**2**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Understand the effects of human activities on a changing shoreline.	2
CO2	Attain knowledge on multiple issues in the coastal zones.	2
CO3	Understand how the currents, waves and tides shape the sand movements.	2
CO4	Identify how the warming climate affect the sea levels.	2
CO5	Engage the coastal community and policy makers aware of describing civil infrastructural projects.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	1	2
CO2	3	-	1	1
CO3	3	-	1	2
CO4	3	-	1	3
CO5	-	-	2	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Unit I

Beach features and classification – Beach cycles – Beach profiles – Erosion and Accretion- Beach Dimensions – Two dimensional beaches – Surf zone – Swash zone – Three dimensional beaches – Beach Quantification – Beach morphodynamics – coastal processes and shore face equilibrium- Coastline changes- Case study.

Unit II

Coastal boundaries – Beach Sediments – Sediment budget - Global changes in coastal sediments – Bar formation- Barrier beach formation -Wave climate – Surf zone – Waves generation- Wave transformation and wave set up – Wave transformation models Longshore currents – Rip currents – Onshore- Offshore sediment transport- Sediment transport models.

References:

1. Beaches and Coasts: C A M King, Edward Arnold, 1961.
2. Beach Processes and Sedimentation. 2 Edition, Komar, Paul D, Prentice Hall, Upper Saddle River (New Jersey), 544 p, 1998.
3. The Coastline: R S K Barnes, Wiley-Blackwell, 1977.
4. Coasts – An Introduction to Coastal Geomorphology: C F Bird, Blackwell Pub; 3 Sub edition, 1984.
5. Coastal Zones: Solutions for the 21st Century, Baztan, Juan, Elsevier, 2015.

Suggested Reading:

1. Coastal Environments- An Introduction to the Physical, Ecological, and Cultural Systems of Coastlines: R W L Carter, Academic Press, 1989.
2. Coastal ocean observing systems, Liu ,Yonggang , Kerkering, Heather, Weisberg, Robert H., Elsevier, 2015.
3. Coastal Sedimentary Environments: R A Davies, Springer; 2nd ed. 1985 edition, 2011.
4. Interactions of land, ocean and humans, Maser, Chris, CRC Press, 2015.
5. Landscapes and landforms of India, Kale, Vishwas S., Springer, 2014.
6. Pitfalls of shoreline stabilization Cooper, Andrew J G., Springer, 2012.
7. Practical guide to geo-engineering: with equations, tables, graphs and check lists, Srbulov, Milutin, Springer, 2014.
8. Quaternary sea-level changes: a global perspective, Murray-Wallace, Colin V., Cambridge University Press, 2014.
9. Sea-level science : understanding tides, surges, tsunamis and mean sea-level changes, Pugh, David, Cambridge University Press, 2015.
10. Waves on beaches: R E Mayer, Academic Press, New York, 1972.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**GIS in Oceanography**	**Elective**	**2**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Explain basics of GIS.	2
CO2	Describe applications of GIS in Oceanography.	2
CO3	Demonstrate coastal zone habitat mapping.	2
CO4	Recognize cartographic importance of thematic mapping in Oceanography.	2
CO5	Identify the major coastal zone resources.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	-	-
CO2	3	-	3	3
CO3	3	-	2	2
CO4	3	-	2	3
CO5	3	-	2	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Unit I

Introduction to Geographical Information System (GIS) – data and analysis techniques – hardware and software – general applications. The Marine Geographic Information Systems – uses in various fields of oceanography – Data sampling – identification of ocean features – mapping seabed.

Unit II

GIS and Coastal Zone – Planning in CZ – data analysis and applications using GIS – managing CZ resources – GIS as a decision support system.

References:

1. An Introduction to GIS: I Heywood, S Cornelius& S Carver, Prentice Hall; 2nd Edn., 2002.
2. GIS – An Introduction: T Bernhardsen, Wiley; 3rd Edn., 2002.
3. GIS & Multi Criteria Decision Making: J Malczewski, John Wiley & Sons, 1999.
4. GIS & Science: P. A.Longley, MF Goodchild, D J Maguire & D W Rhind, Wiley; 3rd Edn., 2010.
5. Geographic Information Systems in Oceanography and Fisheries: V D Valavanis, CRC Press, 2003.

Suggested Reading:

1. Coastal and Marine Geo Information Systems: D R Green & S D King, Springer, 1st Edn., 2003.
2. Hydrological applications of GIS, Gurnell, A. M., Wiley, 2014.
3. Innovations in GIS 5: S Carver, Taylor and Francis, 1998.
4. Integration of GIS and RS: J L Star, J E Estes and K C, McGwire, Cambridge University Press, 1997.
5. Managing Geographic Information System Projects: W. E Huxhold & A G Levinsohn, Oxford University Press, 1995.
6. Spatial Models and GIS New Potential and New Modes (GIS DATA): I Masser, F Salge, A S Fotheringham & M Wegner, CRC Press; 1st Edn., 1999.
7. Wetland and Environmental Application of GIS: JGLyon & J MaCarthy, Lewis Pub. 1995.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Advanced Ocean Dynamics**	**Elective**	**3**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Describe the fundamental models that used for the ocean dynamics, its approximations and boundary conditions.	2
CO2	Discuss the equatorial and coastal ocean response to the surface winds through the generation of Kelvin waves and Rossby waves, its propagation and its reflection at the coastal boundaries.	2
CO3	Explain the Ekman pumping, Ekman balance and Sverdrup balance.	2
CO4	Discuss the different types of small scale instabilities in the mixed layer and its condition.	2
CO5	Discuss the different types of large scale instabilities in the ocean and conditions for their existence.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	-	-
CO2	3	-	-	-
CO3	3	-	-	-
CO4	3	-	-	-
CO5	3	-	-	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, “-” No correlation

Syllabus:

Unit I

Laplace and Fourier transforms, Eigen value problem, Sturm-Liouville equation, Hermite function, Linear Continuously stratified model, one and half layer model, two and half layer model, Approximations and boundary conditions, Types of waves (gravity, Kelvin, and Rossby waves), their dispersion relations, and phase and group speeds.

Unit II

Interior ocean response to wind forcing – Inertial oscillations, Ekman drift, Ekman pumping, radiation of Rossby waves, Sverdrup balance. Coastal ocean response to alongshore winds-coastal Kelvin waves, vertical propagation of Kelvin waves, Rossby wave radiation from eastern boundary. Equatorially trapped waves- how do they differ from off-equatorial waves, reflection of coastal Kelvin waves from an eastern boundary, equatorial Rossby waves, equatorial Kelvin wave and Yanai wave, Yoshida (Wyrtki) jet.

Unit III

Small-scale instabilities – convective overturning and Kelvin-Helmholtz (KH) instability, Mile's condition for KH instability, breaking of internal waves, small scale instabilities in mixed layer, mixed-layer processes and models. Large scale instabilities - barotropic and baroclinic instability, condition for existence of barotropic instability.

References:

1. Atmosphere-Ocean Dynamics, Gill, A. E., International Geophysics Series, Vol. 30, 1982.
2. Geophysical Fluid Dynamics, Pedlosky, J., Springer, Second Edition, 1992.
3. Ocean Dynamics, Olbers, D, Willebrand, J, Eden,C, Springer, 2012.
4. Geophysical Fluid Dynamics I : An introduction to Atmosphere-Ocean Dynamics: Homogeneous Fluids. Emin Ozsoy, Springer, 2020
5. Essentials of Atmospheric and Ocean Dynamics. Geoffrey K. Vallis, Cambridge University Press, 2019.

Suggested Reading:

1. A student's guide to geophysical equations, Lowrie, William, Cambridge University Press, 2011.
2. Atmospheric and oceanic fluid dynamics fundamentals and large-scale circulation, Geoffrey K. Vallis, Cambridge University Press, 2006.
3. Dynamics of the equatorial ocean, Boyd, P, Springer, 2018.
4. Environmental fluid dynamics, Imberger, Jorg, Academic Press, 2013.
5. Mesoscale-convective Processes in the Atmosphere, Trapp, Robert J, Cambridge University Press, 2013.
6. Modelling of Wind-driven circulation, J. P. McCreary, Hawaii Institute of Geophysics, 1980.
7. The Ocean in motion, Manuel G. Velarde, Roman yu. Tarakanov, Alexey V. Marchenko, Springer, 2018.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Wave Dynamics**	**Elective**	**3**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Describe the fundamental equations of wave motion.	2
CO2	Describe the kinematics (such as velocity of propagation, super position energy and particle trajectory) of linear surface gravity waves.	3
CO3	Describe the characteristics of linear waves (Poincare waves, Rossby Waves and coastal Kelvin waves) using dispersion relation.	3
CO4	Analyze any given wave data using Fourier transformations and explain the spectrum.	4
CO5	Describe different terms of a wave model.	4

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	-	-
CO2	3	-	-	-
CO3	3	-	1	-
CO4	3	3	2	1
CO5	3	3	1	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, “-” No correlation

Syllabus:

Unit I

Scales of motion. Wave kinematics – plane wave, wave number, phase of a wave, wave frequency, phase speed. Wave equation, dispersion relation. Super-position of two waves – group velocity, standing waves (Seiches). Wave spectra. Finite amplitude waves. Equations of motion, shallow water equations.

Unit II

Surface gravity waves in non-rotating frame of reference – short wave and long wave approximation. Phase speed of a linear surface gravity wave. Dispersion relation of a linear surface gravity wave. Deep and shallow waters. Particle trajectory - deep and shallow water. Pressure perturbation - deep and shallow water. Energy of a surface gravity wave – kinetic and potential. Group velocity of a surface gravity wave. Energy balance equation. Wave models (SWAN and WAVEWATCH).

Unit III

Gravity waves with rotation – Poincare waves, inertial oscillations, Rossby wave – beta and f plane approximations, quasi-geostrophic approximation. Coastal Kelvin wave. Equatorial beta-plane, Equatorial waves. Normal modes in a continuously stratified fluid. Internal waves, WKB theory.

References:

1. Atmosphere-Ocean Dynamics, Gill, A. E., International Geophysics Series, Vol. 30, 1982.
2. Fluid Mechanics, Kundu, P.K., Cohen, I.M., Dowling, D.R., 6th Edition, Academic Press, Elsevier, 2015.
3. Waves in the Ocean, P.H. LeBlond and Mysak, L.A., Elsevier, 1981.
4. Waves in the Oceanic and Coastal waters, Leo H. Holthuijsen, Cambridge University Press, 2007.
5. Introduction to geophysical fluid dynamics physical and numerical aspects, Benoit Cushman-Roisin, Jean-Marie Beckers, 2nd Edition, Academic press, Elsevier 2011.
6. Essentials of Atmospheric and Oceanic Dynamics, Geoffrey K Vallis, Cambridge University Press, 2019.

Suggested Reading:

1. Fundamentals of Geophysical Fluid Dynamics, James C. McWilliams, Cambridge University Press, 2006.
2. Introduction to geophysical fluid dynamics physical and numerical aspects, Cushman-Roisin, Jean- Marie Beckers, Academic Press, 2009.
3. Ocean wave mechanics: Applications in Marine structures, V. Sundar, Wiley, 280pp. 2017.
4. Ocean waves and oscillating systems, J. Falnes, Cambridge University Press, 2004.
5. Waves in the Ocean and Atmosphere, Introduction to Wave dynamics Pedlosky, J, Springer, 2003.
6. Waves in the Ocean, Elsevier Oceanography Series, LeBlond, P.H., Mysak, L.A., 1978.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Marine Biogeochemistry**	**Elective**	**3**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Describe the carbon, oxygen, nitrogen and nutrient cycling in the oceans.	2
CO2	Explain how these cycles are influenced by physical processes such as ocean circulation, upwelling, entrainment, air-sea exchange and riverine input.	2
CO3	Describe the mathematical representations of nutrient uptake, light and nutrient limitations.	2
CO4	Explain how changes in the cycles are related to global change in past, present and future climate.	2
CO5	Describe how the anthropogenic changes influence these cycles.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	1	-
CO2	3	-	1	-
CO3	3	-	1	-
CO4	3	-	1	3
CO5	3	-	1	3

Correlation levels: 1 = Low, 2 = Medium, 3 = High, “-” No correlation

Syllabus:

Unit I

Introduction: Chemical composition of the ocean - Distribution of nutrients in the ocean - expression of chemicals as 'tracers' - conservation of tracers in the ocean - Cycles of carbon, nitrogen, phosphorus and sulphur. Nitrogen cycling – nitrification and denitrification

Unit II

Biology of the ocean: Organic Matter Production - composition of organic matter - Phytoplankton, Zooplankton and bacteria- Food web in the ocean, microbial loop. Ecosystem processes and role of Light. Ecosystem models: N-P, N-P-Z and N-P-Z-D models. Physical processes influencing primary productivity: upwelling – entrainment. Role of ocean currents and mixing, Light and nutrient limitation.

Unit III

Basic carbon dissolution chemistry in the sea water - solubility pump, biological pump - alkalinity of ocean and ocean acidification - air-sea gas exchange and oceanic pCO2. Carbon dioxide system and climate change - ocean acidification, coral reefs and mangroves, vegetation. Marine sediments and sedimentary cycles. Human impacts.

References:

1. Ocean Biogeochemical Dynamics, J. L. Sarmiento and Nicholas Gruber, Princeton University Press, 2006.
2. Ocean Biogeochemistry, The Role of the Ocean Carbon Cycle in Global Change Editors: Fasham**,** Michael J.R. (Ed.), Springer, 2003.
3. Biodiversity in the marine environment, Goulletquer, Philippe et al., Springer, 2014.
4. Biogeochemistry of Estuaries, Thomas S. Bianchi, Cambridge University Press, 2014.
5. Biogeochemistry of Marine Systems, Kenneth D. Black, Graham B. Shimmield, Wiley, 384pp. 2009.

Suggested Reading

1. Coastal environments and global change, Masselink , Gerd, Wiley-Blackwell, 2015.
2. Interactions of land, ocean and humans, Maser, Chris, CRC Press, 2015.

3. Marine conservation, Ray, Carleton G, Wiley Blackwell, 2014.
4. Marine Ecosystems: Diversity and Functions, André Monaco, Patrick Prouzet, 318pp. 2015.
5. Nitrogen in the Marine Environment, Douglas G Capone, Deborah A Bronk, Margaret R Mulholland, Edward J Carpenter, Elsevier, 2008.
6. The Arctic climate system, Ed.2 Serreze, Mark C., Cambridge University Press, 2014.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Ocean Circulation**	**Elective**	**2**

Course Outcomes:
At the end of the course, the students will be able to :

	Course Outcome	BL
CO1	Describe the fundamental ocean circulation theories such as Ekman theory, Sverdrup theory, Stommel theory and Munk theory.	2
CO2	Discuss the role of stratification and different types of instabilities in the ocean.	2
CO3	Explain the features of thermohaline circulation and abyssal circulation.	2
CO4	Describe the process such as subduction and ventilation.	2
CO5	Discuss the conservation of temperature and salt.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	-	-
CO2	3	-	-	-
CO3	3	-	-	-
CO4	3	-	-	-
CO5	3	-	-	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Unit I

Theories of wind-driven circulation, Sverdrup solution, frictional and inertial boundary regimes; instabilities, meanders and meso-scale features; role of stratification, topography and time dependence.

Unit II

Thermohaline circulation- Conveyor belt- Formation and distribution of water masses-subduction and ventilation- Abyssal circulation- mixing – Isopycnal and diapycnal mixing -Topographic steering, thermodynamic and salinity circulation, equations for salt and temperature conservation, Reynold’s fluxes and eddy diffusivity, thermocline and thermohaline circulation, mixed layer of the ocean.

References:

1. Introductory Dynamic Oceanography: S Pond & G L Pickard, 2nd Edn. Pergamon, 1983.
2. Dynamical Oceanography: J. Proudman, Methuen, 1953.
3. General Oceanography: G Dietrich, Wiley-Interscience, 1963.
4. Introduction to Physical Oceanography: W. S. Von Arx, 1st Edn., 1962.
5. Ocean Circulation and Climate, Volume 103, Second Edition: A 21st century perspective, Siedler, Gerold, Academic Press, 2013.

Suggested Reading:

1. Physical Oceanography: A. Defant, Vol-1, New York Pergamon Press, 1961.
2. Principles of Physical Oceanography: W J Pierson and G Neumann, Prentice Hall, 1966.
3. The Oceans- Their physics, chemistry and general biology: H. U. Sverdrup et al., Prentice-Hall, first edition, 1942.
4. Introduction to Physical Oceanography, John A. Knauss and Newell Garfield, Third edition, 2017
5. Essentials of Atmospheric and Oceanic Dynamics, Geoffrey K. Vallis, Cambridge University Press, 2019.
6. Ocean circulation in three dimensions, Barry A. Klinger and Thomas W.N. Haine, Cambridge University Press, 2019.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Remote Sensing and GIS (Practical)**	**Elective**	**2**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Analyze and process satellite images using software such as SeaDAS.	4
CO2	Generate cartographic data using ArcGIS software and able to analyse various oceanographic features.	3

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	2	3	-	-
CO2	-	3	2	2

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Data Processing Softwares: SeaDAS, ArcGIS,

Applications: Processing of satellite data for the generation of imageries such as chlorophyll, suspended sediments and interpretation by using SeaDAS. Mapping and interpretation of various oceanographic parameters by using GIS.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Marine Remote Sensing Applications**	**Elective**	**3**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Explain fundamentals of remote sensing.	2
CO2	Describe the principles behind various satellite sensors.	2
CO3	Infer Potential fishing zone based on SST and Chlorophyll satellite data	3
CO4	Identify oil slicks and their potential damages.	3
CO5	Apply satellite data for coastline change detection.	3

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	1	1	-
CO2	3	1	1	-
CO3	2	1	1	-
CO4	2	-	1	3
CO5	2	-	1	3

Correlation levels: 1 = Low, 2 = Medium, 3 = High, “-” No correlation

Syllabus:

Unit I

Basics of Remote sensing-electromagnetic radiation, solar and terrestrial radiation, Atmospheric effects, absorption, transmission and scattering – atmospheric windows- spectral signature.

Unit II

Retrieval of Chlorophyll- yellow substance-diffuse attenuation coefficient and PAR-Oceansat-OCM. MODIS and recent satellite sensors for biological studies. Mangroves, coral reefs and bleaching- NOAA-AVHRR, IRS, LANDSAT applications. Oil slicks on the Ocean surface. Water quality studies using recent sensors.

Unit III

Remote sensing application to coastal morphology: studies on erosion, accretion, suspended sediment concentration, wetland mapping, shoreline changes. LANDSAT, CARTOSAT applications.

References:

1. Measuring the Oceans from Space: The principles and methods of satellite Oceanography: I.S.Robinson, Springer, 2004.
2. Satellite Oceanography: I.S.Robinson, Ellis Horwood Ltd, 1985.
3. Advances in Passive Microwave Remote Sensing of Oceans 1st Edition, Victor Raizer, CRC Press, Taylor and Francis Group. 2017.
4. Methods of Satellite Oceanography: Robert H.Stewart, University of California Press, 1985.
5. Satellite based applications on climate change, Qu, John J, Springer, 2013.

Suggested Reading:

1. Advanced Remote Sensing, Liang,Shunlin, Academic Press, 2012.
2. An Introduction to Ocean Remote Sensing 2nd Edition, Seelve Martin, Cambridge Univ. Press. 2014.
3. Climatology from Satellites: E.C.Barret, Methuen Young Books, 1974.
4. Fundamentals of satellite remote sensing, Chuvieco, Emilio, CRC Press, 2016.
5. Introduction to remote sensing, Ed.3 & 5, Campbell, James B, Taylor and Francis, 2011.
6. Introduction to Satellite Oceanography: G.A.Maul, Springer, 2012.
7. Introduction to Satellite Remote Sensing Atmosphere, Ocean, Cryosphere and Land Applications, William Emery, Adriano Camps and Marc Rodriguez-Cassolac., Elsevier, 2017.
8. Oceanographic Applications of Remote Sensing: Motoyoshi Ikeda and W.Dobson, CRC Press, 1995.
9. Satellite Microwave Remote Sensing: T.D.Allan, Ellis Horwood Ltd, 1983.

10. The Application of Remote Sensing Technology to Marine Fisheries: An Introductory Manual-FAO Fisheries Technical Paper 295: M.J.A.Butler, M.C.Moucho, V.Baralet & C.LeBlanc, Food & Agriculture Org, 1989.
11. Remote Sensing of the Asian Seas, Barale, Vittorio, Gade Martin (Eds.), Springer, ISBN 978-3- 319-94065-6, 2019.
12. Satellite Image Analysis: Clustering and Classification, Borra, S., Thanki, R., Dey, N., Springer, ISBN 978-981-13-6423-5, E-book, 2019.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Regional Oceanography**	**Elective**	**3**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Describe the distribution of physical properties in the Indian Ocean.	2
CO2	Discuss the meteorological and oceanographic features of the Arabian Sea and Bay of Bengal.	2
CO3	Explain the different features in the Indian Ocean such as monsoon wind system, monsoon current system and Indian Ocean Dipole.	2
CO4	Identify the upwelling and downwelling regions in the Indian Ocean and describe the mechanism.	2
CO5	Discuss the different resources from the Indian Ocean.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	-	-
CO2	3	-	-	-
CO3	3	-	-	2
CO4	3	-	-	-
CO5	3	-	-	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Unit I

Introduction: history, major expeditions, IIOE - geographical and environmental features, uniqueness of Indian ocean- EEZ- sediment distributions – Arabian sea and Bay of Bengal system.

Unit II

Hydrography: Temperature, salinity, density and oxygen distributions, seasonal variations- General features of Red sea and Persian Gulf – Water mass – T-S diagram, T-S-V diagram- core method. Circulation: Sea level pressure distribution, wind systems and currents, monsoon current system – Somali current, Agulhas current, Leeuwin current, equatorial currents and under currents- upwelling in Arabian sea and Bay of Bengal – Indian ocean dipole mode –ITF

Unit III

Resources: Freshwater, chemicals and minerals, energy from tides, current, wave, salinity gradient energy conversion, OTEC, winds and geothermal energy.

References:

1. Regional Oceanography- an introduction: Tomczack and J.S.Godfrey Pergmon, 1994.
2. Descriptive Physical Oceanography: George L. Pickard and William J. Emery Elsevier, 1990.
3. Glimpses of Indian Ocean: S.Z. Qasim, Sangam books Ltd. 1998.
4. Introduction to Physical Oceanography: W. S. Von Arx, 1st Edn., 1962.
5. Ocean Circulation and Climate, Volume 103, Second Edition: A 21st century perspective, Siedler, Gerold, Academic Press, 2013.

Suggested Reading:

1. Applied Oceanography: Joseph M. Bishop, John Willey and sons Inc.1984.
2. Ocean Wave Energy Conversion: M.E. McCormick, John Willey and sons Inc. 1981.
3. The Encyclopedia of Oceanography Vol. I: Rhodes W. Fairbridge, Rein hold publishing corp, 1966.
4. CZM Handbook: R. J. Clark, Taylor & Francis, 1995.
5. Dynamics of the equatorial ocean, Boyd, P, Springer, 2018.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Ocean Engineering**	**Elective**	**4**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Describe preliminary design criteria of a seawall.	2
CO2	List and detail different hard and soft protection techniques for coastal protection	1
CO3	Explain the sedimentation in coastal region and its remedial measures.	2
CO4	Describe different ocean based energy production technologies.	2
CO5	List and explain different types of offshore structures and their installation techniques.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	1	-
CO2	3	-	1	2
CO3	3	-	1	2
CO4	3	-	1	-
CO5	3	-	1	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, “-” No correlation

Syllabus:

Unit I

Engineering aspects in oceanography, Coastal protection structures- Sea walls, Groins, Breakwaters, Composite breakwaters, geo-textile systems, Artificial reefs, Beach fill stabilization, Artificial nourishment, Sediment bypassing. Impacts of coastal developments-Numerical models of shoreline changes.

Unit II

Marine structures and their functions, Environmental loading-Self-loading-fixed and floating structures, offshore platforms, underwater pipelines and cables. Hydrodynamic forces in unsteady flow- interaction of waves on structures, sea floor soil mechanics and related engineering operations.

Unit III

Natural and artificial harbors, Siltation and control, coastal inlets and stability-Dredging, different types of dredgers- spoil ground location criteria, environmental effects of dredging-DIA. Marine Corrosion, material selection, corrosion control and prevention.

Unit IV

Non-living ocean resources and exploitation, oceanographic factors involved in resource conservation and utilization. Energy from the sea – tidal, wave and thermal energy. Basic principles of desalination.

References:

1. Oceanographic Engineering: R L Weigel, Dover Publications, 2005.
2. Basic Coastal Engineering: Robert M. Sorensen, Springer; 3rd Edn., 2005.
3. Coastal Engineering: R Silvester, Elsevier Scientific Pub. Co., 1974.
4. Ocean Engineering – Goals, Environment, Technology: J F Brahtz, John Wiley and Sons, 1968.
5. Offshore Pipelines, Guo, Boyun, Elsevier, 2014.

Suggested Reading:

1. Structure in the Sea: The Science, Technology and Effects of Purpose-Built Reefs and Related Surfaces, William Seaman, Elsevier Science,2022.

2. Design of Coastal Hazard Mitigation Alternatives for Rising Seas. Japan: World Scientific Publishing Company Pte Limited, Basco D., World Scientific Publishing Company Pvt Limited,2020.
3. Coastlines, Structures and Breakwaters: NWH Allsop, Thomas Telford Ltd, 1998.
4. Maritime Engineering and Technology, Soares,Guedes, C R C Press, 2012.
5. Modeling Marine Systems: A M Davies, CRC Press, 1989Wave Energy – A Design Challenge: R Shaw, Ellis Horwood Ltd, 1982.
6. Physical Modeling in Coastal Engineering: R A Dalrymple, Taylor & Francis, 1985.
7. Pitfalls of shoreline stabilization Cooper, Andrew J G., Springer, 2012.
8. Practical guide to geo-engineering: with equations, tables, graphs and check lists, Srbulov, Milutin, Springer, 2014.
9. Ocean Wave Energy Conversion: M E McCormick, Dover Publications, 2007.
10. Sediment transport in coastal waters; Sylvian Quillon; MDPI Publishers; 2019
11. Coastal engineering theory and practice, Vallam Sundar & S.A Sannasiraj, Advanced series on Ocean engineering, Vol. 47, Publisher: WSPC, 2019.
12. Coastal engineering processes, theory and design practice, Dominic Reeve, Andrew Chadwick & Christopher Fleming, CRC Press, 3rd Edition, 2018.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Applied and Computational Mathematics**	**Elective**	**4**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Demonstrate skills in linear algebra.	2
CO2	Explain the application of ordinary and partial differential equations.	2
CO3	Demonstrate the knowledge of special series and transformations.	2
CO4	Describe the theory behind time-series data analysis techniques such as spectral and wavelet analysis.	2
CO5	Demonstrate a knowledge of probability and statistical analysis.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	-	-
CO2	3	-	-	-
CO3	3	-	-	-
CO4	3	-	-	-
CO5	3	-	-	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, “-” No correlation

Syllabus:

Unit I

Vector algebra: Vector spaces, basis, inner product, linear transformations, spectral decomposition, singular value decomposition, QR and LU decomposition of matrices, vector calculus, system of linear equations, co-ordinate transformations; Lab - Matlab for solving spectral decomposition, singular value decomposition, system of linear equations.

Unit II

Ordinary and partial differential equations: Characterization of ODEs and PDEs, methods of solution, general solution of linear ODEs, special ODEs and PDEs, Euler-Cauchy, Bessel's and Legendre's equations, Diffusion equation, Laplace equation, Wave equation, Sturm-Liouville theory, numerical solutions, convergence and stability; Lab - Matlab programming for numerically solving ODEs and PDEs.

Unit III

Complex analysis: Analytic functions, Cauchy-Riemann conditions and conformal mapping, line and contour integration, Cauchy's theorem. Special functions - Special series and transformations: Laplace and Fourier transforms, Fourier series, FFT algorithms, wavelet transforms; Lab - Matlab programming for FFT, and wavelet analysis.

Unit IV

Probability and Statistics: Mean, median and mode, correlation and regression analysis, probability density function, standard PDF (Binomial, Gaussian, chi-square, t-dbn), sampling distribution, confidence interval, estimation of parameters and testing of hypothesis; Lab - Matlab programming for mean, median, mode, correlation and regression.

References:

1. Advanced Engineering Mathematics, Clarence Raymond Wylie, Louis C. Barrett, McGraw-Hill. 1995.
2. Advanced Engineering Mathematics, Erwin Kreyszig, Herbert Kreyszig, Edward J. Norminton, ISBN 978-0-470-45836-5, John Wiley & Sons, Inc. 2011.
3. Advanced Engineering Mathematics, M.D. Greenberg, Pearson education, Inc. 2009.
4. Advanced Mathematical Methods for Scientists and Engineers, Asymptotic Methods and Perturbation Theory, Carl M. Bender, Steven A. Orszag, Springer. 2013.

Suggested Reading:

1. Applied Statistics and Probability for Engineers, 5th Ed. Douglas C. Montgomery, George C. Runger, ISBN: 9788126537198, 8126537191, Wiley India Pvt. Ltd. 2012.
2. Methods of Applied Mathematics, Francis B. Hildebrand, Prentice-Hall Publications, Inc. 1965.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Ocean Ecosystem Modelling**	**Elective**	**2**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Explain the impact of physical processes on the marine food web.	2
CO2	List the mathematical formulations of energy uptake, growth, reproduction and decay of phytoplanktons.	1
CO3	Explain the chemical formulations of nitrification and denitrification.	2
CO4	Use simple Nitrogen-Phytoplankton-Zooplankton-Detritus models to understand the marine ecosystems.	3
CO5	Explain the challenges in ecosystem modelling.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	-	-
CO2	3	-	-	-
CO3	3	-	-	-
CO4	3	-	-	-
CO5	3	-	-	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Unit I

Impact of physical processes on biology, ocean food web (phytoplankton to fish and microbial loop), nitrogen cycle in the ocean, nitrification and denitrification, Advection-diffusion equation, first order chemical reaction.

Unit II

Growth rate of phytoplankton, nutrient limitation, light limitation, Liebig law of minimum, Michaelis-Menton representation, Redfield ratio, photosynthesis, size consideration of phytoplankton (Diazotroph, picoplankton and diatom), zooplankton grazing, a simple NPZD model, a coupled physical-ecosystem model, challenges involved in modelling of higher trophic levels and fishes.

References:

1. Ocean Biogeochemical Dynamics, J. L. Sarmiento and Nicholas Gruber, Princeton University Press, 2006.
2. Dynamics of Marine Ecosystems: Biological-Physical Interactions in the Oceans, 3rd Edition K. H. Mann, John R. N. Lazie, Wiley, 2013.
3. Empirical and mechanistic models for the particle export ratio, Dunne, J. P., R. A. Armstrong, A. Gnanadesikan, and J. L. Sarmiento Global Bio-geochem. Cycles, 19, GB4026, 2005.
4. Introduction to the modelling of marine ecosystem, W. Fennel and T. Neumann, Elsevier Oceanography Series, 72, Elsevier, 2004.
5. Ocean Biogeochemistry, The Role of the Ocean Carbon Cycle in Global Change Editors: Fasham, Michael J.R. (Ed.), Springer, 2003.

Suggested Reading

1. Phytoplankton productivity: Carbon assimilation in marine and fresh water ecosytems, Williams, P.J.B, Thomas, D.N, Reynolds, C.S, Wiley, 2008.
2. Technical description of the prototype version (v0) of Tracers of Phytoplankton with Allometric Zooplankton (TOPAZ) ocean bio-geochemical model as used in the Princeton IFMIP model, Dunne,

J. P., A. Gnanadesikan, J. L. Sarmiento, and R. D. Slater Bio-geosciences, 7, 3593–3624. 2010.

3. Tools for Oceanography and Ecosystemic modelling, Monaco, A, Prouzet, P, Wiley, 2016.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Statistical Methods in Oceanography (Practical)**	**Elective**	**1**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Calculate the statistical parameters and perform Test of hypothesis.	5
CO2	Apply statistical analyses such as EOF, Wavelet and FFT on ocean-atmospheric data sets.	3

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	-	3	-	-
CO2	-	3	-	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Population and sample – mean, variance, range – confidence intervals – regression – least square method – multivariate regression – hypothesis testing – interpolation – linear, polynomial and spline methods – covariance.

Objective analysis – Empirical Orthogonal Functions – factor analysis – covariance and correlation – autocorrelation – spectral analysis – rotary and cross spectra – wavelet analysis – Fourier analysis and FFT – harmonic analysis - Digital filters – types of filters.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Polar Oceanography**	**Elective**	**3**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Basic understanding of the links between global climate and Polar Regions.	2
CO2	Role played by polar oceans in providing various ecosystem services.	2
CO3	Explain the hydrography and circulation in the polar region.	2
CO4	Familiarisation of various international polar programs and the role played by India.	2
CO5	Understanding the similarities and differences of polar oceans from rest of the oceanic regime.	2

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	-	2
CO2	3	-	-	-
CO3	3	-	-	-
CO4	3	-	-	-
CO5	3	-	-	1

Correlation levels: 1 = Low, 2 = Medium, 3 = High, “-” No correlation

Syllabus:

Unit I

History of polar research and exploration: Past, present and future. Major international polar programs and Indian polar programs. Governance of Antarctic and Arctic regions and its protection. Polar natural resources: Anthropogenic demands and impacts. The impacts of anthropogenic activities and climate change on the polar oceans. Ozone holes-Impacts- Pollution in polar ocean - Emerging pollutants- Microplastics-SOLAS and MARPOL 73/78.

Unit II

Sea ice, Types, Sea ice properties, thermodynamics; sea-ice interactions with atmosphere, ocean; Regional wise distribution of sea ice (in Arctic, Southern Ocean and Antarctica): Gaining and losing Antarctic sea ice variability- trends and mechanism. Losing arctic sea ice-observations of recent decline and the long term context. Impacts of wave motions; Sea ice and climate instability; Low- latitude atmospheric dynamics and Arctic sea ice extent; teleconnections, polynyas and its importance. Observation methods for sea ice and polar oceans. Sea ice in earth system models-sea ice model mechanics. Carbon sequestration in the ocean- Applications from satellite platforms.

Unit III

Hydrography, circulation and watermasses of Antarctic and Arctic oceans, Antarctic circumpolar current: Importance and dynamics. Southern Annular Mode: teleconnections, impacts and dynamics, Arctic oscillation: teleconnections, impacts and dynamics, subarctic seas as a source of Arctic change, Variability of Atlantic water inflow to the Northern Seas, freshwater flux from Northern seas and Atlantic Meridional Overturning Circulation. Arctic cyclones, Roles of polar oceans on deep ocean circulation and global climate system, Future of polar oceanography.

References:

1. A History of Antarctic Science (Studies in Polar Research): G. E. Fogg, Margaret Thatcher, Cambridge University Press, 2005.
2. A Farewell to Ice: A Report from the Arctic, Peter Wadhams E-book, 2017.
3. Introduction to Antarctica. Liggett, D., Storey, B., Cook, Y., Meduna, V. (Eds.)., Springer. 2015.
4. Introduction to the Physics of the Cryosphere. Melody Sandells and Daniela Flocco, Morgan & Claypool Publishers, 2014.
5. Southern Ocean: Oceanographer's Perspective. Jonah Young, Ice press, 2015.

Suggested Reading:

1. Arctic–Subarctic Ocean Fluxes: Defining the Role of the Northern Seas in Climate. Dickson, B., Meincke, J., & Rhines, P, Springer, 2008.
2. Biogeochemical Technologies for Managing Pollution in Polar Ecosystems. Bashkin, V, Springer, 2016.
3. Climate change in the Polar Regions. Turner, J., & Marshall, G. J., Cambridge university press. 2011.
4. National Research Council. Future Science Opportunities in Antarctica and the Southern Ocean. Washington, DC: The National Academies Press, 2011.
5. Polar Oceans from Space, Josefino Comiso, Springer. 2010.
6. Sea Ice, 3rd edition, David Thomas, ed., Wiley, 2017.
7. The New Arctic. Evengård, B., Larsen, J. N., & Paasche, (Eds.), Springer, 2015.
8. The Oceans and Rapid Climate Change. Past, Present, and Future. Seidov, Dan / Haupt, Bernd J. / Maslin, Mark A. (eds.) Geophysical Monograph Series, Wiley & Sons Ltd., 2001.
9. The Technocratic Antarctic: An Ethnography of Scientific Expertise and Environmental Governance. O'Reilly, J, Cornell University Press, 2017.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Oceanographic Computations – Matlab/Octave (Practical)**	**Elective**	**1**

Course Outcomes:
At the end of the course, the students will be able to :

	Course Outcome	BL
CO1	Explain the coding syntaxes in Matlab/Octave.	2
CO2	Write computer programs in Matlab/Octave for oceanographic computations.	6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	-	3	-	-
CO2	-	3	-	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Matlab/Octave: software installation - octave as a calculator (command window) - data types and variables – scalar, vectors and matrices – mathematical functions - input and output – script files - selective operations – loops – user functions – file input and output – graphical plot in octave.

Oceanographic computations in octave: sea water toolbox – computation of density, specific volume anomaly, potential temperature, sound velocity, freezing point and specific heat capacity – conversion of pressure to depth – gravitational constant.

Course Code	Course Title	C/E	Credit
24-319-XXXX	**Data Science & Artificial Intelligence in Oceanography**	**Elective**	**2**

Course Outcomes:
At the end of the course, the students will be able to :

Course Outcome		BL
CO1	Explain various AI methods and their pros and cons.	2
CO2	Acquire knowledge of various data sources related to marine applications.	2
CO3	Formulate the problem and analyze the data for ANN applications.	2
CO4	Design and implement AI for climate applications.	3
CO5	Apply reasoning based on contextual knowledge of complex problems and provide valid conclusions for the society.	3

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	2	-	-	-
CO2	3	-	-	-
CO3	3	-	-	-
CO4	3	-	-	-
CO5	3	-	-	-

Correlation levels: 1 = Low, 2 = Medium, 3 = High, "-" No correlation

Syllabus:

Unit I
Introduction – Foundations of AI – History of AI – The state of the art – Risks and benefits of AI -Intelligent agents – Nature of environment – Structure of agent – Problem solving agents -

Formulating problems. Neural Network: Introduction, Perceptron networks - Unsupervised learning – Principle Component Analysis – Fixed weight competitive nets– Clustering

Unit II

NetCDF data – SST, SSS, SSH, Wind, World Ocean Atlas of temperature and salinity –wind data - global data sets- Argo buoy data- Model, satellite and reanalysis data sets.

Unit III

Forecasting of tropical instability waves, Sea Surface Height -retrieval of thermohaline structure and ocean heat content – tropical cyclone detection and monitoring- eddy detection and analysis based on deep learning- Sea-ice detection.

Reference Books:

1. Artificial Intelligence Oceanography, Xiaofeng Li · Fan Wang Springer. ISBN 978-981-19-6375-9, 2023. https://doi.org/10.1007/978-981-19-6375-9.
2. Machine Learning. Tom Mitchell. First Edition, McGraw- Hill, 1997.

Suggested Reading: Programming for Artificial Intelligence I. Bratko, Fourth edition, Addison-Wesley Educational Publishers Inc., 2011.

1. Introduction to machine learning. C. Muller & Sarah Alpaydin, Ethem. MIT press, 2020.
2. Artificial Intelligence: A Modern Approach. S. Russell and P. Norvig, Prentice Hall, Fourth Edition, 2021
3. Principles of soft computing. S.N.Sivanandam and S.N.Deepa, -Wiley India.3 rd Ed. 2018.

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