M.Sc. (Oceanography)
Course Curriculum & Syllabi – 2023-24
Department of Marine Sciences, Berhampur University

Introduction:

The Department of Marine Sciences was established in the year 1978 at Berhampur University. This is the only University in the state which offers M.Sc., M.Phil. and Ph.D./D.Sc. degree in the subject of Marine Sciences covering both Oceanography and Marine Biology. The genesis for such a department was to produce quality manpower in the field of Marine Sciences**,** both through teaching and R&D activities**,** to meet the demand of the state as well as the country. The Department of Marine Sciences offers two degrees, M.Sc. in Oceanography and M.Sc. in Marine Biology. Candidates with B. Sc. in Physical sciences/B.E./B. Tech as are eligible to take admission in Oceanography while students with B.Sc. in Biological Sciences are eligible to take admission in Marine Biology. Admission to these degrees is through Odisha Common P.G. Entrance Test (CPET) conducted by the Student Academic Management System (SAMS), Odisha. The current Courses of Studies for master's degree (M.Sc.) in Oceanography and Marine Biology are under Choice Based Credit System (CBCS) effective from 2023-2024 Academic Sessions.

Faculty Members:

1. **Dr. Tamoghna Acharyya, Associate Professor (Oceanography)**
2. **Dr. Shesdev Patro, Assistant Professor (Marine Biology)**
3. **Dr. Suchismita Srichandan, Assistant Professor (Marine Biology)**
4. **Dr. Nibedita Behera, Assistant Professor (Oceanography)**

Facilities:

The Postgraduate Department of Marine Sciences has following facilities available for students and research scholars:

Seminar and Library:

The Department has an independent Seminar Hall with a state-of-the-art audio-visual system, where weekly student presentation seminars are conducted under the supervision of faculty-in-Charge. The Departmental library has more than 1200 books and several journals / newsletters / periodicals related to the subject of marine sciences.

Computing facility:

The department has a centralized Computer Laboratory well equipped with internet facility, PC and Servers. Software *viz*. ERDAS Imagine, Arc-view, MATLAB, Surfer, statistical packages are preloaded with the systems and accessible to the students.

Laboratories:

The Department has six practical laboratories viz, Marine Biology, Marine Microbiology, Marine Chemistry, Marine Geology, Physical Oceanography & Meteorology and Remote Sensing.

About the Syllabus:

The syllabus is designed as per CBCS in accordance with the guidelines provided by the University Grant Commission (UGC). The Master of Science in Oceanography and Master of Science in Marine Biology are full time two years programs with four semesters each. The 1st Semester is common for both Oceanography and Marine Biology spanning the period from June to December and 2nd Semester from January to May in the first academic session. The 3rd Semester commences from June to December and similarly the 4th Semester from January to May in the subsequent academic session. The number of credits along with grade points that a student satisfactorily completed, measures the performance of the student. Overall satisfactory progress and completion of course is subject to a student's maintaining a minimum Cumulative Grade Point Average (CGPA), as well as minimum grades in different subjects as per the syllabus. The description and layout of Credit Distribution for each of the Course program is detailed below:

- Total number of Semesters is **Four.**
- Each theory paper comprises of **04 Credit points.**
- Each Practical Paper comprises of **03 Credit points.**
- Each Theory Paper comprises of **100 Marks.**
- Each Practical Paper comprises of **50 Marks.**
- Project comprises of **200 Marks.**
- Number of Core Papers (Theory) are **13 (Spread over Semester I, II and III).**
- Number of Elective Papers (Theory) are **01 (In 3rd Semester).**
- One Choice Based Credit Transfer CBCT Paper (Theory) in **3rd Semester (Mandatory).**
- Number of project/dissertations is **01** (**4th Semester**).
- Core papers (13) are **Mandatory with no choice.**
- Elective papers (01) are **Mandatory with Choice Departmentally.**
- Value added course (VAC) (02) **mandatory in 2nd and 3rd semester.**
- Add-on Course (AC) (01) is a non-credit course in the 4th Semester.
- Total number of Papers **is 22 including 01 Project Work in 4th Semester excluding VAC and AC.**
- Total number of Credits is **86 Credit points.**
- Total Marks for all **04 Semesters is 2000.**

Syllabus for M.Sc. (Oceanography)

The Syllabus has been designed covering practical/dissertations/field works/seminars etc., wherever applicable. A list of Textbooks is provided against each paper for all Semesters. However, students may also make use of authentic online sources for their benefit. A student is advised to deliver at least one seminar talk on a selected topic based on the syllabus during each semester (weekly-at least one Seminar by one of the students, to cover all students). During the course work, students are allowed to interact with the faculty to clarify their doubts, if any. They may be also assessed through weekly tests (duration: 45 minutes) of multiple-choice questions and short answers (individual or all subjects of the Semester, Combined) as appropriate.

General Course Framework & Structure

SEMESTER I- Total Credits- 26 & Core papers: 05; Elective Papers: Nil; Practical: 02

Course Code	Title of the Paper	Marks			Credit
		IA	Exam	Total Mark	
MARO C101	Introduction to Earth and Atmospheric System	20	80	100	4
MARO C102	Fundamentals of Oceanography	20	80	100	4
MARO C103	Fundamentals of Marine Biology	20	80	100	4
MARO C104	Basic Statistics and Data Analysis	20	80	100	4
MARO C105	Fish Technology and Pisciculture	20	80	100	4
MARO P106	Practical I on Paper C101 and C102	-	50	50	3
MARO P107	Practical II on Paper C103 and C105	-	50	50	3
Total Marks/Credit (C 05 + Practical 02)				**600**	**26**

**Semester I is common for both Oceanography and Marine Biology students*

SEMESTER II- Total Credits- 26 & Core papers: 05; Elective Papers: Nil; Practical: 02; Non-credit: 01

Course Code	Title of the Paper	Marks			Credit
		IA	Exam	Total Mark	
MARO C201	Geophysical Fluid Dynamics	20	80	100	4
MARO C202	Ocean in the Anthropocene	20	80	100	4
MARO C203	Introductory Physical Oceanography	20	80	100	4
MARO C204	Introductory Meteorology	20	80	100	4
MARO C205	Introductory Chemical and geological Oceanography	20	80	100	4
MARO P206	Practical I on Paper C201 and C203.	-	50	50	3
MARO P207	Practical II on Paper C202, C204 and C205	-	50	50	3
Total Marks/Credit (C 05 + Practical 02)				**600**	**26**
MARO VAC-I	Certificate Course on Value Addition of Marine Fishery Product	Non-credit			

SEMESTER III- Total Credits- 26 & Core papers: 03; Elective Papers: 01; CBCT: 01; Practical: 02; Non-credit: 01

Course Code	Title of the Paper	Marks			Credit
		IA	Exam	Total Mark	
MARO C301	Advanced Physical Oceanography and Meteorology	20	80	100	4
MARO C302	Remote Sensing and Geographical Information System (GIS) in Marine Sciences	20	80	100	4
MARO C303	Marine Biogeochemical Processes	20	80	100	4

Course Code	Title of the Paper	Marks			Credit
		IA	Exam	Total Mark	
MARO E304	Marine Geomorphology and Geodynamics	20	80	100	4
MARO E305	Numerical Weather Prediction	20	80	100	4
MARO E306	Ocean Modelling	20	80	100	4
MARO CT300	Environmental Impact Assessment (EIA) and Management Plans	20	80	100	4
MARO P307	Practical I on papers C302 and C303	-	50	50	3
MARO P308	Practical II on paper MARO C301	-	50	50	3
Total Marks/Credit (C 03+ E 01+ CBCT 01+ Practical 02)				**600**	**26**
MARB VAC-II	Certificate Course on Marine Litter Monitoring and Management	Non-credit			

SEMESTER IV- Total Credits- 8 & Project: 01

Course Code	Title of the Paper	Marks			Credit
		IA	Exam	Total Mark	
MARO P401	Project Work, Dissertation & Open Viva-Voce	-	200	200	8
MARO VAC	Cultural Heritage of South Odisha				Non-credit
Total Marks/Credit (Project 01)				**200**	**8**

Details of Syllabus
Semester- I

Semester: First Semester	**Course Name:**	Introduction to Earth and Atmospheric System
Course No.: MARO C101	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the interdisciplinary overview about the earth and atmosphere.	*Students will be able to understand the origin, composition and tectonic of earth along with its process of formation. They will also be getting an idea of global atmospheric phenomena.*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Earth & Solar system:** Milky Way and the solar system. Modern theories on the origin of the Earth and other planetary bodies. Earth's orbital parameters, Kepler's laws of planetary motion, Geological Time Scale; Space and time scales of processes in the solid Earth, atmosphere and oceans. Radioactive isotopes and their applications. Meteorites Chemical composition and the Primary differentiation of the earth. Basic principles of stratigraphy. Theories about the origin of life and the nature of fossil records. Earth's gravity and magnetic fields and its thermal structure: Concept of Geoid and, spheroid; Isostasy	20
Unit 2	**Earth Materials, Surface Features and Processes:** Gross composition and physical properties of important minerals and rocks; properties and processes responsible for mineral concentrations; nature and distribution of rocks and minerals in different parts of the earth and different parts of India. Physiography of the Earth; weathering, erosion, transportation and deposition of Earth's material; formation of soil, sediments and sedimentary rocks; physiographic features and river basins in India	20
Unit 3	**Interior of the Earth, Deformation and Tectonics** Basic concepts of seismology and internal structure of the Earth. Physico-chemical and seismic properties of Earth's interior. Concepts of stress and	20

Units	Contents	Hours/ Semester
	strain. Behavior of rocks under stress; Folds, joints, and faults. Earthquakes – their causes and measurement. Inter-plate and intraplate seismicity. Paleomagnetism, sea floor spreading and plate tectonics	
Unit 4	**Meteorology:** Structure and chemical composition of the atmosphere, lapse rate and stability, scale height, Atmospheric turbulence, and boundary layer. geopotential, greenhouse gases and global warming. Cloud formation and precipitation processes, air- sea interactions on different space and time scales. Insulation and heat budget, radiation balance, general circulation of the atmosphere and ocean. Climatic and sea level changes on different time scales. Coupled ocean-atmosphere system, El Nino Southern Oscillation (ENSO). General weather systems of India, - Monsoon system, cyclone and jet stream, Western disturbances and severe local convective systems, distribution of precipitation over India	20

Suggested Text / References

1. Kent C. Condie, Earth as an Evolving Planetary System, Academic Press.
2. Naotatsu Shikazono, Introduction to Earth and Planetary System Science: New View of Earth, Planets and Humans, Springer.
3. H. Jay Melosh, Planetary Surface Processes, Cambridge University Press.
4. Pickard G.L. and W.J. Emery, Descriptive Physical Oceanography - Pergamon Press (Latestedition).
5. Lynne D. Talley, G.L. Pickard, W.J. Emery and James Swift, Descriptive Physical Oceanography: An Introduction- Elsevier (Latest edition).
6. John A. Knauss. Introduction to Physical Oceanography, Waveland Pr. Inc.
7. Wallace and Hobbs. Atmospheric Science (Latest Edition), An Introductory Survey, Elsevier.
8. An Introduction to the General Circulation of the Atmosphere, D. A. Randall, Colorado State University Press, 2005.
9. Marshall. John, and R. Alan Plumb. Atmosphere, Ocean, and Climate Dynamics: An Introductory, Academic Press.
10. Observed Global Climate, Geophysics Series, Volume 6: Edited by M. Hantel, Springer, 2005.

Semester: First Semester	**Course Name:**	Fundamentals of Oceanography
Course No.: MARO C102	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	

To provide the basics about physical, chemical and geological processes of ocean	*Students will be able to understand the physical, chemical and geological properties of the ocean and the factors affecting them. .*

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Physical oceanography:** Ocean and Sea, Major Oceans of the world and their dimensions, Light in the sea, Color of the sea, Sound in the sea, Temperature, Salinity, conductivity, effect of temperature, salinity and pressure on density, Potential density and specific volume. Specific volume anomaly. Adiabatic changes of sea water. Properties of sea water, Basic pure water characteristics, molecular, colligative, optical and acoustical properties of sea water. Horizontal and vertical distribution of temperature, salinity and density in the oceans. Heat budget equation.	20
Unit 2	**Circulations and currents:** Oceanic mixed layer, barrier layer and thermal inversion. Seasonal and permanent thermocline, Halocline and Pycnocline. Heat and freshwater transport, Conservation of salt and heat, Water type and water masses, T-S diagram, Bottom-Deep-Intermediate and surface water masses. Thermohaline and Wind driven Circulation, World Ocean circulation – Major Ocean currents, Equatorial Currents, Undercurrent, Antarctic Circumpolar Current and Western and Eastern Boundary Currents, Langmuir Circulation. Currents and Circulation in the Indian Ocean, Arabian Sea and Bay of Bengal during southwest and northeast monsoon seasons.	20
Unit 3	**Marine Chemistry** Historical perspectives, Symbols and units used in chemical oceanography, Composition of Sea Water, Major nutrients, Geochemical balance of the oceans, Residence time, Constancy of relative ionic composition of seawater, Conditions under which major elements may not be conservative, Factors affecting the distribution of trace elements in the sea, Chlorinity and salinity, Practical salinity scale, , Residence times of elements in the sea water, Dissolved Gases(other than CO_2) in Sea Water, Solubility of gases in seawater, Air-sea gas exchange and processes affecting their distribution, Dissolved oxygen	20

Units	Contents	Hours/ Semester
	in the ocean, CO_2 equilibria in seawater, pH, Alkalinity and buffering capacity of oceans, Components of CO_2 system in seawater, Percentage composition of inorganic carbon, Calcium carbonate precipitation and dissolution phenomena	
Unit 4	**Marine Geology:** Geomorphology of ocean floor: Abyssal plain, oceanic island, sea mounts, trenches, Island Arc, Atolls and Guyots. Submarine canyons and mid oceanic ridges, hydrothermal vents. Sea floor spreading and Plate tectonics. Salient features of Indian Ocean floor: Bathymetric maps, Different methods of exploring ocean floor, Definition and classification of coast, Coastal erosion, Beach sediments and morphology, weathering of beach materials. Alongshore and cross-shore sediment transport, Beach profile, Factors controlling geomorphology of beaches.	20

Suggested Text / References

1. Pickard G.L. Descriptive Physical Oceanography, Pergamon PressOxford, 1963.
2. Open University of U.K. Sea water: its composition, properties and behaviour. Pergamon Press.
3. LynneD.Talley, G.L. Pickard, W.J. Emery and JamesSwift (2011): Descriptive Physical Oceanography: An Introduction- Elsevier (6th edition,2011).
4. Sverdrup H.U., Johnson M.W. and Fleming R.H (1958): The Oceans: their physics, chemistry and general biology, Prentice Hall Inc., New Jersey,1958.
5. A.S.N. Murty & V.S.N. Murty. Physical Oceanography, A.P.H. Publishing Co, New Delhi, 2010.
6. M. Tomczak. Regional Oceanography. Daya Publishing House, New Delhi
7. Open University of U.K. Ocean circulation. Pergamon Press.
8. Bird, E.C., Coasts – An introduction to systematic geomorphology.
9. Sheppard, F.P., 1967, Submarine Geology.
10. Shepard F.P., The Earth beneath the Sea.
11. Lauff, G.H., Estuaries
12. P.D. Komar, Shore Processes and Sedimentation.
13. Ippen, A.T., Estuary and coastline hydrodynamics.
14. Johnson, D.W., Shore processes and shoreline development.
15. Open University of U.K., Sea water: its composition, properties and behavior. Pergamon Press.
16. Martin, D.P., Marine Chemistry, Vol 1 & 2.
17. Riley J.P.& Chester, R, Introduction to Marine Chemistry.

18. Riley, J.P.& Skirrow, G, Chemical Oceanography.

Semester: First Semester	**Course Name:**	Fundamentals of Marine Biology
Course No.: MARO C103	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the basics about biological oceanography	*Students will be able to understand the different flora and fauna of the ocean, their adaptations and the methods to study them.*	

Course Details

Units	**Contents**	**Hours/ Semester**
Unit 1	**Introduction to marine environment:** Sea as a biological medium and role of environmental factors including light, salinity, temperature, pH, turbidity, dissolved oxygen, nutrients, trace elements, Major divisions of marine environment (Pelagic and benthic), Pelagic environment (neritic and oceanic), benthic environment (supralittoral, littoral, sublittoral, bathyal, abyssal and hadal) **Life in the sea and coastal regions** Classification of marine flora and fauna (Plankton, Nekton, Pleuston, Benthos, seagrass, mangrove, salt marsh, seaweed)	20
Unit 2	**Plankton** Classification of plankton based on category, size, shape, mode of life cycle and habitat. *Phytoplankton*: Taxonomic classification of phytoplankton, Methods of phytoplankton collections, preservation and identification. Methods for estimation of standing stock in marine environment. *Zooplankton*: Taxonomic classification of zooplankton, Methods of zooplankton collections, preservation and identification. Methods for estimation of their biomass in marine environment.	20
Unit 3	**Benthos** Classification of benthic organisms, the intertidal region- rocky shore, sandy and muddy shore, Salient features of different shores and	20

Units	Contents	Hours/ Semester
	adaptations of organisms living in rocky, sandy and muddy shores; deep sea benthos and their adaptations. Methods of collection, preservation and estimation of standing crop and biomass of benthos.	
Unit 4	**Marine Flora of India** Seagrass, mangrove, salt marsh and seaweed, their distribution, ecological and economical significance	20

Suggested Text / References

1. Peter Mc Roy, C. and G. Helterinch., 1977. Seagrass Ecosystems. A Scientific Perspective. Marael Dekker Inc. New York.
2. Parsons, T.R., M. Takahashi and B Hargrave (2nd Ed. s) 1977, Biological oceanography Processes Pergamon Press, Oxford.
3. Chapman, V.J. & D.J. Chapman, 1980, Seaweeds and their uses, Chapman and Hall, London Ltd.
4. Spoel S. Vander and Heyman, R.P., 1983. Comparative atlas of Zooplankton biological patterns in the oceans. Springer-Verlag, Berlin.
5. Lalli C.M., Parson, Parson, C.R., 1997, Biological oceanography: An introduction, Elsevier Butterworth-Heinemann
6. Tomas, C.R., 1997. Identifying marine phytoplankton. Acaedmic press, 858p
7. S.Z. Qasim., 1998. Glimpses of the Indian Ocean, IBH Press, New Delhi.

Semester: First Semester	**Course Name:**	Basic Statistics and Data Analysis
Course No.: MARB C104	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the basics about application of statistics in ocean studies	*Students shall be able to learn the application of statistics in ocean studies by using different software and tools.*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Basics of statistics:** Definition of statistics, Concepts of population, sample, Census and sample surveys, Classification of data, frequency and cumulative frequency table. Diagrammatic and graphical representation of data - bar	15

Units	Contents	Hours/ Semester
	diagrams, pie-diagram, histogram, frequency polygon, frequency curve and Ogives.	
Unit 2	**Central tendency and dispersion:** Important measures of central tendency - arithmetic mean median and mode. Relative merits and demerits of these measures. Important measures of dispersion, Range, Mean Deviation, Variance and Standard Deviation. Relative merits and demerits of these measures. Coefficient of variation; Normal Curve, Concepts of Skewness and kurtosis.	15
Unit 3	**Probability distribution and hypothesis testing:** Definitions of probability, mutually exclusive and independent events, conditional probability, Random variable, concepts of theoretical distribution; Binomial, Poisson and Normal distributions and their application in fisheries. Basic concept of sampling distribution; standard error and central limit theorem. Introduction to statistical inference, general principles of testing of hypothesis, types of errors. Tests of significance based on Normal, t, and Chi-square distributions. Bivariate data, scatter diagram, simple linear correlation, measure and properties, linear regression, equation and fitting; relation between correlation and regression	15
Unit 4	**Software and Tools:** Data Processing and Plotting principles and methods using different Software and Tools. Concept of Database and Applications.	15

Suggested Text / References

1. Gupta, S.P., Stastical Methods.
2. Gupta and Kapoor (2000): Fundamentals of Mathematical Statistics.
3. Zar, J.H. (2003): Bio-statistical Analysis. 4th edition. Pearson Education.
4. Croxton F.E. and Cowden D.J. (2000): Applied General Statistics. PrenticeHall.
5. Kendall M.G. and Stuart A., The advanced theory of statistics. Vol. I &II.
6. Computer Programming in FORTRAN 90/95, (1997): V. Rajaraman, Prentice Hall of India, New Delhi.
7. Computer Oriented Numerical Methods, Fourth Edition, V. Rajaraman.

Semester: First Semester	**Course Name:**	Fish Technology & Pisciculture
Course No.: MARO C105	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
	Students shall learn about the technology, crafts and gears used in Indian fisheries. The paper will also help to understand	

To provide knowledge on techniques used in Indian fisheries. *the role of fisheries, aquaculture and their management in countries economical growth*

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Basics of fishery technology** Scope and Importance of Fish Technology. Fish as food, role of fish in human nutrition, Chemical composition and nutritive value of fin fish and shellfish **Pisciculture** Present status of pisciculture in India, aquatic environment management, aquatic animal health, business management, fish nutrition and feed technology, fisheries economics, sea ranching	20
Unit 2	**Fish products and their preservation** Diversified fish products and by products dried and cured, fish meal and oil, fish oils, fish liver oil, liver rinsed fish in silage, fish maws and isinglass, fish preservation, canning mechanism, freezing of fish, spoilage of wet fish and causative factors	20
Unit 3	**Fishing crafts** Common fishing crafts with special reference to Indian coast, Indigenous crafts used along the Odisha coast, design and construction of fishing crafts and fishing boats. Traditional and modern materials used for boat building, care and maintenance of fishing boats. Methods of detection of fish in the sea, Fish Aggregating Device (FAD) **Fishing gears** Common gears of Indian coast, gear fabrication, net design, Seine net, trap net, drop net, cast net, gill net, fixed net, bag net, scoop net, hooks and lines, Treatment and preservation of fishing gears	20
Unit 4	**Economics & Management** Oceans as a common heritage of mankind, Exclusive Economic Zone (EEZ) and its significance, export of fin fish and shellfish to different countries, fishing harbor and shore facilities	20

Units	Contents	Hours/ Semester
	Regulations on fishing of craft and gears – Indian Fisheries Act, OMFRA, other policy framework on fishing permission and restrictions in Odisha	

Suggested Text / References

1. Saints bury Commercial fishing methods.
2. Cornell: Control of fish quality.
3. Nedelee: FAO catalogue at small scale fishing gear.
4. Sohile: FAO catalogue of fishing gear designs.
5. Trgung: Fishing boats of the world, Vol.1, 2 & 3.
6. Kreuzer: Fishery Products, FAO Publication, 1977.
7. Kreezer: Fish inspection and qualify control, FAO Publication.
8. Govindan J.K. 1985, Fish Processing technology Oxford and IBH Publishing Company Pvt. Ltd. New Delhi.
9. Stanshy M.E. 1963. Industrial Fishery Technology, Reinhold Publishing Corporation.
10. Anon 1979. Handling Processing and Marketing of tropical fish tropical products institutes, London.

Semester: First Semester	**Course Name:** Practical I	
Course No.: MARO P106	**Credits:** 02	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the hands-on training on some of the basic instruments and tools used in physical, chemical, geological oceanography and meteorology	*Students shall be able to learn the use of basic instruments and analyzing techniques.*	

Course Details

Units	Contents	Hours/ Semester
	1. Identification of common rocks and minerals 2. Tabulate the monthly river discharges to the sea using open-source data. 3. Plotting of the bathymetric contours using digitized depth values from a published hydrographic chart or using digital data (open sources) for the Indian Ocean.	

Units	Contents	Hours/ Semester
	4. Estimation of grain size parameters by mechanical sieving 5. Determination of salinity of sea water, Alkalinity of seawater, dissolved oxygen, and measurement of pH of seawater. 6. Principles and mechanisms of different meteorological instruments and measurements of local weather parameters such as air temperature, pressure, wind, humidity, and rainfall at a given location. 7. Preparation of an atmospheric pressure contours (synoptic) during any given month (January to December) of Indian Ocean (40° to 100°E, 0° to 30°N) 8. Preparation of synoptic contour maps (spatial distribution) of sea surface temperature and salinity for a given month (January to December) in the Indian Seas (40° to 100°E, 0° to 30°N) from open-source data. 9. Plotting of vertical profiles (monthly variability) of sea surface temperature and salinity for a given location (January to December) in the Indian Ocean (40° to 100°E, 0° to 30°N) manually using open-source data. 10. Preparation of a chart (use a printed world map showing the land boundaries) depicting World Ocean circulation: Major Ocean currents -Equatorial Currents, Antarctic Circumpolar Current and Western and Eastern Boundary Currents. 11. Plot time-series of sea surface wind speed & direction; sea surface temperature and current (speed & direction) at a given location during a selected period (January to December) in the Indian Seas (40° to 100°E, 0° to 30°N) manually using satellite data from open sources.	

Semester: First Semester	**Course Name:** Practical II	
Course No.: MARO P106	**Credits:** 02	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the hands-on training on some of the basic instruments and tools used in biological oceanography and statistics	*Students shall be able to learn the use of basic instruments and analyzing techniques.*	

Course Details

Units	**Contents**	**Hours/ Semester**
	Practical session on paper C103 and C104 1. Methods of marine Plankton collection, preservation and analysis 2. Identification of phytoplankton (Diatoms and Dinoflagellates) and Zooplanktons, locally available sea weeds and sea grasses 3. Methods of benthos collection, preservation and analysis 4. Identification of marine benthos 5. Fish identification and taxonomy, Length-Weight relationship 6. Hands on experience in MATLAB and Excel for computing simple statistical estimates such as mean, moving average and standard deviation (use a subroutine here) using time-series temperature (SST – Sea Surface Temperature), salinity, estimated standing crop & biomass, surface wind and current data. 7. Demonstrate () distance between two spatially apart input data points and continue for a set of 10 such data pairs, estimate path of 10 circles having equivalent diameters (i.e., estimated distances). Compute correlation coefficient between a sample time-series wind (speed only) data from two neighboring locations in the Bay of Bengal and fit a straight line for the same data (simple linear regression). 8. Computation of mean monthly wind and current data using MATLAB Programming for the Indian Seas (400 to 1000E, 00 to 300N, choose 10 grid size) for a given month (January – December) using available Remote Sensing data from open sources. 9. Plot the above outputs (Sl. No. 5 to 8) using Grapher, excel and Surfer (Golden Software) appropriately. 10. Use MATLAB instead of FORTRAN for two selected data sets as above (Sl. No. 5 and 8) to process and plot the data.	

Semester- II

Semester: Second Semester	**Course Name:**	Geophysical Fluid Dynamics
Course No.: MARO C201	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide deeper understanding of the dynamics of fluid flow in ocean-atmosphere system and the application of numerical methods	*Knowledge on geo-physical fluid dynamics and numerical methods provide the basic background for numerical modelling study of ocean-atmosphere system.*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Basic concepts of fluids:** Fluid continuum, Fluid properties, Ideal fluid, Actual fluids, Types of flow; Statics: Pressure surface and body forces on a fluid element; Fundamental equation of fluid statics: Application to compressible and incompressible fluids, Perfect gas equation, Hydrostatic equation.	15
Unit 2	**Kinematics:** Lagrangian and Eulerian methods of description of fluid flow, Streamlines, Streak lines and Trajectories, Steady and non-steady flow, Decomposition of the field of motion in the vicinity of a point, Translation, Rotation, Divergence and deformation, Stream function, Divergence and vorticity, Local and convective derivatives.	20
Unit 3	**Dynamics**: Equation of continuity and its applications, non-viscous incompressible flow, Eulerian equations of motion, Inertial and rotational frames of reference, Coriolis force, Irrotational flow, Velocity potential, Integration of the equations of motion, Bernoulli's theorem and its applications	20
Unit 4	**Fluid dynamics equations:** Viscous fluids, Coefficient of viscosity, Navier-Stoke's equations of motion for a viscous Newtonian fluid; Laminar flow of viscous incompressible fluids, Reynold's number and dynamic similarity of flows, Physical significance of Reynold's number, Low and high Reynolds number. Reynolds stresses and eddy viscosity, Rossby number, Ekman number, Dynamic stability, Circulation and vorticity, Stoke's theorem, Kelvin's theorem, Barotropic and baroclinic fluids, Absolute and relative circulation-Bjerknes circulation theorem and interpretation.	25

Suggested Text / References

1. S.W. Yuan (1967): Foundations of Fluid Mechanics.
2. J. Pedlosky (1987): Geophysical Fluid Dynamics.
3. G.K. Batchelor (1967): An introduction to Fluid Mechanics.
4. S.L. Hess (1959): An introduction to Theoretical Meteorology.
5. Samual A. Elder and J. Williams (1989): Fluid Physics for Oceanographers and Physicists.
6. Benoit Cushman-Roisin and Jean-Marie Beckers (2009): Introduction to Geophysical Fluid Dynamics. Physical and Numerical Aspects.
7. Pedlosky, J. (2013): Geophysical fluid dynamics. Springer Science & Business Media.
8. Chuen-Yen Chow: An introduction to computational Fluid mechanics, John Wiley.
9. Schlichting, Herman: Boundary layer theory. McGraw Hill.
10. Batchelor, G. K. (2000): An introduction to fluid dynamics. Cambridge University Press.
11. Currie, I. G. (2012). Fundamental mechanics of fluids. CRC Press.
12. M.K. Jain, S.R.K. Iyengar &R.K. Jain: Numerical methods for scientific and engineering computation. Wiley Eastern Ltd.
13. Krishnamurti, T. N. (2006). An introduction to global spectral modeling. Springer Science & Business Media.

Semester: Second Semester	**Course Name:**	Ocean in the Anthropocene
Course No.: MARB C202	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the insight about impact of human activities on the health ocean	*Students shall learn about the impact of anthropogenic effect on the world ocean.*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Global warming and Climate Change**: Definition and historical context, The difference between weather and climate, Atmosphere, hydrosphere, lithosphere, and biosphere, The role of oceans and their influence on climate, Understanding the greenhouse effect, Major greenhouse gases and their sources, Natural drivers of climate change (solar cycles, volcanic activity, etc.), Past climate variations from geological records, Anthropogenic greenhouse gas emissions, Deforestation and land-use changes, Historical temperature records and trends, Global warming projections and uncertainties, Ecosystem changes and biodiversity loss, Human health implications, Strategies for reducing greenhouse gas emissions, Adapting to the impacts of climate change, Overview of major international agreements (e.g.,	20

Units	Contents	Hours/ Semester
	Paris Agreement), The role of governments and policymakers in addressing climate change	
Unit 2	**Ocean Acidification:** Definition and significance of ocean acidification, Historical context and evidence of changing ocean pH, Key chemical processes and the carbon dioxide-carbonic acid system, Anthropogenic carbon dioxide emissions and the carbon cycle Ocean uptake of carbon dioxide and its impact on pH, other factors influencing ocean acidification (e.g., nutrient pollution), Effects of lower pH on carbonate chemistry, Implications for calcifying organisms (corals, mollusks, plankton). Disruption of marine food webs and trophic interactions, Species-specific vulnerabilities and potential winners and losers, Cascading effects on fisheries and economic implications, reducing carbon dioxide emissions and ocean acidification drivers, Ocean-based solutions for carbon sequestration and mitigation, Policy measures and international efforts to address acidification	20
Unit 3	**Marine Pollution:** Definition and scope of marine pollution, Historical and current significance of the issue, Chemical pollutants (oil, heavy metals, pesticides), Plastic pollution and microplastics, Nutrient pollution (eutrophication), Causes and consequences of oil spills , Case studies of significant oil spill incidents, The prevalence and persistence of plastic waste, Ecological consequences of plastic waste on marine life and ecosystems, Sources and pathways of heavy metal and POP pollution, Bioaccumulation and biomagnification in marine food webs, Eutrophication: causes and effects, Harmful algal blooms and their impacts on marine organisms, Impacts of Marine Pollution on Biodiversity, Effects on marine species (corals, fish, seabirds, etc.), Loss of biodiversity and ecosystem functioning, Human health risks from contaminated seafood Economic losses in fisheries and coastal tourism, Overview of international agreements (e.g., MARPOL, UNCLOS), Role of organizations like IMO and UNEP in combating marine pollution, Mitigation strategies - Source reduction and waste management strategies, The role of technology in pollution prevention and cleanup	20
Unit 4	**Sustainable Marine Fishing:** The Importance of Marine Fisheries, The significance of fisheries in global food security, Economic and social	20

Units	Contents	Hours/ Semester
	importance of fishing communities, Causes of Overfishing : Overcapacity and technological advancements, Market demand and global trade dynamics ; Consequences of Overfishing: Decline of target fish populations, Ecosystem impacts and trophic cascades , Fishing Gear and Bycatch: Different types of fishing gear and their impacts , Bycatch, Fisheries Management, Principles of sustainable fisheries management, Regulatory frameworks and international agreements, Fishing Quotas and Total Allowable Catch (TAC), Implementing fishing quotas and TACs (Total Allowable Catch), Successes and limitations of quota-based management, Sustainable Fishing Practices, Selective fishing techniques, Eco-labeling and certification programs Role of Aquaculture, Sustainable aquaculture practices as an alternative to wild-caught fish, Challenges and environmental impacts of aquaculture, International Cooperation and IUU Fishing.	

Suggested Text / References

1. "Ocean Acidification" (2nd Edition), Authors: Jean-Pierre Gattuso and Lina Hansson
2. Title: "Ocean Acidification: A Comprehensive Overview" Editors: Debabrata Saha and Shubha Sagar Trivedi
3. Title: "Ocean Acidification: Challenges Facing Science and Society" Editors: J.-P. Gattuso and L. Hansson
4. Overfishing: Causes, Consequences, and Solutions by J. Anderson and L. Johnson.
5. Marine Pollution: Sources, Consequences, and Solutions by R. Clark and A. Smith

Semester: Second Semester	**Course Name:**	Introductory Physical Oceanography
Course No.: MARO C203	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the knowledge of fundamentals of physical oceanography	*Students can learn about the basic governing principles of physical oceanography and tidal phenomena*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Basic Hydrodynamic Equations:** Equation of motion in oceanography and the terms pressure gradient, Coriolis and friction forces. Equation of continuity, Horizontal and vertical components of equations of motion and their significance. Geopotential, barotropic and baroclinic fields.	20
Unit 2	**Currents:** Inertial, geostrophic and gradient or meandering, currents. Level of no motion. Relative and absolute currents, Ekman 's assumptions and derivation of wind driven current. Ekman spiral, Ekman Net transport and upwelling. Causative factors and effects of upwelling and downwelling. Upwelling along Indian coasts.	20
Unit 3	**Hydrodynamic equations**: Euler's equation of motion, Bernoulli's equation, Laplace equation and velocity potential.	15
Unit 4	**Tides:** Introduction to Tides, Tide and Tidal current in the sea, Astronomical and Meteorological Tide, Tide producing forces, Lunar and Solar components, Semi-diurnal and Diurnal tides - range differences, Tidal currents and its variability, Internal tides, Spring and Neap tides - Phase and amplitude, Amplitude and cycle time, Tidal Bores, Amphidromic points, Co-tidal lines. Tides in typical ocean regions – Coastal Ocean – Estuaries –Bays - Open Ocean. Newton's law of gravitation – Tidal potential – Harmonic analysis of Tides, Tide generating forces in the ocean, Tide generation theories, Equilibrium theory - Dynamic theory- Observations and Prediction of tides.	20

Suggested Text / References

1. Kraus, E. B. and J. A. Businger Atmosphere - Ocean Interaction, 2ndedition.
2. G.T. Csanady, Air-sea interaction: laws and mechanisms.
3. Y. Toba (2004): Ocean-Atmosphere interactions.
4. John Marshall and Alan Plumb (2007): Atmosphere, Ocean and climate Dynamics – An introductory text.
5. Adrian E. Gill (1982): Atmosphere-Ocean Dynamics.
6. Neil Wells, (1986): The atmosphere and Ocean – A physical Introduction.
7. Pond and Pickard, (1983): Introductory Dynamical Oceanography.
8. Robert H. Stewart, (2003): Introduction to Physical Oceanography- online edition (public domain).
9. Benoit Cushman-Roisin and Jean-Marie Beckers, (2009): Introduction to Geophysical Fluid Dynamics. Physical and Numerical Aspects.
10. Gill, A. E., (1982): Atmosphere-Ocean Dynamics.

11. John A. Knauss (1997): Introduction to Physical Oceanography.
12. Henk A. Dijkstra (2008): Dynamical Oceanography

Semester: Second Semester	**Course Name:**	Introductory Meteorology
Course No.: MARO C204	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide basic knowledge about meteorology	*Students can learn about the general circulation of atmosphere, air masses, monsoon and cyclone*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Introduction:** The evolution and composition of the atmosphere. Vertical distribution of temperature and associated layers. Electromagnetic spectrum and solar radiation, Radiation Balance of the earth-atmosphere system. Greenhouse effect, Relative, absolute, and specific humidity, Mixing ratio, Dew point temperature, Dry and wet bulb temperature.	20
Unit 2	**Clouds, Precipitation and Air masses:** Clouds and their classification. Theories of formation of precipitation-Bergeron Findeisen and Accretion processes. Different forms of precipitation-convective, frontal, monsoonal etc. Artificial Rain making. Introduction to Air masses and Fronts.	20
Unit 3	**Monsoon:** Definition of Monsoon, synoptic features associated with monsoon. Definition, areas of occurrence, synoptic features associated with monsoon, onset and withdrawal, Global boundary conditions and their impacts. Predictability of monsoon – active and break cycles.	20
Unit 4	**Cyclone and ENSO:** Definition of tropical cyclone, areas of formation, structure and conditions favorable for tropical cyclone genesis, classification and concept of naming; El Niño and La Niña, their mechanisms, Southern Oscillation, impacts of ENSO on Indian Monsoon, IOD.	15

Suggested Text / References

1. S.L. Hess: Introduction to theoretical meteorology, Robert E Krieger Publishing Co
2. Holton, J. R., & Hakim, G. J. (2012). An introduction to dynamic meteorology (Vol. 88). Academic press.
3. S. Panchev: Dynamical Meteorology, D. Reidel Publishing Company
4. George Haltiner, J., & Frank Martin, L. (1957). Dynamical and physical meteorology
5. S. Petterssen: Weather analysis and forecasting vol.1, Mc Graw Hill

Semester: Second Semester	**Course Name:**	Introductory Chemical and geological Oceanography
Course No.: MARO C205	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide understanding about the basics of Chemical and geological Oceanography	*Students can learn about the chemical constituents of ocean its interaction with ocean and various geological processes.*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Sea Water Composition:** Major and minor constituents of sea water. Residence time and geo chemical balance of different constituents. Factors affecting the distribution of trace elements in the sea and their significance. Nitrogen and Phosphorous cycles in the oceans. CNP ratio. Distribution of Nitrogen and Phosphorous in the oceans.	20
Unit 2	**Sea Water Chemistry:** Particulate, dissolved, colloidal and organically complex trace metals in the sea. Radioactive nuclides in the sea: Factors affecting concentration of gas in sea water. Theory of CO_2 equilibrium in sea water. Distribution of CO_2 in the atmosphere and sea. Organic compound in sea water, CO_3 equilibrium in seawater. organic matter: dissolved and particulate matter in seawater.	20
Unit 3	**Marine Instrumentation:** IR spectroscopy, Beer's law. Principles and instrumentation of spectrophotometers. Emission spectroscopy, atomic absorption spectrophotometer, Principles, and different components of atomic absorption spectroscopy.	20
Unit 4	**Marine Sediment:** Source, classification and distribution, Rate of sedimentation, and Age determination, The science of marine minerals, polymetallic manganese nodules, their distribution and mineralogy. Hydrocarbon from offshore river basins, Gas hydrates, Relict Carbonates,	15

Units	Contents	Hours/ Semester
	Phosphorites, Beach Placers with special reference to Indian coast.	

Suggested Text / References

1. Chemical oceanography, 1982 – Broecker and Peng.
2. Chemical oceanography, 1992 – Millero and Saha, M.L.
3. Introduction to marine chemistry, 1981 – Riley, J.P. and Chester, R.
4. Oceanography of the Indian Ocean, 1992 – B.N. Dessai (Ed.)
5. Chemical oceanography (Vol.1,2, 3 & 8), 1975 – Riley, J.P. & skirrow, G.
6. Dynamic processes in the chemistry of the upper ocean,1986 - Burton et al., Plenum Press.
7. The chemistry of the atmosphere and oceans, 1978 – Holland, H.D.
8. Marine Chemistry, 1969 – Horne, R.A.
9. Chemical Oceanography of the Indian Ocean, North of Equator. Deep Sea Res. 1984, 31A, 671-706.
10. Chemical Oceanography, 1996 – F.J. Miller
11. Marine Chemistry (Vol.2), 1970 – Martin, D.F.
12. The Earth through time,2006: Harold l. Lewin
13. Submarine Geology, 1967: F.P. Shepard
14. Dynamic Earth: Plates, Plumes and Mantle Convection 2000: Geoffrey F. Davies

Semester: Second Semester	**Course Name:**	Practical I
Course No.: MARO P206	**Credits:** 02	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide hands on training on observation of fundamental oceanographic parameters and their analysis	*Students learn about the techniques and mechanisms of the instruments used for measurements of basic oceanographic parameters and their analysis*	

Course Details

Units	Contents	Hours/ Semester
	Practical session on paper C201 and C203 1. Plotting of vertical sections of temperature, salinity, density and sound speed (measured and estimated) data. Conversion to standard depths. Interpretation of oceanographic features. Preparation of horizontal sections of temperature, salinity and sound speed. Computations of specific volume anomalies and potential temperature using sample data sets. Plotting of T-S diagram and identification of water mass	

Units	Contents	Hours/ Semester
	characteristics. 2. Oceanographic data collection and Field trips: Spatial and Time-Series stations, Winches, Wire ropes, Messengers, Nansen water bottles, Reversing thermometers, Bucket thermometer for SST, Collection of salinity and oxygen samples, Thermo-salinograph, Autosal and Salinity calibration, Sachi Disk and Radio meter, Mechanical Bathy Thermograph (MBT) and Expendable Bathy Thermograph (XBT), Conductivity, Temperature and Depth (CTD) with Rosette sampler, XCTD. Shipborne hull mounted ADCP, Argo floats and Gliders for Oceanographic data collection, Towed Oceanographic Data Collection Systems, AUV and AXBT.	

Semester: Second Semester	**Course Name:** Practical II	
Course No.: MARB P207	**Credits:** 02	**Core/Elective:** Core
Course Objective: *To provide hands on training on observation of waves, tides and their analysis*	**Student Learning Outcome** *Students learn about the techniques and mechanisms of the instruments used for measurements of waves, tides and their analysis*	

Course Details

Units	Contents	Hours/ Semester
	Practical session on paper C202, C204 and C206 1. Wave and Tide Measurements and Data Processing: Bottom mounted pressure sensors, Ship-Borne Wave Recorder (SBWR), Wave-rider Buoys, Directional Wave buoys, Tide Staff and Tide Gauges, Acoustic Tide Gauges, Mooring of Wave buoys and Tide sensors, Coastal and ship-borne Radars for measuring waves. 2. Installation of Automatic Weather Station (AWS), Bathymetry using Echo-sounders, Current measurements in shallow water - Eulerian and Lagrangian methods, Types of Current meters: Propeller and Acoustic Devices, Speed and Direction measurements, Mooring of Current meters, Shallow (<15m) and Deep water (>100m) moorings, Bottom mounted Acoustic Doppler Current Profiler (ADCP). 3. Measurements of nutrients in Spectrophotometer; NO_2^-, NO_3^-, NH_4^+,	

	PO_4^{3-}, SiO_4^{2-}	

Semester: Second Semester	**Course Name:**	Certificate Course on Value Addition of Marine Fishery Product
Course No.: MARO VAC-I	**Credits**: NC	**Core/Elective:** value added
Course Objective: *To provide a platform for the synergy between formal and informal science and technology, institutions and knowledge system.*	**Student Learning Outcome** *Creating technology networks can help students to gain efficiency in preparing value added products from the thrown-away fishes, which in turn shall help in creating a better environment on the beach and nearby. Value addition through research and development is a key focus to train SHGs so that they become entrepreneurs and develop their socio-economic conditions and alternative livelihood options. Keeping in view the proximity of the university very near to the coast and the available expertise at the Department of Marine Sciences, the course shall help in providing inclusive solutions to the local fishermen and promotes entrepreneurship.*	

Course Details

Units	**Contents**	**Hours/ Semester**
Unit 1	Status of marine fishery resources in the world, India and Odisha. Value addition to marine resources and its reason, Nutritional value of value-added products-in the world, India and Odisha.	NC
Unit 2	Different components of value addition of marine resources- Lime and handicrafts making from seashell, methods preservation and fish processing for value addition, methods of packaging of value-added marine products, drying and dried fish products, smoking and smoked fish products, different value-added fish products. Export and import potential of value-added marine resources.	NC

Unit 3	Working principles of fish drying machines, Smoking kiln, meat mincer, Vacuum Dryer, Meat Picking Machine, Fish de-boner, Deep Fridge and other accessory instruments. Polymer identification through FTIR Analysis	NC

Semester- III

Semester: Third Semester	**Course Name:**	Advanced Physical Oceanography and Meteorology
Course No.: MARO C301	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide advanced knowledge on physical oceanography and meteorology	*Students can learn about the waves and their classifications; and get knowledge about the equation of atmospheric circulation.*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Wave:** Small amplitude waves: Boundary conditions. Derivation of small amplitude wave equations, length and period. Classification of waves: Classification of waves according to relative depth. Shallow and deep-water wave equations and their orbital motion of wave particles. Classification as surface and long waves, seiches, internal waves and tsunamis.	20
Unit 2	**Classification of Waves**: Seasonal variability of waves: Rough weather period - southwest monsoon, Fair weather period – north-east monsoon, Internal wave variability in Indian Seas, Theory of Internal Waves, two-layer ocean, Normal modes of internal waves, causes of internal waves, Submarine generated internal waves, Dead water. Planetary Waves, Poincare, Rossby, Kelvin, and Yanai waves, Generation and propagation of Tsunami Waves and Seiches.	20
Unit 3	**Circulation & Vorticity**: Kelvin & Bjerknes circulation theorems, its physical interpretation of the terms and its application to land and sea breezes. Vorticity equation and its physical interpretation. Conservation of absolute vorticity and its application. Scale analysis of vorticity equation.	20

Unit 4	**Atmospheric turbulence:** Reynold's stresses and Reynold's equation of motion. Prandtl's mixing length theory. Wave motion in the atmosphere: Pure Sound waves and internal gravity waves. Surface gravity waves, Rossby waves. Geostrophic adjustment. Barotropic and Baroclinic instability.	20

Suggested Text / References

1. Schlichting Herman: Boundary Layer Theory, McGraw Hill. 17
2. R. Davidson Arnott (2010) Introduction to coastal processes and geomorphology, Cambridge University press.
3. P.D. Komar: Beach Processes and sedimentation, Prentice Hall.
4. Ippen, A. T. (1966). Estuary and coastline hydrodynamics.
5. Open university of U.K: Waves, Tides & shallow water processes. Pergamon press
6. Open university of U.K: Ocean Circulation
7. T. Shibayama: Coastal processes, World Scientific Publication

Semester: Third Semester	**Course Name:**	Remote Sensing and Geographical Information System (GIS) in Marine Sciences
Course No.: MARO C302	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide knowledge on Remote Sensing	*Students can learn about the methods used in Remote Sensing and its applications in oceanography*	

Course Details

Units	**Contents**	**Hours/ Semester**
Unit 1	**Introduction to Remote Sensing**: Principles of aerial photography, Electromagnetic radiation, Solar and terrestrial radiation, Atmospheric effects, Absorption, Transmission and scattering, Spectral response of earth's surface features, Atmospheric windows– concept of signature. Infrared Remote Sensing: Thermal emission, Atmospheric absorption, IR sensors, SST retrieval, Atmospheric correction, Effect of cloud, Thermal skin layer, Skin and bulk SST.	20

Unit 2	**Microwave Remote Sensing:** Theory of microwave radiometry, Microwave emission of sea surface, Atmospheric effects, Retrieval of salinity and wind vector, Passive microwave radiometers: SMMR, SSM/I, TRMM/TMI and AMSR, Active microwave radiometers: Microwave interaction with the sea surface, NSCAT, Sea Winds - Altimetry: principles – sea surface height anomaly – ERS, T/P, Jason-1 – observing planetary waves.	20
Unit 3	**Remote Sensing Applications:** Applications of AVHRR, Altimeters, SAR - Monitoring of SST, Geostrophic currents, Mesoscale variability, Eddies, Fronts, Upwelling, Sea Ice Satellite capabilities, Global scale coverage, Different types of satellite data products available SeaWiFS, MODIS, OCM-1& 2, SARAL- Altika, TOPEX-Poseidon, ERS - 1 & 2, JASON, QuikScat, etc.	20
Unit 4	**GIS:** Definition of GIS – Components of GIS, Geographical concepts, Input data for GIS, Types of output products, Application of GIS, GIS Data types – Data representation – Data sources – Data acquisition – Geo referencing of GIS data – Spatial data errors – Spatial data structures. Essential Goal of Marine GIS, Spatial Thinking and GIS Analysis in the Marine Context, Conceptual Model of a Marine GIS and GPS techniques	20

Suggested Text / References

1. I.S. Robinson, (1985): Satellite Oceanography- An Introduction for Oceanographers and Remote Sensing Scientists.
2. Seelye Martin (2014): An Introduction to Ocean Remote Sensing, 2nd Edition, Cambridge Press.
3. Motoyoshi Ikeda and Frederic W. Dobson (1995): Oceanographic Applications of Remote Sensing, CRC Press, USA.
4. Robert H. Stewart, (1985): Methods of Satellite Oceanography.
5. T.D. Allan, (1983): Satellite Microwave Remote Sensing.
6. G.A. Maul, (1985): Introduction to Satellite Oceanography.
7. I. S. Robinson, (2004): Measuring the Oceans from space: The principles and methods of satellite Oceanography.
8. Paul Bolstad, (2019): GIS Fundamentals – A First Text on Geographical Information System, NEW and UPDATED, Sixth Edition. ISBN-13: 978-1593995522.
9. Francis Harvey, (2015): A Primer of GIS, Fundamentals of Geographic and Cartographic Concepts. ISBN-13: 978-1462522187.
10. Karen Steede -Terry, (2000): Integrating GIS and the Global Positioning System. ISBN-13: 978-1879102811.
11. Bradley A. Shellito, (2016): Discovering GIS and ArcGIS. ISBN-13: 978-1319060473.
12. Christian Harder and Clint Brown, (2017): ArcGIS Book. ISBN-13: 978-1589484870.

13. Heather Kennedy, (2006): Introduction to 3D data – Modelling with ArcGIS 3D Analyst and Google Earth. ISBN-13: 978-0470381243.

Semester: Third Semester	**Course Name:**	Marine Biogeochemical Processes
Course No.: MARB C303	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To understand the interdisciplinary nature of bio-geochemical processes occurred in the ocean.	*Students can learn about the concept of nutrient cycle, influence of physical and chemical factors on biogeochemical processes. The course will also help in understanding the impact of climate change on oceanic processes*	

Course Details

Units	**Contents**	**Hours/ Semester**
Unit 1	**Major ocean biogeochemical cycles:** Carbon, Nitrogen, Silicon and Phosphorus cycles, Micro-nutrient dynamics and cycling, Organic matter: dissolved, particulate and colloidal species, sources, classification, composition, distribution, seasonal variations, Ecological significance, Growth promoting and growth inhibiting effects, Biogeochemical cycles with special reference to estuaries.	15
Unit 2	**Plankton and Productivity** : Phytoplankton and primary productivity, pigments, photosynthesis, Net and gross primary productivity, Rate of primary production in inshore and offshore regions of Arabian Sea and Bay of Bengal, Latitudinal and Seasonal variations in primary productivity, Factors affecting primary production, methods of estimation, Relationship of phytoplankton productivity to light and nutrients, Role of phytoplankton in global carbon cycle, Impacts of climate change, Algal blooms – HABs and TABs- Ocean Colour Monitoring and estimation of primary productivity, Organism sediment relations, Benthic pelagic coupling, CDOM. Plankton as indicators of fisheries, SST variations and pelagic fisheries, Influence of upwelling on oil sardine fishery in Arabian Sea.	25
Unit 3	**Influence of Physical processes on primary productivity:** Hydrodynamic forcing, Upwelling, stratification, mixed layer depth, turbulent mixing, monsoon driven biogeochemical processes in the Arabian Sea and Bay of Bengal, Spatial and Temporal variations in the	20

	nutrient concentrations, Response of marine pelagic ecosystems to climatic forcing, OMZ, HNLC, Ocean currents and their impact on marine life.	
Unit 4	**Source and sinks of particulate and organic matters in the ocean**: Suspended matter, Methods of collection and analysis, spatial and temporal variation of total suspended particulate matter in the ocean, Component composition and settling rates of suspended matter, Particle flux in the ocean and various techniques of measurement, Particulate organic matter in the sea: its origin, nature, composition and methods of measurements. Chemical and biological aspects of dissolved organic matter in the sea, Sources of supply and processes of removal of dissolved organic matter. Radioactivity – Classification – Primary, Cosmogenic and artificial radio nuclides; distribution and occurrence of radionuclides, their properties in the marine environment and their decay series, Sampling and storage of radionuclides, Radio chemical separation, Applications of radionuclides to the geochronology of marine sediments and rocks, Carbon dating methods in marine sediments, Oceanic mixing and residence time.	15

Suggested Text / References

1. John H Simpson and Jonathan Sharples, (2012): Introduction to the Physical and Biological Oceanography of Shelf Seas; Cambridge University Press.
2. Tom Beer (1996): Environmental oceanography (CRC Marine Science), 2nd Edition, CRC Press.
3. J. P. Riley & Chester, Introduction to Marine Chemistry, Academic Press London and New York.
4. Carol M. Lalli & Timothy R. Parsons, Biological Oceanography and Introduction. Elsevier, Butterworth-Heinemann.
5. Peter Castro & Michel E. Huber, Marine Biology, The Mcgraw-hill companies.
6. Tom Garrison & Robert Ellis (2013), Oceanography: An invitation to Marine Science (9th Edition Cengage Learning.
7. Frank J. Millero (2013), Chemical Oceanography (4th Edition) by, CRC Press, Taylor & Francis Group.
8. Susan Libes (2009), Introduction to Marine Biogeochemistry (2nd Edition) by, Academic Press.
9. H. Elderfield (2006) The Oceans and Marine Geochemistry (1st Edition) by, Elsevier.
10. Gerry Bearman (2005), Marine biogeochemical cycles (2nd edition) by, The Open University.
11. Thomas S. Bianchi (2007), Biogeochemistry of Estuaries by, Oxford University Press.
12. Horst D. Schulz Matthias Zabel (2006), Marine Geochemistry (2nd edition) by, Springer.

13. Michael E. Q. Pilson (2005), An introduction to the Chemistry of the Sea (2nd Edition) University Press.

Semester: Third Semester	**Course Name:**	Marine Geomorphology and Geodynamics
Course No.: MARO E304	**Credits:** 04	**Core/Elective:** Elective
Course Objective:	**Student Learning Outcome**	
To provide knowledge on geomorphology and geodynamics in marine environment	*Students can learn about the formation of various structures and features of marine landscapes.*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Fundamentals of Geomorphology:** Nature and scope of Geomorphology, Fundamental concepts- Recent trends in Geomorphology. Approaches to geomorphology- static, dynamic, environmental and applied. Earth movements – Landforms - endogenetic and exogenetic, epirogenic and orogenic, climatic and tectonic factors and rejuvenation of landforms. Dynamics of geomorphology; geomorphic processes and resulting landforms.	20
Unit 2	**Weathering and erosion:** Basic principles. Concepts of gradation, types of weathering and mass wasting. Concept of erosion cycles. Geomorphology of fluvial tracts, arid zones, coastal regions and glacial regions.	15
Unit 3	**Applied Geomorphology**: Flood management. Applications of geomorphology in mineral prospecting, Geomorphology of Indian coast with special reference to Odisha.	15
Unit 4	**Plate Tectonics:** Introduction to geodynamics, Continental Drift: Concept and different lines of evidence. The concept of the Super continent - Gondwanaland and its fragments. Vertical Tectonics: Introduction to Vertical tectonics. Concept of Isostasy.	20

Suggested Text / References

1. Physical Geology - Wm and C Brown - Montgomery, C.W. (1990).
2. An introduction to Coastal Geomorphology - Pethick, J. (1984), Edward Arnold, London, 259p.
3. Process Geomorphology, 5th edition - Ritter, D.F., R.C. Kochel and J.R. Miller (2011). McGraw Hill, NY. Rental text
4. Principles of Geomorphology - Thornbury, W.D. (1969): Wiley Eastern Limited, New Delhi: 594 p.
5. Introduction to Geomorphology - Kale & Gupta (2001). 9. The Evolving Continents - Brain F. Windley (1977), John Wiley & Sons. 385p.
6. Geodynamics Elsevier - Artyushkov E.V. (1983)
7. Introduction to Coastal Processes & Geomorphology: Robin Davidson – Arnott - CUP.
8. Magnetic anomalies over ocean ridges - Vine, F. J., and Matthews, P. M. (1963) Nature, 199, 947-949.
9. The Geology of Continental Margins - Springler Verlag, NY - Burk C. A. & Drake, C. L. (1974).

Semester: Third Semester	**Course Name:**	Numerical Weather Prediction
Course No.: MARB E305	**Credits:** 04	**Core/Elective:** Elective
Course Objective:	**Student Learning Outcome**	
To provide basic knowledge on Numerical weather prediction	*Students can learn about the governing equation and different processes taken into consideration for numerical weather prediction.*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Introduction**: Overview of numerical weather prediction. Governing equations: continuous equations, map projections, vertical coordinate system, wave oscillations in the atmosphere, filtering approximations.	20
Unit 2	**Numerical methods**: finite-difference methods, time and space differencing, stability analysis; spectral method, spherical harmonics, boundary conditions	20
Unit 3	**Numerical models**: Global models, regional models, mesoscale models. Parameterization of sub-grid scale physical processes: planetary boundary layer, moist microphysics physics, cumulus convection, radiation, air-sea interaction processes, and land surface processes.	20
Unit 4	**Data assimilation**: Objective analysis schemes, continuous data assimilation techniques-3D & 4D Variational assimilation; initialization. Predictability and Ensemble forecasting: Fundamental concept about chaotic systems and atmospheric predictability. Introduction to Weather Research and Forecasting (WRF) Model and hands on experience.	20

Suggested Text / References

1. Tim Vasquez Weather Analysis and Forecasting Handbook, Weather Graphics Technologies.
2. Eugenia Kalnay. Atmospheric modelling, data assimilation and predictability, Cambridge UniversityPress.
3. Patrick Santurette, Christo Georgiev. Weather Analysis and Forecasting: Applying Satellite Water Vapor Imagery and Potential Vorticity Analysis 1st Edition, Academic Press.
4. Jean Coiffier: Fundamentals of Numerical Weather Prediction. Cambridge University Press.
5. George J. Haltiner: Numerical Weather Prediction, Wiley.
6. Lahouari Bounoua and T. N. Krishnamurti: An Introduction to Numerical Weather Prediction Techniques. C R C Press.
7. Peter Lynch: The Emergence of Numerical Weather Prediction.Cambridge University Press.
8. Thomas T. Warner: Numerical Weather and Climate Prediction. Cambridge University Press
9. Haltiner, G.J and R.T. Williams: Numerical Prediction and Dynamic Meteorology Jhon Wiley & Sons.

Semester: Third Semester	**Course Name:**	Ocean Modelling
Course No.: MARB E306	**Credits:** 04	**Core/Elective:** Elective
Course Objective:	**Student Learning Outcome**	
To provide basic knowledge on Ocean modeling	*Students can learn about the governing principles used for ocean modeling and get an idea of types of ocean model used for different purposes.*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	Introduction to Ocean Circulation Modelling: Mechanistic and Simulation models, Conservation of Mass and Momentum – Navier-Stokes equations and Ocean circulation modelling, Spherical coordinates, Conservation of angular momentum, Conservation of Mechanical Energy, Global Ocean Modelling, Hydrostatic Primitive Equations, Initial and Kinematic Boundary conditions, Shallow water equations, Geostrophic adjustment - Quasi-Geostrophy.	20
Unit 2	Numerical Schemes in Ocean Circulation Modelling, Finite Differences-Forward, Backward and Central differences, Explicit and Implicit schemes. Horizontal and vertical grid types, Finite difference and finite element, Lateral boundary conditions, Bathymetry, Model forcing, Model Initialization and Spin up, Ocean data assimilation, Time Differencing and Time Splitting.	20

Unit 3	Barotropic and Reduced gravity models. Basin scale models and regional models- Cox's Model of Indian Ocean- O'Brien's model of North Pacific Ocean, Holland and Hirschman's Model of Atlantic Ocean.	20
Unit 4	Three-Dimensional Ocean Models, GFDL Modular Ocean Model (MOM), Princeton Ocean Model (POM), ROMS and HYCOM.	20

Suggested Text / References

1. D.B. Haidvogel and A. Beckmann, (1999): Numerical Ocean Circulation Modeling (Vol.2), Imperial College Press.
2. James J Obrien, (1985): Advanced physical oceanographic numerical modeling (Nano science series).
3. Pond and Pickard, (2013: Introductory Dynamical Oceanography, Butterworth-Heinemann.
4. Kantha &Clayson, (2000): Numerical Models of Oceans and Oceanic Processes, Academic Press.
5. Benoit Cushman-Roisin and Jean-Marie Beckers, (2009): Introduction to Geophysical Fluid Dynamics. Physical and Numerical Aspects.
6. Muller H. von Storch, (2004): Computer Modelling in Atmospheric and Oceanic Sciences.

Semester: Third Semester	**Course Name:**	Environmental Impact Assessment and Management Plans
Course No.: MARB CT300	**Credits:** 04	**Core/Elective:** Elective CBCT
Course Objective:	**Student Learning Outcome**	
To provide knowledge on environmental monitoring and assessment.	*Students can learn about the methods and procedures used in assessment and monitoring during EIA studies. The proper will also give a brief idea about different types of tools used in EIA studies*	

Course Details

Units	**Contents**	**Hours/ Semester**
Unit 1	Introduction to Environmental Impact Assessment. Environmental impact Statement and Environmental Management Plan. EIA notifications of Government of India from time to time. Guidelines for Environmental audit.	20

Unit-2	Environmental Impact Assessment (EIA) Methodologies. Generalized approach to impact Assessment. EIA processes, Scoping EIA methodologies, Procedure for reviewing Environmental impact analysis and statement. Environmental Management Plan and its monitoring, Evaluation of proposed actions.	20
Unit 3	Nexus between development and environment, Socio-economic impacts, Aid to decision making, Formulation of development actions, Sustainable development, categorization of projects under EIA, project planning and implementation, Impact prediction, Mitigation measures.	20
Unit 4	Introduction to. Selection of appropriate procedures, Restoration and rehabilitation technologies. Land use policy for India. Urban planning for India. Rural planning and land use pattern. Environmental priorities in India and sustainable development. CRZ notifications and Environmental Impact Assessment in coastal zones. Coastal zone management plans of India.	20

Suggested Text / References

1. W.P. Cunningham, 2010: Principles of Environmental Science.
2. Satsangi and A. Sharma 2015: Environmental Impact Assessment and Disaster Management.
3. R.R. Barthwal 2002: Environmental Impact Assessment.
4. R. Paliwal and L. Srivastava, 2014: Policy Intervention Analysis- Environmental Impact Assessment.
5. C.H. Ecceleston, 2004: Environmental Impact Assessment.
6. J. Hou, 2015: New Urbanism: The future City is Here.
7. James R. Craig, 2010: Earth Resources and the Environment.
8. J. Glassion, 2011: Introduction to Environmental Impact Assessment.
9. Glasson J., Therivel R., Chadwick A, (2005): Introduction to environmental impact assessment Taylor & Francis Group, London and NewYork.
10. Morris P., Therivel R., (2009): Methods of Environmental Impact Assessment 2009, 3rd edition, Routledge, Taylor & Francis Group, London and New York.
11. Morris P., Therivel R., (2001): Methods of Environmental Impact Assessment 2001, 2nd edition, Spon Press, Taylor & Francis Group, London and NewYork.
12. Eccleston C. H., (2011): Environmental Impact Assessment 2011, CRC Press, Taylor & FrancisGroup.

Semester: Third Semester	**Course Name:**	Practical I
Course No.: MARB P307	**Credits:** 02	**Core/Elective:** Core

Course Objective:	Student Learning Outcome
To provide hands on training on the instruments used in marine biodiversity studies, aquaculture and remote sensing.	*Students can learn about the application of the tools and techniques used in studying marine biodiversity and coastal aquaculture and remote sensing.*

Course Details

Units	Contents	Hours/ Semester
	Practical session on theory papers C302, 303 1. Live feed culture, Culture of marine invertebrates 2. Principles and functioning of Global Positioning System (GPS) and preparation of the boundary map for a local site and identification of the major installations, buildings etc. using their co-ordinates of survey and compare results with Google Map. 3. Aerial Photo interpretation, Digital image Processing using ERDAS, Shoreline measurement using Arc Pad, Measurement of beach profile using total Station. 4. Remote sensing application for ocean resources: Ocean color and chlorophyll estimation, SST 5. SPM estimation, CDOM, DIC estimation, Carbon estimation of sediment	

Semester: Third Semester	**Course Name:** Practical II	
Course No.: MARB P308	**Credits:** 02	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide training on data analysis and interpretation by using oceanography instruments.	*Students can learn about the use and handling of oceanographic instruments and develop skills to interpret the generated data*	

Course Details

Units	Contents	Hours/ Semester
	Wave and Tide Measurements and Data Processing: Bottom mounted pressure sensors, Ship-Borne Wave Recorder (SBWR), Wave-rider Buoys, Directional Wave buoys, Tide Staff and Tide Gauges, Acoustic Tide Gauges, Mooring of Wave buoys and Tide sensors, Coastal and ship-borne Radars for measuring waves, Plotting of Geostrophic current using SSHA data	

Semester: Third Semester	**Course Name:**	Certificate Course on Marine Litter Monitoring and Management
Course No.: MARB VAC-II	**Credits**: NC	**Core/Elective:** value added
Course Objective:	**Student Learning Outcome**	
To provide knowledge on marine litter pollution.	*Students can learn about the cause and management of marine litter pollution and about the techniques used in assessing the marine litter pollution*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Fundaments on marine litters, status, impacts and transport mechanisms.** Marine litter, types of marine litters and their sources, Marine litter-a global problem and present status, marine litter around the world ocean with special reference to Indian Ocean, Impacts of marine litters-marine ecosystem, human health and economy. Transport mechanisms of marine litters-different oceanographic and meteorological parameters, riverine transport, transport through ships and tourism and recreation activities.	NC
Unit 2	**Prevention, clean up and legislation.** Legislation for prevention of marine litters around the world including India- convention and agreements. Prevention and clean-up of marine litter. Education and awareness on marine litter with special reference	NC

	to plastics (macro and micro plastics). Plastics in Indian seas and strategy for clean-up of plastic debris, Marine strategy Framework directive (MSFD)- Single use plastics and fishing gear. Methods for measurement of microplastics to reduce releases to the environment, Environmental and health risks of microplastic pollution and its prevention.	
Unit 3	**Monitoring of marine litters and laboratory methods for their analysis: Methods for the analysis of macro, meso, micro plastics in beach samples** • Apparatus and Materials • Beach sediment sample preparation • Segregation of beach litters and their quantification • Density Separation • Determine the mass of Total solids • Wet peroxide oxidation (WPO) • Density Separation of total solids • Use of Microscope for identification • Gravimetric Analysis • Polymer identification through FTIR Analysis	NC

Semester- IV

Semester: Fourth Semester	**Course Name:**	Project/Dissertation
Course No.: MARB P401	**Credits:** 08	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To train students to carry independent research	*Students can learn about the procedure for conducting independent research by designing the study, doing field surveys, sample analysis, data generation and interpretation and to write research article and thesis*	

Course Details

Units	Contents	Hours/ Semester
	Project work is compulsory. Topics will be assigned before the end of 3rd Semester by distributing students equally among the department faculty members (internal guides). Students are free to choose any appropriate topic relating to the field of Oceanography if accepted by both internal and external guides (outside department). The students need to do the literature review and deliver a pre-Project presentation (50 mark) before the faculty members exhibiting the objective of the project work and possible outcomes for finalisation of the topic. The students shall begin their study once the topic selected. There will be a continuous internal monitoring by the guiding/supervising teacher (internal guide). After completion of the project work (within the department or in any other state/national/international level institutes/laboratories/industries engaged in similar or allied R&D work), the candidate must submit the project report/dissertation (100 marks) and defend his report by presenting about 20 technical slides in an open viva-voce (50 marks) of the department by inviting an external expert. Students should at least send one communication to any journals/periodicals/newsletters out of their project work.	Entire semester

Semester: Fourth Semester	**Course Name:**	Cultural Heritage of South Odisha
Course No.: MARO AC	**Credits**: NC	**Core/Elective:** Add-on course
Course Objective: *To familiarizing all the P.G. Students of Berhampur University with the excellent craftsmanship exemplified by the literary stalwarts including Kabi Samrat Upendra Bhanja along with the Arts, Culture and Folk Tradition of South Odisha.*	**Student Learning Outcome** *Student Learning Outcome Students passing out from BU will have knowledge about the history and culture of south Odisha and Kabi Samrat Upendra Bhanja.*	

Course Details

Units	**Contents**	**Hours/ Semester**
Unit 1 ୟୁନଟି ୧	Literary works of Kabi Samrat Upendra Bhanja କବିସମ୍ରାଟ ଉପେନ୍ଦ୍ର ଭଞ୍ଜଙ୍କ କୃତିଓ କୃତିତ	NC
Unit 2 ୟୁନଟି ୨	Other Litterateurs of South Odisha ଦକ୍ଷିଣ ଓଡ଼ିଶାର ଅନନ୍ୟାନନ୍ୟ ସାରସ୍ୱତ ସାଧକ	NC
Unit 3 ୟୁନଟି ୩	Cultural Heritage of South Odisha ଦକ୍ଷିଣ ଓଡ଼ିଶାର ସାସ୍କୃତିକ ବିଭବ	NC
Unit 4 ୟୁନଟି ୪	Folk and Tribal Traditions of South Odisha ଦକ୍ଷିଣ ଓଡ଼ିଶାର ଆଦିବାସୀ ଓ ଲୋକ ପରମ୍ପରା	NC

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