M.Sc. (Marine Biology)
Course Curriculum & Syllabi – 2022-23
Department of Marine Sciences, Berhampur University

Introduction:

Department of Marine Sciences was established in the year 1978 in 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 separately. Candidates with B. Sc. in either Physical sciences/B.E./B.Tech. with Physics as one of the core subjects 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 entrance tests. The Courses of Studies for Master's Degree (M.Sc.) in Oceanography and Marine Biology are under Choice Based Credit System (CBCS) effective from 2020-2021 Academic Session.

Faculty Members:

1. Dr. Pratap Kumar Mohanty, Professor (Oceanography)
2. Dr. Shesdev Patro, Assistant Professor (Marine Biology)
3. Dr. Suchsmita 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 state of art audio-visual system, where weekly student presentation seminars are conducted under the supervision of a 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. Softwares *viz*. ERDAS Imagine, Arc-view, MATLAB, Surfer, Statistica and other statistical packages are preloaded with the systems and accessible by 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 programmes 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 commence from June to December and similarly the 4th Semester from January to May in the subsequent academic session. The uniform nature of credits specified for the Master's Programmes describe the equitable weightages of various courses. 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 programme is detailed below:

- Total number of Semesters is **Four.**
- Each 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 **100 Marks**
- Number of Core Papers (Theory) are **12 (Spread over all four Semesters).**
- Number of Elective Papers (Theory) are **03 (In 3rd and 4th Semesters).**
- One CBCT Paper (Theory) in **3rd Semester (Mandatory)**
- Number of project/dissertation is **01** (**4th Semester**)
- Core papers (12) are **Mandatory with no choice.**
- Elective papers (03) are **Mandatory with Choice Departmentally.**
- Value added courses(VAC) (02) are **non-credit courses in 2nd and 3rd semester**
- Add-on Course(AC) (01) is **non-credit course in 4th Semester**
- Total number of Papers is **23 including 01 Project Work in 4th Semester excluding VAC and AC.**
- Total number of Credits is **88 Credit points.**
- Total Marks for all **04 Semesters is 2000.**

Note on CBCT: Marine Biology students may opt for CBCT courses offered by other bio-science departments of the university while Oceanography students may opt for CBCT courses offered by physical science departments of the university

Guidelines for value added courses

Value Added Course is not mandatory to qualify for any programme and shall be offered as non-credit course. Value Added Courses completed by a student shall be reflected in the mark sheet as non-credit course in the 2nd and 3rd semester. It is a teacher assisted learning course open to students of the concerned department without any additional fee. However, students shall pay the prescribed examination fee and register along with other courses in that particular semester. A student will be permitted to register only one Value Added Course in a Semester. The course can be offered only if there are at least 10 students opting for it where the total strength is 50. In case of lower strength, it will be proportionate.

Syllabus for M.Sc. (Marine Biology)

The Syllabus has been designed covering practicals/dissertations/field works/seminars etc., wherever applicable. A list of Text Books 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- 22 & Core papers: 04; Elective Papers: Nil; Practical: 02

Course Code	Title of the Paper	Marks			Credit
		IA	Exam	Total Mark	
MARB C101	Introduction to Earth, Ocean, Atmosphere and Climate	20	80	100	4
MARB C102	Fundamentals of Physical, Chemical, Geological Oceanography and Marine Meteorology	20	80	100	4
MARB C103	Fundamentals of Marine Biology and Pisciculture	20	80	100	4
MARB C104	Basic Mathematics, Statistics and Computer Programming	20	80	100	4
MARB P105	Practical I on Paper C101 and C102	-	50	50	3
MARB P106	Practical II on Paper C103 and C104	-	50	50	3
Total Marks/Credit (C 04 + Practical 02)				**500**	**22**

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

SEMESTER II- Total Credits- 22 & Core papers: 04; Elective Papers: Nil; Practical: 02; Non-credit: 01

Course Code	Title of the Paper	Marks			Credit
		IA	Exam	Total Mark	
MARB C201	Plankton and Productivity in the Ocean	20	80	100	4
MARB C202	Cytology, Molecular Genetics and Evolution	20	80	100	4
MARB C203	Marine Biodiversity, Conservation & Management	20	80	100	4
MARB C204	Marine Invertebrate and their Biology	20	80	100	4
MARB P205	Practical I on Paper C201 and C202.	-	50	50	3
MARB P206	Practical II on Paper C203 and C204.	-	50	50	3
Total Marks/Credit (C 04 + Practical 02)				**500**	**22**
MARB VAC-I	Certificate Course on Value Addition of Marine Fishery Product	Non-credit			

SEMESTER III- Total Credits- 22 & Core papers: 04; Elective Papers: Nil; Practical: 02; Non-credit: 01

Course Code	Title of the Paper	Marks			Credit
		IA	Exam	Total Mark	
MARB C301	Marine Ecology and Biogeography	20	80	100	4
MARB C302	Remote Sensing and Geographical Information System (GIS) in Marine Sciences	20	80	100	4
MARB E303	Coastal Aquaculture	20	80	100	4
MARB E304	Marine Biotechnology	20	80	100	4

Course Code	Title of the Paper	Marks			Credit
		IA	Exam	Total Mark	
MARB CT300	Environmental Impact Assessment (EIA) and Management Plans	20	80	100	4
MARB P305	Practical I on papers C 301, C302 and C304/305	-	50	50	3
MARB P306	Practical II on Marine Biological Instruments, Measurements and Data Analysis	-	50	50	3
Total Marks/Credit (C 04 + Practical 02)				**500**	**22**
MARB VAC-II	Certificate Course on Marine Litter Monitoring and Management	Non-credit			

SEMESTER IV- Total Credits- 22 & Core paper: 02; Elective Papers: 02; Project: 01; Add-on course: 01

Course Code	Title of the Paper	Marks			Credit
		IA	Exam	Total Mark	
MARB C401	Physiology and Biochemistry	20	80	100	4
MARB C402	Marine Biogeochemical Processes	20	80	100	4
MARB E403	Fish Technology	20	80	100	4
MARB E404	Ichthyology and Fisheries	20	80	100	4
MARB E405	Marine Pollution	20	80	100	4
MARB E406	Marine Microbiology	20	80	100	4
MARB E407	Marine Microbial Ecology	20	80	100	4
MARB P408	Project Work, Dissertation & Open Viva-Voce	-	100	100	6

Course Code	Title of the Paper	Marks			Credit
		IA	Exam	Total Mark	
Total Marks/Credit (C 02 + E 02 + Project 01)				**500**	**22**
MARB AC	Cultural Heritage of South Odisha	Non-credit			

NOTE:

- *In 4th Semester, a student is allowed to opt for any two elective papers (E). The elective papers are available in combination based on different specialization. Therefore, a student can opt for either E403 & E404 or E405 & E406 or E407.*

Details of Syllabus

Semester- I

Semester: First Semester	**Course Name:**	Introduction to Earth, Ocean, Atmosphere and Climate
Course No.: MARB C101	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the interdisciplinary overview about the domain of oceanography	*Students can be able to understand the basics about various fundamental concepts related to the ocean, atmosphere, earth and climate*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Earth:** Earth and the solar system, Modern theories on the origin of the Earth and the planetary system, Kepler's laws of planetary motion, Geological Time Scale, Theories about the origin of life, Earth's gravity and magnetic fields and its thermal structure, Concept of Geoid and Spheroid. Weathering, Erosion, Transportation and deposition of Earth's materials, Formation of soil, Sediments and sedimentary rocks, Physiographic features and river basins in India. Basic concepts of seismology and internal structure of the Earth. Earthquakes and their causes.	20
Unit 2	**Ocean:** Ocean and Sea, Major Oceans of the world and their dimensions, Seafloor features, Shoreline, Continental Shelf, Continental slope, Continental Rise, Mid ocean ridges and Hydrothermal Vents. Methods for mapping bottom topography, Light in the sea, Color of the sea, Sound in the sea. Major Ocean Expeditions: Challenger Expedition, METEOR and DISCOVERY Expeditions, International Geophysical Year (IGY), International Indian Ocean Expedition (IIOE), Tropical Ocean Global Atmosphere (TOGA), World Ocean Circulation Experiment (WOCE), Joint Global Ocean Flux Studies (JGOFS). Monsoon	20

Units	Contents	Hours/ Semester
	Experiments in Indian Ocean (MONEX, BOBMEX and ARMEX).	
Unit 3	**Atmosphere:** Atmosphere and its composition, Global distribution of atmospheric mass, Zonal wind, Meridional wind. Geopotential height, Vertical velocity and the mean meridional circulation. Inter tropical convergence zone (ITCZ), Potential temperature coordinates. Global distribution of water vapour, Precipitation, Surface fluxes due to turbulence, Effects of large-scale eddies on the zonally averaged flow.	20
Unit 4	**Climate:** Weather and Climate, Global climate and the general circulation, Global climatic features, Global teleconnections, Pressure oscillations and teleconnection patterns. The Southern Oscillation and El Niño and La Nina, ENSO mechanisms, Teleconnections with ENSO, Extratropical teleconnection patterns, North Atlantic Oscillation, North Pacific Oscillation, Arctic and Antarctic Oscillation, Zonally symmetric oscillations, Tropical–extratropical teleconnections, Inter-annual to inter-decadal oscillations. Indian Monson - Indian Ocean Basin Mode (IOBM), Indian Ocean Dipole (IOD).	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, DescriptivePhysical 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 Physical, Chemical, Geological Oceanography and Marine Meteorology
Course No.: MARB C102	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the basics about physical, chemical, geological and meteorological processes of ocean	*Students can be able to understand the properties of seawater and about the factors controlling oceanic environment*	

Course Details

Units	**Contents**	**Hours/ Semester**
Unit 1	**Physical oceanography:** A historical background, Temperature, Salinity, conductivity, effect of temperature, salinity and pressure on density, Potential density and specific volume. Specific volume anamoly and thermosteric 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. **Circulations and currents:** Oceanic mixed layer, barrier layer and thermal inversion. Seasonal and permanent thermocline, Halocline and Pycnocline. Heat and fresh water transports, 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

Units	Contents	Hours/ Semester
Unit 2	**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, Radioactive nuclides, Residence times of elements in the sea water, Dissolved Gases(other than CO2) in Sea Water, Solubility of gases in seawater, Air-sea gas exchange and processes affecting their distribution, Dissolved oxygen in the ocean, CO2 equilibria in seawater, pH, Alkalinity and buffering capacity of oceans, Components of CO2 system in seawater, Percentage composition of inorganic carbon, Calcium carbonate precipitation and dissolution phenomena	20
Unit 3	**Marine Geology:** An overview, Geomorphology of ocean floor: Abyssal plain, oceanic island, sea mounts, trenches, Island Arc, Atolls and Guyots. Submarine canyons and mid oceanic ridges. 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
Unit 4	**Marine Meteorology** An introduction. Earth's rotation and revolution around the sun, seasonal changes, Composition of the atmosphere, Vertical distribution of temperature and atmospheric layers, Radiation balance of the earth-atmosphere system, Greenhouse effect. Relative, absolute and specific humidity, Mixing ratio, Dew point temperature, Dry and wet bulb temperature, Cloud formation and its classification, Indian monsoon flow, tropical cyclones – cyclogenesis, classification, frequency of occurrence and land fall.	20

Suggested Text / References

1. Pickard G.L. Descriptive Physical Oceanography, Pergammon Press Oxford, 1963.

2. Open University of U.K. Sea water: its composition, properties and behaviour. Pergammon Press.
3. LynneD.Talley,G.L.Pickard,W.J.EmeryandJamesSwift(2011):DescriptivePhysicalOceanography: 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. Pergammon Press.
8. Fairs Rhode Bridge. Encyclopodia of Atmospheric Sciences.
9. Wallace, J. M., & Hobbs, P. V., 2006. Atmospheric science: an introductory survey (Vol. 92). Academic press.
10. J.S. Fein and P.L. Stephens, Monsoons, Wiley Interscience.
11. World Meteorological Organisation, International Cloud Atlas.
12. X.Rodo and F.A. Comin, Global Climate. Springer-Verlag.
13. G.G.Tarakanov, Tropical Meteorology, MIR Publishers.
14. Bird, E.C., Coasts – An introduction to systematic geomorphology.
15. Sheppard,F.P., 1967, Submarine Geology.
16. Shepard F.P., The Earth beneath the Sea.
17. Lauff,G.H., Estuaries
18. P.D.Komar, Shore Processes and Sedimentation.
19. Ippen,A.T., Estuary and coastline hydrodynamics.
20. Johnson,D.W., Shore processes and shoreline development.
21. Open University of U.K., Sea water: its composition, properties and behavior. Pergammon Press.
22. Martin, D.P., Marine Chemistry, Vol 1 & 2.
23. Riley J.P.& Chester, R, Introduction to Marine Chemistry.
24. Riley,J.P.& Skirrow,G, Chemical Oceanography.

Semester: First Semester	**Course Name:**	Fundamentals of Marine Biology and Pisciculture
Course No.: MARB C103	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the basics about biological oceanography	*Students can be able to understand about different flora and fauna of the ocean, their adaptations and also about 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 (neretic 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, Pleustone, Benthos, seagrass, mangrove, salt marsh, seaweed)	20
Unit 2	**Plankton** Classification of planktons 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 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.	20
Unit 4	**Marine Flora of India** Seagrass, mangrove, salt marsh and seaweed, their distribution, ecological and economical significance **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

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 Mathematics, Statistics and Computer Programming
Course No.: MARB C104	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the basics about application of mathematics in ocean studies	*Students can 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	**Basic mathematics** Laws of indices, Logarithms, Linear and parabolic functions, Permutation and combination, Arithmetic and geometric progression. Differentiation, Application of differentiation - Velocity, acceleration, related rates. Application of integration to growth and decay problems, Matrics - Addition, subtraction, multiplication. Vector addition - Dot and cross products.Cartesian and spherical coordinate systems, distance between two points, equation of a circle, parabola and ellipsoid in their simplest form.	20
Unit 2	**Basic Statistics** Methods of summarization of statistical data: Averages, Dispersion, Skewness and Kurtosis. Correlation and Regression: Linear, Partial and Multiple Correlation. Curve fitting: Method of Least Squares,	20

Units	Contents	Hours/ Semester
	Linear and Multiple Regression. Probability and Distributions: Random variables, Expectations and moments. Binomial, Normal, Exponential, Weibull, Rayleigh and Log-normal Distributions. Sampling distributions: Standard Error, Chi-square, Students "T" and "F" distributions. Confidence interval for the mean and proportions. Tests of Significance concerning Mean, Proportion and Variance.	
Unit 3	**Computer programming** Introduction to Computer programing, Programming Languages and Software and Tools applicable to Oceanography and Marine Biology. FORTRAN Programming(90/95): History and importance of Fortran, Versions, Programming steps, Variables and Data types, Input and Output, Operators, Functions, Subroutines, Control statements, Loops, Arrays, Programming steps, Flow charts and Algorithms, Selected numerical algorithms.	20
Unit 4	**Software and Tools** Introduction to Golden Software – Grapher and Surfer, MATLAB, Ferret, GMT. Geographical Information System (GIS) – Applications to Oceanography and Marine Biology. Data Processing and Plotting principles and methods using different Software and Tools. Concept of Database and Applications.	20

Suggested Text / References

1. Narayan, S. (1993): Mathematical Analysis. Sultan Chand and Co.
2. Gilbert Strang (2012): Linear Algebra and its applications 4th Edition.
3. RavindraB. (2012):Linear Algebra and Linearmodels.
4. Murray, An Introduction to differential equations.
5. Sendor I, Elements of partial differential equations.
6. Gupta, S.P., Stastical Methods.
7. Gupta and Kapoor (2000): Fundamentals of MathematicalStatistics.
8. Zar, J.H. (2003): Bio-statistical Analysis. 4th edition. PearsonEducation.
9. Croxton F.E. and Cowden D.J. (2000): Applied General Statistics. PrenticeHall.
10. Kendall M.G. and Stuart A., The advanced theory of statistics. Vol. I &II.
11. Emery and Thomson, (2001): Data Analysis Methods in physical oceanography,Permagon Press.
12. Babu Ram and Pearson (2009), EngineeringMathematics.

13. Computer Programming in FORTRAN 90/95, (1997): V. Rajaraman, Prentice Hall of India, New Delhi.
14. Computer Oriented Numerical Methods, Fourth Edition, V. Rajaraman.
15. FORTRAN 90/95 for Scientists & Engineers, 1998 - S.J. Chapman, Mc-Graw Hill.
16. Grapher, Users Guide, Golden Software, Inc. Colorado 80401-1866, U.S.A.
17. Surfer, Full Users Guide, Golden Software, Inc.,Colorado 80401-1866, U.S.A.
18. S.N. Alam & S.S. Alam: Understanding MATLAB: A Text Book for Beginners,I.K. International PublishingHouse.
19. FERRET USER'S GUIDE Ver sion 6.02 NOAA/PMEL/TMAP Steve Hankin Jon Callahan, Ansley Manke Kevin O'Brien, Jing Li April 26, 2007.
20. THE GENERIC MAPPING TOOLS GMT API Documentation Release 5.4.5 P. Wessel, W. H. F. Smith, R. Scharroo, J. Luis, and F. Wobbe Jan 03, 2019
21. Francis Harvey, (2015): A Primer of GIS, Fundamentals of Geographic and Cartographic Concepts. ISBN-13: 978-1462522187.
22. Andrew Skidmore, (2017): Environmental Modelling with GIS and Remote Sensing. ISBN-13: 978-1138430594.

Semester: First Semester	**Course Name:**	Practical I
Course No.: MARB P105	**Credits:** 02	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the handson training on some of the basic instruments and tools used in physical, chemical, geological oceanography and meteorology	*Students can be able to learn the use of basic instruments and analysing techniques.*	

Course Details

Units	Contents	Hours/ Semester
	Practical session on paper C101 and C102 1. Digitization of the world map (Printed Map/Charts or Google Earth) using Cartesian coordinates and plotting on graph paper indicating the major world oceans based on their geographical boundaries. 2. Plotting of the bathymetric contours using digitized depth values from a published hydrographic chart or using digital data (open sources) on a graph paper for the Indian Ocean. 3. Preparation of a composite chart of Indian Seas (400 to 1000E, 00 to 300N) indicating the major rivers (plot using their geographic coordinates on a graph paper) and the daily atmospheric pressure	

Units	Contents	Hours/ Semester
	contours (synoptic) during any given month (January to December). Tabulate the monthly river discharges to the sea using open source data. 4. Principles and functioning of Global Positioning System (GPS) and preparation of the boundary map for a local site (say Berhampur University Campus) and identification of the major installations, buildings etc. using their co-ordinates of your survey and compare results with Google Map. 5. 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. 6. Principle and mechanism of various marine geological instruments. 7. Estimation of grain size parameters by mechanical sieving, heavy mineral separation by gravity method and calcium carbonate in marine sediments. 8. Preparation of synoptic counter maps (spatial distribution) of sea surface temperature and salinity for a given month (January to December) in the Indian Seas (400 to 1000E, 00 to 300N) manually using synoptic data from open sources. 9. Plotting of vertical profiles (monthly variability) of sea surface temperature and salinity for a given location (January to December) in the Indian Seas (400 to 1000E, 00 to 300N) manually using data from open sources. 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. Preparation of charts for north-east and south-west monsoon wind flow (contours of monthly wind speed and direction with arrows) in the Indian Ocean. 12. 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 (400 to 1000E, 00 to 300N) manually using satellite data from open sources. 13. Determination of salinity of sea water, Alkalinity of seawater, dissolved oxygen and measurement of pH of seawater.	

Semester: First Semester	**Course Name:**	Practical II
Course No.: MARB P106	**Credits:** 02	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the handson training on some of the basic instruments and tools used in biological oceanography and statistics	*Students can be able to learn the use of basic instruments and analysing 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. Hands on experience in FORTRAN 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. Repeat this exercise for 30 input data sets available in 30 different files and save the data in a single as well as individual output files. 6. Demonstrate (Fortran) 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). 7. Computation of mean monthly wind and current data using Fortran 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. 8. Plot the above outputs (Sl. No. 5 to 8) using Grapher and Surfer (Golden Software) appropriately. 9. 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:**	Plankton and Productivity in the Ocean
Course No.: MARB C201	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the details about the planktons and their relation with environmental factors	*Students can learn about the relation between the environmental parameters and plankton distribution. It will also help in determining productivity of the ocean*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Phytoplankton** Distribution of phytoplankton in the ocean and the environmental factors affecting their distribution, Phytoplankton patchiness, Phytoplankton bloom, Red tide, Harmful algal bloom (HAB), causes and consequences of HABs, Phytoplankton succession in coastal water	20
Unit 2	**Primary Productivity** Definition of primary productivity, factors effecting primary productivity in the marine environment, methods of estimation of primary productivity- phytoplankton standing crop, analyzing the pigment, estimation of dissolved oxygen, C^{14} method, Comparison of primary productivity in Bay of Bengal and Arabian sea	20
Unit 3	**Zooplankton** Holoplankton and meroplankton, Distribution of zooplankton and the environmental factors affecting their distribution, Migration of zooplankton – Dial vertical migration and seasonal vertical migration, zooplankton as bioindicator	20
Unit 4	**Secondary Productivity** Methods of estimation of secondary production, Factors affecting secondary production, Regional difference in secondary production with special reference to the Bay of Bengal and the Arabian Sea. **Plankton ecology**	20

	Interrelation between phytoplankton and zooplankton, primary and secondary productivity in different marine ecosystems	

Suggested Text / References

1. Wimpunny, R.S. 1966. Plankton of the Sea. Feber and Feber Limited, London
2. Raymont, J.E. G, 1973. Plankton and Productivity in the Ocean (Vol.-1) Pergamon Press, London.
3. Raymont, J.E.G. 1973. Zooplankton (Vol-II) Pergamon Press, London.
4. Parsons, J.R. M. Takahasi and hargrave 9IIed), 1977, Biological oceanographic Processes. Pergaman Press, Oxford.
5. Spoel S.Vender and Heyman, R.P. 1983. Comperative atlas of Zooplankton biological patterns in the oceans, Springer, Verlag, Berlin.
6. Tomas, C.R., 1993. Marine phytoplankton: A guide to naked flagellates and coccoithophores. Academic Press
7. Mitra, A., Banerjii, K., Gangopadhyay, A., 2011, Introduction to marine plankton

Semester: Second Semester	**Course Name:**	Cytology, Molecular Genetics and Evolution
Course No.: MARB C202	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the insight about basic cell and molecular biology	*Students can learn about the application of molecular and cellular techniques to understand the evolution of marine organisms.*	

Course Details

Units	**Contents**	**Hours/ Semester**
Unit 1	**Cell Membrane structure and Function** Structure of model membrane, lipid bilayer and membrane protein diffusion, Osmosis, Ion channels, Active transport, Membrane pumps, Mechanism of sorting and regulation of intracellular transport	20
Unit 2	**Structural organization and function of intracellular organelles** Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes,	20

Units	Contents	Hours/ Semester
	endoplasmic reticulum, peroxisomes, plastids, chloroplast **Cell division and cell cycle** Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle	
Unit 3	**Genetics** History of genetics and mendelism, Structure and function of gene, Molecular structure of DNA and its replication, Molecular structure and function of RNA (m-RNA, r-RNA, t-RNA), DNA as the genetic material, Chromosomal basis of inheritance	20
Unit 4	**Evolution** Evolution: Principles and theories of organic evolution, mechanism of evolution- Darwinism, Lamarkism and Neo-Darwinism, Molecular aspects of evolution.	20

Suggested Text / References

1. M.W. Strickberger, 1976: Genetics, macmillan Publishing Co., INC, new York.
2. Irwing. H. Herokokiuitz, 1977, Principles at Genetics. Second edition, mac Millian Publishing Co. Inc. New York
3. De Robertis, E.D.P. and E.M.F., De-Robertis, 1980. Cell and Molecular biology, Holt Saunders International Edition, Japan.
4. George, W. Burns, 1980. The Science of Genetics; An Introduction to Heredeity. Fourth Edition, Marcmillan Publishing co. Inc. New York.
5. William Hexter, J and Henry M. Yost Jr. 1980. The science of genetics, Prentice Hall of India Pvt. Ltd. , New Delhi.
6. B. Alberts, D. Bray, J. Lowis, K .Roberts and J.D. Watson, 1996. Molecular Biology of the cell. Garland Publishing Inc., New York,
7. Sheller, D.E .Bianchi, 2002. Cell and Molecular biology

Semester: Second Semester	**Course Name:**	Marine Biodiversity, Conservation & Management
Course No.: MARB C203	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the knowledge about	*Students can learn about the marine organisms of India and*	

national and regional marine biodiversity	*Odisha and understand about the existing conservation mechanisms*

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Introduction** Introduction to marine biodiversity, Biodiversity of plankton, benthos and nekton, Factors affecting marine biodiversity- environmental (salinity, temperature and bathymetry) and biological factors (reproduction and food availability), migration of marine organisms – Birds, reptiles, fish and mammals	20
Unit 2	**Marine and coastal Biodiversity of India** Major marine habitats – Estuary, coastal lagoons, coastal and oceanic Islands, mangrove, seagrass, salt marsh, coral reef, sand dunes**,** Marine mammals of India and their distribution, Status of Olive ridley turtles and horseshoe crabs with special reference to Odisha coast.	20
Unit 3	**Biodiversity assessment in marine ecosystems** Mapping of marine ecosystems, Methods for biodiversity assessment in mangrove, seagrass, salt marsh, coral reef, sand dunes – quadrat method, line transect method **Threats to marine biodiversity** Anthropogenic impact on marine biodiversity, Impact of pollution on marine biodiversity- Domestic, industrial and agricultural, Biological invasion, eutrophication, Climate change impact on marine ecosystem and biodiversity, Habitat destruction and fragmentation	20
Unit 4	**Biodiversity conservation and management** IUCN categories, Marine scheduled species of India, Conservation Laws and strategy – Wildlife Protection Act, 1972; Forest Conservation Act, 1980; Biological Diversity Act, 2002; Water (Prevention and Control of Pollution) Act, 1974, Coastal Regulation Zones (CRZ), Biosphere reserve, National Park, Sanctuary, Ramsar sites, Ecosensitive Zones, ICMBA (Important Coastal Marine Biodiversity Area – areas identified by WII based on biodiversity and uniqueness), Policy framework for conservation and management of coastal and marine biodiversity *viz*. UNDP, UNEP, UNCCD, UNCCC, CMS, IOSEA etc.	20

Suggested Text / References

1. Martens et al., 2006, Marine Biodiversity Patterns and Processes, Assessment, Threats, Management and Conservation, Springer, Dordrecht
2. Hiscock, K. 2014. Marine biodiversity conservation: A practical approach, Routledge
3. English, S., Wilkinson, C., Baker, V., 1997. Survey Manual for Tropical Marine Resources, Australian Institute of Marine Science, Townsville
4. Venkataraman, K., Sivaperuman, C. 2015. Marine faunal diversity in India: Taxonomy, ecology and conservation, Academic Press

Semester: Second Semester	**Course Name:**	Marine Invertebrate and their Biology
Course No.: MARB C204	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide basic knowledge about the marine invertebrates	*Students can learn about the marine invertebrates and their habitat, taxonomy and life histiory*	

Course Details

Units	**Contents**	**Hours/ Semester**
Unit 1	**Protozoa, Porifera, Coelenterata and Polychaete** Life History and Phylogenetic relationship of Protozoa and sponges, Coelenterata- Polymorphism-Life history, Theories on Coral reefs and their distribution. Polychaete taxonomic classification, morphology, reproduction and adaptive radiation.	20
Unit 2	**Minor Phyla** Functional Morphology, development and Evolution of (a) Nemertinea, (b) Entoprocta, (c) Ectoprocta, (d) Phoronida, (e) Pogonophora **Crustacea** Classification, comparative morphology, crustacean appendages, larval forms and evolution	20
Unit 3	**Mollusca** Classification, general characters with reference to bivalves, gastropods and cephalopods, Torsion	20

Units	Contents	Hours/ Semester
	Echinodermata Water vascular system, larvae-their comparative morphology and evolution. **Biofouling** Marine fouling and boring organisms: their biology and adaptations, economic importance, antifouling and anti boring treatments.	
Unit 4	**Biosystematics and taxonomy** Definition and basic concepts of biosystematics taxonomy and classification. History of Classification Trends in biosystematics : Chemotaxonomy cytotaxonomy and molecular taxonomy Dimensions of speciation and taxonomic characters.	20

Suggested Text / References

1. Meglitsch, Paul, 1991. Invertebrate Zoology. Oxford press New York.
2. Pechenick, Jan A, 2000. Biology of Invertebrates. Tata McGraw Hill.
3. Ruppert, E.E and R.D Barnes. 1994. Invertebrates Zoology. 6th Edition. Saunders College Publishers, Philadelphia
4. Kaestner, A., 1967. Invertebrate Zoology vols. I to III. Willey Interscience Publishers. New York
5. Barnes, R.D 1980 Invertebrate Zoology. 4th edition Saunders College Publishers, Philadelphia.
6. Hyman L., 1967. The Invertebrate Zoology Vols. I to IV. McGraw Hill Books Co., New York

Semester: Second Semester	**Course Name:**	Practical I
Course No.: MARB P205	**Credits:** 02	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide hands on training on primary production and secondary production in ocean	*Students can learn about the techniques and instruments used for analyzing the marine food chain*	

Course Details

Units	Contents	Hours/ Semester
	Practical session on paper C201 and C202 1. Methods of pigment estimation 2. Estimation of standing crop in the ocean 3. Methods of estimation of primary productivity 4. Methods of estimation of secondary productivity	

Semester: Second Semester	**Course Name:**	Practical II
Course No.: MARB P206	**Credits:** 02	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide practical knowledge on conservation strategy of marine organisms in India	*Students can learn about the biodiversity databases and conservation strategy to protect marine organisms*	

Course Details

Units	Contents	Hours/ Semester
	Practical session on paper C203 and C204 1. Use of national and international biodiversity databases 2. Preparation of the list of Marine National Parks, Sanctuaries of India 3. Preparation of list of marine scheduled species available in Odisha 4. Preparation of the list of Schedule marine mammals of India 5. Museum specimen identification (vertebrate and invertebrate)	

Semester: Second Semester	**Course Name:**	Certificate Course on Value Addition of Marine Fishery Product
Course No.: MARB VAC-I	**Credits**: NC	**Core/Elective:** value added

Course Objective:	**Student Learning Outcome**
To provide provides a platform for the synergy between formal and informal science and technology, institutions and knowledge system.	*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 an 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 sea shell, 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:**	Marine Ecology and Biogeography
Course No.: MARB C301	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide knowledge on structure and function of marine ecosystems.	*Students can learn about the concept of population and community, species interactions, food chain and food web and biogeographical information of marine ecosystems*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Marine environment** Concept of marine ecosystem and its components – biotic and abiotic, Concept of ecological niche and ecotone	20
Unit 2	**Population ecology** Characteristic of population, Population growth and factors a affecting population growth; Concept of Carrying capacity **Community concept** Structures and functions of ecological community, Diversity and stability in community- species diversity, species richness, species evenness **Ecological succession** Types; Mechanism; Changes involved in succession; Concept of climax, Factors affecting succession	20
Unit 3	**Ecosystem Function** Energy flow in ecosystem, Food chain and food web in marine and estuarine environment; Bio-geo-chemical cycling of nutrients **Species interaction** Types of interactions- interspecific and intraspecific competition, Predation, Mutualism/Symbiosis, Commensalism, Ammensalism	20
Unit 4	**Biogeography** The major geographical provinces of the World Oceans. General	20

Units	Contents	Hours/ Semester
	attributes; the warm water shelf fauna with special reference to Indo-West Pacific, Arctic and Antarctic fauna, Biogeographical classification of India (Coast), Archipelagoes and Volcanic Islands of India, Island Biogeography-Andaman, Nicobar – Biodiversity Hotspot.	

Suggested Text / References

1. Barnes R. S. K, 1999, Introduction to Marine Ecology, Blackwell Science.
2. Jeffery S. Levinton 2000 Marine Ecology, Biodiversity and Function. Oxford University Press.
3. Bertness, M.D, S. D. Gaines and M.K. Hay 2000. Marine Community Ecology Sinauer Associates.
4. Gage. J.D. and P.A. Tyler, 1991. Deep Sea Biology, Cambridge University Press, Cambridge.
5. Balakrishna Nair, N. and D.M. Thampy, 1980. A text Book of Marine Ecology, The Macmillan Co. of India Ltd., New Delhi.
6. Crowder, 1991 William Seashore Life Between the Tides, Dover Publication

Semester: Third Semester	**Course Name:**	Remote Sensing and Geographical Information System (GIS) in Marine Sciences
Course No.: MARB C302	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide knowledge on structure and function of marine ecosystems.	*Students can learn about the concept of population and community, species interactions, food chain and food web and biogeographical information of marine ecosystems*	

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–	20

Units	Contents	Hours/ Semester
	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.	
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	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	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.	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:**	Coastal Aquaculture
Course No.: MARB E303	**Credits:** 04	**Core/Elective:** Elective
Course Objective:	**Student Learning Outcome**	
To provide knowledge on aquaculture in brackish and marine waters.	*Students can learn about the methods of finfish and shell fish farming in estuaries and ocean water*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Introduction** Fundamentals of aquaculture, Types of aquaculture, scope and importance of coastal aquaculture	20
Unit 2	**Construction of aquaculture farm and hatchery** Design and construction of fish farm, Design and construction of shrimp hatchery, Site selection, factors of consideration and development of infrastructure	20
Unit 3	**Seed Production and transportation** Methods of seed collection- Induced breeding and wild, packing and transportation of fish seed **Culture** Mono culture and poly culture, Traditional, Extensive, semi-intensive and intensive system of culture, Cages, Pen and Raft culture, Culture of mullets, milk fish, ornamental fish, prawn, crabs, oysters, mussels and seaweeds, Culture of live feeds, frog culture, culture of fishes in circulating water	20

Units	Contents	Hours/ Semester
Unit 4	**Maintenance of aquaculture farm** Common aquatic weeds in fish farm and their methods of control, Fish diseases in culture fishes and their control, Effect of pollution on aquaculture	20

Suggested Text / References

1. Inversion, E.s. 1976, Farming on the edge of the sea. Fishing News (Books) Limited, London.
2. Chen, T.P. 1976, Aquaculture Practices in Taiwan Fishing News (Books) Ltd. London.
3. Chapman V.J. 1980: Sea weeds and their uses, Chapmans Hall, London.
4. Kurien C.V. and Subastian, V.O. 1982, Prawn and Prawn fisheries of India, Hindustan Publishing Corporation (India), Delhi.
5. Pillay, T.R. ed. 1982, Coastal aquaculture in Indo-Pacific region, Fishing News (Books) Limited London.
6. Bal. D.V. and D.V.Rao, 1984. Marine Fisheries Tata, Mc.Graw. Hill Publishing Co.Ltd., New Delhi.
7. Meske, C. 1985, Fish aquaculture-technology and experiments, Pergamon Press Ltd. London.
8. Guasim, S.Z. 1998, Glimpses at the Indian Ocean, University Press (India) Hyderabad.
9. Dey, V.K. Ornamental fishes, hand book on Aquafarming, Presented by MPEDA, Kochi.
10. Nayak. L. 2001, Recent trends in aquaculture, Berhampur University.

Semester: Third Semester	**Course Name:**	Marine Biotechnology
Course No.: MARB E304	**Credits:** 04	**Core/Elective:** Elective
Course Objective:	**Student Learning Outcome**	
To provide knowledge on tools and techniques used in marine biotechnology.	*Students can learn about the tools and techniques of biotechnology used in genetic engineering, isolation of marine bioactive compounds and aquaculture industry.*	

Course Details

Units	Contents	Hours/ Semester

Unit 1	**Introduction** Marine biotechnology, history and its applications in marine biology **Basics of genetic engineering** Plasmid and bacteriophages, DNA isolation and cloning, insertion of foreign DNA into host cell, recombinant DNA technology	20
Unit 2	**Marine natural products** Bioactive marine natural products - anti tumor compounds, anti inflammatory / analgesic compounds, anti viral agents, Isolation of bioactive compound- liquid extraction, membrane separation, chromatography, identification of marine bioactive compounds- IR, UV, NMR and mass spectroscopy, Commercial development of marine natural products- Agar, chitin	20
Unit 3	**Application of biotechnology in aquaculture** Induced breeding in marine organisms, in-vitro fertilization, cryopreservation, Chromosome manipulation in aquaculture – hybridization; Ploidy induction; Gynogenesis, Androgenesis and sex reversal in commercially important fishes.	20
Unit 4	**Tools and techniques in marine biotechnology** RIA, ELISA, FISH, PCR Gene probes	20

Suggested Text / References

1. Italy, E (Eds). 1998, New Developments in Marine Biotechnology, Plenum Pub. Corp.
2. Milton Fingerman and Rachakonda Nagabhushanam, 1996, Molecular Genetics of Marine Organisms, Science Pub Inc.
3. Y. Le Gal and H.O.Halvorson 1998, New Developments in Marine Biotechnology. Springer.
4. David H. Attaway, 2001. Marine Biotechnology, Volume 1, Pharmaceutical and Bioactive Natural Products.
5. Rita R. Colwell 1984. Biotechnology in the Marine Sciences (Advances in Marine Science & Biotechnology) Wiley Interscience.
6. Scheupr, P.J. (Ed.), 1984. Chemistry of Marine Natural Products, Chemical and Biological Perspectives. Vol. I III, Academic Press, New York.

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. Landuse policy for India. Urban planning for India. Rural planning and landuse pattern. Environmental priorities in India and sustainable development. CRZ notifications and Environmental Impact Assessment in coastal zone. 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 NewYork.
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 P305	**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.*	

Course Details

Units	Contents	Hours/ Semester
	Practical session on theory papers C301, 302, 304/305 1. Estimation of species biodiversity, richness and evenness 2. Estimation of biochemical composition of marine fishes 3. Aquaculture pond design and construction 4. Live feed culture 5. Remote Sensing Application for ocean resources: Ocean color and chlorophyll estimation, SST, Bio-optical algorithm, Fishery	

Units	Contents	Hours/ Semester
	resources, PFZ forecast & data dissemination. 6. Remote sensing application to marine and coastal environment: Monitoring marine and wetland environment, coastal vegetation, coral reefs, Land use/Land cover study, Environmental Impact Assessment (EIA) studies, CRZ Laws and coastal zone management.	

Semester: Third Semester	**Course Name:** Practical II	
Course No.: MARB P306	**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
	Practical session on Marine Biological Instruments, Measurements and Data Analysis 1. Use of biodiversity related softwares 2. Use of microscopes 3. use of refractometer 4. Use of water quality probe 5. Use of pH meter 6. Use of centrifuge 7. Use of spectrophotometer 8. Use of laminar flow 9. Data analysis	

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 also 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 andeconomy. 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-upof marine litters. Education and awareness on marine litters with special reference 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.	NC
Unit 3	**Monitoring of marine litters and laboratory methods for their analysis: Methods for the analysis of mezo, meso, micro plastics in beach samples** • Apparatus and Materials • Beach sediment sample preparation	NC

Units	**Contents**	**Hours/ Semester**
	• Segregation of beach litters and their quantification • Density Separation • Determine the mass of Total solids • Wet petroxide oxidation (WPO) • Density Separation of total solids • Use of Microscope for identification • Gravimetric Analysis • Polymer identification through FTIR Analysis	

Semester- IV

Semester: Fourth Semester	**Course Name:**	Physiology and Biochemistry
Course No.: MARB C401	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide understanding about the ocean and atmospheric dynamics in the polar region.	*Students can learn about the unique physiological adaptations of marine organisms to survive in dynamic oceans and also about their biochemical compositions.*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Physiology of digestion in marine organisms** Food types and feeding mechanisms of marine organisms, Mechanism of digestion, Digestive enzymes and their action	20
Unit 2	**Physiology of respiration in fishes** Mechanism of respiration in cyclostome, bony fish and elasmobranch, factors affecting respiration in fishes, transport of gases **Osmoregulation and ion exchange in fishes** Physiology of osmoregulation and ion exchange, Ions in body fluids, mechanisms of ionic regulations, response to osmotic conditions and types of osmoregulatory adaptations	20
Unit 3	**Nervous system** Physiology of nervous systems, impulse generation and conduction, Interneuronic transmission Types of sensory organs-structure, properties and functions of sensory organs.	20
Unit 4	**Biochemistry** Structure and properties of carbohydrates, proteins and lipids, Metabolism of proteins, carbohydrates and lipids, Types of enzymes and their functions, mechanism of enzyme action and factors affecting enzyme action, Vitamins and their role in physiology	20

Suggested Text / References

1. Prosser, C.L. (Ed) 1973, comparative animal Physiology, Saunders, Philadelphia.
2. Lehinger, A.L.Nellson. D.L.Cox., M.M. 1993 Principles of Biochemistry, CBS Publishers and Distributors, New Delhi, pp.1-36.
3. Florey, E. 1966, An introduction to general and comparative Physiology, Sounders, Philadelphia.
4. Gordon, M.S., 1971. Animal function: Principles and applications, Amerird Publicizing Co. New Delhi.
5. Baldwin, E. 1966, Dynamics aspects at Bio-chemistry, Cambridge, England.
6. Conn, E.E. and P.K. Stumff, 1963. Outline of Biochemistry. John Wiley and Sons Inc. New York and London.

Semester: Fourth Semester	**Course Name:**	Marine Biogeochemical Processes
Course No.: MARB C402	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To understand the circulation by using different ocean circulation model (MOM, POP, HYCOM, and ROMS).	*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	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,	25

Units	Contents	Hours/ Semester
	Algal blooms – HABs and TABs- Ocean Colour Monitoring and estimation of primary productivity. Zooplankton communities in estuarine, neritic and oceanic systems. Secondary production- Linkages to higher trophic level, Plankton as indicators of fisheries. Indicator species of water masses. Benthic ecosystem processes, benthic environment and community structure, Organism sediment relations. Benthic pelagic coupling, CDOM.	
Unit 3	Influence of Physical processes on primary productivity, Hydrodynamic forcing, Upwelling, stratification, mixed layer depth, turbulent mixing, monsoon driven biogeochemical processes in the Arabian Sea and Bay of Bengal, Spatial and Temporal variations in the nutrient concentrations, Response of marine pelagic ecosystems to climatic forcing, OMZ, HNLC, Ocean currents and their impact on marine life, Phytoplankton distribution and patchiness.	20
Unit 4	Plankton in relation to fisheries, Plankton as indicators of fisheries, Potential Fishery Zones, SST variations and pelagic fisheries, Influence of upwelling on oil sardine fishery in Arabian Sea, Larval transport and recruitment, Effects of climate change on Coastal upwelling systems, Fish migrations.	15

Suggested Text / References

1. John H Simpson and Jonathan Sharples, (2012): Introduction to the Physical andBiological Oceanography of Shelf Seas; Cambridge UniversityPress.
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 andNew York.
4. Carol M. Lalli & Timothy R. Parsons,Biological Oceanography an Introduction. Elsevier, Butterworth-Heinemann.
5. Peter Castro & Michel E. Huber, Marine Biology, The Mc-Grawcompanies.
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: Fourth Semester	**Course Name:**	Fish Technology
Course No.: MARB E403	**Credits:** 04	**Core/Elective:** Elective
Course Objective:	**Student Learning Outcome**	
To provide knowledge on techniques used in Indian fisheries.	*Students can learn about the technology, crafts and gears used in Indian fisheries. The paper will also help to understand the role of fisheries 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 shell fish	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 insilage, 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)	20

Units	Contents	Hours/ Semester
	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	
Unit 4	**Economics & Management** Oceans as a common heritage of mankind, Exclusive Economic Zone (EEZ) and its significance, export of fin fish and shell fish to different countries, fishing harbour and shore facilities Regulations on fishing of craft and gears – Indian Fisheries Act, OMFRA, other policy framework on fishing permission and restrictions	20

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: Fourth Semester	**Course Name:**	Ichthyology and Fisheries
Course No.: MARB E404	**Credits:** 04	**Core/Elective:** Elective
Course Objective:	**Student Learning Outcome**	
To provide knowledge on coastal and marine fishes.	*Students can learn about the taxonomy, anatomy, physiology, ecology, stock assessment and behavior of Indian marine and brackish water fishes*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Classification and distribution** General morphology and outline classification of fishes, major group of fishes of the world and their characteristics **Anatomy and physiology** Basic anatomy of fishes, Detail structure and function of gills, Types of air breathing organs in fishes, Structure and function of swim bladder, Food and feeding habit of pelagic and demersal fishes, Reproductive system in fishes and reproductive mechanism, Electrical organs in fishes and their function, Endocrine organ and their functions	20
Unit 2	**Fish Ecology** General attributes of fish population growth, mortality and recruitment of the fishes in the oceans, Principle of tagging in fish population studies and their significance, Hydrography in relation to fisheries, Factors affecting the maturation and spawning of fishes, Age determination in fishes	20
Unit 3	**Fishery resources of India** Acts of overfishing and its effect on sustenance of marine fisheries. The major marine fishery resources of Indian seas- Sardine, Mackerel, Pomfrets, Tuna and Hilsha fishery resources, The fisheries of Chilika lake, Estuarine fishery resources of Odisha, Methods of resource assessment, Survey of fish eggs and fish larvae with reference to fish population features, Types of pelagic and demersal fish eggs, Fishing methods in different parts of India – east coast, west coast, islands	20
Unit 4	**Fish behavior and status** Fish migration and factors affecting migration, Schooling behavior of fishes, Status of endangered fishes along Odisha coast, Stock assessment. Ornamental fishes of India with special reference to Odisha.	20

Suggested Text / References

1. K.F, Lagler T.E. Bardach and R.R. Miller, 1962. Ichthyology. John Wiley and Sons and Inc. New York.
2. Carl, E. Bond, 1979. Biology of fish, W.B. Saunders Company. Philadelphia.

3. King, M. 1995. Fisheries biology Assessment and Management. Fishery News Books.
4. Jones, E.R.H. 1980. Fish Migration Edward Arnold Ltd, London.
5. Nikolski, G.V. 1969. Theory of fish population dynbamics as th biological background for rational exploitation and management of fishery resources. Otto Roeltz Science publishers. Berling.
6. Saint and Shury: Commercial fishery methods.
7. D.V. Bal and K.V. Rao, 1984: Marine Fisheries.
8. Jhingran, J,.V: Fish and Fisehries of India.

Semester: Fourth Semester	**Course Name:**	Marine Pollution
Course No.: MARB E405	**Credits:** 04	**Core/Elective:** Elective
Course Objective:	**Student Learning Outcome**	
To provide knowledge on coastal and marine pollution.	*Students can learn about the various types of marine pollution, their causes, mitigation and management techniques*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Introduction** Marine Pollution – definition and types, major pollutants, sources, transport path and dynamics, Anthropogenic impact on estuaries, mangroves, coral beds and interstitial communities, case study of Indian and World Oceans	20
Unit 2	**Sewage pollution** Industrial, agricultural and domestic pollutants, Impact on marine environment and control, Eutrophication and its ecological significance, Plastic pollution and its impact on marine ecosystem, Impact of Mining and dredging to marine biodiversity, Pollution by aquaculture farms, Red tide, Fish kill, Case study. Organic matter pollution, petroleum hydrocarbon pollution, trace metal pollution, nutrient (nitrate, ammonium and phosphate) pollution.	20
Unit 3	**Oil and heavy metal pollution** Composition, source, impact on marine environment and control	20

Units	Contents	Hours/ Semester
	techniques, success stories on curbing metal pollution **Thermal and radioactive pollution** Thermal pollution – sources, uses of waste heat and ecological impact, Radioactive pollution- sources (natural and artificial), biological effects of radiation, Possible areas in India and case studies of the World Ocean.	
Unit 4	**Monitoring and management** Environmental monitoring methods for critical pollutants, Biological and ecological indicators of pollution and bio ecological monitoring, Control of marine pollution-legal aspects and international cooperation.	20

Suggested Text / References

1. Clark R.B 1992. Marine pollution 3rd edition Clavendron, Press Oxford.
2. Williams 1996. Introduction to Marine Pollution Control. John Wiley.
3. Michael J. Kennish 1994. Practical Handbook on Estuarine and Marine Pollution.
4. Johnston, R. (ed), 1976. Marine Pollution, Academic Press, London.
5. Goldberg, E. D. 1974. The Health of the oceans, UNESCO Press. Paris.
6. Park, P .K, Kester D.R., J.W. Deudall and B.H Ketchum, 1983. Wastes in the Ocean. Vols. 1 to 3. Wiley Interscience Publishers, New York.

Semester: Fourth Semester	**Course Name:**	Marine Microbiology
Course No.: MARB E406	**Credits:** 04	**Core/Elective:** Elective
Course Objective: *To provide basic knowledge on marine microbial community*	**Student Learning Outcome** *Students can learn about the diversity and distribution of marine microbes, their culture methods and about required nutrition*	

Course Details

Units	Contents	Hours/ Semester

Units	Contents	Hours/ Semester
Unit 1	**Introduction to microbiology** General introduction to microbiology, marine microbiology- Definition, importance and its significance in Oceanographic studies **Diversity and distribution of marine microbes** Ecology of coastal, shallow and deep sea microorganism - importance and their significance, Diversity of microorganism - Archaea, bacteria, cyanobacteria, algae, fungi, viruses and actinomycetes in the mangroves and coral environment	20
Unit 2	**Culture method and identification** Methods of collection of water and sediment samples for microbiological studies, Methods of isolations and culture of marine bacteria, Enumeration of marine bacteria by total and viable counts, Identification of marine bacteria by total and viable counts, Identification of marine bacteria based on their morphological, physiological and biochemical characteristics, Structure and biology of marine bacteria	20
Unit 3	**Microbial nutrition** Common nutrient requirements of microbes, Requirement for carbon, hydrogen and oxygen, Nutritional types of microorganisms, Requirements of nitrogen, phosphorus and sulfur, uptake of nutrients by cell	20
Unit 4	**Actinomycetes** Occurrence, distribution and morphological feature of actinomycites, Ecological and economic significance of actinomycites.	20

Suggested Text / References

1. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's microbiology. New York: McGraw-Hill.
2. John Paul 1999. Marine Microbiology, Elsevier.
3. Munn and Munn 1996. Marine Microbiology: Ecology and Applications. BIOS Scientific publisher.
4. Atlas, R.M 1988. Microbiology, Fundamentals and applications Maxwell McMillan International Editions

5. Rheinheimer, G., 1980 Aquatic Microbiology-an Ecological Approach. Blackwell Scientific Publications
6. Kirchman, L Microbial Ecology of the Oceans 2000 John Wiley and Sons.
7. The Prokaryotes: 1992 A Handbook on the biology of Bacteria. Vol. 1-4 Springer & Verlag New York

Semester: Fourth Semester	**Course Name:**	Marine Microbial Ecology
Course No.: MARB E407	**Credits:** 04	**Core/Elective:** Elective
Course Objective:	**Student Learning Outcome**	
To provide knowledge on role of marine microbes and their adaptations	*Students can learn about the ecological role of marine microbes, their adaptations, their genomics and their role in marine food industry*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Introduction** Marine Microbiology its importance, existence and need; History of marine microbiology; Microbial habitats and major types (producers, consumers, symbionts, probionts) in relation to their habitats **Characteristics and adaptations** Characteristics of marine microbes; Distribution and abundance and their adaptations to pressure, depth, salt, temperature; nutrient, ions of major and trace elements, Toxicity and mechanism of tolerance in marine microbes	20
Unit 2	**Ecological role of microbes** Microbial role in cycling of N, P, S, and C; Concept of microbial loop in relation to marine food web dynamics ; Role of micro-organisms in DOM production and consumption; Role of marine microbes sequestering of carbon dioxide; Pollution indictor and pathogenic marine microbes.	20
Unit 3	**Food Microbiology** Pathogenic microorganisms, distribution, indicator organisms prevention and control, Quality standards- International and National standards. Microbiology of processed finfish and shellfish products.	20

Units	Contents	Hours/ Semester
	Microbial diseases - diagnosis and control	
Unit 4	**Microbial genomics** Principles and applications of TFF for microbial molecular analysis; DNA/RNA extraction, principles and methods; Principles and applications of PCR; GEL electrophoresis, DNA purification and visualization techniques	20

Suggested Text / References

1. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's microbiology. New York: McGraw-Hill.
2. John Paul 1999. Marine Microbiology, Elsevier.
3. Munn and Munn 1996. Marine Microbiology: Ecology and Applications. BIOS Scientific publisher.
4. Atlas, R.M 1988. Microbiology, Fundamentals and applications Maxwell McMillan International Editions
5. Rheinheimer, G., 1980 Aquatic Microbiology-an Ecological Approach. Blackwell Scientific Publications
6. Kirchman, L Microbial Ecology of the Oceans 2000 John Wiley and Sons.
7. The Prokaryotes: 1992 A Handbook on the biology of Bacteria. Vol. 1-4 Springer & Verlag New York

Semester: Fourth Semester	**Course Name:**	Project/Dissertation
Course No.: MARB P408	**Credits:** 04	**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 also to write research article and thesis*	

Course Details

Units	Contents	Hours/ Semester

Units	**Contents**	**Hours/ Semester**
	Project work is compulsory. Topics will be assigned before the end of 3rdSemester by distributing students equally among the department faculty members (internal guides). Preferable two students can opt for any one topic suggested and prepare dissertation in two different aspects of the same problem. Students are free to choose any other relevant and appropriate topic relating to the field of Oceanography if accepted by both internal and external guides (outside department). 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 has to submit the project report/dissertation (80marks) and defend his report by presenting about 20 technical slides in an open viva-voce (20 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.	

Semester: Fourth Semester	**Course Name:**	Cultural Heritage of South Odisha
Course No.: MARB AC	**Credits**: NC	**Core/Elective:** Add-on course
Course Objective:	**Student Learning Outcome**	
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.	*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**

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

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