गोंय विद्यापीठ
ताळगांव पठार,
गोंय – ४०३ २०६
फोन : +९१-८६६९६०९०४८

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GU/Acad –PG/BoS -NEP/2025-26/313 Date: 08.08.2025

CIRCULAR

The Academic Council & Executive Council of the University has approved Ordinance OA-35A relating to PG Programmes offered at the University campus and its affiliated Colleges based on UGC 'Curriculum and Credit Framework for Postgraduate Programmes'. Accordingly, the University has proposed introduction of Ordinance OA-35A from the Academic year 2025-2026 onwards.

The Programme structure and syllabus of Semester I and II of the **Master of Science in Marine Sciences** Programme approved by the Standing Committee of the Academic Council in its meeting held on 24th & 25th June 2025 is attached.

The Dean & Vice-Dean (Academic) of the School of Earth, Ocean and Atmospheric Sciences are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2025.08.08 15:23:27 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,
1. The Dean, School of Earth, Ocean and Atmospheric Sciences, Goa University.
2. The Vice-Dean (Academic), School of Earth, Ocean and Atmospheric Sciences, Goa University.

Copy to:
1. Chairperson, BoS in Marine Sciences, Goa University.
2. Programme Director, M.Sc. Marine Sciences, Goa University.
3. Controller of Examinations, Goa University.
4. Assistant Registrar Examinations (PG), Goa University.
5. Director, Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

GOA UNIVERSITY

MASTER OF SCIENCE IN MARINE SCIENCES

(Effective from the Academic Year 2025-26)

ABOUT THE PROGRAMME

The Marine Science programme, established in 1985, is a key component of the School of Earth, Ocean, and Atmospheric Sciences (SEOAS), Goa University. The programme adopts a holistic, interdisciplinary approach to Earth System Science, reflecting the interconnected nature of the lithosphere, atmosphere, hydrosphere, cryosphere and biosphere.

The programme is dedicated to advancing academic understanding and research in dynamic processes governing the marine environment. Aligned with the UGC-NET syllabus, the curriculum is designed to support high-quality postgraduate education and research. It covers diverse areas including Physical Oceanography, Marine Chemistry, Marine Biology and Marine Geology.

Goa University has been shortlisted as the National Resource Centre in Marine Science under the Ministry of Human Resource Development (MHRD) initiative for the online professional development of higher education faculty using the MOOCs platform SWAYAM (Study Webs of Active learning for Young Aspiring Minds).

The Marine Science programme has received funding from the Department of Science and Technology, India, under the scheme of Fund for Improvement of S&T Infrastructure in Universities and Higher Educational Institutions (FIST) for the period of 5 years (2014 - 2018). The faculties of Marine Science have been awarded research grants from agencies such as MoES, UGC, DST, ISRO, etc. A strong interdisciplinary faculty and research infrastructure make it one of the most recognised programmes in the country.

Eligibility: A Bachelor's degree in Science from this University or any other recognized university deemed equivalent, with specialization in Physics, Mathematics, Electronics, Computer Science, Information Technology, Chemistry, Industrial Chemistry, Analytical Chemistry, Pharmaceutical Chemistry, Botany, Zoology, Microbiology, Biotechnology, Biosciences, Fisheries, Aquatic Sciences, Earth Sciences, Geology, or any equivalent discipline.

Approved by: Standing Committee of the Academic Council on 24th & 25th June 2025

OBJECTIVES OF THE PROGRAMME
1. To impart basic and advanced knowledge in physical, chemical, biological, and geological oceanography. 2. To foster understanding of ocean-atmosphere interactions and their role in global climate systems. 3. To evaluate the impact of anthropogenic activities on marine and coastal environments. 4. To encourage interdisciplinary research and innovation for sustainable use and conservation of marine resources. 5. To equip students with the knowledge and skills required for pursuing careers in academia, research, and industry in the field of Marine Sciences.

PROGRAMME SPECIFIC OUTCOMES (PSO)	
PSO 1.	To demonstrate and apply oceanographic techniques and tools to analyse marine processes across the disciplines of physical, chemical, biological and geological oceanography.
PSO 2.	To analyse and evaluate physical oceanographic processes and design effective approaches for marine observation and monitoring.
PSO 3.	To evaluate the biogeochemical processes in the marine environment and critically assess the impact of anthropogenic inputs.
PSO 4.	To investigate marine geological processes using geophysical techniques, paleo-oceanography and sediment flux.
PSO 5.	To analyse marine biodiversity, processes, biotic interactions and develop research-based solutions for conservation and sustainable management of marine resources.

PROGRAMME STRUCTURE

Master of Science in Marine Sciences

Effective from Academic Year 2025-26

BRIDGE COURSE			
Sr. No.	**Course Code**	**Title of the Course**	**Credits**
1	MSC-1000	Fundamentals of Marine Science	2T

Note: Bridge course is optional for students who have registered for M.Sc. Marine Science.

SEMESTER I				
Discipline Specific Core (DSC) Courses (16 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	MSC-5000	Physical Oceanography	3T	400
2	MSC-5001	Physical Oceanography Practical	1P	400
3	MSC-5002	Marine Chemistry	3T	400
4	MSC-5003	Marine Chemistry Practical	1P	400
5	MSC-5004	Marine Biology	3T	400
6	MSC-5005	Marine Biology Practical	1P	400
7	MSC-5006	Marine Geology	3T	400
8	MSC-5007	Marine Geology Practical	1P	400
Total Credits for DSC Courses in Semester I			**16**	
Discipline Specific Elective (DSE) Course (4 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	MSC-5201	Ocean-Atmosphere Coupling and Climate	3T	400
2	MSC-5202	Ocean-Atmosphere Coupling and Climate Practical	1P	400
3	MSC-5203	Marine Geochemistry	3T	400
4	MSC-5204	Marine Geochemistry Practical	1P	400
5	MSC-5205	Marine Ecology	3T	400
6	MSC-5206	Marine Ecology Practical	1P	400
7	MSC-5207	Principles of Mineralogy and Geochemistry	3T	400
8	MSC-5208	Principles of Mineralogy and Geochemistry Practical	1P	400
Total Credits for DSE Courses in Semester I			**4**	
Total Credits in Semester I			**20**	

Note: Students opting for a 3-credit theory course (DSE) are required to take the corresponding 1-credit practical course.

Semester II				
Discipline Specific Core (DSC) Courses				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	MSC-5008	Estuarine and Coastal Physical Oceanography	3T	500
2	MSC-5009	Estuarine and Coastal Physical Oceanography Practical	1P	500
3	MSC-5010	Estuarine and Coastal Chemistry	3T	500
4	MSC-5011	Estuarine and Coastal Chemistry Practical	1P	500
5	MSC-5012	Estuarine and Coastal Biology	3T	500
6	MSC-5013	Estuarine and Coastal Biology Practical	1P	500
7	MSC-5014	Estuarine and Coastal Geology	3T	500
8	MSC-5015	Estuarine and Coastal Geology Practical	1P	500
Total Credits for DSC Courses in Semester II			**16**	
Discipline Specific Elective (DSE) Courses (4 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	MSC-5209	Geophysical Fluid Dynamics	3T	400
2	MSC-5210	Geophysical Fluid Dynamics Practical	1P	400
3	MSC-5211	Marine Pollution	3T	400
4	MSC-5212	Marine Pollution Practical	1P	400
5	MSC-5213	Marine Biodiversity	3T	400
6	MSC-5214	Marine Biodiversity Practical	1P	400
7	MSC-5215	Sedimentology	3T	400
8	MSC-5216	Sedimentology Practical	1P	400
Total Credits for DSE Courses in Semester II			**4**	
Total Credits in Semester II			**20**	

Note: Students opting for a 3-credit theory course (DSE) are required to take the corresponding 1-credit practical course.

BRIDGE COURSE

Title of the Course	Fundamentals of Marine Science
Course Code	MSC-1000
Number of Credits	02
Theory/Practical	Theory
Level	100
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	Yes (Bridge Course)
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• Introduce core concepts, history, and branches of marine science. • Understand seawater properties and nutrients. • Explore marine habitats, biodiversity, role of marine organisms in ecosystem functioning. • Understand marine geology and mineral resources.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Explain the scope and branches of marine science, describe physical variables and teach geographical features.	PSO 1, PSO 2
	CO 2. Interpret seawater properties, chemical composition, and nutrient distribution.	PSO 1, PSO 3
	CO 3. Classify marine habitats and organisms, and analyse biodiversity and food web	PSO 1, PSO 5

	interactions.			
	CO 4. Describe ocean floor features and identify marine resources.		PSO 1, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Introduction to Marine Science -Definition, scope, and history; Branches - Physical, Chemical, Biological, and Geological Oceanography; Importance of the oceans to Earth systems; Maps of the world, coastal countries, islands, seas, spheres of the Earth, physical variables; Chemical composition of seawater, pollutants of concern, nutrients and their distribution.	**15**	CO1, CO2	K2, K3
Module 2:	Marine habitats, classification of marine flora and fauna, marine biodiversity, trophic levels and food webs; Human impacts on marine environment; Minerals; crystals; rocks; world oceans; major and minor continents; seafloor structure; marine sediments; geomorphology of ocean basins.	**15**	CO3, CO4	K4, K2
Pedagogy:	Lectures/ tutorials/ assignments / case study analysis/ group discussion			
References/ Readings:	1. Pinet, P. R. (2021). Invitation to oceanography (8th ed.). Jones & Bartlett Learning, Burlington, MA. 2. Garrison, T. (2018). Essentials of oceanography (8th ed.). Cengage Learning, Philadelphia, PA. 3. Thurman, H. V., & Trujillo, A. P. (2017). Introductory oceanography (11th ed.). Pearson. 4. Levinton, J. S. (2020). Marine biology: Function, biodiversity, ecology (5th ed.). Oxford University Press, USA. 5. Miller, G. T., & Spoolman, S. E. (2021). Environmental science (16th ed.). Cengage, Boston, MA.			
Web Resources:	1. https://oceanexplorer.noaa.gov 2. https://ioc.unesco.org 3. https://openstax.org			

SEMESTER I

Discipline Specific Core Courses

Title of the Course	Physical Oceanography
Course Code	MSC-5000
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide a basic understanding of physical oceanographic variables and processes	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Describe and explain the basic properties of water, physical oceanographic variables in different parts of the world ocean and the heat fluxes.	PSO 2
	CO 2. Sketch and explain the atmospheric and oceanic circulation.	PSO 2
	CO 3. Illustrate and explain the major climatic oscillations.	PSO 2

	CO 4. Distinguish the major water masses of the world ocean.		PSO 2	
	CO 5. Calculate wind stress.		PSO 2	
	CO 6. Describe the earth in space, its atmosphere, the instruments measuring temperature, salinity and wind, atmospheric humidity, temperature systems and scales, sea-ice, oceans and dimensions and oceanic processes.		PSO 2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Oceanographic explorations – Evolution of theoretical ideas – Units used in oceanography – The role of observations in oceanography – Ocean and seas – Dimensions of the ocean-Physical properties of water – Influence of dissolved salts-Physical properties of seawater – Salinity – Temperature - Density – Distribution of temperature, salinity and density in low, mid and high latitudes and their seasonal variations – Oceanic mixed layer and thermocline – Instruments used for the measurement of temperature and salinity – Sound in the sea – Propagation of sound in the sea – Light in the sea – The oceanic heat budget – Shortwave radiation, longwave radiation – Sensible and latent heat fluxes and net heat flux – Bowen's ratio – Temperature Salinity Volume (TSV) diagram – Temperature Salinity (TS) diagram.	**15**	CO1, CO5, CO6	K2, K4, K2
Module 2:	The Earth in space – Composition of atmosphere – Vertical extent of atmosphere – Measurement of wind – Calculations of wind stress – Coriolis force – General circulation of atmosphere – Atmospheric temperature – Temperature systems and scales – Atmospheric humidity – Vapour pressure – Ocean Circulation: Wind-driven and thermohaline circulations – Sea ice	**15**	CO2, CO5, CO6	K3, K4, K2
Module 3:	Equatorial processes – El Niño and Southern Oscillation and their tele-connections – Indian Ocean Dipole (IOD) – Indian Ocean Circulation – Oceanic fronts – Upwelling: open ocean and coastal upwelling – Surface, intermediate and deep water masses in the ocean – Fronts – Eddies – Lagrangian and Eulerian methods for measuring currents.	**15**	CO2, CO3, CO4, CO6	K3, K3, K2, K2

Pedagogy:	Lectures/ tutorials/ assignments
References/ Readings:	1. Stewart, R. H. (2008). Introduction to physical oceanography. Robert H. Stewart. https://open.umn.edu/opentextbooks/textbooks/20 2. Webb, P. (2023). Introduction to oceanography. Roger Williams University. https://rwu.pressbooks.pub/webboceanography/ 3. Colling, A. (2001). Ocean circulation (2nd ed., Vol. 3). Butterworth-Heinemann, Oxford, in association with The Open University, Milton Keynes. 4. Wright, J., & Colling, A. (1995). Seawater: Its composition, properties, and behavior (2nd ed.). Pergamon Press, Oxford, in association with The Open University, Milton Keynes. 5. Talley, L. D., Pickard, G. B., Emery, W. J., & Swift, J. H. (2011). Descriptive physical oceanography: An introduction (6th ed.). Academic Press, Boston. 6. Neumann, G. S., & Pierson Jr., W. J. (1966). Principles of physical oceanography. Prentice-Hall, Englewood Cliffs, N.J. 7. Ahrens, C. D. (1985). Meteorology today: An introduction to weather, climate, and the environment (2nd ed.). West Publishing, St. Paul. 8. Wells, N. C. (2012). The atmosphere and ocean: A physical introduction. Wiley-Blackwell, Chichester. 9. Tomczak, M., & Godfrey, J. S. (2001). Regional oceanography: An introduction. https://www.physocean.icm.csic.es/regoc/pdfversion-en.html 10. Defant, A. (1960). Physical oceanography (Vol. 2). Pergamon Press, Oxford.
Web Resources:	1. https://open.umn.edu/opentextbooks/textbooks/20 2. https://rwu.pressbooks.pub/webboceanography/ 3. https://www.physocean.icm.csic.es/regoc/pdfversion-en.html

Title of the Course	Physical Oceanography Practical			
Course Code	MSC-5001			
Number of Credits	01			
Theory/Practical	Practical			
Level	400			
Effective from AY	2025-2026			
New Course	No			
Bridge Course/ Value added Course	No			
Course for advanced learners	No			

Pre-requisites for the Course:	Nil			
Course Objectives:	To develop an ability to analyse physical oceanographic properties and decipher associated processes			
Course Outcomes:	Student will learn to:		**Mapped to PSO**	
	CO 1. Analyse vertical profiles of temperature, salinity and density at low, mid and high latitudes of the world ocean.		PSO1, PSO 2	
	CO 2. Distinguish between upwelling and non-upwelling regions by evaluating temperature, salinity and density sections.		PSO1, PSO 2	
	CO 3. Interpret vertical sections of temperature, salinity, and density and to interpret the underlying oceanographic processes across a transect.		PSO1, PSO 2	
	CO 4. Estimate and analyse the ocean heat content across the ocean.		PSO1, PSO 2	
Content:		**No of**	**Mapped**	**Cognitive**

		hours	to CO	Level
Module 1:	1. Analysis of vertical profiles of temperature, salinity and density to understand the physical processes at low, mid and high latitudes of the world ocean. 2. Distinguish variation in properties of upwelling and non-upwelling periods/ regions using a) temperature, b) salinity and c) density. 3. Vertical section of temperature to study the physical processes along a transect. 4. Vertical section of salinity to study the physical processes along a transect. 5. Vertical section of density to study the physical processes along a transect. 6. Estimation and analysis of heat content in different parts of World Ocean.	30	CO1, CO2, CO3, CO4	K4, K5, K2,
Pedagogy:	Tutorials/ assignments/ practical/ field study			
References/ Readings:	1. Wright, J., & Colling, A. (1995). Seawater: its composition, properties, and behavior (Second Edition). Pergamon Press, in association with the Open University, Milton Keynes 2. Stewart, R. H. (2008). Introduction to physical oceanography. Robert H. Stewart. https://open.umn.edu/opentextbooks/textbook s/20 3. Colling, A. (2001). Ocean circulation (Second Edition) (Vol. 3). Butterworth-Heinemann in association with The Open University, Milton Keynes 4. Tomczak, M., & Godfrey, J. S. (2004). Regional Oceanography: an Introduction. Online edition. https://www.geo.uni- bremen.de/~apau/dynamicclimate/course_materials_2015/Resources/tomczak_godfrey_1994.pdf 5. Fofonoff, N. P., & Millard Jr., R. C. (1983). Algorithms for the computation of fundamental properties of seawater. UNESCO Technical Papers in Marine Science 44, Endorsed by UNESCO/SCOR/ICES/IAPSO/ Joint Panel on Oceanographic Tables and Standards and SCOR Working Group 51; Place de Fontenoy, Paris, France: UNESCO. d.o.i.: https://doi.org/10.25607/OBP-1450			
Web Resources:	1. https://open.umn.edu/opentextbooks/textbook s/20 2. https://www.geo.uni-bremen.de/~apau/dynamicclimate/course_materials_2015/Resources/tomczak_godfrey_1994.pdf 3. https://doi.org/10.25607/OBP-1450			

Title of the Course	Marine Chemistry
Course Code	MSC-5002
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To learn the basic concepts of the chemistry of the marine environment that concerns the study of the properties and interactions of the substances	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Describe the properties and interactions of the chemical substances present in the marine environment.	PSO 3
	CO 2. Evaluate the factors influencing the distribution of trace elements in seawater.	PSO 3
	CO 3. Analyse the influence of temperature, salinity and pressure on the solubility of gases in seawater	PSO 3
	CO 4. Examine the mechanisms of air-sea interactions.	PSO 3

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Symbols and units used in chemical oceanography – Major and minor elements in seawater – Geochemical balance of the oceans – Goldschmidt material balance – cycle of cationic and anionic species in the lithosphere, atmosphere, hydrosphere and biosphere systems, residence time of the elements in the ocean, chemical speciation in seawater – Dissolved species – Particulate species – Activity coefficient – Hydration of ion in seawater.	**15**	CO1	K2
Module 2:	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, interaction of trace elements with marine organisms, enrichment factor, vertical distribution of trace elements in the ocean, Chlorinity and salinity: definition and significance, practical salinity scale, Radioactive nuclides in the sea.	**15**	CO2	K5
Module 3:	Dissolved gases in seawater – Basic concepts: effect of pressure, salinity, temperature on solubility of gases in seawater, air – sea gas exchange, processes affecting their distribution, dissolved oxygen in the ocean – Dissolved gases (CO_2) in seawater – Carbon dioxide equilibria in seawater; pH, Total, carbonate and Borate alkalinity, and buffering capacity of oceans: components of CO_2 system in seawater – Percentage composition of inorganic carbon; calcium carbonate precipitation and dissolution phenomena – Lysocline and carbonate compensation depth.	**15**	CO3, CO4	K4, K3
Pedagogy	Lectures/ tutorials/ assignments/ self-study			
References/ Readings:	1. Blasco, J., & Tovar-Sánchez, A. (2022). Marine Analytical Chemistry. Springer, Switzerland AG. 2. Pilson, M. E. Q. (2013). An Introduction to the Chemistry of the Sea. Cambridge University Press, New York. 3. Satyanarayana, D., & Sarma, V. V. S. S. (2018). Handbook of Marine Chemistry. Daya Publishing House, New Delhi. 4. Turekian, K. K. (2010). Marine Chemistry and Geochemistry. Academic Press, London. 5. Millero, F. J. (2005). Chemical Oceanography. CRC Press, Boca Raton. 6. Fasham, M. J. R. (2003). Ocean Biogeochemistry: The role of the ocean carbon cycle in Global change. Springer,			

	Berlin. 7. Wright, J., & Colling, A. (2004). Seawater: Its composition, properties & behaviour. Oxford: Butterworth-Heinemann in association with the Open University, England. 8. Riley, J. P., & Chester, R. (1971). Introduction to Marine Chemistry. Academic Press, London. 9. Riley, J. P., & Skirrow, G. (1975). Chemical Oceanography. Academic Press, London. 10. Martin, D. F. (1970). Marine Chemistry. Marcel Dekker, New York.

Title of the Course	Marine Chemistry Practical
Course Code	MSC-5003
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To measure the chemical parameters of seawater.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Perform salinity estimation of seawater using titrimetric methods.	PSO 1, PSO 3
	CO 2. Determine the concentration of dissolved oxygen in seawater using Winkler's Iodometric method.	PSO 1, PSO 3
	CO 3. Measure pH and total alkalinity of seawater using potentiometric methods.	PSO 1, PSO 3
	CO 4. Verify the Beer's law using spectrophotometric techniques.	PSO 1, PSO 3

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Estimation of salinity of seawater by the Mohr- Knudsen chlorinity titration method. 2. Estimation of salinity of seawater by Harvey's method. 3. Determination of dissolved O2 of seawater by Winkler's iodometric titration method. 4. Determination of pH of seawater by potentiometric method using pH meter and determination of total alkalinity of seawater by potentiometric titration using pH meter. 5. Estimation of carbonate and bicarbonate alkalinity by titrimetric method. 6. Spectrophotometry: Verification of Beer's law.	**30**	CO1, CO2, CO3, CO4	K3, K3, K5, K5
Pedagogy	Laboratory experiments/ field studies			
References/ Readings:	1. Aoyama, M., Cheong, C., & Murata, A. (2025). Chemical Reference Materials for Oceanography: History, Production, and Certification. Springer, Singapore. 2. Crompton, T. R. (2006). Analysis of Seawater: A Guide for the Analytical and Environmental Chemist. Springer, Berlin. 3. Kennish, M. J. (2019). Practical Handbook of Marine Science (4th ed). CRC Press, Boca Raton. 4. Grasshoff, K., Ehrhardt, M., & Kremling, K. (1983). Methods of Seawater Analysis. Wiley-vch, Verlag Chemie, Weinheim. 5. Ewing, G. W. (1981). Instrumental Methods of Chemical Analysis. McGraw-Hill, New York. 6. Parsons, T. R., Maita, Y., & Lalli, C. M. (1984). A Manual of Chemical and Biological Methods for Seawater Analysis. Oxford, United Kingdom. 7. Martin, D. F. (1972). Marine Chemistry. Marcel Dekker, New York.			
Web Resources:	https://lamotte.com/amfile/file/download/file/980/product/391/			

Title of the Course	Marine Biology
Course Code	MSC-5004
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To introduce marine life and biological processes that underpin ecosystem function, with emphasis on larval ecology and trophic dynamics in the marine environment.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Describe the history, classification, and major theories of marine biology, including hypotheses on the origin and evolution of life in the ocean.	PSO 5
	CO 2. Determine basic ecological concepts and biotic structures in marine environment.	PSO 5
	CO 3. Elucidate the physiological responses of marine organisms to environmental changes.	PSO 5
	CO 4. Evaluate primary productivity processes in the marine environment.	PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Introduction to marine biology – oceanographic processes, history, classification, theories, expeditions, hypothesis testing; Origin of life – life processes, abio-genesis, theories of natural selection, organic evolution, primordial soup hypothesis, organic molecules, chemical evolution, iron sulfide and black smoker's theory, RNA world hypothesis, theory of evolution and panspermia, Theory of evolution.	**15**	CO1	K2
Module 2:	Basic ecological concepts and marine biotic structure, marine larval ecology, larval types and strategies, and bi-phased life cycle, Deep sea and coastal environment, biological zonation, inter-tidal ecosystem - rocky shore - zonation pattern - physical and biological factors, sandy shores and protected sand flats - physical and biological factors, faunal composition and adaptations.	**15**	CO2	K3
Module 3:	Sea as biological environment - physiological changes, regulators and conformers, scope for growth, temperature and metabolic rates, Production and distribution organic matter, microbial loop, re- mineralization. Primary productivity - mechanism, light and dark reaction, intermediate products, factor affecting primary productivity, role of pigments, methods of assessment, biological pump and transformation of organic matter, vertical profile of primary productivity and Sub-surface Chlorophyll Maxima (SCM), turbulence and Mixed Layer Depth (MLD), Human impact and biological productivity.	**15**	CO3, CO4	K2, K5
Pedagogy	Lectures/ tutorials/ assignments/ self-study			
References/ Readings:	1. Castro, P., & Huber, M. E. (2023). Marine biology (12th ed.). McGraw-Hill Education, New York, NY, USA. 2. Karleskint, G., Turner, R., & Small, J. (2012). Introduction to marine biology (4th ed.). Cengage Learning, Belmont, CA, USA. 3. Lalli, C. M., & Parsons, T. R. (2019). Biological oceanography: An introduction (3rd ed.). Elsevier, Amsterdam, Netherlands. 4. Nair, N. B., & Thampy, D. M. (1980). Textbook of marine ecology. Macmillan, New Delhi, India.			

	5. Thurman, H. V., & Webber, H. H. (1991). Marine biology (2nd ed.). HarperCollins Publishers, New York, NY, USA. 6. Lewis, J. R. (1965). The ecology of rocky coasts. English Universities Press, London, United Kingdom. 7. Price, J. H., Irvine, D. E. G., & Farnham, W. F. (1980). The shore environment (Vols. 1 & 2): Methods and ecosystems. Systematics Association Special Volume. Cambridge University Press, Cambridge, United Kingdom. 8. Barnes, R. S. K., Calow, P. P., Olive, P. J. W., Golding, D. W., & Spicer, J. I. (2001). The invertebrates: A synthesis (3rd ed.). Wiley-Blackwell, Oxford, United Kingdom. 9. Nybakken, J. W., & Bertness, M. D. (2005). Marine biology: An ecological approach (6th ed.). Pearson/Benjamin Cummings, San Francisco, CA, USA.

Title of the Course	Marine Biology Practical			
Course Code	MSC-5005			
Number of Credits	01			
Theory/Practical	Practical			
Level	400			
Effective from AY	2025-2026			
New Course	No			
Bridge Course/ Value added Course	No			
Course for advanced learners	No			

Pre-requisites for the Course:	Nil			
Course Objectives:	To learn the basic concepts of the chemistry of the marine environment that concerns the study of the properties and interactions of the substances			
Course Outcomes:	Student will learn to:		**Mapped to PSO**	
	CO 1. Identify and operate standard oceanographic sampling instruments for water and sediment analysis.		PSO 1, PSO 5	
	CO 2. Design field surveys for the collection and preliminary assessment of marine biological parameters.		PSO 1, PSO 5	
	CO 3. Apply standard methods for the preservation, analysis and storage of aquatic biological communities to carry out their identification.		PSO 1, PSO 5	
	CO 4. Perform quantitative and qualitative assessment of plankton and benthic invertebrates.		PSO 1, PSO 5	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	1. Introduction to standard sampling devices / instruments employed for collection and analysis of biological parameters in water and sediments used in oceanographic studies. 2. Design and execution of field / sampling surveys for collection of water and sediment samples. 3. Analysis of biological communities (water and sediment), their preservation and storage techniques using standard methods. 4. Quantitative estimation & identification of phytoplankton in seawater. 5. Quantitative estimation of zooplankton using volume displacement, wet weight and dry weight method. 6. Qualitative estimation of zooplankton using stereoscopic microscope. 7. Quantitative and qualitative estimation of benthic invertebrates.	**30**	CO1, CO2, CO3, CO4	K1, K6, K3 K3
Pedagogy	Demonstrations/ practical/ designing of experiments/ identification techniques			
References/ Readings:	1. Barnes, R. D. (1980). Invertebrate zoology (4th ed.). Saunders College, Philadelphia, PA, USA. 2. Day, J. H. (1967). A monograph on the Polychaeta of Southern Africa. Natural History Museum Publications, London, United Kingdom. 3. Goswami, S. C. (2004). Zooplankton methodology, collection and identification: A field manual. National Institute of Oceanography, Goa, India. 4. Lyla, P. S., Velvizhi, S., & Ajmal Khan, S. (1999). A monograph on the amphipods of Parangipettai coast. Annamalai University, Parangipettai, Tamil Nadu, India. 5. Steele, J. H., Thorpe, S. A., & Turekian, K. K. (2010). Marine ecological processes: A derivative of Encyclopedia of Ocean Sciences (2nd ed.). Academic Press, Burlington, MA, USA. 6. Tagliapietra, D., & Sigovini, M. (2010). Benthic fauna: Collection and identification of macro-benthic invertebrates. In J. Dominik et al. (Eds.), Terre et Environnement, 88, 253–261. Université de Genève, Section des Sciences de la Terre. 7. Verlecar, X. N., & Desai, S. R. (2004). Phytoplankton identification manual. National Institute of Oceanography, Goa, India.			
Web Resources:	Intergovernmental Oceanographic Commission (1994). Protocols for the Joint Global Ocean Flux Study (JGOFS) core measurements (Manuals and Guides No. 29; JGOFS Report No. 19). UNESCO. https://doi.org/10.25607/OBP-1409			

Title of the Course	Marine Geology
Course Code	MSC-5006
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	To provide a basic understanding of ocean basins, sediment processes, marine resources, and fossil use in paleoclimate and monsoon studies.			
Course Outcomes:	Student will learn to:		**Mapped to PSO**	
	CO 1. Discuss the origin, structure, and evolution of the Earth and ocean basins in relation to geological time and plate tectonic processes		PSO 4	
	CO 2. Analyse the composition and distribution of sediments of near-shore areas.		PSO 4	
	CO 3. Appraise with techniques in sedimentology and data interpretation.		PSO 4	
	CO 4. Reconstruct paleo-environment using micro fossils		PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	The solar system and the Earth- origin - Internal structure - Geological time scale	**15**	CO1	K2

	– Origin of ocean basins: Pacific, Atlantic and Indian – Continental drift, seafloor spreading and plate tectonics – Evolution of the Indian ocean –Morphology and structure of continental margins, mid oceanic ridges and seafloor.			
Module 2:	Sediment, sediment grade scale and analysis – Classification, composition, distribution and source of sediments with emphasis on near shore areas – Surveying, sampling and laboratory techniques for the study of coastal and estuarine sediments – Analysis of sedimentological data and interpretation – Instruments used in marine geology. Beach and beach profile, variations in beach morphology and its significance – Near shore geological processes: erosion, transportation and deposition.	**15**	CO2, CO3	K4, K5
Module 3:	Seabed minerals with emphasis on Indian ocean – Polymetallic nodules, phosphorites, carbonates, placer deposits and petroleum resources, gas hydrates – Fossilization process – Types of microfossils and classification, technique for paleoclimate reconstruction with respect to oxygen isotope studies, role of microfossils in paleoceanography, paleoclimate, marine archaeology, petroleum exploration, monitoring marine pollution and its mitigation.	**15**	CO4	K6
Pedagogy	Lectures / Assignments / Seminars / Discussion			
References/ Readings:	1. Dyer, K. R. (1986). Coastal and estuarine sediment dynamics. Chichester: Wiley. 2. Haq, Bilal U. & Milliman, John D. (1984). Marine geology and oceanography of Arabian Sea and coastal Pakistan. Van Nostrand Reinhold/Scientific and Academic Editions, New York. 3. Kennett, J. P. (1982). Marine geology. Prentice Hall INC Englewood, Cliffs, N. J. 4. Komar, P. D. (1976). Beach processes and sedimentation. Prentice-Hall, Englewood Cliffs, N.J. 5. Hemleben, C., Spindler, M., & Anderson, O. R. (2012). Modern planktonic foraminifera. Springer Science & Business Media, New York. 6. Teleki, P. G., Dobson, M. R., Moore, J. R., & von Stackelberg, U. (Eds.). (2012). Marine minerals: advances in research and resource assessment. D. Reidel publishing company, Dordrecht, Holland. 7. Thurman, H. V., & Trujillo, A. P. (2004). Introductory oceanography. Pearson Prentice Hall, Upper Saddle River, N.J.			

Title of the Course	Marine Geology Practical
Course Code	MSC-5007
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	To introduce techniques to measure parameters to understand near-shore and beach dynamics, bathymetry and heavy minerals.			
Course Outcomes:	Student will learn to:		**Mapped to PSO**	
	CO 1. Apply field survey techniques, including the use of compass and GPS, and construct beach profiles.		PSO 1, PSO 4	
	CO 2. Determine heavy mineral composition in coastal sediment.		PSO 1, PSO 4	
	CO 3. Use bathymetric data to determine geomorphology.		PSO 1, PSO 4	
	CO 4. Identify and evaluate applications of microfossils in paleo studies.		PSO 1, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. Field survey - locating a station using compass, GPS and plotting it; Collection of samples from different parts of the beach and constructing a beach profile,	**30**	CO1, CO2,	K3, K3, K5, K1

	volume computation. 2. Selection of representative samples, pre-treatment of sediment sample to remove calcium carbonate, organic matter and ferruginous material. 3. Grain size analysis of marine sediments. 4. Computation of weight and cumulative percentages, plotting frequency and probability graphs, computation of modes of transport and grain size parameters and their interpretation. 5. Heavy mineral separation from different fractions of sand and their interpretation. 6. Plot bathymetry lines and interpret geomorphology. 7. Identification of microfossils under binocular microscope and its applications in paleoclimate.		CO3, CO4	
Pedagogy	Field surveys and sampling / Laboratory experiments / Computations / Plotting and interpretations			
References/ Readings:	1. Friedman, G. M., & Johnson, K. G. (1982). Exercises in sedimentology. Wiley, New York. 2. Dionne, J.C. (1978). Komar, P.D. (1976). Beach Processes and Sedimentation. Prentice-Hall, Englewood Cliffs, New Jersey. 3. Babu, S. K. & Sinha, D. K. (1987): Sedimentary Petrology Practical. CBS Pub., N. Delhi. 4. Mero, J. L. (1965). The mineral resources of the sea. Elsevier Pub. Co, Amsterdam. 5. Saraswati, P. K., & Srinivasan, M. S. (2015). Micropaleontology: Principles and applications. Springer, Switzerland. 6. Jones, E J. W. (1999). Marine Geophysics. Wiley, Chichester. 7. Lindholm, R. (2012). A practical approach to sedimentology. Springer Science & Business Media.			

Discipline Specific Elective Courses

Title of the Course	Ocean-Atmosphere Coupling and Climate
Course Code	MSC-5201
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	To learn exchange of mass and energy across air-sea interface and its role in global climate.			
Course Outcomes:	Student will learn to:		**Mapped to PSO**	
	CO 1. Describe exchange of momentum and ocean heat flux influencing climate change.		PSO 2	
	CO 2. Examine the process of generation of winds, formation of waves and growth and decay of ENSO.		PSO 2	
	CO 3. Analyse the variability and dynamics of air sea fluxes.		PSO 2	
	CO 4. Evaluate wind field structure within maritime frictional layer.		PSO 2	
Content:		**No of**	**Mapped**	**Cognitive**

		hours	to CO	Level
Module 1:	Wind generation, forces acting on wind, wind stress, Methods of estimation of wind stress, drag coefficient – Geostrophic winds, cyclostrophic winds, thermal winds – Wind wave generation – Scales of interactions, General character of sea surface as a lower boundary of air flow – Geometry of the sea surface: Gravity waves, Wavelets and ripples, Sea-surface slopes, Slicks on the sea surface – Wind streaks, Periodic bands, Intermittent rippling, Non-periodic slicks – Instruments used in marine meteorology	**15**	CO2	K3
Module 2:	The wind field in the maritime frictional layer in thermal indifferent conditions: Observational challenges, Theoretical considerations, Simplifying conditions, Hydrodynamic analogy – Austausch coefficient – Dynamic roughness – Measured wind profiles – General consideration of air-sea interaction – Planetary boundary layer – Laminar boundary layer, surface layer and Ekman layer	**15**	CO4	K5
Module 3:	Determination of air-sea fluxes – Profile method and non-profile methods – Variation of air-sea fluxes with special reference to upwelling – Indian Summer Monsoons: causes, inter-annual and intra-seasonal variability, Monsoon trough, Low-Level Jet (LLJ), Tibetan Low, Mascarenhas High, tropical easterly jet (T.E.J.), Madden-Julian Oscillation (M.J.O.), Relationship of El Niño, La Niña and Indian Ocean Dipole (I.O.D.) in Indian Monsoon. Concepts in climatology – Radiation and its role on tropical circulation – Role of ocean heat fluxes in influencing climate change.	**15**	CO1, CO3	K2, K4
Pedagogy	Lectures/ tutorials/ assignments			
References/ Readings:	1. Rohli, R.V., Vega, A.J., Hendersen, K.G. (2024). Atmospheric and Oceanic circulation: An explanation of Earth's Climate Pattern. Springer Nature Switzerland. 2. Nakamura, H., Isobe, A., Minobe, S., Mitsudera, H., Nonaka, M., & Suga, T. (2016). Hot Spots in the Climate System: New Developments in the Extratropical Ocean- Atmosphere Interaction Research. Springer Japan. d.o.i.: https://doi.org/10.1007/978-4-431-56053-1 3. Bortkovskii, R. S. (1987). Air-Sea Exchange of Heat and Moisture During Storms. Revised English edition by Edward C. Monahan. Springer Netherlands.			

	4. Roll, H. U. (1965). Physics of the marine atmosphere. International Geophysics Series, Vol. 7. [Ed.] J. van Miegham. Academic Press, New York and London. 5. Asnani, G. C. (1993). Tropical meteorology (Volume 1). Asnani, Indian Inst. of Tropical Meteorology, Pune, India. 6. Asnani, G. C. (1993). Tropical meteorology (Volume 2). Asnani, Indian Inst. of Tropical Meteorology, Pune, India. 7. Keshavamurthy, R. N., & Rao, M. S. (1992). The physics of monsoons. Allied Publishers Limited, New Delhi, Bombay, Calcutta, Madras, Nagpur, Ahmedabad, Bangalore, Hyderabad, Lucknow. 8. Pörtner, H.-O., Roberts, D. C., Tignor, M., Poloczanska, E. S., Mintenbeck, K., Alegría, A., Craig, M., Langsdorf, S., Löschke, S., Möller, V., Okem, A., Rama, B. (2022). Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. In Press. https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/ 9. Wallace, J. M., & Hobbs, P. V. (2006). Atmospheric science: an introductory survey (Second Edition). Academic Press, Canada 10. Wells, N. C. (2012). The atmosphere and ocean: a physical introduction. Wiley-Blackwell, Chichester, West-Sussex, UK.
Web Resources:	1. https://doi.org/10.1007/978-4-431-56053-1 2. https://www.ipcc.ch/report/sixth-assessment-report- working-group-ii/

Title of the Course	Ocean-Atmosphere Coupling and Climate Practical
Course Code	MSC-5202
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To analyse air-sea fluxes associated with different oceanic- atmospheric processes in the different parts of the world ocean.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Assemble extracted data from global datasets.	PSO 1, PSO 2
	CO 2. Analyse the distribution and variation of shortwave and longwave radiation from the extracted global data sets.	PSO 1, PSO 2
	CO 3. Interpret the distribution of the sensible and latent heat flux.	PSO 1, PSO 2
	CO 4. Compute the net heat flux and analyse its distribution.	PSO 1, PSO 2

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Data extraction from global data sets of shortwave radiation and analysis of its distribution/variation. 2. Data extraction from global data sets of long wave radiation and analysis of its distribution. 3. Data extraction from global data sets of sensible heat flux and analysis of its distribution. 4. Data extraction from global data sets of latent heat flux and analysis of its distribution. 5. Estimation of net heat flux from above extracted data sets and analysis of its distribution.	**30**	CO1, CO2, CO3, CO4	K2, K3, K4, K6
Pedagogy	Tutorials/ assignments/ practical			
References/ Readings:	1. Roll, H. U. (1965). Physics of the marine atmosphere. International Geophysics Series, Vol. 7. [Ed.] J. van Miegham. Academic Press, New York and London. 2. Pörtner, H.-O., Roberts, D. C., Tignor, M., Poloczanska, E. S., Mintenbeck, K., Alegría, A., Craig, M., Langsdorf, S., Löschke, S., Möller, V., Okem, A., Rama, B. (2022). Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. In Press. https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/ 3. da Silva, A. M., Young, C. C., & Levitus, S. (1994). Atlas of surface marine data 1994, Vol. 1: Algorithms and procedures. NOAA Atlas NESDIS, 6. Department of Commerce, Washington, D.C., USA. 4. Berry, D. I., & Kent, E. C. (2011). Air–sea fluxes from ICOADS: The construction of a new gridded dataset with uncertainty estimates. International Journal of Climatology, 31(7), 987–1001. d.o.i.: 10.1002/joc.2059. https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/joc.2059 5. Asnani, G. C. (1993). Tropical meteorology (Volume 1). Asnani, Indian Inst. of Tropical Meteorology, Pune, India. 6. Asnani, G. C. (1993). Tropical meteorology (Volume 2). Asnani, Indian Inst. of Tropical Meteorology, Pune, India. 7. Wells, N. C. (2012). The atmosphere and ocean: a physical introduction. Wiley-Blackwell, Chichester, West-			

	Sussex, UK. 8. Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S. L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M. I., Huang, M., Leitzell, K., Lonnoy, E., Matthews, J. B. R., Maycock, T.K., Waterfield, T., Yelekçi, O., Yu, R., & Zhou, B. (2021). IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. https://www.ipcc.ch/report/sixth-assessment-report- working-group-i/ 9. Rohli, R.V., Vega, A.J., Hendersen, K.G. (2024). Atmospheric and Oceanic circulation: An explanation of Earth's Climate Pattern. Springer Nature Switzerland 10. Shukla, P. R., Skea, J., Slade, R., Al Khourdajie, A., van Diemen, R., McCollum, D., Pathak, M., Some, S., Vyas, P., Fradera, R., Belkacemi, M., Hasija, A., Lisboa, G., Luz, S., & Malley, J. (2022). IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, NY, USA: Cambridge University Press. doi: 10.1017/9781009157926 https://www.ipcc.ch/report/sixth-assessment-report- working-group-3/ 11. Houghton, J. T., Meira Filho, L. G., Callander, B. A., Harris, N., Kattenberg, A., & Maskell, K. (1996). Climate change 1995: The science of climate change: contribution of working group I to the second assessment report
Web Resources:	1. https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/joc.2059 2. https://www.ipcc.ch/report/sixth-assessment-report- working-group-i/ 3. https://www.ipcc.ch/report/sixth-assessment-report- working-group-3/ 4. https://digitallibrary.un.org/record/223181?ln=en

Title of the Course	Marine Geochemistry
Course Code	MSC-5203
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To introduce concepts of Marine Geochemistry to understand processes associated with energy and material transfer from land to sea.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Classify the geochemical elements in the lithosphere.	PSO 3
	CO 2. Determine the role of physico-chemical factors in sedimentation.	PSO 3
	CO 3. Summarize the dynamics of dissolved organic matter and to assess the role of radionuclides in marine geochronology.	PSO 3
	CO 4. Explain the role of electro-kinetic phenomena and surface chemistry in trace metal partitioning.	PSO 3

	CO 5. Differentiate between the colloidal processes and adsorption mechanisms at the solid-solution interface.		PSO 3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Geochemical classification of elements - distribution and abundance of elements in lithosphere – Principle geochemical cycle, Chemical weathering. Suspended matter – Methods of collection and analysis, variation, composition of total suspended particulate matter in the ocean - settling rates of suspended matter - Physico-chemical factors in sedimentation - ionic potential, hydrogen ion concentration, redox potential and colloids – Behavior of major and trace elements during sedimentation - Geochemistry of deep-sea sediments – Application of major and minor elements in the reconstruction of marine paleo- environment.	**15**	CO1, CO2	K2, K3
Module 2:	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**	CO3	K5
Module 3:	The solid-solution interface – Electro-kinetic phenomena, The electrical double layer, the structure of water at the solid solution interface, surface chemistry of oxides, hydroxides and oxide minerals; the colloidal state, origin of surface charge, aggregation of colloids, the role of coagulation in natural waters – Surface phenomena – Langmuir and Freundlich Adsorption isotherms, trace metal partitioning on solid-solution phases, particle concentration effects.	**15**	CO4, CO5	K2, K4
Pedagogy	Lectures / Assignments / Seminars / Discussion			
References/ Readings:	1. Emerson, S. R., & Hamme, R. C. (2022). Chemical Oceanography: Element Fluxes in the Sea. Cambridge University Press, New York 2. Chester, R., & Jickells, T. D. (2012). Marine Geochemistry (3rd ed.). Wiley-Blackwell, United Kingdom.			

	3. Millero, F. J. (2013). Chemical Oceanography (4th ed.). CRC Press, Boca Raton 4. Harff, J., Meschede, M., Petersen, S., & Thiede, J. (Eds.). (2016). Encyclopedia of Marine Geosciences. Springer, Dordrech. 5. Roy-Barman, M., & Jeandel, C. (2016). Marine Geochemistry: Ocean Circulation, Carbon Cycle and Climate Change. Oxford University Press, Oxford. 6. Krauskopf, K. B. (1967). Introduction to Geochemistry. McGraw-Hill, New York. 7. Riley, J. P., & Skirrow, G. (1975). Chemical Oceanography. Academic Press, London 8. Burton, J. D., & Liss, P. S. (1976). Estuarine Chemistry. Academic Press, New York and London. 9. Krauskopf, K. B., & Bird, D. K. (1995). Introduction to Geochemistry. McGraw-Hill, New York 10. Schulz, H. D., & Zabel, M. (Eds.). (2006). Marine Geochemistry (2nd ed.). Springer, New York

Title of the Course	Marine Geochemistry Practical
Course Code	MSC-5204
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	To determine the chemical composition of the Earth and the principles regulating elemental distribution.			
Course Outcomes:	Student will learn to:		**Mapped to PSO**	
	CO 1. Perform titrimetric analysis to determine organic carbon content in sediment samples.		PSO 1, PSO 3	
	CO 2. Estimate phosphorus concentration in sediments using standard analytical techniques.		PSO 1, PSO 3	
	CO 3. Execute acid digestion of sediments for elemental analysis.		PSO 1, PSO 3	
	CO 4. Measure concentrations of elements in sediments.		PSO 1, PSO 3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. Determination of organic carbon in sediment by titrimetric method.	**30**	CO1,	K3, K4,

	2. Determination of phosphorus in sediment. 3. Digestion of sediment using HF: HNO_3:$HClO_4$ acid mixture. 4. Estimation of concentration of Cu in sediment. 5. Estimation of concentration of Zn in sediment.		CO2, CO3, CO4	K3, K5
Pedagogy	Demonstrations/ Laboratory experiments			
References/ Readings:	1. Rice, E. W., & Bridgewater, L. (2012). Standard Methods for the Examination of Water and Waste Water Analysis. Washington DC: American Public Health Association. 2. Millero, F. J. (2013). Chemical Oceanography (4th ed.). CRC Press, Boca Raton. 3. Kennish, M. J. (2019). Practical Handbook of Marine Science (4th ed.). CRC Press, Boca Raton 4. Riley, J. P., & Skirrow, G. (1975). Chemical Oceanography. Academic Press, London 5. Parsons, T. R., Maita, Y., & Lalli, C. M. (1984). A Manual of Chemical and Biological Methods for Seawater Analysis. Oxford, United Kingdom 6. Loring, D. H., & Rantala, R. T. (1992). Manual for Geochemical Analysis of Marine Sediments and Suspended Particulate Matter. Earth Science Reviews, 32, 235-283. 7. Grasshoff, K., Ehrhardt, M., & Kremling, K. (1999). Methods of Seawater Analysis. Verlag Chemie, Weinheim.			

Title of the Course	Marine Ecology
Course Code	MSC-5205
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To learn the concepts related to marine habitats and their role in ecosystem function.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Evaluate marine ecosystem structures and functions, analyze key ecological processes, and explain adaptations and environmental influences on deep-sea and polar marine communities.	PSO 5
	CO 2. Describe hydrothermal and cold seep ecosystems and evaluate microbial roles in marine food webs and nutrient cycling.	PSO 5
	CO 3. Analyze the causes and impacts of HABs, associated ecological interactions, toxin production, and control strategies in marine environments.	PSO 5
	CO 4. Describe fouling communities, assess impacts of bio-invasions, and evaluate benthic	PSO 5

	metabolism and sediment ecology.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Marine ecosystems – pelagic and benthic, indiscriminate predation and area hypothesis, bio-turbation and turbidity currents, Deep sea biology – scheme of zonation, sampling, constraints, environmental factors, OMZ and food sources, adaptations, reproductive strategy, bioluminescence, night vision and mechanism of production, benthic community structure, diversity, hypothesis, Polar seas - physical and biological factors, sea ice communities, microbial food web, soft sediment communities, Hydrothermal vents and cold seep communities, deep sea sulfide metabolism, symbiotic associations, food web – vent communities, Marine food webs – role of pico and nano plankton, viruses and host specific interactions, nutrient dynamics, bacteria, heterotrophic flagellates, protozoans and their role in trophic transfer.	**15**	CO1, CO2	K5, K2
Module 2:	Harmful Algal Blooms (HAB), major outbreaks, concern, oceanographic and ecological systems with HAB, effects and losses, HAB phenomena – oceanographic processes, population dynamics, adaptations, life history strategies, mixo-trophy and life cycle, behavioral and morphological adaptations, bio- toxin production, physical, chemical and biological interactions, impact of HAB, brevetoxins, causative species, bloom initiation, formation, propagation, decomposition, prevention - alterations in nutrient input, fresh water flow, circulation, restriction of introductions, and control – Chemical, biological, flocculants, role of zooplankton, viruses, parasites, bacteria.	**15**	CO3	K4
Module 3:	Fouling communities – biofilm, chemistry, EPS, quorum sensing, dispersal and adhesion mechanism in *Enteromorpha* and barnacle and fouling control, Introduces species - human caused global changes, invasions and extinctions, human health , and bio- invasion - anthropogenic input, range extensions, effect on life cycle and fish mortality, Benthic metabolism - benthic autotrophic processes, photochemical reactions, nutrient leaching, benthic production and vertical stratification, chemical composition of sediments, predators in sediment	**15**	CO4	K2

	communities.			
Pedagogy	Lectures / Assignments / Seminars / Discussion			
References/ Readings:	1. Dipper, F., & Tait, R. V. (1998). Elements of marine ecology (4th ed.). Elsevier, Jordan Hill, Oxford, UK 2. Kaiser, M. J., Attrill, M. J., Jennings, S., & Thomas, D. N. (Eds.). (2020). Marine ecology: Processes, systems, and impacts (3rd ed.). Oxford University Press, 198 Madison Avenue, New York, USA. 3. Lalli, C. M., & Parsons, T. R. (2019). Biological oceanography: An introduction (3rd ed.). Elsevier, Amsterdam, Netherlands. 4. Levinton, J. S. (2001). Marine biology: Function, biodiversity, ecology (2nd ed.). Oxford University Press, Oxford, New York 5. Mann, K. H., & Lazier, J. R. N. (2005). Dynamics of marine ecosystems: Biological-physical interactions in the oceans (3rd ed.). Wiley-Blackwell, Maldan, MA. 6. Nybakken, J. W., & Bertness, M. D. (2005). Marine biology: An ecological approach (6th ed.). Pearson/Benjamin Cummings, San Francisco. 7. Parsons, T. R., Takahashi, M., & Hargrave, B. (2013). Biological oceanographic processes (4th ed.). Elsevier, Oxford, England. 8. Raymont, J. E. G. (1980). Plankton and productivity in the oceans: Volume 1: Phytoplankton (2nd ed.). Elsevier, Oxford, England. 9. Raymont, J. E. G. (1983). Plankton and productivity in the oceans: Volume 2: Zooplankton (2nd ed.). Pergamon Press, Oxford, England. 10. Valiela, I. (1995). Marine ecological processes (2nd ed.). Springer-Verlagz, New York.			

Title of the Course	Marine Ecology Practical
Course Code	MSC-5206
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To elucidate the methods of estimating water quality/ environmental parameters and the use of different techniques to address various issues in Marine Ecology	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Estimate primary production using the light and dark bottle method.	PSO 1, PSO 5
	CO 2. Quantify chlorophyll and phaeo-pigments in seawater using spectrophotometric techniques.	PSO 1, PSO 5
	CO 3. Estimate total organic carbon in seawater and sediment.	PSO 1, PSO 5
	CO 4. Compute species diversity indices to analyze plankton data for ecological assessments.	PSO 1, PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Estimation of primary production by using light and dark bottle method. 2. Estimation of chlorophyll and phaeo-pigments in seawater sample using a Spectrophotometric method. 3. Estimation of total organic carbon in seawater and/or sediment samples. 4. Designing of an experimental set-up to study uptake of oxygen by fish in the laboratory. 5. Computation of species diversity (H', J and D) indices using the data of phytoplankton/ zooplankton analysis and their implications in ecological studies.	**30**	CO1, CO2, CO3, CO4	K2, K3, K2, K3
Pedagogy	Laboratory techniques, designing of experiments, computations and data interpretation.			
References/ Readings:	1. Aminot, A., & Rey, F. (2001). Chlorophyll a: Determination by spectroscopic methods (pp. 17 pp). ICES Techniques in Marine Environmental Sciences. No. 30, Copenhagen, Denmark. 2. Begon, M., Mortimer, M., & Thompson, D.J. (1996). Population ecology: A unified study of animals and plants (3rd ed.). Wiley-Blackwell, Malden, MA. 3. Bolduc, M., Lamarre, S., & Rioux, P. (2002). A simple and inexpensive apparatus for measuring fish metabolism. Advances in Physiology Education, 26(2), 129–132, Bethesda, MD, USA. 4. Dickson, A.G., Sabine, C.L., & Christian, J.R. (Eds.). (2007). Guide to best practices for ocean CO_2 measurements. PICES Special Publication 3; IOCCP Report 8. 5. El Wakeel, S.K., Riley, J.P. (1957). Determination of organic carbon in the marine muds. Journal Du Conseil Intrenational Pour L'exploration De La Mer, 22, 180–183. 6. Selvaraj, G.S.D. (2005). Estimation of primary productivity (modified light and dark bottle oxygen method). In G.J. Parayannilam (Ed.), Mangrove ecosystems: A manual for the assessment of biodiversity (pp. 199–200). CMFRI Special Publication No. 83, Kochi, India.			

Title of the Course	Principles of Mineralogy and Geochemistry
Course Code	MSC-5207
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	To learn the principles of crystal chemistry, mineralogy and geochemistry.			
Course Outcomes:	Student will learn to:		**Mapped to PSO**	
	CO 1. Examine crystal structures and phase diagrams to assess mineral stability.		PSO 4	
	CO 2. Classify different minerals and their evolution.		PSO 4	
	CO 3. Evaluate the distribution of elements in different rock types.		PSO 4	
	CO 4. Distinguish meteorites on the basis of origin and composition.		PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Crystal chemistry: Ionic radii, co-ordination of ions, Pauling's Rules, different types of chemical bonding, crystal growth, crystal defects, external and internal symmetry, XRD: powder and single crystal diffraction. Twinning, Polymorphism	**15**	CO1	K3

	and pseudomorphism. Mineral stability and phase diagram, two component eutectic systems, incongruent melting, solid solution system, exsolution.			
Module 2:	Classification of minerals, Physical and Chemical properties of minerals, Composition, structure, Chemistry and paragenesis of the mineral groups: Olivine, Pyroxene, Amphibole, Mica, Feldspar, clays, Garnet, Sulphide, Sulphate, Carbonate and Oxides. Optical mineralogy: Study of isotropic and anisotropic minerals under convergent light. Working principles of XRD, ICPMS, SEM.	**15**	CO2	K2
Module 3:	Introduction to geochemistry, elements: origin, abundance of elements in the solar system and earth. Geochemical classification of elements. Distribution and behaviour of major, trace elements and REE in igneous, sedimentary and metamorphic processes and products. Introduction to isotope geochemistry: Elements of nuclear systematics, introduction to isotopes and their properties. Introduction to Meteorites, origin, composition, classification and mineral constituents of meteorites	**15**	CO3, CO4	K5, K4
Pedagogy	Lectures/ tutorials/assignments/field study/discussion			
References/ Readings:	1. Deer, W. A., Howie, R. A., & Zussman, J. (2013). An introduction to the rock-forming minerals. 3rd ed. Berforts Information Press, UK. 2. Klein, C., Hurlbut, C. S., and Dana, J. D. (1999). Manual of mineralogy: (after James D. Dana). J. Wiley, New York. 3. Winchell, A. N. (1991). Elements of optical mineralogy: An introduction to microscopic petrography. Wiley, New York. 4. Nesse W. (2012). Introduction to Optical Mineralogy. 4th ed. Oxford University Press, New York. 5. Mason B., and Moore C.B. (1982). Principles of geochemistry. 4th ed. John Wiley, Chichester. 6. Krauskopf, K. B., and Bird, D. K. (1995). Introduction to geochemistry. McGraw-Hill, New York. 7. Klein, C., and Dutrow, B. (2007). Manual of mineral science. John Wiley and sons ltd, New York 8. Walther, J. V. (2009). Essentials of geochemistry. Jones and Bartlett Publishers, Sudbury, Massachusetts. 9. White, W. M. (2014). Isotope Geochemistry. Wiley, Hoboken.			

Title of the Course	Principles of Mineralogy and Geochemistry Practical
Course Code	MSC-5208
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	To develop skills in analysing mineral properties, chemical constituents and solving numerical problems.			
Course Outcomes:	Student will learn to:		**Mapped to PSO**	
	CO 1. Identify minerals in hand specimen.		PSO 1, PSO 4	
	CO 2. Interpret minerals using optical properties.		PSO 1, PSO 4	
	CO 3. Analyse chemical constituents in rocks using instrumentational methods.		PSO 1, PSO 4	
	CO 4. Determine isotopic ratio in rocks.		PSO 1, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. Observing and recording properties of representative minerals in hand	**30**	CO1,	K1,

	specimens. 2. Observation and recording of optical properties of rock forming minerals. 3. Determination of different chemical constituents in water/soil/rock using spectrophotometer. Reading of plots/graphs. 4. Numerical problems on partition coefficient, calculation of isotope ratios.		CO2, CO3, CO4	K2, K4, K3
Pedagogy	Megascopic and microscopic identification of minerals/Demonstrations/Laboratory experiments/Plotting and Interpretations.			
References/ Readings:	1. Mackenzie, W. S. (2015). Atlas of the rock-forming minerals in thin section. Routledge, London. 2. Barker, A. J. (2017). A key for identification of rock-forming minerals in thin section. CRC Press, London. 3. Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals. 2nd ed. Longman Scientific and Technical, Harlow, Essex, England. New York. 4. Khandpur, R. S. (2006). Handbook of analytical instruments. McGraw-Hill Education LL, New York. 5. Griffith, J. C., 1967, Scientific Methods in Analysis of Sediments: McGraw-Hill, New York. 6. Walther, J. V. (2009). Essentials of geochemistry. Jones and Bartlett Publishers, Sudbury, Mass. 7. White, W. M. (2014). Isotope Geochemistry. Wiley, Hoboken.			

SEMESTER II

Discipline Specific Elective Courses

Title of the Course	Estuarine and Coastal Physical Oceanography
Course Code	MSC-5008
Number of Credits	03
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To study oceanic and atmospheric systems, with emphasis on estuaries, waves, cyclones, climate impacts, and observational tools.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Categorise and explain types of estuaries and estuary-related processes.	PSO 2
	CO 2. Differentiate types of oceanic waves and currents.	PSO 2
	CO 3. Illustrate and explain tropical cyclones and related aspects.	PSO 2

	CO 4. Describe and explain physical oceanographic and atmospheric instruments and also research vessels.		PSO 2	
	CO 5. Describe and discuss *khazan* lands and processes in lakes.		PSO 2	
	CO 6. Evaluate Global Warming, sea level change, its impacts and mitigation measures.		PSO 2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Definition of estuaries – Physical characteristics of estuaries – Classification on the basis of fluid dynamics principles – Tides and tidal currents in estuaries – Tide-producing forces – tidal analysis and prediction – Salinity intrusion – Estuarine circulation and mixing – Stratification and entrainment – Fronts in estuaries – *Khazan* lands – Processes in lakes – Anthropogenic impacts. Ekman transport – Upwelling and downwelling – Waves: Kelvin and Rossby waves, Edge waves, Seiches, Internal Waves, Tides, Surface Waves, Tsunamis – Longshore currents – Rip currents – Erosion – Deposition.	**15**	CO1, CO2, CO5	K4, K4, K2
Module 2:	Tropical cyclones: Cyclone structure, generation, growth and decay – Temperature, pressure field and wind speed and direction – Impact of cyclone landfall – Storm surges, wind and precipitation impact – Cyclones in north Indian Ocean. Global warming and sea level change and its impact – Mitigation measures.	**15**	CO3, CO6	K3, K5
Module 3:	Equipment used for physical oceanographic studies: Mechanical bathythermograph (MBT), Expendable bathythermograph (XBT), Reversing thermometers, CTD, Current meter, Acoustic Doppler Current Profiler (ADCP), sonic anemometer, Autosal, Moorings. Equipment used for atmospheric studies: psychrometer, anemometer, radio sonde, sun- photometer, radiation meter, Automatic Weather Station (A.W.S.). Facilities onboard research vessels: O.R.V. *Sagar Kanya*, F.O.R.V. *Sagar Sampada*, R.V. *Sindhu Sadhana*.	**15**	CO4	K2
Pedagogy	Lectures/ tutorials/ assignments/ case-studies			
References/ Readings:	1. Valle-Levinson, A. (Ed.). (2010). Contemporary issues in estuarine physics. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9780511676567			

	2. Dronkers, J., & van Leussen, W. (1988). Physical processes in estuaries. Springer-Verlag, Berlin. 3. Dyer, K. R. (1997). Estuaries: A physical introduction (2nd ed.). John Wiley & Sons, Chichester. 4. Gade, H. G., Edwards, A., & Svendsen, H. (1982). Coastal oceanography. Plenum Press, New York. 5. Open University Course Team. (2000). Waves, tides and shallow-water processes (2nd ed.). The Open University, Milton Keynes & Butterworth-Heinemann, Oxford. 6. Asnani, G. C. (2005). Tropical meteorology (Revised ed.). G. C. Asnani, Indian Institute of Tropical Meteorology, Pune. 7. Pörtner, H.-O., Roberts, D. C., Tignor, M., Poloczanska, E. S., Mintenbeck, K., Alegría, A., Craig, M., Langsdorf, S., Löschke, S., Möller, V., Okem, A., & Rama, B. (2022). Climate change 2022: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge. https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/ 8. Shukla, P. R., Skea, J., Slade, R., Al Khourdajie, A., van Diemen, R., McCollum, D., Pathak, M., Some, S., Vyas, P., Fradera, R., Belkacemi, M., Hasija, A., Lisboa, G., Luz, S., & Malley, J. (2022). Climate change 2022: Mitigation of climate change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge. https://doi.org/10.1017/9781009157926 9. Sonak, S. M. (2014). Khazan ecosystems of Goa: Building on indigenous solutions to cope with global environmental change. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-7202-1 10. de Sousa, S. N. (n.d.). The Khaznam of Goa. http://www.niobioinformatics.in/pdf/events/indianestuaries/dsouza.pdf 11. Valle-Levinson, A. (2022). Introduction to estuarine hydrodynamics. Cambridge University Press, Cambridge.
Web Resources:	1. https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/ 2. https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/

Title of the Course	Estuarine and Coastal Physical Oceanography Practical
Course Code	MSC-5009
Number of Credits	01
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To build practical skills in analysing ocean and atmospheric data, including water masses, sound speed, wind stress, topography, humidity, and cyclone intensity.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Identify some common water-masses using TS diagram.	PSO 1, PSO 2
	CO 2. Determine the stability of the water column using TS diagram.	PSO 1, PSO 2
	CO 3. Estimate the speed of sound in the world ocean.	PSO 1, PSO 2
	CO 4. Analyse wind-stress over the world ocean and dynamic topography.	PSO 1, PSO 2
	CO 5. Measure meteorological variables using instruments.	PSO 1, PSO 2

Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. Identification of water masses and determination of stability of water column using Temperature-Salinity (TS) diagram. 2. Estimation of sound speed and determination of SOFAR channel in different parts of the world ocean. 3. Analysis of wind stress over world ocean. 4. Computation and analysis of dynamic topography. 5. Measurements of atmospheric pressure, humidity, minimum and maximum temperature, computation of absolute humidity, specific humidity – Mixing ratio. 6. Determination of cyclone intensity from satellite images using Dvorak technique.	30	CO1, CO2, CO3, CO4, CO5	K2, K3, K4, K4, K5
Pedagogy	Tutorials/ assignments/ practical/ field study			
References/ Readings:	1. Wright, J., & Colling, A. (1995). Seawater: Its composition, properties, and behavior (2nd ed.). Pergamon Press, Oxford in association with The Open University, Milton Keynes. 2. Colling, A. (2001). Ocean circulation (2nd ed., Vol. 3). Butterworth-Heinemann, Oxford in association with The Open University, Milton Keynes. 3. Pond, S., & Pickard, G. L. (1983). Introductory dynamical oceanography (2nd ed.). Butterworth-Heinemann, Oxford. 4. Kennish, M. J. (2001). Practical handbook of marine science (3rd ed.). CRC Press, Boca Raton. 5. Fofonoff, N. P., & Millard Jr., R. C. (1983). Algorithms for the computation of fundamental properties of seawater. UNESCO Technical Papers in Marine Science, 44. Endorsed by UNESCO/SCOR/ICES/IAPSO/Joint Panel on Oceanographic Tables and Standards and SCOR Working Group 51. UNESCO, Paris. https://doi.org/10.25607/OBP-1450 6. Ahrens, C. D. (1985). Meteorology today: An introduction to weather, climate, and the environment (2nd ed.). West Publishing, St. Paul. 7. Ackerman, S. A., & Knox, J. A. (2012). Meteorology: Understanding the atmosphere (3rd ed.). Jones & Bartlett			

	Learning, Sudbury, MA. 8. Velden, C., Harper, B., Wells, F., Beven, J. L., II, Zehr, R., Olander, T., Mayfield, M., Guard, C., Lander, M., Edson, R., Avila, L., Burton, A., Turk, M., Kikuchi, A., Christian, A., Caroff, P., & McCrone, P. (2006). The Dvorak tropical cyclone intensity estimation technique: A satellite-based method that has endured for over 30 years. Bulletin of the American Meteorological Society, 87(9), 1195–1210. https://doi.org/10.1175/BAMS-87-9-1195 9. Pörtner, H.-O., Roberts, D. C., Tignor, M., Poloczanska, E. S., Mintenbeck, K., Alegría, A., Craig, M., Langsdorf, S., Löschke, S., Möller, V., Okem, A., & Rama, B. (2022). Climate change 2022: Impacts, adaptation, and vulnerability: Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge. https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/ 10. Shukla, P. R., Skea, J., Slade, R., Al Khourdajie, A., van Diemen, R., McCollum, D., Pathak, M., Some, S., Vyas, P., Fradera, R., Belkacemi, M., Hasija, A., Lisboa, G., Luz, S., & Malley, J. (2022). Climate change 2022: Mitigation of climate change: Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge. https://doi.org/10.1017/9781009157926
Web Resources:	1. https://doi.org/10.25607/OBP-1450 2. https://doi.org/10.1175/BAMS-87-9-1195 3. https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/ 4. https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/

Title of the Course	Estuarine and Coastal Chemistry
Course Code	MSC-5010
Number of Credits	03
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	To study the chemical properties of estuaries.			
Course Outcomes:	Student will learn to:		**Mapped to PSO**	
	CO 1. Explain the chemical processes in estuaries, including salinity distribution, and the behavior of dissolved constituents.		PSO 3	
	CO 2. Demonstrate the forms, distribution and biogeochemical cycles of micro-nutrient elements in estuaries.		PSO 3	
	CO 3. Illustrate the uptake of nutrients and their regeneration in estuaries.		PSO 3	
	CO 4. Examine the origin, thickness and chemistry of surface microlayer in estuaries.		PSO 3	
	CO 5. Evaluate the chemistry of estuarine water and sediment using analytical equipments/instruments.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	Estuary – a chemical perspective, Classification based on geomorphology, salinity, tidal range - flushing time, mixing and diffusion dispersal of pollutants in estuaries and near shore areas – Conservative and non – conservative properties of dissolved constituents during estuarine mixing – Behaviour of dissolved oxygen and pH, dissolved organic matter in estuaries – sources, sinks and general biogeochemistry.	**15**	CO1	K2
Module 2:	Micro-nutrient elements (P, N and Si) in estuaries – Forms, distribution and cycle, N:P ratios – Stoichiometry of the uptake and regeneration of the nutrient elements and of oxygen, Biogeochemistry of P, N and Si in estuaries, Minor and trace metals in estuaries – metal ion species – behaviour.	**15**	CO2, CO3	K3, K4
Module 3:	Chemistry of surface water microlayer – Origin, thickness and collection of surface water material, properties of the surface water microlayer, Chemistry of estuaries along east and west coast of India – water chemistry – surface sediment and core sediment chemistry - biochemistry, role of physico-chemical and biological factors in estuarine chemistry, Equipments and instruments used in chemical study	**15**	CO4, CO5	K4, K5
Pedagogy	Lectures/tutorials/assignments/self-study.			
References/ Readings:	1. Kennish, M. J., Paerl, H. W., & Crosswell, J. R. (2023). Climate Change and Estuaries. (1st ed). CRC Press, Boca Raton. 2. Das, S., & Ghosh, T. (2021). Estuarine Biogeochemical Dynamics of the East Coast of India. Springer, Switzerland. 3. Sarkar, S. K. (2018). Trace metals in a tropical mangrove wetland. Springer, Singapore. 4. Nielsen, P. (2009). Coastal and Estuarine Processes. World Scientific, Singapore. 5. Bianchi, T. S. (2007). Biogeochemistry of Estuaries. Oxford University Press, London. 6. Hansell, D. A., & Carlson, C. A. (2002). Biogeochemistry of Marine Dissolved Organic Matter. Academic Press, San Diego. 7. Burton, J. D., & Liss, P. S. (1976). Estuarine Chemistry. Academic Press, London. 8. Head, P. C. (1985). Practical Estuarine Chemistry. Cambridge University Press, London. 9. Olausson, E., & Cato, I. (1980). Chemistry and Biogeochemistry of Estuaries. John Wiley & Sons, Chichester. 10. Riley, J. P., & Chester, R. (1978). Chemical Oceanography. Academic Press, London.			

Title of the Course	Estuarine and Coastal Chemistry Practical
Course Code	MSC-5011
Number of Credits	01
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To estimate micro-nutrients from estuarine water.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Estimate the concentration of dissolved inorganic phosphate and silica in estuarine water spectrophotometrically.	PSO 1, PSO 3
	CO 2. Measure the concentration of nitrite and nitrate in estuarine water spectrophotometrically.	PSO 1, PSO 3
	CO 3. Determine the concentration of dissolved ammonia in estuarine water spectrophotometrically.	PSO 1, PSO 3
	CO 4. Construct the copper coated cadmium column for the reduction of nitrate to nitrite.	PSO 1, PSO 3

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Spectrophotometric determination of dissolved inorganic phosphate in estuarine water by ammonium molybdate – ascorbic acid method. 2. Spectrophotometric determination of nitrite in estuarine water by sulphanilamide – diamine method. 3. Spectrophotometric determination of nitrate in estuarine water by reduction to nitrite using copper – coated cadmium reduction column. 4. Spectrophotometric determination of ammonia in estuarine water by indophenol blue method. 5. Spectrophotometric determination of dissolved inorganic silicate in estuarine water by ammonium molybdate – ascorbic acid – oxalic acid method.	**30**	CO1, CO2, CO3, CO4	K3, K4, K5, K6
Pedagogy	Laboratory experiments/ field studies			
References/ Readings:	1. Meena, M. L., Deshmukh, N., Rajput, J., & Rani, S. (2023). Water Research and Technology. Bhumi Publishing, Kolhapur. 2. Wurl, O. (2009). Practical Guidelines for the Analysis of Seawater. CRC Press, Boca Raton. 3. Kopp, B. S., & Neckles, H. A. (2010). A Protocol for Monitoring Estuarine Nutrient Enrichment in Coastal Parks of the National Park Service Northeast Region. Natural Resource Report, National Park Service, U.S. Department of the Interior. https://www.govinfo.gov/content/pkg/GOVPUB-I29-PURL-gpo139130/pdf/GOVPUB-I29-PURL-gpo139130.pdf 4. Grasshoff, K., Ehrhardt, M., & Kremling, K. (1983). Methods of Seawater Analysis. Verlag Chemie, Weinheim. 5. Ewing, G. W. (1981). Instrumental Methods of Chemical Analysis. McGraw-Hill, New York. 6. Parsons, T. R., Maita, Y., & Lalli, C. M. (1984). A Manual of Chemical and Biological Methods for Seawater Analysis. Oxford, United Kingdom.			
Web Resources:	https://www.govinfo.gov/content/pkg/GOVPUB-I29-PURL-gpo139130/pdf/GOVPUB-I29-PURL-gpo139130.pdf			

Title of the Course	Estuarine and Coastal Biology
Course Code	MSC-5012
Number of Credits	03
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To explore the carbon dioxide cycle and ecosystem processes in estuarine and coastal environments, with emphasis on anthropogenic impacts, adaptations, and fish migrations.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Analyze productivity and carbon dynamics in coastal and estuarine waters.	PSO 5
	CO 2. Explain the processes related to carbon cycling in the marine environment.	PSO 5
	CO 3. Describe key coastal ecosystems and assess their ecological roles, biodiversity, productivity, and conservation needs.	PSO 5
	CO 4. Assess estuarine secondary production, heterotrophic pathways, and key adaptations, migrations, and symbioses in marine organisms.	PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Productivity in coastal and estuarine waters, Carbon cycle - production and transformation, Inorganic carbon, carbon – carbonate system, Dissolved Organic Carbon (DOC) sources, aerobic environments, processes, losses of organic carbon, processes, decomposers, anoxic environments - Fermentation, sulfate reduction, Methanogenesis, DOC internal and external sources, Role of phytoplankton in carbon export.	**15**	CO1, CO2	K4, K2
Module 2:	Salt marsh ecosystem – species composition, distribution, nutrient dynamics, primary productivity and ecological processes and fate of salt marsh plant; Mangrove ecosystem species composition, distribution, adaptations, primary productivity, heterotrophic production, secondary communities and energy flow. Coral reef – types, calcification, nutrient dynamics, Nutrition in coral, benthic algae, role in calcification, total system function. Seagrass and seagrass beds – growth and reproduction, biodiversity and ecosystem benefits, habitat alteration, blue carbon, key functions, threats and conservation.	**15**	CO3	K2
Module 3:	Secondary production and estuarine ecosystem function, Heterotrophic processes and pathways, Plankton, nekton and benthic communities, adaptations such as buoyancy, locomotion and defense in coastal and estuarine plankton and nekton population, Fish migrations biology and energetics, Symbiosis in marine environment.	**15**	CO4	K5
Pedagogy	Lectures/ tutorials/ assignments/ self-study			
References/ Readings:	1. Blaxter, J. H. S., Southward, A. J., & Tyler, P. A. (Eds.). (1990). Advances in marine biology (Vol. 26). Academic Press, San Diego, CA, USA. 2. Dipper, F., & Tait, R. V. (1998). Elements of marine ecology (4th ed.). Elsevier, Oxford, United Kingdom. 3. Dyer, K. R. (2012). Estuarine ecology (2nd ed.). Wiley, Chichester, West Sussex, United Kingdom. 4. Mann, K. H. (2000). Ecology of coastal waters: With implications for management (2nd ed.). Blackwell Science, Malden, MA, USA.			

	5. Meadows, P. S., & Campbell, J. I. (2013). An introduction to marine science. Springer, Dordrecht, Netherlands. 6. Nair, N. B., & Thampy, D. M. (1980). A textbook of marine ecology. Macmillan, New Delhi, India. 7. Nybakken, J. W., & Bertness, M. D. (2005). Marine biology: An ecological approach (6th ed.). Pearson/Benjamin Cummings, San Francisco, CA, USA. 8. Valiela, I. (1995). Marine ecological processes. Springer, Dordrecht, Netherlands. 9. Wilson, J. G. (2012). The biology of estuarine management. Springer, Dordrecht, Netherlands.

Title of the Course	Estuarine and Coastal Biology Practical
Course Code	MSC-5013
Number of Credits	01
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To train students in identifying commonly occurring marine organisms based on their morphological characteristics.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Identify key marine organisms.	PSO 1, PSO 5
	CO 2. Describe the life cycles, biological characteristics, and ecological significance of key marine organisms.	PSO 1, PSO 5
	CO 3. Identify prawns and shrimps, determine their sex, and describe key biological and ecological traits.	PSO 1, PSO 5
	CO 4. Conduct morphometric measurements and meristic counts of the Indian Mackerel (*Rastrelliger kanagurta*) and interpret their significance.	PSO 1, PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Identification of mangroves, their lifecycle and few biological characteristics. 2. Identification of hard corals and a few biological characteristics. 3. Identification of few commonly occurring teleosts (ray-finned fishes) and their biological characteristics. 4. Identification of brachyuran crabs using morphology and gonopod characteristics, sex determination and their biological importance. 5. Identification of prawns and shrimps using external characteristics, sex determination and biological aspects. 6. Morphometric measurements and meristic counts of the Indian Mackerel, *Rastrelliger kanagurta*.	**30**	CO1, CO2, CO3, CO4	K1, K2, K1, K5, K3
Pedagogy	Identification of sampling devices, marine flora and fauna, Laboratory experiment			
References/ Readings:	1. Bhendarkar, M. P., Naik, S. D., Ramteke, M. H., Raut, S. M., & Swain, S. (2014). Morphometric and meristic studies of Indian mackerel, Rastrelliger kanagurta (Cuvier, 1817) off southern coast of Maharashtra, India. Ecology, Environment and Conservation, 20(4), 1705–1708. 2. Carpenter, K. E., & Niem, V. H. (Eds.). (1988). FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific, Volume 2: Cephalopods, crustaceans, holothurians and sharks. Food and Agriculture Organization of the United Nations, Rome, Italy. 3. Carpenter, K. E., & Niem, V. H. (Eds.). (1999). FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific, Volume 4: Bony fishes part 2 (Mugilidae to Carangidae). Food and Agriculture Organization of the United Nations, Rome, Italy. 4. Carpenter, K. E., & Niem, V. H. (Eds.). (2001a). FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific, Volume 5: Bony fishes part 3 (Menidae to Pomacentridae). Food and Agriculture Organization of the United Nations, Rome, Italy. 5. Carpenter, K. E., & Niem, V. H. (Eds.). (2001b). FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific, Volume 6: Bony fishes part 4 (Labridae to Latimeriidae), estuarine crocodiles, sea turtles, sea snakes and marine mammals. Food and Agriculture Organization of the United Nations,			

	Rome, Italy. 6. De, K., Venkataraman, K., & Ingole, B. (2019). The hard corals (Scleractinia) of India: A revised checklist. Indian Journal of Geo-Marine Sciences, 48(10), 1651–1660. 7. Dhargalkar, V. K., D'Souza, R., Kavlekar, D. P., & Untawale, A. G. (2014). Mangroves of Goa. Forest Department, Government of Goa and Mangroves Society of India, Goa, India. 8. Hogarth, P. J. (2015). The biology of mangroves and seagrasses. Oxford University Press, Oxford, United Kingdom. 9. Untawale, A. G. (1985). Mangroves of India: Present status and multiple use practices. UNDP/UNESCO Regional Mangrove Project, National Institute of Oceanography (NIO), Dona Paula, Goa, India. 10. Venkataraman, K., Satyanarayana, C., Alfred, J. R. B., & Wolstenholme, J. (2003). Handbook on hard corals of India. Zoological Survey of India, Kolkata, India.

Title of the Course	Estuarine and Coastal Geology
Course Code	MSC-5014
Number of Credits	03
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To study the geological processes of estuaries.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Classify estuaries and determine the sediment source and composition.	PSO 4
	CO 2. Estimate metal and other pollutants in mangroves and mudflat sediments and to compare the seasonal variation.	PSO 4
	CO 3. Reconstruct global sea level change based on coastal signatures.	PSO 4
	CO 4. Analyse the impact of natural disaster and anthropogenic activities on coastal processes.	PSO 4

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Estuaries: Classification based on tide - geological classification and evolution – sub-environments in estuaries: mudflats, salt marsh, mangrove, salt pans –sediment source, transportation and deposition – bed and suspended sediment sampling and analysis – mineralogy and geochemistry of estuarine sediments.	**15**	CO1	K2, K3
Module 2:	Estuaries of the western coast of India. Metals and other pollutants – their seasonal variation and metal variation with time in the mudflats and mangroves. Application of metals in paleo-monsoon, sea level changes and paleoenvironment. Health of estuaries – Impact of human activities on estuaries and restoration of estuaries.	**15**	CO2	K3
Module 3:	Coasts: classification, types of coasts with reference to Indian coast line – evolution of the Indian coast - global sea level changes: eustatic, tectonic and isostatic. Coastal signature of sea level changes. Coastal resources and coastal zone management, Coastal Regulation Zone (CRZ), CRZ notification, regulations and Integrated Coastal Zone Management (ICZM). Impact of floods, tsunamis and anthropogenic interferences in coastal processes, coastal erosion, preparedness and precaution measures.	**15**	CO3, CO4	K6, K4
Pedagogy	Lectures / Assignments / Seminars / Discussion			
References/ Readings:	1. Riley, & Chester, R. (1976). Chemical oceanography. Vol.5 edited by J.P. Riley and R. Chester (2nd ed.). Academic Press, London, UK. 2. Wright, J., Colling, A., & Park, D. (Eds.). (1999). Waves, tides and shallow-water processes (Vol. 4). Gulf Professional Publishing, Boston, MA, USA. 3. Dyer, K. R. (1986). Coastal and estuarine sediment dynamics. Wiley, Chichester. 4. Dyer, K. R. (1986). Estuarine hydrography and sedimentation, John Wiley & Sons. 5. Komar, P. D. (2018). Beach processes and erosion—an introduction. In Handbook of coastal processes and erosion (pp. 1-20). CRC Press, Boca Raton, London, New York. 6. Milliman, J. D., & Haq, B. U. (Eds.). (1996). Sea-level rise and coastal subsidence: Causes, consequences, and strategies (Vol. 2). Springer Science & Business Media, Boston, London.			

	7. Krauskopf, K. B., & Bird, D. K. (1967). Introduction to geochemistry (Vol. 721). McGraw-Hill, New York. 8. Pethick, J. S. (1984). An introduction to coastal geomorphology. Dept. of Geography, Univ. of Hull, US.

Title of the Course	Estuarine and Coastal Geology Practical
Course Code	MSC-5015
Number of Credits	01
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To analyse sediment grain size, depositional environments and coastal geomorphology.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Analyse sediment grain size using pipette method and identify heavy mineral from sediments.	PSO 1, PSO 4
	CO 2. Estimate total organic carbon from the estuarine sediments.	PSO 1, PSO 4
	CO 3. Classify coastal geomorphological features.	PSO 1, PSO 4
	CO 4. Identify sedimentary depositional environment.	PSO 1, PSO 4

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Grain size analysis – sand, silt, clay using pipette method – estimation and interpretation – atleast ten samples from a sediment core. 2. Determination of organic carbon – atleast ten samples from a sediment core. 3. Heavy mineral identification. 4. Study of depositional environments. 5. Study of coastal geomorphological features (Field work).	**30**	CO1, CO2, CO3, CO4	K4, K4, K4, K1
Pedagogy	Laboratory experiments / Computations / Plotting and Interpretations and analysis/ Field Visit			
References/ Readings:	1. Friedman, G. M., & Johnson, K. G. (1982). Exercises in sedimentology. Wiley, New York. 2. Carver, R. E. (1971). Procedures in sedimentary petrology. Wiley-Interscience, New York. 3. V.K. Verma and Prasad C (1981). A text book of Sedimentary Petrology. International Book Distribution, 4. Griffith, J. C., 1967, Scientific Methods in Analysis of Sediments: McGraw-Hill, New York, NY. 5. Monroe, J. S., Wicander, R., & Hazlett, R. W. (2007). Physical geology: exploring the earth (Vol. 584). Belmont: Thomson Brooks/Cole, Belmont, CA, USA. 6. Lindholm, R. (2012). A practical approach to sedimentology. Springer Science & Business Media, UK.			

Discipline Specific Elective Courses

Title of the Course	Geophysical Fluid Dynamics
Course Code	MSC-5209
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To impart an insight into fluid dynamics, including flow types, governing equations, and applications in atmospheric and oceanic systems.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Describe the fundamental concepts of fluid properties, flow types, and the influence of rotation and stratification on fluid dynamics in atmospheric and oceanic systems.	PSO2
	CO 2. Compute the application of fluid statics, including pressure forces, hydrostatic equations, and the Coriolis force, in analysing fluid behaviour.	PSO2
	CO 3. Interpret the governing equations of fluid dynamics, to explain the dynamics of fluid flows	PSO2

	CO 4. Formulate solutions for complex fluid flow problems, integrating concepts like vorticity, Reynolds number, and turbulent diffusion in stratified and viscous fluids.		PSO2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Basic concepts: fluid continuum, fluid properties, ideal fluid, types of flows; Scales of motions; Importance of rotation and stratification; Distinction between atmosphere and oceans. Statics: pressure surface and body forces on a fluid element; fundamental equation of fluid statics: application to compressible and incompressible fluids, hydrostatic equation along the vertical, application to the atmosphere, units of measurement; Newtonian and non- Newtonian fluids; Coriolis force; rotating frame of reference.	**15**	CO1, CO2	K2, K3
Module 2:	Kinematics: Lagrangian and Eulerian methods; stream lines, streak lines and trajectories; steady and non- steady flow; decomposition of the field of motion in the vicinity of a point; translation, rotation, divergence and deformation; Principles of Prandtl's mixing length theory; momentum budget; salt and moisture budget; summary of governing equations; Boussinesq approximation; typical flow patterns; stream function; divergence and vorticity in different co-ordinate systems; material, local and convective derivatives. Equation of continuity and its applications; non-viscous incompressible flow; Eulerian equations of motion; inertial and rotational frames of reference; irrotational flow; velocity potential; integration of the equations of motion; Bernoulli's theorem and its applications	**15**	CO3	K4
Module 3:	Circulation and vorticity; Stokes' theorem; Kelvin's theorem; Helmholtz's theorems; barotropic and baroclinic fluids; absolute and relative circulation; V. Bjerknes' circulation theorem and its interpretation; conservation of potential vorticity; Eddy coefficients; Important dimensionless numbers; turbulent diffusion; combination of advection and diffusion; geostrophic flow and vorticity dynamics; laminar flow of viscous incompressible fluids; turbulence in stratified flows; Reynolds number and dynamic similarity of flows; physical significance of Reynolds number; low and high Reynolds' number.	**15**	CO4	K6

Pedagogy	Lectures/ tutorials/ assignments/ seminars
References/ Readings:	1. Cushman-Roisin, B., & Beckers, J.-M. (2011). *Introduction to Geophysical Fluid Dynamics– Physical and Numerical Aspects.* Academic Press, 2nd Edition, Netherlands 2. Modi, P. N., & Seth, S. M. (1985). *Hydraulics and Fluid Mechanics.* Standard Book House, New Delhi. 3. Yuan, S. W. (1969). *Foundation of Fluid Mechanics.* Prentice Hall, New Delhi. 4. Batchelor, G. K. (1967). *An Introduction to Fluid Mechanics.* Cambridge University Press, Cambridge, UK. 5. Lamb, H. (1975). *Hydrodynamics.* Cambridge University Press, Cambridge, U.K. 6. Rathy, R. K. (1976). *Introduction to Fluid Mechanics.* Oxford and IBH Publishing Company, New Delhi. 7. Roll, H. U. (1965). Physics of the marine atmosphere. *International Geophysics Series*, Vol. *7*. [Ed.] J. van Miegham. Academic Press, New York and London. 8. Gill, A. E. (1982). *Atmosphere- Ocean Dynamics.* International Geophysics Series, Volume 30. Academic Press, New York. 9. Vallis, G. K. (2017). *Atmospheric and Ocean Fluid Dynamics– Fundamentals and Large-Scale Circulation.* Cambridge University Press. 2nd Edition, Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo. 10. Pedlosky, J. (1987). *Geophysical Fluid Dynamics (Second Edition).* Springer, New York, USA..

Title of the Course	Geophysical Fluid Dynamics Practical
Course Code	MSC-5210
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide hands-on experience through field observations and numerical techniques that reinforce theoretical learning.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Construct streamline patterns of wind and ocean currents using isotach and isogon analysis to examine flow dynamics.	PSO1, PSO2
	CO 2. Interpret air parcel trajectories from synoptic charts and to calculate divergence and vorticity in horizontal flows to assess atmospheric dynamics and fluid motion.	PSO1, PSO2
	CO 3. Analyse streamline patterns of simple flows to interpret underlying fluid dynamics and predict flow behaviour.	PSO1, PSO2
	CO 4. Assess conductivity temperature and depth (CTD) data to analyse physical oceanographic	PSO1, PSO2

	parameters and assess water column structure in estuarine environments.			
	CO 5. Evaluate aerosol transport pathways using the HYbrid Single – Particle Lagrangian Integrated Trajectory (HYSPLIT) model to assess atmospheric dispersion and potential environmental impacts.		PSO1, PSO2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. Kinematics analysis of wind and ocean current – Isotach and isogon analysis and construction of streamline patterns. 2. Construction of trajectories of air parcels from successive synoptic charts. 3. Computation of divergence and vorticity in horizontal flow. 4. Construction of stream lines for simple types of flow. 5. Analysis of physical oceanographic parameters of estuarine waters using data of CTD instrument. 6. Analysis of aerosol trajectory using HYSPLIT model.	**30**	CO1, CO2, CO3, CO4, CO5	K6, K2, K4, K5, K5
Pedagogy	Tutorials/ assignments/ practical/ field study			
References/ Readings:	1. Stewart, R. H. (2008). *Introduction to physical oceanography*. Robert H. Stewart. 2. Guide to Wave Analysis and Forecasting. (2018). *World Meteorological Organization (WMO-No. 702).* ISBN 978-92-63-10702-2. 3. Siedler, G., Griffies, S., Gould, J., & Church, J. (2013). *Ocean Circulation and Climate– A 21st Century Perspective.* Academic Press, Netherlands. 4. HYSPLIT- Hybrid Single Particle Lagrangian integrated Trajectory Model, Air Resources Laboratory, http://www.arl.noaa.gov/ . 5. Draxler, R. R., & Hess, G. D. (2020). *Description of the Hysplit_4 Modelling System; NOAA Technical Memorandum ERL ARL- 224. 1997, (Revised 2020).* Silver Spring, Air Resources Laboratory, Maryland, USA. 6. Roll, H. U. (1965). Physics of the marine atmosphere. *International Geophysics Series*, Vol. *7*. [Ed.] J. van Miegham. Academic Press, New York and London. 7. Gill, A. E. (1982). *Atmosphere- Ocean Dynamics.* International Geophysics Series, Volume 30. Academic Press,			

	New York and London.
Web Resources:	1. https://open.umn.edu/opentextbooks/textbooks/20 2. https://library.wmo.int/doc_num.php?explnum_id=10979 3. https://www.arl.noaa.gov/documents/reports/arl-224.pdf

Title of the Course	Marine Pollution
Course Code	MSC-5211
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To introduce the types, sources, impacts, and control of marine pollution with emphasis on monitoring, treatment, and mitigation strategies.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Explain the sources, types, and classifications of marine pollutants, including organic wastes, industrial discharges, and solid waste.	PSO3
	CO 2. Apply knowledge of sewage treatment and pollution control methods.	PSO3
	CO 3. Analyse the ecological impacts of oil spills, pesticides, metals, and radioactive pollutants on marine ecosystems.	PSO3
	CO 4. Evaluate monitoring strategies, indicator organisms, and global pollution scenarios to propose sustainable marine pollution management practices.	PSO3

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Marine Pollution: Definition, categories of additions, Pollutant and its classification. Organic wastes: Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), dilution factor, Fluctuations in Dissolved Oxygen (DO), Consequences of organic discharges to estuaries with examples; Thames and Mersey estuary; Consequences of sludge dumping at sea with reference to Thames and Firth of Clyde. Sewage treatment: Primary, Secondary and Tertiary treatment processes. Solid waste pollution: Classification and disposal of solid wastes. Industrial pollution: sources, nature and their treatment processes with reference to wastes from paper and pulp and soap manufacturing industries. Marine corrosion: Definition, corrosion reactions, classification of corrosion, factors affecting corrosion of metals in sea water and prevention of marine corrosion. The state of some seas in the world (pollution aspect); The North Sea, The Mediterranean Sea and the Baltic Sea.	**15**	CO1, CO2	K2, K3
Module 2:	Oil spills and cleanup: sources, major accidental spills, fate of spilled oil on the sea, consequences of oil spills and treatment of oil spills. Pesticide pollution: inputs, fate in the sea, factors affecting the bioaccumulation of pesticides, DDT-the most widespread molecule, Impact of pesticides on the Environment, Mode of poisoning of pesticides, Methods to minimize pesticide pollution. Conservative pollutants: Measures of contamination, toxicity, measurement of toxicity, acute and chronic exposure, Detoxification. Metal pollution in coastal waters (Hg, Pb, Cd, Cu, Zn and Fe). The present status of coastal pollution in India and future strategies. Radioactive Pollution: Sources Classification and effects of radiation; Protection and control from radiation: Maximum permissible dose concept, dose limits, Disposal of radioactive wastes; Beneficial aspects of radiation and food safety.	**15**	CO3	K4
Module 3:	Indicator organisms: Criteria for selection of indicator organism: Quantification of pollution load, basic pre- requisites, response to different pollution load and time integration capacity, Macro algae, crustaceans and mollusks as indicator organisms for monitoring of trace metal pollution; Red tides: distribution, types of poisoning, effects and methods to minimize red tides in the sea. Monitoring strategies of marine pollution:	**15**	CO4	K5

	Critical pathway approach and Mass balance approach. Standards in water quality: Assessment of pollution damage: The need, seriousness of damage, assessment of damage and problems of measuring impact.			
Pedagogy	Lectures/ tutorials/ assignments/ self-study			
References/ Readings:	1. Kathryrn, A. W., Serra-Gonçalves, C., Kelsey, R., Qamar, A. S., Halfdan, P., Kelli, A., Jonathan, S. S., Joanna. V., Britta, D. H., Chris, W., Barbara, F. N., Jennifer, L. L., Jayson, M. S., Dean, G., Catriona, M., Nunnoq, P. O. F., & Peter, S. P. (2021). Cleaner seas: reducing marine pollution. Reviews in fish biology and fisheries, 32:145-160. 2. Beiras, R. (2018). Marine pollution: sources, fate and effects of pollutants in coastal ecosystems. In: Beiras, R. (ed) Marine pollution. Elsevier, Amsterdam, pp 293-311. 3. Joanna, B. (2006). Biological indicators: types, development, and use in ecological assessment and research. Environmental Bioindicators, 1:22–39. 4. Kumar, P.S. (2021). Pesticides clean-up. In: Kumar, P. S, (ed) Modern treatment strategies for marine pollution. Elsevier, Amsterdam, pp 89 –107. 5. Riley, J. P. & Chester, R. (1976). Chemical oceanography. (2nd edition), Academic Press, London. 6. Clark, R. B. (1986). Marine Pollution. Oxford science Publications, Oxford. 7. Sharma, B. K., & Kaur, H. K. (1994). Thermal and radioactive pollution, Prakasham Mandir (pub), Meerut. 8. Sharma, B. K., & Kaur, H. K. (1994). Water Pollution. Goel Publishing, Meerut. 9. Chandler, K. A. (1985). Marine Offshore corrosion, Butter Worths (pub) London.			

Title of the Course	Marine Pollution Practical
Course Code	MSC-5212
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To analyze water quality and trace metals using standard methods.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Determine and interpret dissolved oxygen levels in polluted water samples to assess water quality.	PSO1, PSO3
	CO 2. Synthesize Biochemical Oxygen Demand, and Chemical Oxygen Demand results to assess water quality.	PSO1, PSO3
	CO 3. Evaluate the effectiveness of pre-concentration methods for trace metal analysis in aquatic samples using Atomic Absorption Spectrometer (AAS).	PSO1, PSO3
	CO 4. Estimate the concentration of cadmium and copper in polluted waters and biological samples.	PSO1, PSO3

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Determination of dissolved oxygen in polluted water. 2. Determination of biochemical oxygen demand in polluted water. 3. Determination of chemical oxygen demand in polluted water. 4. Pre-concentration of water for estimation of trace metals by AAS. 5. Estimation of Cd in polluted water and biological sample. 6. Estimation of Cu in polluted water and biological samples.	**30**	CO1, CO2, CO3, CO4	K3, K6, K5, K4
Pedagogy	Demonstrations/ Lab experiments.			
References/ Readings:	1. Kennish, M. J. (2017). Practical Handbook of Estuarine and Marine Pollution. CRC Press. 2. Beiras, R. (2018). Marine pollution: sources, fate and effects of pollutants in coastal ecosystems. In: Beiras R (ed) Marine pollution. Elsevier, Amsterdam, pp 293–311. 3. Martin, D. F. (1972). Marine Chemistry. Academic Press, London. 4. Strickland, J. D. H., & Parsons, T. R. (1972). A practical hand book of seawater analysis. Fisheries Board of Canada bulletin. (2nd edition). 5. Riley, J. P., & Skirrow, G. (1975). Analytical chemistry of seawater, In: Chemical Oceanography, Riley, J. P., & Skirrow, G. (eds.). Academic Press, London. 6. Allen, S. E., Grimshaw, H. M., Parkinson, J. A., Quarmby, C., & Roberts, J. D. (1976). Chemical Analysis. In: Methods in plant Ecology, S. B. Chapman (eds.), Blackwell Scientific Publications, Oxford. 7. Grasskhoff, K. M. (1999). Methods of Seawater analysis. Ehrdardt and K. Krembling (eds.), Verlag Chemie, Weinneim. 8. Rice, E. W., & Bridgewater, L. A. (2012). Standard methods for the examination of water and waste water analysis (22nd edition), Public health association, Washington DC.			

Title of the Course	Marine Biodiversity
Course Code	MSC-5213
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide a basic understanding of biodiversity and enable assessment of the effects of global warming and climate change on marine ecosystems.	
Course Outcomes:	Student will learn to:	**Mapped to PSO**
	CO 1. Define biodiversity and explore its types.	PSO 5
	CO 2. Apply various approaches to measure biodiversity and genetic variations.	PSO 5
	CO 3. Assess factors influencing marine biodiversity, understand ecosystem functions and keystone species, and evaluate biodiversity hypotheses.	PSO 5
	CO 4. Analyse marine biodiversity strategies, and the role of marine protected areas in India.	PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Biodiversity, definition, concept, types; Biodiversity measurements - taxic, phylo-genetic and molecular approaches; Intra-specific Genetic variance and factors affecting, biodiversity and intra-specific variations, dominance and over-dominance hypothesis, adaptive polymorphism, Genetic variations, loss and increase	**15**	CO1, CO2	K1, K3, K3
Module 2:	Marine Biodiversity and ecosystem functions, competition, predation and heterogeneity as biodiversity determinants; ecosystem approach, functions and keystone species, engineer organisms, diversity-stability, rivet, drivers and passenger, idiosyncratic hypothesis, co-operative relations, top down and bottom-up theories, cascade effect, dynamics of biological diversity, conceptual models, hypothesis proposed in deep sea biodiversity.	**15**	CO3	K5
Module 3:	Semi-intensive shrimp culture and mangroves, environmental costs, problems associated with conservation of mangroves and shrimp culture, banned fishing practices, coastal tourism, Biodiversity conservation - corals, turtles, dugong, holothurians and shark, Biological diversity Act, sanctuaries, marine parks, protected areas and marine biosphere reserves of India - Bhitarkanika wildlife sanctuary, Gulf of Kachch Marine National Park and Sanctuary, Gulf of Mannar biosphere reserve, Wandoor Marine National Park.	**15**	CO4	K4
Pedagogy	Lectures/ Tutorials/ Assignments/ Self-study			
References/ Readings:	1. Garcia, S. M., & Rice, J. (2020). Assessing progress towards Aichi Biodiversity Target 6 on sustainable marine fisheries (Technical Series No. 87). Secretariat of the Convention on Biological Diversity, Montreal, Quebec, Canada. 2. Harding, S., & Cousins, N. (2022). Review of the impacts of anthropogenic underwater noise on marine biodiversity and approaches to manage and mitigate them (Technical Series No. 99). Secretariat of the Convention on Biological Diversity, Montreal, Quebec, Canada. 3. Hiscock, K. (2014). Marine biodiversity conservation: A practical approach (1st ed.). Routledge, Oxfordshire, United Kingdom. 4. Kailash, C., Raghunathan, C., & Mondal, T. (2017). Glimpses of coastal and marine biodiversity of India. Zoological Survey of India, Kolkata, India.			

	5. Queiroga, H., Cunha, M. R., Cunha, A., Moreira, Q. V., Rodrigues, A. M., Serôdio, J., & Warwick, R. M. (2007). Marine biodiversity: Patterns, processes, assessment, threats, management conservation. Springer, Dordrecht, Netherlands. 6. Secretariat of the Convention on Biological Diversity. (2016). Ecologically or biologically significant marine areas (EBSAs): Special places in the world's oceans, Volume 3: Southern Indian Ocean. Secretariat of the Convention on Biological Diversity (CBD), Montreal, Quebec, Canada 7. Shiva, V. (1994). Biodiversity conservation. Indian National Trust for Art and Cultural Heritage, New Delhi, India. 8. Venkataraman, K., Raghunathan, C., Raghuraman, R., & Sreeraj, C. R. (2012). Marine biodiversity in India. Zoological Survey of India, Kolkata, India.

Title of the Course	Marine Biodiversity Practical
Course Code	MSC-5214
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	To acquaint with methods involved in assessing marine biodiversity and marine census.			
Course Outcomes:	Student will learn to:	**Mapped to PSO**		
	CO 1. Implement methods involved in cataloguing of marine organisms.	PSO 1, PSO 5		
	CO 2. Utilize databases focused on marine species to study their biodiversity.	PSO 1, PSO 5		
	CO 3. Describe the global patterns of marine species distribution.	PSO 1, PSO 5		
	CO 4. Assess the spatial distribution of marine organisms using biogeographic principles and marine biodiversity databases.	PSO 1, PSO 5		
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. Photo documentation of marine species.	**30**	CO1, CO2,	K3, K3, K2, K5

	2. Biogeography of plankton, nekton and benthic organisms. 3. Marine Biodiversity through the World Register of Marine Species (WoRMS, COML, CedMAR) and related databases.		CO3, CO4	
Pedagogy	Tutorials/ Assignments/ Practical/ Field study.			
References/ Readings:	1. Anderson, M. J., & Rodriguez, J. G. (2022). Advances in underwater imaging for marine biodiversity monitoring. Marine Ecology Progress Series, 678, 45–62. 2. Beaugrand, G. (2017). Plankton biodiversity and biogeography. In C. Castellani & M. Edwards (Eds.), Marine plankton: A practical guide to ecology, methodology, and taxonomy (1st ed., pp. 15–35). Oxford University Press, Oxford, United Kingdom. 3. Borda, C., Popescu, S., & El Mahdy, J. C. (2014). Marine species identification by underwater photography. ProEnvironment, 7, 59–63. 4. Costello, M. J., Appeltans, W., Bailly, N., Berendsohn, W. G., de Jong, Y., Edwards, M., & Zachos, F. E. (2022). World Register of Marine Species (WoRMS): Enhancing marine biodiversity informatics. Biodiversity Data Journal, 10, e82397. 5. Costello, M. J., Bouchet, P., Boxshall, G., Fauchald, K., Gordon, D., Hoeksema, B. W., et al. (2013). Global coordination and standardisation in marine biodiversity through the World Register of Marine Species (WoRMS) and related databases. PLoS ONE, 8(1), e51629. 6. Lirman, D., Schopmeyer, S., Manzello, D., Griffin, S., & Joshi, S. (2021). Integrating new photographic technologies for large-scale coral reef monitoring. Coral Reefs, 40(2), 439–455. 7. Longhurst, A. R. (2010). Ecological geography of the sea (2nd ed.). Academic Press, Amsterdam, Netherlands. 8. Vandepitte, L., Schiettekatte, N., & Appeltans, W. (2023). Sustaining and expanding the World Register of Marine Species: Lessons learned and future directions. Data Science Journal, 22, 3. 9. Vandepitte, L., Vanhoorne, B., Decock, W., Vranken, S., Lanssens, T., Dekeyzer, S., et al. (2018). A decade of the World Register of Marine Species – General insights and experiences from the Data Management Team: Where are we, what have we learned and how can we continue? PLoS ONE, 13(4), e0194599.			

Title of the Course	Sedimentology
Course Code	MSC-5215
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	To develop ability to identify sediment types and sedimentary rock, understand diagenetic processes of sedimentary rocks and interpret depositional environment.			
Course Outcomes:	Student will learn to:		**Mapped to PSO**	
	CO 1. Classify sedimentary rocks and explain the genesis of different sedimentary rocks.		PSO 4	
	CO 2. Reconstruct sedimentary facies and analyse factors controlling them.		PSO 4	
	CO 3. Interpret different sedimentary depositional environments.		PSO 4	
	CO 4. Interpret paleoenvironmental conditions using sedimentary and faunal markers.		PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Sedimentary rocks – Classification, properties, origin and importance – Sandstone, Limestone, mudstones and evaporites. Distribution and genesis of terrigenous,	**15**	CO1	K2, K4

	biogenous, chemogenous, volcanogenic, authigenic and extraterrestrial (cosmogenous) sediments in the world ocean – Rate of sedimentation in the oceans.			
Module 2:	Concepts of sedimentary facies, facies construction and interpretation, factors controlling the nature and distribution of facies – Provenance – Heavy minerals, rock particles and clay minerals – Mineral stability – Goldich stability series, sediment maturity – X-ray diffraction technique and its use in mineral and sediment study.	**15**	CO2	K6, K4
Module 3:	Sedimentary structures – Diagenesis: general considerations, terrigenous clastic sediments, carbonate sediments, evaporates and hydrocarbons. Sedimentary depositional environments – Aeolian, lacustrine, glacial desert, fluvial, coastal shallow marine and deep sea – Sedimentary and faunal markers of paleoenvironmental conditions. Biostratigraphy and its applications.	**15**	CO3, CO4	K3, K3
Pedagogy	Lectures / Assignments / Seminars / Discussion			
References/ Readings:	1. Reineck, H. E., & Singh, I. B. (2012). Depositional sedimentary environments: with reference to terrigenous clastic. Springer Science & Business Media, New York. 2. Allen, J. R. L. (1982). Sedimentary Structures: Their Character and Physical Basis. Vol. 1. Developments in Sedimentology. Elsevier, Amsterdam. 3. Pettijohn, F. J., & Potter, P. E. (2012). Atlas and glossary of primary sedimentary structures. Springer Science & Business Media, New York. 4. Sengupta, S. (2017). Introduction to sedimentology. Routledge, London. 5. Leeder, M. R. (2012). Sedimentology: process and product. Springer Science & Business Media, Netherlands. 6. Boggs, S. (2012). Principles of sedimentology and stratigraphy. Pearson Prentice Hall, Upper Saddle River, New Jersey. 7. Tucker, M. E., & Jones, S. J. (2023). Sedimentary petrology. John Wiley & Sons. USA, UK. 8. Pettijohn, F. J., Potter, P. E., & Siever, R. (2012). Sand and sandstone. Springer Science & Business Media, New York.			

Title of the Course	Sedimentology Practical
Course Code	MSC-5216
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	To demonstrate methods to identify sedimentary rocks and to analyse marine sediments.			
Course Outcomes:	Student will learn to:			**Mapped to PSO**
	CO 1. Identify and classify sedimentary rocks and sedimentary structure.			PSO 1, PSO 4
	CO 2. Interpret sedimentary faces.			PSO 1, PSO 4
	CO 3. Estimate the percentage of clay minerals from marine sediments.			PSO 1, PSO 4
	CO 4. Measure paleocurrent using sedimentary structure.			PSO 1, PSO 4
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. Measurement of sphericity and roundness of sediment grains. 2. Identification of sedimentary rocks.	**30**	CO1, CO2, CO3,	K1, K2, K3, K4, K5

	3. Identification of sedimentary structures. 4. Study of sedimentary facies. 5. Preparation of samples for X-ray diffraction analysis (XRD). 6. XRD analysis for clay minerals, Clay mineral identification and estimation of Semiquantitative percentages and interpretation. 7. Paleocurrent analysis.		CO4	
Pedagogy	Laboratory experiments/ Computations/ Plotting and interpretations and analysis.			
References/ Readings:	1. Friedman, G. M., & Johnson, K. G. (1982). Exercises in sedimentology. Wiley, New York. 2. Lindholm, R. C. (1987). A practical approach to sedimentology. Allen &Unwin, London. 3. Carver, R. E. (1971). Procedures in sedimentary petrology. Wiley-Interscience, New York. 4. K. Verma & Prasad C. (1981). A text book of Sedimentary Petrology Intl., Book Distribution. 5. Griffith, J. C. (1967). Scientific Methods in Analysis of Sediments: McGraw-Hill, New York. 6. Moorhouse, W. W. (1959). The study of rocks in thin sections. Harper, New York. 7. Lindholm, R. (2012). A practical approach to sedimentology. Springer Science & Business Media, UK. 8. Girard, I., Klassen, R. A., & Laframboise, R. R. (2004). Sedimentology laboratory manual. Ottawa, Ontario: Natural Resources Canada, Geological Survey of Canada, Terrain Sciences Division, Ottawa, Ontario, Canada. 9. Stow, D. A. (2005). Sedimentary Rocks in the Field: A color guide. CRC Press, London.			