Syllabus
for
The M.Sc. Course in
Ocean Geomatics with AI

Coastal Observatory and Outreach Centre (COOC)
Vidyasagar University
Midnapore
Paschim Medinipur, West Bengal
PIN – 721 102

Brief history

The Coastal Observatory and Outreach Centre (COOC) of Vidyasagar University is an interdisciplinary advanced skill development centre, where students can pursue their education and R&D using geospatial techniques and modelling in the field of operational oceanography, disaster and climate studies. One of the major mandates of COOC is to build the capacity of the regional students in the above-mentioned field and to fulfil the objective, COOC is announcing full-fledged M.Sc. course on ***"Ocean Geomatics with AI"*** from 2025-2026 onwards on self-financial mode. The coastal laboratory and the outreach centre of COOC is established at Digha, West Bengal, India in collaboration with Indian National Centre for Ocean Information Services (INCOIS), Ministry of Earth Sciences (MoES), Govt. of India. Students will get their hands-on exposure from this centre.

Program Outcomes (POs)

The Master of Science (M.Sc.) degree is designed to produce postgraduate students who are highly skilled, knowledgeable, and responsive to the demands of their respective fields. The core program outcomes (POs) for M.Sc. graduates are as follows:

- Advanced Knowledge: Graduates gain an in-depth understanding of their specific field of study, including theoretical foundations, practical applications, and current trends.
- Research Skills: Students develop robust research skills, enabling them to formulate, design, and conduct scientific research. This includes proficiency in using modern research methodologies, critical analysis, and data interpretation.
- Technical Proficiency: They are trained in the use of advanced tools and technologies relevant to their discipline, enhancing their analytical and problem-solving capabilities through machine learning and artificial intelligence techniques.
- Communication Skills: M.Sc. graduates are equipped with the skills to effectively communicate complex information in a clear and concise manner, both in writing and verbally, to both specialist and non-specialist audiences.
- Ethical Practices: Students are instilled with a strong sense of ethical responsibility, ensuring that their professional activities are conducted with integrity and adhere to applicable standards and regulations.
- Professional Competence: Graduates demonstrate the ability to work independently and as part of a team, managing projects efficiently and making informed decisions that reflect expert knowledge and judgment.
- Innovation and Creativity: The program encourages innovation and critical thinking, enabling graduates to contribute novel solutions to problems in their fields.
- Lifelong Learning: Graduates are prepared to engage in continuous learning, adapting to changes and pursuing further educational opportunities to remain relevant in their professions.

These outcomes prepare graduates not only to excel in their immediate roles but also to contribute effectively to the advancement of their fields and to address broader societal challenges.

Programme Specific Outcomes

The Master of Science (M.Sc.) degree in ***"Ocean Geomatics with AI"*** equip students with a comprehensive skillset and knowledge base that prepares them for diverse professional roles and further research in the field. The specific program outcomes include:

- Technical Proficiency: Graduates will demonstrate advanced proficiency in the principles and applications of operational oceanography, disaster and climate studies using geospatial and advanced AI/ML modelling techniques. This includes competency in data acquisition, processing, analysis, and interpretation.
- Analytical Skills: Students will develop strong analytical skills, enabling them to tackle complex spatial problems using geospatial and advanced AI/ML techniques. They learn to integrate multiple data sources and apply quantitative and qualitative analysis techniques.
- Problem-Solving Abilities: The curriculum fosters the ability to design a campaign on operational oceanography, disaster and climate studies using geospatial and advanced AI/ML modelling that address real-world issues, emphasizing strategic problem-solving and decision-making skills.
- Research Capability: Graduates will be capable of conducting independent research, utilizing advanced tools and methodologies in remote sensing & GIS, AI/ML. This includes designing research proposals, managing projects, and synthesizing findings coherently.
- Technological Adaptability: Keeping pace with rapid technological advancements in the field, students will gain proficiency in the latest remote sensing software and GIS and AI/ML tools, ensuring they remain adaptable and industry-relevant.
- Communication Skills: Effective communication is pivotal, and graduates will be skilled at presenting complex geospatial information to diverse audiences, including scientists, policymakers, and the general public.
- Professional Development: The program prepares students for a professional career in various sectors, including government, academia, private industry, and non-profit organizations, by inculcating a strong ethos of ethical practice and continuous professional development.
- Collaborative Experience: Through collaborative dissertations and projects with State and Central Government Agencies, as well as renowned research institutes, students gain valuable teamwork and leadership experience.

These outcomes ensure that graduates not only enter the workforce as highly qualified remote sensing, GIS and AI/ML professionals but also contribute innovatively to their fields of expertise.

DIVISION OF MARKS

Total Marks: 1100

SEM-I Marks: 275

SEM-II Marks: 275

SEM-III Marks: 275

SEM-IV Marks: 275

Theoretical Marks: 525 (SEM-I: 175; SEM-II: 175; SEM-III: 175)

Practical Marks: 300 (SEM-I: 100; SEM-II: 100; SEM-III: 100)

Industry Readiness: 50 (SEM-IV)

Term paper: 50 (SEM-IV)

Research Dissertation (Examination): 50 marks (SEM-IV)

Research Dissertation (Viva-Voce): 50 marks (SEM-IV)

Skill Enhance Course: 25 (SEM-IV)

Grand Viva: 50 marks (SEM-IV)

M. Sc. in Ocean Geomatics with AI

Semester	Course No.	Course Titles	Full Marks	No. of Lectures (hours)	Credits (Lecture-Tutorial-Practical) (L-T-P)
Sem-I	OG-101	Fundamental Concept of Oceanography and Ocean Optics	50	40	4 (2-2-0)
	OG-102	Physics of Remote Sensing and Fundamental of GIS	50	40	4 (2-2-0)
	OG-103	Introduction to Operational Oceanography	50	40	4 (2-2-0)
	OG-104	Indian Knowledge System (IKS)	25	20	2 (1-1-0)
	OG-105	Vidyasagar: Life & Philosophy	Non-Credit		
		Practical			
	OG-106	Conventional Surveying and Remote Sensing & GIS (Practical)	50	80	4 (0-0-4)
	OG-107	Ocean Optics and Coding in Oceanography (Practical)	50	80	4 (0-0-4)
	Total		**275**	**300**	**22**
Sem-II	OG-201	Coastal Processes and Coastal Hazards	25	20	2 (1-1-0)
	OG-202	Introduction to Machine Learning and Artificial Intelligence (AI)	50	40	4 (2-2-0)
	OG-203	Ocean Geology and Digital Image Processing	50	40	4 (2-2-0)
	OG-204	Geospatial Science and Web GIS (MOOC)	50	40	4 (2-2-0)
		Practical			
	OG-205	Ocean-Atmospheric Data and Satellite Image Processing (Practical)	50	80	4 (0-0-4)
	OG-206	Geodesy and Machine Learning/Artificial Intelligence (Practical)	50	80	4 (0-0-4)
	Total		**275**	**300**	**22**
Sem-III	OG-301	Coastal Zone, Climate Change and Disaster Management	50	40	4 (2-2-0)
	OG-302	Research Methodology and Ethics	25	20	2 (1-1-0)
	OG-303	Elective Special Papers (Any One): *i. OG-303A: Physical Oceanography;* *ii. OG-303B: Chemical Oceanography;* *iii. OG-303C: Geoinformatics and AI&ML in Operational*	50	40	4 (2-2-0)

		Oceanography; *iv. OG-303D: Advanced Remote Sensing, GIS and AI/ML.* *v. OG-303E: Geological Oceanography.* *vi. OG-303F: Geoinformatics and AI&ML in Coastal Management*			
	OG-304	MSD 011: Sustainability Science (MOOC)	50	40	4 (2-2-0)
		Practical			
	OG-305	Geo-statistics and Digital Cartography (Practical)	50	80	4 (0-0-4)
	OG-306	Coastal and Ocean Modelling (Practical)	50	80	4 (0-0-4)
	Total		**275**	**300**	**22**
	OG-401	Industry Readiness	50		4 (0-0-4)
	OG-402	Term paper	50		4 (0-0-4)
	OG-403	Research Dissertation (Examination)	50		4 (0-0-4)
	OG-404	Research Dissertation (Viva-Voce)	50		4 (0-0-4)
	OG-405	Skill Enhance Course	25		2 (0-0-2)
	OG-406	Grand-viva	50		4 (0-0-4)
	Total		**275**	**300**	**22**
GRAND TOTAL			**1100**	**1200**	**88**

The total credit for the course is 88 and the total mark is 1100.

Distinctive features of course content:

- **Value-added course: OG- 106, 107, 201, 302, 305.**
- **Employability / entrepreneurship/ skill development: OG-104, 105, 106, 202, 203, 204, 205, 206, 101, 102, 103, 401, 402 405.**
- **Ethics, environment & sustainability: OG-101, 103, 301, 303.**
- **The new course introduced: OG-105, 202, 304, 401, 402, 405.**
- **Field Survey (academic excursion): OG-204, 304, 306, 403.**
- **Internship (optional): OG-401, 402 405.**

STRUCTURE OF THE SYLLABUS (SEM-I)

SEMESTER-I: Theoretical Papers: 04; Elective Papers: Nil; Practical: 02

Course Code	Title of the Papers	Marks Division			Theoretical/ Practical	Credits	Exam. Time
		Internal Assessment	Examination	Total Marks			
OG-101	Fundamental Concept of Oceanography and Ocean Optics	10	40	50	Theory	4	2 hrs.
OG-102	Physics of Remote Sensing and Fundamental of GIS	10	40	50	Theory	4	2 hrs.
OG-103	Introduction to Operational Oceanography	10	40	50	Theory	4	2 hrs.
OG-104	Indian Knowledge System (IKS)	05	20	25	Theory	2	1 hrs.
OG-105	Vidyasagar: Life & Philosophy	Non-Credit					
OG-106	Conventional Surveying and Remote Sensing & GIS	Notebook + Viva-Voce = 10; Practical = 40		50	Practical	4	4 hrs.
OG-107	Ocean Optics and Coding in Oceanography	Notebook + Viva-Voce = 10; Practical = 40		50	Practical	4	4 hrs.
Total				**275**		**22**	**15**

STRUCTURE OF THE SYLLABUS (SEM-II)

SEMESTER-II: Theoretical Papers: 04; Elective Papers: Nil; Practical: 02

Course Code	Title of the Paper	Marks Division			Theoretical/ Practical	Credits	Exam. Time
		Internal Assessment	Examination	Total Marks			
OG-201	Coastal Processes and Coastal Hazards	05	20	25	Theory	2	1 hrs.
OG-202	Introduction to Machine Learning and Artificial Intelligence (AI)	10	40	50	Theory	4	2 hrs.
OG-203	Ocean Geology and Digital Image Processing	10	40	50	Theory	4	2 hrs.
OG-204	Geospatial Science and Web GIS (MOOC)	15	35	50	Theory	4	2 hrs.
OG-205	Ocean-Atmospheric Data and Satellite Image Processing	Notebook + Viva-Voce = 10; Practical = 40		50	Practical	4	4 hrs.
OG-206	Geodesy and Machine Learning/Artificial Intelligence	Notebook + Viva-Voce = 10; Practical = 40		50	Practical	4	4 hrs.
Total				**275**		**24**	**15**

STRUCTURE OF THE SYLLABUS (SEM-III)

SEMESTER-III: Theoretical Papers: 03; Elective Papers: 01; Practical: 02

Course Code	Title of the Paper	Marks Division			Theoretical/ Practical	Credits	Exam. Time
		Internal Assessment	Examination	Total Marks			
OG-301	Coastal Zone, Climate change and Disaster Management	10	40	50	Theory	4	2 hrs.
OG-302	Research Methodology and Ethics	05	20	25	Theory	2	1 hrs.
OG-303	Elective Special Papers (Any One)	10	40	50	Theory	4	2 hrs.
OG-304	MSD 011: Sustainability Science (MOOC)	15	35	50	Theory	4	2 hrs.
OG-305	Geo-statistics and Digital Cartography	Notebook + Viva-Voce = 10; Practical = 40		50	Practical	4	4 hrs.
OG-306	Coastal and Ocean Modelling	Notebook = 30 and Viva-Voce = 20		50	Practical	4	4 hrs.
Total				**275**		**22**	**15**

STRUCTURE OF THE SYLLABUS (SEM-IV)

SEMESTER-IV: Core Papers: 00; Elective Papers: Nil; Practical: 06

Course Code	Title of the Paper	Marks Division			Theoretical/ Practical	Credits	Exam. Time
		Internal Assessment	Examination	Total Marks			
OG-401	Industry Readiness	00	50	50	Practical	4	4 hrs.
OG-402	Term paper	00	50	50	Practical	4	4 hrs.
OG-403	Research Dissertation (Examination)	00	50	50	Practical	4	4 hrs.
OG-404	Research Dissertation (Viva-Voce)	00	50	50	Practical	4	4 hrs.
OG-405	Skill Enhance Course	00	25	25	Practical	2	2 hrs.
OG-406	Grand viva	00	50	50	Practical	4	4 hrs.
Total				**275**		**22**	**22**

The students have to select any one of the following subjects, likely to be offered as elective special papers:

i. OG-303A: Physical Oceanography;
ii. OG-303B: Chemical Oceanography;
iii. OG-303C: Geoinformatics and AI&ML in Operational Oceanography;
iv. OG-303D: Advanced Remote Sensing, GIS and AI/ML.
v. OG-303E: Geological Oceanography.
vi. OG-303F: Geoinformatics and AI&ML in Coastal Management

Important Note:

- Total intake capacity of the Centre (SEM-I) every year will be 15+5 (with special permission) candidates at present.
- The intake capacity of each special paper (SEM-III) will be decided by the Departmental Committee before commencement of SEM-III classes.
- First-Class 60%, Second-Class 50%, No third class. Min. marks for passing Theory Papers-20, Practical Papers-13.
- Field/Project work is compulsory for Students of Semester–III.
- Internal assessment will be based on seminar presentation, class tests, quiz and assignments.
- Students will get maximum 5 months to complete his/her dissertation work in semester-IV.
- Students may visit their field of study during dissertation work at their own expenses.
- Students may have to carry out Dissertation works in an outstation institution at their own expenses.
- Grand viva will be based on the overall understanding of the subject.

SEMESTER-I PAPER

Semester-I (Theory)

OG-101: (*EXAMINATION TIME: 2 HOURS)*

Fundamental Concept of Oceanography and Ocean Optics (50 Marks)

Full Marks 50. Number of lectures to be delivered for this paper is 40. Pattern of setting questions: Eight questions of 10 marks are to be set. Four questions of 10 marks are to be answered from this module.

Course Outcome:

- They also learn regarding Ocean Optics including radiometer operations and chlorophyll-a, sea surface temperature and water clarity measurement will be taught in this module.
- Students will learn about the various aspects of physical and chemical oceanography, like ocean energy and tidal energy including wave propagation.
- Mass balance in the ocean, origin of seawater and physical chemistry of seawater will also be cultured.

OG-101: Fundamental Concept of Oceanography and Ocean Optics:

i. Basic concepts of physical, chemical, geological, and biological oceanography.
ii. Types of ocean waves and their characteristics, wave propagation, refraction, and reflection, wave spectrum and principles of wave forecasting, storm wave and wave induced near shore current, long shore current, rip current and sediment movement.
iii. Composition and stoichiometry of seawater, constancy of composition for seawater, chlorinate & the concept of salinity and the methods of their determination and air-sea interaction.
iv. Definition of plankton and its importance, classification based on size, mode of life and habitat, methods of collection, estimation of standing crop.
v. Fundamentals of ocean optics including radiometer operations and chlorophyll-a, sea surface temperature and water clarity measurement.

Internal Assessment (10 Marks)

OG-102: (*EXAMINATION TIME: 2 HOURS)*

Physics of Remote Sensing and Fundamental of GIS (50 Marks)

Full Marks 50. Number of lectures to be delivered for this paper is 40. Pattern of setting questions: Eight questions of 10 marks are to be set. Four questions of 10 marks are to be answered from this module.

Course Outcome:

- Students will know the various sources of energy and their interaction properties for the use of remote sensing studies.
- They also understand the characteristics of scanning system, sensor's resolution to understand the variety field of data remote sensing.
- Learners will get the knowledge regarding GIS data format, data structure and data capture for the processing of various data and application in GIS platform.

OG-102: Physics of Remote Sensing and Fundamental of GIS:

i. Concept and scope of Electro Magnetic Radiation (EMR), Electro Magnetic Spectrum (EMS), wavelength-frequency, and energy interaction with atmosphere and earth surface features and principle of Remote Sensing.

ii. Types of Remote Sensing, characteristics and classification of platform, sensor, resolution, scanning system, and satellite orbit and orbital law (Kepler's Law), concept of satellite image and FCC band composition.
iii. Basic concepts and definition of GIS, areas of GIS application, advantage and limitation of GIS
iv. Component of Geographical Information System (GIS), data types, data structure, visual image interpretation.
v. Types of digitizing error, topology, geodatabase creation and analytical approach.

Internal Assessment (10 Marks)

OG-103: (*EXAMINATION TIME: 2 HOURS)*
Introduction to Operational Oceanography (50 Marks)

Full Marks 50. Number of lectures to be delivered for this paper is 40. Pattern of setting questions: Eight questions of 10 marks are to be set. Four questions of 10 marks are to be answered from this module.

Course Outcome:

- Students will know the processes that take place in seas and oceans and their variability, along with their causes, focused on those that affect biological production and those that alter the ecosystem
- They will learn regarding the timely and accurate information about the ocean's state, using a combination of data from satellites, in-situ measurements, and ocean models.
- They will also gain the knowledge how to improve the weather forecasting, disaster preparedness (like storm surge warnings), support for marine industries (shipping, fishing), and better understanding of climate change impacts

OG-103: Introduction to Operational Oceanography:

i. Introduction to ocean general circulation: General Ocean circulation features: Temperature, Salinity, Currents, mixed layer. Wind-waves: properties of wind-waves such as wave height, wave period, wave length, Significant Wave Height (SWH), Swells, Swell surges, rip currents etc., Tides.
ii. Prediction of ocean general circulation: Elements of ocean forecasting, Basics of numerical ocean modelling, Ocean General Circulation Models, Wind-wave models, Introduction to Ocean data assimilation, Atmospheric Forcing, prediction tides.
iii. Ocean State Forecasting: Global scenario and perspective, forecast generation, Quantitative evaluation of forecasts and forcing fields using statistics-delayed mode and real-time, Oceanographic and meteorological conventions on parameters, Standard Operating Procedure, Feedback collection mechanism, User interaction and awareness workshops, Indian Ocean Forecast System (INDOFOS). Storm Surge Warning.
iv. Introduction to Tropical Cyclones: Structure, Thermodynamics, Dynamics, Genesis and life cycle, Storm surge: Basic features, Physics of storm surge, Forecasting Storm Surges, Storm surge modelling
v. Dissemination of forecasts and advisories: Users of operational oceanographic services, modes of dissemination, templates of forecast systems.

Internal Assessment (10 Marks)

OG-104: (*EXAMINATION TIME: 1 HOURS)*

Indian Knowledge System (IKS) (25 Marks)

Full Marks 25. Number of lectures to be delivered for this paper is 20. Pattern of setting questions: Four questions of 10 marks are to be set. Two questions of 10 marks are to be answered from this module.

Course Outcome:

- The students will learn the very rich and versatile knowledge system and cultural heritage.
- They will also learn the historical prospective of ideas occurrence in the ancient society, and implication to the concept of material world, and religious, social, and cultural beliefs.
- Tribal knowledge as well as indigenous and traditional learning methods which will cover and include mathematics, astronomy, philosophy, yoga, architecture, medicine, agriculture, engineering, linguistics, literature, sports, games, as well as governance, polity and conservation

OG-104: Indian Knowledge System (IKS):

i. Introduction and foundational concepts of IKS: various streams of knowledge in India and classification of ancient Indian texts, Psychology from Indian perspective, Yoga and Indian Linguistics: Introduction to Yoga; theory of emotions, Paṇini's contribution to linguistics, Indian.

ii. Mathematics and Astronomy: An overview of Indian mathematics, Development of arithmetic geometry and Trigonometry, Vedic Mathematics and Indian Astronomy, Medicinal traditions in India.

iii. An Introduction to Āyurveda, Indian Architecture and Planning, Traditional measurement system used in Vāstuśāstra and Economics, Management and Governance from Indian perspectives.

Internal Assessment (5 Marks)

OG-105: (*EXAMINATION TIME: 2 HOURS)*

Vidyasagar: Life & Philosophy

Semester-I (Practical)

OG-106: PRACTICAL (*EXAMINATION TIME: 4 HOURS)*

Conventional Surveying and Remote Sensing & GIS (50 Marks)

Full Marks 50. At least even number of periods to be assigned (preferably in batches). Pattern of setting questions: 40 marks compulsory questions are to be set. 10 marks are to be allotted for evaluation of practical notebook and viva-voce. Right-hand side parentheses indicate lecture / demonstration hours.

Course Outcome:

- Students will get the knowledge of conventional and advanced field survey techniques for the ground truthing in various field. They will also able to handle the surveying instruments (Auto level, Total station and GPS) during the field work and to collect the in-situ data for the ground truth validation.
- Students will able to handle the Remote Sensing & GIS software and to process the satellite imageries.
- They will handle GIS data base for the application of shape file with attribute management, thematic mapping, visualization of various data in different scales.

OG-106: Conventional Surveying and Remote Sensing & GIS:

i. Importance of field survey and ground trothing, advanced field survey instruments / techniques (Auto Level, Total Station and GPS). Plane and geodetic surveying (traversing, triangulation and levelling).
ii. Introduction to different Remote Sensing and GIS software, concept of bands and channels, true colour, false colour and standard false colour composition.
iii. Physical and cultural features identification/extraction from satellite imageries through visual image interpretation techniques.
iv. Georeferencing, coordinate system, digitization with point, line polygon, managing & joining attribute data.
v. Conversion of raster-vector data, topology, visualization tools, handling geo-database, creation of chart & diagrams etc.

OG-107: PRACTICAL (*EXAMINATION TIME: 4 HOURS)*

Ocean Optics and Coding in Oceanography (50 Marks)

Full Marks 50. At least even number of periods to be assigned (preferably in batches). Pattern of setting questions: 40 marks compulsory questions are to be set. 10 marks are to be allotted for evaluation of practical notebook and viva-voce. Right-hand side parentheses indicate lecture / demonstration hours.

Course Outcome:

- Students will also learn the fundamentals of ocean optics including radiometer operations and chlorophyll-a, sea surface temperature and water clarity measurement.
- They will use different processing tools Ocean Optics measurement for the application/modelling purpose.
- They will able to know the coding components focused on data analysis and modelling, often using programming languages and others software.

OG-107: Ocean Optics and Coding in Oceanography:

i. Ocean optics including radiometer operations and chlorophyll-a, sea surface temperature and water clarity measurement.
ii. Application of Radiometry in Ocean Optics and
iii. Automatic Satellite Data Processing Chain (ADPC) in Bio optics.
iv. Mathematical and Statistical Methods: linear algebra, probability, and statistics, providing the mathematical background for oceanographic modelling.
v. Oceanographic Data Analysis: Focus on techniques for analyzing various types of oceanographic data (temperature, salinity, currents, etc.)

SEMESTER-II PAPER

Semester-II (Theory)

OG-201: (*EXAMINATION TIME: 1 HOURS)*
Coastal Processes and Coastal Hazards (25 Marks)

Full Marks 25. Number of lectures to be delivered for this paper is 20. Pattern of setting questions: Four questions of 10 marks are to be set. Two questions of 10 marks are to be answered from this module.

Course Outcome:

- Students will understand the characteristics and formation of wave, currents, tides, and another physical environment of coastal region.
- They also able to get the knowledge of shoreline dynamic and functional interrelationship between forms and processes in a coastal region and their dynamic equilibrium.
- They will assess the coastal hazard, risk, vulnerability in coastal region to prevent the early warning disaster. Students are expected to carry out the concepts on different phases of disaster management such as disaster preparedness, mitigation, response, recovery rehabilitation and reconstruction.

OG-201: Coastal Processes and Coastal Hazards:

i. Consequences of coast and coastal studies, nearshore water circulation, sediment movements by waves and currents (longshore & rip current) in shallow water environment.
ii. Wave hydrodynamics, wave modification with special reference to attenuation, breaker types & surf zone, energy dissipation during breaking wave, tidal environment with special reference to estuary.
iii. Beach morphology (beach profiles, beach erosion & accretion, long shore bars, sand spits, mud bank) and dune formation & classification.
iv. Introduction of natural coastal hazards (Sea level rise, erosion, sedimentation and tropical cyclones, coastal engineering and its impacts, ports and harbours) and its impact measure.
v. Types of coastal hazards of West Bengal coast (Factors, risks, vulnerability and management) and coastal hazards zonation techniques.

Internal Assessment (5 Marks)

OG-202: (*EXAMINATION TIME: 2 HOURS)*
Introduction to Machine Learning and Artificial Intelligence (AI) (50 Marks)

Full Marks 50. Number of lectures to be delivered for this paper is 40. Pattern of setting questions: Eight questions of 10 marks are to be set. Four questions of 10 marks are to be answered from this module.

Course Outcome:

- Introduce the concept of learning patterns from data and develop a strong theoretical foundation for understanding state of the art Machine Learning algorithms to the students.
- This approach is broad in scope and gives the student a holistic understanding of the subject.
- They will also learn regarding the meaning of Artificial Intelligence and explore various paradigms for knowledge encoding in computer systems.

OG-202: Introduction to Machine Learning and Artificial Intelligence (AI):

i. Review of Important Python and C++ Concepts, Machine Learning Algorithms with Scikit-learn, Building a Neural Network with Tensor Flow.
ii. Idea of Machines learning from data classification of problem with Linear Regression, Logistic Regression, Neural Networks, Support Vector Machines, Recommender Systems.
iii. Introduction to artificial intelligence, background and applications, turing test and rational agent approaches to AI.
iv. Problems of AI techniques (State Space Search and Heuristic Search Techniques), Knowledge Representation Issues. Using Predicate Logic and Representing Knowledge as Rules.
i. Probability and Bayes Theorem, Certainty factors, Probabilistic Graphical Models, Bayesian Networks, Markov Networks, Fuzzy Logic, Symbolic Logic under Uncertainty.

Internal Assessment (10 Marks)

OG-203: (*EXAMINATION TIME: 2 HOURS)*
Ocean Geology and Digital Image Processing (50 Marks)

Full Marks 50. Number of lectures to be delivered for this paper is 40. Pattern of setting questions: Eight questions of 10 marks are to be set. Four questions of 10 marks are to be answered from this module.

Course Outcome:

- Students will be able to understand the basics knowledge of the structure, composition, tectonic activity, mineral composition, rock types.
- They will also understand the dynamism development and evolution of oceanic crust.
- Students will learn the satellite data processing algorithm, basic image classification algorithm and indices to differentiate / extract the spatial and temporal features from different ocean sensor's data.

OG-203: Ocean Geology and Digital Image Processing:

i. Structure and composition of the oceanic crust, formation of three-layered structure of oceanic crust, sea water - basalt interaction, ocean floor metamorphism, principles of Ichnology.
ii. Basic concepts and geological evidences of continental drift, sea-floor spreading and plate tectonics, mid-oceanic ridges, oceanic islands, trenches, earthquakes and plate tectonics.
iii. Definition of digital image, data formats, sources and types of error in image data, techniques of resampling, geometric and radiometric calibration.
iv. Techniques of image enhancement, transformation, advanced image classification techniques (Supervised unsupervised, SAM, Fuzzy) and post classification (LU/LC) with Kappa Statistics.
v. GIS data modelling and image arithmetic operation with special reference to ocean studies, integration and linkage of digital image with ocean information services.

Internal Assessment (10 Marks)

OG-204: (*EXAMINATION TIME: 2 HOURS)*
Geospatial Science and Web GIS (MOOC) (50 Marks)

Full Marks 50. At least even number of periods to be assigned (preferably in batches). Pattern of setting questions: 40 marks compulsory questions are to be set. 10 marks are to be allotted for evaluation of practical notebook and viva-voce. Right-hand side parentheses indicate lecture / demonstration hours.

Course Outcome:

- By combining MOOCs from different platforms and focusing on areas of interest within Geospatial Science and Web GIS, individuals can build a strong foundation in this field and pursue careers in various sectors, including urban planning, environmental management, resource management, and more.
- The students learn about spatial data management, analysis, and visualization. Key areas covered include remote sensing, GIS, spatial analysis, cartography, and programming for geospatial applications.
- They also learn the concepts and skill of geospatial applications online, often using Web GIS substantial project related to Geospatial Science and Web GIS.

OG-204: Geospatial Science and Web GIS (MOOC)

i. Fundamental concepts and techniques for analysing spatial data, including spatial statistics, modelling, and prediction.
ii. Implementation, and management of spatial databases, including understanding data models, database technologies, and spatial indexing.
iii. Foundation in programming languages and tools commonly used for geospatial development and automation.
iv. Concepts of spatial data infrastructure, including standards, services, and the integration of data into geospatial systems.
v. Web Mapping technologies and methods for building and deploying web-based mapping applications and cloud platforms for hosting and processing geospatial data and applications.

Internal Assessment (10 Marks)

Semester-II (Practical)

OG-205: PRACTICAL (*EXAMINATION TIME: 4 HOURS)*

Ocean-Atmospheric Data and Satellite Image Processing (50 Marks)

Full Marks 50. At least even number of periods to be assigned (preferably in batches). Pattern of setting questions: 40 marks compulsory questions are to be set. 10 marks are to be allotted for evaluation of practical notebook and viva-voce. Right-hand side parentheses indicate lecture / demonstration hours.

Course Outcome:

- Students will able to enhance the remote sensing and other forms of data in reliable techniques for the better identification ocean / coastal measures.
- They will also prepare some model based on the scientific algorithm in this part.
- They will also classify the satellite data methodically to represent various oceanographic and coastal features changeability in their environment.

OG-205: Ocean-Atmospheric Data and Satellite Image Processing:

i. Creation of ROI, Sub-setting, mosaicking, generation of spectral signature curve, Feature extraction, image enhancement (Histogram, contrast, filtering, indices, transformation).
ii. Classification (Supervised & unsupervised), SQL, network analysis, proximity, buffer, topology, overlay. Generation of TIN, DEM, slope, aspect, drainage and contour plan.

iii. Coastal feature extraction from satellite image and assessment of coastal vulnerability index through the RS & GIS techniques.
iv. Identification of Phytoplankton in micro and macro algae, sea grasses, identification of marine invertebrates and vertebrates (fish and prawns), morphometric features of the mangroves and its associates.
v. Identification of common minerals and rocks in hand specimens, identification and interpretation of common sedimentary structures in hand specimens, interpretations of topographic and bathymetric maps and selective fossils.

OG-206: PRACTICAL (*EXAMINATION TIME: 4 HOURS)*

Geodesy and Machine Learning/Artificial Intelligence (50 Marks)

Full Marks 50. At least even number of periods to be assigned (preferably in batches). Pattern of setting questions: 40 marks compulsory questions are to be set. 10 marks are to be allotted for evaluation of practical notebook and viva-voce. Right-hand side parentheses indicate lecture / demonstration hours.

Course Outcome:

- They will also get the knowledge of mathematical earth, surface geometry, vertical and horizontal datum for exploration of the ocean surface and coastal bathymetry.
- Students will learn to analyse the data using basic and advanced statistical methods and distribution functions. They will also apply the mathematical functions in geospatial data and to derive important information from it
- They can prediction the ocean weather and climate, habitat modelling and distribution, species identification, coastal water monitoring, marine resources management, detection of oil spill and pollution and wave modelling.

OG-206: Geodesy and Machine Learning/Artificial Intelligence:

i. Introduction to satellite constellation, geo-positioning-concepts. NAVSTAR, GLONASS, Indian Regional Navigational Satellite System (IRNSS), various segment of GPS and positioning types.
ii. Principles of geodesy, mathematical surface model and characteristics of earth geometry (Ellipsoid & Geoid), concept of great circle and spherical triangle. Properties of datum and coordinate transformation (WGS-84, Everest spheroid, UTM, GCS), Significance of geodesy in coastal and ocean application.
iii. Oceanic Weather and Climate: Machine learning analyses historical data to predict ocean currents, sea surface temperatures, and other factors crucial for understanding and forecasting weather patterns and long-term climate changes.
iv. Habitat Modelling: AI used to map and predict the distribution of marine species based on environmental data, helping in conservation efforts and resource management.
v. Coastal Processes: Machine learning models can predict sea level fluctuations and other coastal changes, which is vital for coastal management and infrastructure planning.

SEMESTER-III PAPER

Semester-III (Theory)

OG-301: (*EXAMINATION TIME: 2 HOURS)*

Coastal Zone, Climate Change and Disaster Management (50 Marks)

Full Marks 50. Number of lectures to be delivered for this paper is 40. Pattern of setting questions: Eight questions of 10 marks are to be set. Four questions of 10 marks are to be answered from this module.

Course Outcome:

- Students will get knowledge about the difficulties of emerging coastal issues. They will apply their knowledge for the better management techniques to develop the coastal region.
- Students are expected to carry out the concepts on different phases of disaster management such as disaster preparedness, mitigation, response, recovery rehabilitation and reconstruction.
- They will get employment opportunities as research scientist in the various organization / institutes like INCOIS, MOEF, DST, NIO, NCSCM, Dept. of Earth Sciences and TOURISIM Department etc.

OG-301: Coastal Zone, Climate Change and Disaster Management:

i. Concepts, definition and approach of coast, general classification of coastal zones, guidelines for Coastal zone management.

ii. Impacts of construction on coastal zone, construction of jetties, breakwaters, sea walls, bulkheads groynes, revetments etc. Application of ICZM for sustainability of coastal ecosystems. Applications of GIS in coastal zone development and management.

iii. Assessment of coastal vulnerability, ecosystem valuation of coast, CRZ mapping and Environmental Impact Assessment (EIA) in response to climate change. Coastal urbanization and population pressures.

iv. Disaster management plans with special reference to India. Onsite Plans: Standard operating procedures, control room, safety officer, Different committees for Disaster management, rescue team, training, exercises and mock drills.

v. Management plan for Offsite Plans: Dissemination of information, identification of vulnerable locations, need and damage assessment, rescue and relief plans, compensation.

Internal Assessment (10 Marks)

OG-302: (*EXAMINATION TIME: 1 HOURS)*

Research Methodology and Ethics (25 Marks)

Full Marks 25. Number of lectures to be delivered for this paper is 20. Pattern of setting questions: Four questions of 10 marks are to be set. Two questions of 10 marks are to be answered from this module.

Course Outcome:

- Students will be able to learn initial training on various steps involved in research.
- They will identify the research problem/gap to set the research objectives.
- They will learn to develop or prescribe a research approach or project management structure starting from input data, techniques with expected outcome.

OG-302: Research Methodology and Ethics:

i. Introduction to research ethics and philosophy, definition, nature and scope.
ii. Identification of research problems, development of theoretical background- literature review, research gap, research design, descriptive and hypothesis-testing.
iii. Concept of research, motivation, significance, style of referencing, bibliography and appendices, abstract and synopsis writing.
iv. Steps in sampling design, types of sampling and their applications in research, collection of spatial and temporal data.
v. Significance and introduction of publication ethics and Plagiarism.

Internal Assessment (5 Marks)

OG-303: (*EXAMINATION TIME: 2 HOURS)*
Elective Special Paper (50 Marks)

Full Marks 50. Number of lectures to be delivered for this paper is 40. Pattern of setting questions: Eight questions of 10 marks are to be set. Four questions of 10 marks are to be answered from this module.

Course Outcome:

- Students will be able to analyse various tasks to solve the problem in a specific domain.
- They will gain the knowledge in various specialized area of research.
- They will also prepare a sustainable management plan of their specialized area.

OG-303: Elective Special Paper (Any One):

[i] OG-303A: Physical Oceanography;
[ii] OG-303B: Chemical Oceanography;
[iii] OG-303C: Geoinformatics and AI&ML in Operational Oceanography;
[iv] OG-303D: Advanced Remote Sensing, GIS and AI/ML;
[v] OG-303E: Geological Oceanography;
[vi] OG-303F: Geoinformatics and AI&ML in Coastal Management

[i] OG-303A: Physical Oceanography:

i. Physical properties of seawater, ocean waves and their characteristics, shallow and deep-water waves, wave induced near shore current, long shore current, reap current and sediment movement.
ii. Basic mathematics to oceanography, De-Moivre's theorem and its applications, chaos complexity & bifurcations, non-linear systems, gravity waves, Stokes' Law and its application in marine organisms
iii. Definition of inverse circular and hyperbolic functions, Eigen Values and Eigen vectors matrix to oceanography, application of differentiation of velocity, acceleration, related rates.
iv. Problems related to oceanography, integration to growth and decay problems, centre of gravity, moment of inertia.
v. Differential equation (first and second order linear equations). Concept of simultaneous differential equations, partial differentiation, partial differential (wave equation, heat equation).

Internal Assessment (10 Marks)

[ii] OG-303B: Chemical Oceanography:

i. Physical chemistry of seawater (Laws of thermodynamics and chemical equilibrium) activity scales and activity coefficients, ionic interaction and chemical speciation in seawater.
ii. Origin of seawater (composition of rain, river and sea water and the sources of dissolved elements in them), crustal rock weathering and sodium balance concept, transport of material to the ocean, the river pathway.
iii. Acidification of ocean and concept of blue carbon, chemical exchanges across interfaces, residence times of elements in seawater, atmospheric pathway and the hydrothermal pathway.
iv. Typical distribution of water characteristics in the oceans, major water masses of the world's oceans and their characteristics; T-S diagram, water cycle.
v. Mass balance in the ocean (steady state ocean, global element cycle, geochemical balances), concept of residence time, mass balance and two box model for oceans.

Internal Assessment (10 Marks)

[iii] OG-303C: Geoinformatics and AI&ML in Operational Oceanography:

i. Prediction methods of storm surge warnings system and Tsunami early warning system, Indian seismic and GNSS network.
ii. Modelling of Potential Fishing Zone (PFZ), marine fisheries advisories and Ocean State Forecast (OSF).
iii. Modelling of Coral bleaching alerts, algal bloom information services, and coastal geospatial application.
iv. Modelling and estimation of multi hazards zonation and climate indices.
v. Estimation of Sea Surface Temperature (SST) anomaly, El-Nino, Indian Ocean Dipole (IOD).

Internal Assessment (10 Marks)

[iv] OG-303D: Advanced Remote Sensing, GIS and AI/ML

i. Introduction of aerial photographs and photogrammetry, geometry of aerial photograph, determination of scale and height, distortions, relief displacement, camera properties and colour concept, stereoscopy interpretation keys (shape, size, pattern, tone, texture, shadow, site and associations).
ii. Concept and foundation of Remote Sensing, fundamental of thermal and microwave remote sensing, radiation laws (wavelength-frequency-energy relationship of EMR), influence of atmosphere on Remote Sensing operation.
iii. Physical principles and characteristics of various satellites sensor, sensor selection parameters, resolution, Remote Sensing Data: Data acquisition and reception, Data products, storage and dissemination.
iv. Introduction to Digital Image Processing (DIP), image pre-processing, radiometric, geometric, atmospheric corrections, image enhancement, transformation, filtering, classification and arithmetic operations.
v. Concept and component of GIS, data type, structure & model, GIS data analysis system and applications of GIS in various aspects of coastal and marine environment.

Internal Assessment (10 Marks)

[v] OG-303E: Geological Oceanography:

i. The Shape and main features of ocean basins, Ocean Ridges – Ridge topography, The Evolution of ocean basins. Indian basins- Bengal basin, Andaman basin and Krishna-Godavari basin.

ii. Morphologic and tectonic domains of the ocean floor; structure, composition and mechanism of the formation of oceanic crust. Ocean margins and their significance

iii. Ocean Circulation, Coriolis effect and Ekman spiral, convergence, divergence and upwelling, El Nino. Indian Ocean Dipole Thermohaline circulation and oceanic conveyor belt. Formation of Bottom waters; major water masses of the world's oceans.

iv. Oceanic sediments: Factors controlling the deposition and distribution of oceanic sediments; geochronology of oceanic sediments, diagenetic changes in oxic and anoxic environments.

v. Tectonic evolution of the ocean basins. Deep sea sediments and their relation to oceanic processes. Methods and instruments for exploring the ocean floor. Marine stratigraphy, correlation and chronology.

Internal Assessment (10 Marks)

[vi] OG-303F: Geoinformatics and AI&ML in Coastal Management:

i. Coastal morpho-dynamics (Micro, macro and biogenic forms). Systems of change in coasts: cyclical and progressive. Classification of coasts based on processes and sediment characteristics.

ii. Coastal biogeography with special reference to sea weeds, mangroves, dune vegetation and corals, Coastal pollution: Sources, impacts and management, Integrated Coastal Management: Concepts, techniques and applications.

iii. Natural coastal hazards and their management: Sea level rise, erosion, sedimentation and tropical cyclones, Coastal engineering and its impacts: Ports and harbours, measures for prevention of erosion and sedimentation.

iv. Shoreline dynamic (coastal water movement, circulation in surf zone, beaches, beach profiles, sediment budgets, coastal dunes, barrier islands, tidal inlets, cliffed coasts, deltas, effects of storms. Human impacts on the coastline).

v. Human utilisation of coasts, environmental impacts and management: Navigation, mining, fishing and fish-processing, off-shore oil exploitation, reclamation and tourism.

Internal Assessment (10 Marks)

OG-304: (*EXAMINATION TIME: 2 HOURS)*

MSD 011: Sustainability Science (MOOC) (50 Marks)

Full Marks 50. At least even number of periods to be assigned (preferably in batches). Pattern of setting questions: 40 marks compulsory questions are to be set. 10 marks are to be allotted for evaluation of practical notebook and viva-voce. Right-hand side parentheses indicate lecture / demonstration hours.

Course Outcome:

- The students explore the interdisciplinary field of sustainability science. Also get knowledge of the genesis and principles of sustainable development, its tools, implementation, and assessment strategies.

- It delves into the relationship between humans and the environment, focusing on ecological foundations, natural resource management, and ethical considerations.
- This topic aims to equip learners with the knowledge and skills needed to understand and contribute to sustainable development practices, both locally and globally.

OG-304: MSD 011: Sustainability Science (MOOC)

i. Introduction to Sustainable Development: principles, concept and goals of sustainable development. Global challenges of sustainable development and its pathways
ii. Sustainability Science: ecological foundation of basic human needs. Concept of sustainability science, SDGs and sustainability indicators.
iii. Approaches to Sustainable Development: natural resource management, landscape ecology, watershed management and participation in policy and planning.
iv. Ecology, Economics: human resource development and eco-friendly lifestyle, education.
v. Ethics: awareness and environmental ethics, moving towards green technology.

Internal Assessment (10 Marks)

Semester-III (Practical)

OG-305: PRACTICAL (*EXAMINATION TIME: 4 HOURS)*

Geo-statistics and Digital Cartography (50 Marks)

Full Marks 50. At least even number of periods to be assigned (preferably in batches). Pattern of setting questions: 40 marks compulsory questions are to be set. 10 marks are to be allotted for evaluation of practical notebook and viva-voce. Right-hand side parentheses indicate lecture / demonstration hours.

Course Outcome:

- Students will learn how to analyze the data using basic and advanced statistical methods and distribution functions.
- They will also apply the mathematical functions in geospatial data and to derive important information from it.
- This will be very helpful for coastal and oceanographic modelling.

OG-305: Geo-statistics and Digital Cartography:

i. Fundamentals statistics of Z-Score, T-test, Correlation, Neighbourhood analysis and Principal Component analysis, moving average and cluster analysis.
ii. Scatter diagram, Bi-variate & multi variate correlation, linear regression, standard error estimation, significance level test and RMSE.
iii. Role of interpolation techniques for surface modelling (IDW, kriging, topo to raster, spline and trend), Methods of Interpolation, types of kriging.
iv. Application for ocean and coastal modelling & Simulation (Data extraction, processing, assimilation, distribution, model evolution & validation, prediction and response).
v. Point and line data collection using GPS with different datum, GPS and GIS integrations output preparation. Concept of digital cartography, map scales, cartographic design and visual variables, map lettering, map composition.

OG-306: PRACTICAL (*EXAMINATION TIME: 4 HOURS)*

Coastal and Ocean Modelling (50 Marks)

Full Marks 50. At least even number of periods to be assigned (preferably in batches). Pattern of setting questions: 40 marks compulsory questions are to be set. 10 marks are to be allotted for evaluation of practical notebook and viva-voce. Right-hand side parentheses indicate lecture / demonstration hours.

Course Outcome:

- Students will be able to learn different remote sensing and GIS application techniques for coastal and ocean monitoring.
- They will segregate and assimilate the oceanographic data for model validation purpose.
- They will learn Ecopath with Ecosim and basics of Regional Ocean modelling.

OG-306: Coastal and Ocean Modelling:

i. Application GIS with special reference to coastal zone management (monitoring surface waters in Coastal Regulatory Zone (CRZ), study of suspended material in water.
ii. Study of chlorophyll in water, measurement of Sea Surface Temperature (SST).
iii. Shoreline dynamics and sediment transportation path assessment through transect method.
iv. Different application of satellite remote sensing for ocean and coastal modelling.
v. Ecopath with Ecosim and basics of Regional Ocean Modelling.

SEMESTER-IV

OG-401: Industry Readiness (50 Marks)

Full Marks 50. At least even number of periods to be assigned (preferably in batches). Pattern of setting questions: 40 marks compulsory questions are to be set. 10 marks are to be allotted for evaluation of practical notebook and viva-voce. Right-hand side parentheses indicate lecture / demonstration hours.

Course Outcome:

- The students explore the practical skills and knowledge necessary to excel in the professional world, particularly within their chosen industry.
- They often learn a mix of technical skills relevant to the field, along with soft skills like communication, teamwork, and problem-solving.
- They able to bridge the gap between academic learning and the demands of the professional world, preparing graduates to be successful and adaptable in their chosen fields.

OG-401: Industry Readiness:

i. Soft Skills Development: Communication skills (written, verbal, and visual), teamwork, leadership, problem-solving, creativity, critical thinking.
ii. Industry-Specific Knowledge: Specialized training in areas like project management, quality assurance, software testing, quality assurance, specific industry standards.
iii. Core Technical Skills: Foundations of Machine Learning, Analytics and Data Science, Database Systems, practical application through labs, projects, and case studies.
iv. Professional Development: Career planning, resume writing, interview skills, understanding professional ethics.
v. Practical Experience: Internships, industry-sponsored projects, research projects with industry involvement.

OG-402: Term Paper (50 Marks)

Course Outcome:

- Students will write to demonstrate their understanding of a specific topic within their field of study.
- They will use powerful tools for data analysis, autonomous exploration, predictive modelling, and sustainable management of marine and coastal resources.
- They will prepare advanced form of Remote Sensing, GIS, AI and ML technologies and also expand their understanding of the ocean, coast and addressing critical environmental challenges.

OG-403: Research Dissertation (Examination) (50 Marks)

Course Outcome:

- The individual student able to identify a small research problem, and try to generate a solution of the problem.
- Dissertation consisting of relevance of the problem to be studied and its aims and objectives, methodology adopted to study such problem.
    - Chapter Scheme:
        - Problem Identification
        - Objective
        - Review of Literature
        - Database and Methodology
        - Result and Discussion
        - Conclusion

OG-404: Research Dissertation (Viva-Voce) (50 Marks)

- Presentation on satisfactory completion of the taught component of the course, students will normally proceed to the M.Sc. research dissertation which must be completed by the end of fourth semester.
- This should be a substantial piece of research work, which both reinforces the skills learned in the taught component of the course and provides a genuine opportunity to undertake valuable research.
- Each student is required to defend his/her thesis through a presentation in front of an external expert and faculty and students.

OG-405: Skill Enhance Course (25 Marks):

Full Marks 25. At least even number of periods to be assigned (preferably in batches). Pattern of setting questions: 25 marks compulsory questions are to be set. 25 marks are to be allotted for evaluation of practical notebook and viva-voce. Right-hand side parentheses indicate lecture / demonstration hours.

- It will help individuals improve existing skills or acquire new ones, with a focus on practical application and employability.
- These courses often include hands-on training or fieldwork.
- They can be found across various fields, including leadership, management, personal finance, digital marketing, and more.

OG-406: Grand-Viva (50 Marks)

- Grand viva will be based on the overall understanding of the subject in front of external and internal examiner.

LISTS OF BIBLIOGRAPHY/REFERENCES:

Semester-I (Theory)

OG-101: Fundamental Concept of Oceanography and Ocean Optics:

1. Descriptive Physical Oceanography: An Introduction.Ed.6, Lynne D. Talley, George L. Pickard, William J. Emery and James H. Swift, Elsevier, 2011.
2. Introduction to Physical Oceanography: R. H. Stewart, E-book, 2005
3. Denny, M. (2008). *How the ocean works: an introduction to oceanography*. Princeton University Press.
4. Neumann, G. and Pierson, W.J., 1966. Principles of Physical Oceanography. Coastal Ocean Optics and Dynamics, Volume 17, Issue 2 of JARE data reports: Oceanography, Oceanography Society, 2009.
5. Colour of Inland and Coastal waters -A methodology for its interpretation: Dimitry Pozdnyakov and Hartmut, Springer with Praxis Publishing, UK, 2003.
6. Light Absorption in Sea Water, By Bogdian Wozniak, Jerzy Dera, Springer, 2014.
7. Ocean Biogeochemical Dynamics, J. L. Sarmiento and Nicholas Gruber, Princeton University Press, 2006.
8. Peter McRoy, C. and G. Helferich, 1977, Seagrass Ecosystems. A Scientific Perspective. Marcel Dekker Inc., New York.
9. Pillai, N.K. 1986. Introduction to Planktonology. Himalaya Publ. House.
10. Ocean Biogeochemical Dynamics, J. L. Sarmiento and Nicholas Gruber, Princeton University Press, 2006.
11. Spinrad, R. W., Carder, K. L., & Perry, M. J. (1994). *Ocean optics*. Oxford University Press.
12. Shifrin, K. S. (1998). *Physical optics of ocean water*. Springer Science & Business Media.
13. Lalli, C., & Parsons, T. R. (1997). *Biological oceanography: an introduction*. Elsevier.
14. Watson, J., & Zielinski, O. (Eds.). (2013). *Subsea optics and imaging*. Elsevier.

OG-102: Physics of Remote Sensing and Fundamental of GIS:

1. Joseph, George, (2003), Fundamental of Remote Sensing, University Press (India) Pvt. Ltd, Orient Longman Pte. Ltd., Hyderabad, India.
2. Jensen J.R. (2007) Remote Sensing of the Environment: An Earth Resource Perspective, 2nd ed., Prentice Hall.
3. Jensen J.R. (2005) Digital Image Processing: A Remote Sensing Perspective, 3rd ed., Prentice Hall.
4. Campbell J.B. (2002) Introduction to Remote Sensing, 3rd ed., the Guilford Press.
5. Burrough, Peter A. and Rachael McDonnell, 1998, 'Principles of Geographical Information Systems' Oxford University Press, New York.
6. Chakraborty and Sahoo, 2008, Fundamentals of Geographic Information Systems, Viva Books Private Limited, India.
7. C.P.Lo and Albert K.W.Yeung 2005 "Concepts and Techniques of Geographic Information Systems" Prentice Hall of India,New Delhi.

OG-103: Introduction to Operational Oceanography:

1. Garrison, T.S. (2007): Oceanography: An Introduction to Marine Science, Prentice Hall. 6th Edition, Brooks Cole, Chicago.
2. Lal, D. S., 2003. Oceanography, 3rd Edn. 288p.

1. Modeling atmospheric and oceanic flows, Larcher, Thomas von, American Geophysical Union, 2013.
3. Modeling coastal and marine processes by Phil Dyke, Imperial College Press 2016.
4. Modeling Marine Systems: A M Davies, CRC Press, 1989Wave Energy – A Design Challenge: R. Shaw, Ellis Horwood Ltd, 1982.
2. Modelling and Prediction of the Upper Layers of the Ocean. Kraus, E. B, Pergamon Press, 1977.
5. Modelling Coastal and Marine Processes. Phil Dyke, Prentice Hall, 2016.
3. Numerical Modelling of Ocean Circulation. Cambridge, Robert N. Miller, 2007.
4. Numerical Modelling of Ocean Dynamics. Kowalik Z. & T. S. Murthy, World Scientific, 1995.
6. Ocean Circulation and Climate: Observing and Modelling the Global Ocean. International Geophysical Series, Vol. 77, Gerold Sielder, John church and Jon Gould, Academic Press, 2001.
7. Ocean modelling and parameterization. Chassignet, E. P., & Verron, J. (Eds.), Springer Science & Business Media, 2012.
8. Singh, S. (2008): Oceanography, Prayag Pustakalaya, Allahabad.

OG-104: Indian Knowledge System (IKS):

1. Mahadevan, B., Bhat, V. R., & NAGENDRA, P. R. (2022). Introduction to Indian knowledge system: concepts and applications.
2. Khan, S., & Sharma, M. (2024). An Overview on Indian Knowledge System. *Integrated Journal for Research in Arts and Humanities*, *4*(4), 42-46.
3. Mohanapriya, B., & Suriya, M. (2025). *Indian knowledge systems: Principles and practices*. SSS PUBLICATIONS.
4. Mohanapriya, B., & Suriya, M. (2025). *Indian knowledge systems: Principles and practices*. SSS PUBLICATIONS.
5. Thapliyal, P. (2023). Indian Knowledge Systems in the Curriculum of Higher Education: A Proposed Model of a PG Course in IKS. *International Journal of Research Publication and Reviews. 2582-7421: 4 (7)*, 3296-3301.

OG-105: Biography and Education of Vidyasagar:

1. Hatcher, B. A. (2014). Vidyasagar: The Life and After-life of an Eminent Indian. Routledge India.
2. Mandal, K. R., & Pal, S. K. (2021). A STUDY OF RELEVANCE OF VIDYASAGAR ON HIS BICENTENARY. Jamshedpur Research Review.
3. Banerjee, A., & Kendra, B. V. C. (2019). Was Vidyasagar a Failure as A Social Reformer?. ResearchGate, retrieved on https://www. researchgate. net/publication/338409566_Was_Vidyasagar_a_Failure_as_A_Social_Reformer https://en. wikipedia. org/wiki/Ishwar_Chandra_Vidyasagar.

Semester-I (Practical)

OG-106: Conventional Surveying and Remote Sensing & GIS (Practical):

1. Hussain, S.K. and Nagaraj, M.S. 1992: Text Book of Surveying, S. Chand & Co. Ltd., New Delhi:
2. Kanetkar, T.P. and Kulkatni, S. V. 1988: Surveying and Levelling, Part I, Pune Vidyarthi Griha Prakashan, Pune: 608p.
3. Terry-Karen Steede, 2002, Integrating GIS and the Global Positioning System, ESRI Press.

4. Gopi, S. (2007). *Advanced surveying: total station, GIS and remote sensing*. Pearson Education India.
5. Joseph, George, (2003), Fundamental of Remote Sensing, University Press (India) Pvt. Ltd, Orient Longman Pte. Ltd., Hyderabad, India.
6. Jensen J.R. (2007) Remote Sensing of the Environment: An Earth Resource Perspective, 2nd ed., Prentice Hall.
7. Jensen J.R. (2005) Digital Image Processing: A Remote Sensing Perspective, 3rd ed., Prentice Hall.

OG-107: Ocean Optics and Coding in Oceanography (Practical)

1. Colour of Inland and Coastal waters -A methodology for its interpretation: Dimitry Pozdnyakov and Hartmut, Springer with Praxis Publishing, UK, 2003.
2. Light Absorption in Sea Water, By Bogdian Wozniak, Jerzy Dera, Springer, 2014. Spinrad, R. W., Carder, K. L., & Perry, M. J. (1994). *Ocean optics*. Oxford University Press.
3. Shifrin, K. S. (1998). *Physical optics of ocean water*. Springer Science & Business Media.
4. Watson, J., & Zielinski, O. (Eds.). (2013). *Subsea optics and imaging*. Elsevier.
5. Kelley, D. E. (2018). *Oceanographic analysis with R*. New York, NY, USA: Springer.
6. Thomson, R. E., & Emery, W. J. (2024). *Data analysis methods in physical oceanography*. Elsevier.
7. Wunsch, C. (2015). *Modern observational physical oceanography: understanding the global ocean*. Princeton University Press.

Semester-II (Theory)

OG-201: Coastal Processes and Coastal Hazards:

1. Bird, E. C. (2011). *Coastal geomorphology: an introduction*. John Wiley & Sons.
2. Woodroffe, C. D. (2002). *Coasts: form, process and evolution*. Cambridge University Press.
3. Paul, A., 2002. Coastal Geomorphology and Environment, ACB Publications, Kolkata, 582p.
4. Beaches Processes and Sedimentation: P D Komar, Prentice Hall, 2nd Edn., 1997.
5. Pethic, J., 1983. An Introduction to Coastal Geomorphology, Arnold Publishers.
6. Carter, R. W. G., 1989. Coastal Environments: An Introduction to Physical, Ecological and Cultural Systems of Coastlines, Academic Press Ltd.
7. Robert, K. and Alder, J. 2005. Coastal Planning and Management. 2nd edn. CRC Press, ISBN-13: 978-0415317733, 400 p.
8. Waves, tides and shallow-water processes. Open University Oceanography Series Vol.4. Oxford: Pergamon Press in association with the Open University, 187 pp., 1989.
9. Sediment transport in coastal waters; Sylvian Quillon; MDPI Publishers; 2019.
10. Environmental Hazards-Assessing Risk and Reducing Disasters: K. Smith, 5th Edn, Routledge, 2009.
11. Encyclopedia of Disaster Management: P. C. Sinha, Anmol, India, 2002.
12. Coastal environments and global change, Masselink, Gerd, Wiley-Blackwell, 2015.
13. Global Environmental Change: Past, Present and Future: Karl K. Turekian, Prentice Hall; 1st Edition, 1996.
14. Smith,K. (2004): Environmental Hazards, Assessing Risk and reducing Disaster, 4th Edition, Routledge, London.

15. Paul, A., 2005. Tsunami-an assessment of disasters, ACB Publications, Kolkata, 125p.
16. Smith,K.(2004):Environmental Hazards, Assessing Risk and reducing Disaster, 4th Edition, Routledge, London.
17. Smith, K. (1996). Environmental hazards: assessing risk and reducing disaster.
18. Alexander, D. (1993): *Natural Disasters*, Research Press, New Delhi: 619p.
19. Hazardous Materials Disaster Management-Arunkumar Talwar, Coomnwealth Publisher.

OG-202: Introduction to Machine Learning and Artificial Intelligence (AI):

1. Linear Algebra and Its Application, 3rd Edition, David C. Lay.
2. The C++ Programming Language by Bjarne Stroustrup, Pearson Education.
3. Introduction to Computer Programming using Python, John V Guttag.
4. Optimization Concepts and Applications in Engineering, Belegundu. Machine Learning, Tom M. Mitchell.
5. Building Machine Learning Systems with Python, Richert & Coelho Lillesand, T.M.
6. Kieffer, R.W., 2003. Remote Sensing and Image Interpretation, 5th Edition., Wiley, New York.
7. Artificial Intelligence: A Modern Approach, Stuart Russel, Peter Norvig.
8. Artificial Intelligence, 2nd Edition, Rich and Knight.
9. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, Prentice-Hall.
10. Norvig, P. R., & Intelligence, S. A. (2002). A modern approach. *Prentice Hall Upper Saddle River, NJ, USA: Rani, M., Nayak, R., & Vyas, OP (2015). An ontology-based adaptive personalized e-learning system, assisted by software agents on cloud storage. Knowledge-Based Systems*, *90*, 33-48.
11. Nils J. Nilsson, Artificial Intelligence: A New Sythesis, Morgan-Kaufmann.
12. Russell &Norvig, Artificial Intelligence-A Modern Approach, LPE, Pearson Prentice Hall, 2nd edition, 2005.
13. DAN.W. Patterson, Introduction to A.I and Expert Systems – PHI, 2007.
14. Ivan Bratko, Prolog Programming for Artificial Intelligence, Addison-Wesley, Pearson Education, 3rd edition, 2000.

OG-203: Ocean Geology and Digital Image Processing:

1. Eugen Seibold, Wolfgang Berger. 2017. The Sea Floor: An Introduction to Marine Geology. Springer International Publishing.272 pp.
2. Jon Erickson, Timothy, Ph.D. Kusky. 2002. Marine Geology: Exploring the New Frontiers of the Ocean. Facts on File 333 pp.
3. Kennish, M. J., 2001. Practical Handbook of Marine Science, Third Edition. CRC Press: 876 pp.
4. Pond, S., and Pickard. G.L. 1983. Introductory Dynamical Oceanography. 2nd ed. Pergamon Press, Oxford: 329 pp.
5. Introductory Dynamic Oceanography: S Pond & G L Pickard, 2nd Edn. Pergamon, 1983.
6. Jensen J.R. (2007) Remote Sensing of the Environment: An Earth Resource Perspective, 2nd ed., Prentice Hall.
7. Jensen J.R. (2005) Digital Image Processing: A Remote Sensing Perspective, 3rd ed., Prentice Hall.
8. Nag P. and Kudrat M. Digital Remote Sensing New Delhi: Concept Publishing.
9. Bonham Carter G.F (1994) GIS for Geoscientists: Modeling with GIS Pergamon Publications.

10. Methods of Satellite Oceanography: Robert H.Stewart, University of California Press, 1985.
11. Ocean Colour Remote Sensing in Polar Seas. Edited by Babin, M., Arrigo, K., Bélanger, S. and Forget, M-H. (pp. 129).
12. Ocean-Colour Observations from a Geostationary Orbit. Edited by David Antoine, pp. 102.
13. Remote Sensing of Ocean Colour in Coastal, and Other Optically-Complex, Waters. Edited by Shubha Sathyendranath, pp. 140.
14. Status and Plans for Satellite Ocean-Colour Missions: Considerations for Complementary Missions. Edited by James A. Yoder, pp. 43.

OG-204: Geospatial Science and Web GIS (MOOC):

1. Reed, C. N. (2011). The open geospatial consortium and web services standards. In *Geospatial Web Services: Advances in Information Interoperability* (pp. 1-16). IGI Global Scientific Publishing.
2. Hatzopoulos, J. N., & Hatzopoulos, D. J. (2024). *Topographic Mapping: Covering the Wider Field of Geospatial Information Science & Technology (GIS&T)*. Universal-Publishers.
3. Petras, V., Petrasova, A., Harmon, B., Meentemeyer, R. K., & Mitasova, H. (2015). Integrating free and open source solutions into geospatial science education. *ISPRS International Journal of Geo-Information*, *4*(2), 942-956.
4. Yue, P. (2013). *Semantic web-based intelligent geospatial web services* (Vol. 48). New York, NY, USA: Springer.
5. Chakraborty, D., Sarkar, D., Agarwal, S., Dutta, D., & Sharma, J. R. (2015). Web based GIS application using open source software for sharing geospatial data. *international journal of advanced remote sensing and gis*, *4*(1), 1224-1228.
6. Scharl, A., & Tochtermann, K. (Eds.). (2009). *The geospatial web: how geobrowsers, social software and the Web 2.0 are shaping the network society*. Springer Science & Business Media.
7. Kraak, M. J., & Ormeling, F. (2020). *Cartography: visualization of geospatial data*. CRC Press.
8. Atzmanstorfer, K., & Blaschke, T. (2013). The geospatial web: A tool to support the empowerment of citizens through E-participation?. In *Citizen e-Participation in urban governance: Crowdsourcing and collaborative creativity* (pp. 144-171). IGI Global Scientific Publishing.

Semester-II (Practical)

OG-205: Ocean-Atmospheric Data and Satellite Image Processing: (Practical):

1. Walford, P.,1995: Geographical Data Analysis, John Wiley and Sons Inc., New York
2. Richards J.A. and Jia X. (2006) Remote Sensing Digital Image Analysis: An Introduction, 4th ed., Springer.
3. Jensen J.R. (2007) Remote Sensing of the Environment: An Earth Resource Perspective, 2nd ed., Prentice Hall.
4. Jensen J.R. (2005) Digital Image Processing: A Remote Sensing Perspective, 3rd ed., Prentice Hall.
5. Marshall, J., & Plumb, R. A. (1961). *Atmosphere, ocean and climate dynamics: an introductory text* (Vol. 2). Academic Press.
6. Krasnopolsky, V. M. (2013). Atmospheric and Oceanic Remote Sensing Applications. In *The Application of Neural Networks in the Earth System Sciences: Neural*

Networks Emulations for Complex Multidimensional Mappings (pp. 47-79). Dordrecht: Springer Netherlands.
7. Barale, V., Gower, J. F., & Alberotanza, L. (Eds.). (2010). *Oceanography from space: revisited*. Springer Science & Business Media.
8. Xie, S. P. (2022). *Coupled atmosphere-ocean dynamics: From El Niño to climate change*. elsevier.

OG-206: Geodesy and Machine Learning/Artificial Intelligence (Practical):

1. Lu, Z., Qu, Y., & Qiao, S. (2014). Geodesy. *Introduction to Geodetic Datum and Geodesy*.
2. Hooijberg, M. (2012). *Practical geodesy: using computers*. Springer Science & Business Media.
3. Teunissen, P. J., & Kleusberg, A. (Eds.). (2012). *GPS for Geodesy*. Springer Science & Business Media.
4. Xu, G. (Ed.). (2010). *Sciences of geodesy* (pp. 83-85). Berlin, Germany: Springer.
5. Ogaja, C. A. (2022). *Introduction to GNSS Geodesy*. Cham, Switzerland: Springer.
6. Ping, D. (2024). *The Machine Learning Solutions Architect Handbook: Practical strategies and best practices on the ML lifecycle, system design, MLOps, and generative AI*. Packt Publishing Ltd.
7. Sharma, D.D. (2002). Geo-statistics with application in Earth Sciences, Capital Publ.
8. Introduction to Computer Programming using Python, John V Guttag.
9. Artificial Intelligence: A Modern Approach, Stuart Russel, Peter Norvig.
10. Gopi, S. (2005). *Global positioning System: Principles and applications*. Tata McGraw-Hill Education.
11. Optimization Concepts and Applications in Engineering, Belegundu. Machine Learning, Tom M. Mitchell.

Semester-III (Theory)

OG-301: Coastal Zone, Climate Change and Disaster Management:

1. Brahtz, J.F.P. 1972. Coastal Zone Management. UN Department of International Economic & Social Affairs, New York.
2. Coastal Zone Management: D R Green, Thomas Telford Pub., 2009.
3. Relationships between Coastal Sea Level and Large Scale Ocean Circulation, Ponte, R.M., Meyssignac,B., Domingues, C., Stammer, D., Cazenave, A & Lopez, T. (Eds.), Springer, ISBN 9783-030-45633-7, 2020.
4. Coastal Zones: Solutions for the 21st Century, Baztan, Juan, Elsevier, 2015.
5. Estuary and Coastline Hydrodynamics: A T Ippen, McGraw Hill, 1966.
6. Clark, J.R. 1992.Integrated Management of Coastal Zones. FAO Fisheries Tech. Paper No. 327, FAO, Rome.
7. Environmental Hazards-Assessing Risk and Reducing Disasters: K. Smith, 5th Edn, Routledge, 2009.
8. Encyclopedia of Disaster Management: P. C. Sinha, Anmol, India, 2002.
9. Coastal environments and global change, Masselink, Gerd, Wiley-Blackwell, 2015.
10. Global Environmental Change: Past, Present and Future: Karl K. Turekian, Prentice Hall; 1st Edition, 1996.
11. Herr, D. and Galland, G.R. 2009. The Ocean and Climate Change. Tools and Guidelines for Action. IUCN, Gland, Switzerland. ISBN: 978-2-8317-1201-7, 72 p.
12. Coley, D.2008. Energy and Climate Change: Creating a Sustainable Future, Wiley and Sons, Chichester, UK, 656 p.

OG-302: Research Methodology and Ethics:

1. Kothari, C. R., 1985. Research Methodology: Methods and Techniques, New Age International Pvt. Ltd.
2. Murthy, C., 2009, Research Methodology, Vrinda Publications Ltd.
3. Ahuja, R., 2010. Research Methods, Rawat Publication.
4. Mishra, R. C. and Soota, T., 2005, Modern Project Management, New Age International Ltd.
5. W.E. Huxold & A.G. Lerinsons Aronoft.S.(1989) Managing Geographic Information Projects.
6. Berkun, Scott (2005). Art of Project Management. Cambridge, MA: O'Reilly Media.
7. Earickson, R, and Harlin, J. (1994) Geographic Measurement & Quantitative Analysis, Macmillan, New York.

OG-303: Elective Special Paper:

[i] OG-303A: Physical Oceanography:

1. Descriptive Physical Oceanography: An Introduction.Ed.6, Lynne D. Talley, George L. Pickard, William J. Emery and James H. Swift, Elsevier, 2011.
2. Principles of Physical Oceanography: G.Neumann & WJ Pierson, Jr., Prentice Hall,1st edn.,1966.
3. Introduction to Physical Oceanography: R. H. Stewart, E-book, 2005.
4. Introduction to Physical Oceanography, Third edition, John A. Knauss and Newell Garfield, Waveland press, Inc., 2017.
5. Descriptive Physical Oceanography, Reddy, M. P. M., 2000, New Delhi Oxford & IBH.
6. Stewart, R. H. (2008). Introduction to physical oceanography.
7. Neumann, G. and Pierson, W.J., 1966. Principles of Physical Oceanography. Prentice-Hall Inc., New Jersey Norton W.H., 2004. The Elements of Geology. Kessinger Publishing. 272pp.

[ii] OG-303B: Chemical Oceanography:

1. The Oceans, their Physics, Chemistry and General Biology, H.U. Sverdrup, Prentice Hall, 1969.
2. Ocean Biogeochemical Dynamics, J. L. Sarmiento and Nicholas Gruber, Princeton University Press, 2006.
3. Ocean Biogeochemistry, the Role of the Ocean Carbon Cycle in Global Change Editors: Fasham, Michael J.R. (Ed.), Springer, 2003.
4. Biogeochemistry of Estuaries, Thomas S. Bianchi, Cambridge University Press, 2014.
5. Millero, F. J. (2005). *Chemical oceanography* (Vol. 30). CRC press.
6. Biogeochemistry of Marine Systems, Kenneth D. Black, Graham B. Shimmield, Wiley, 384pp. 2009.
7. Nitrogen in the Marine Environment, Douglas G Capone, Deborah A Bronk, Margaret R Mulholland, Edward J Carpenter, Elsevier, 2008.

[iii] OG-303C: Geoinformatics and AI&ML in Operational Oceanography:

1. Schiller, A., Mourre, B., Drillet, Y., & Brassington, G. (2018). Overview of operational oceanography. *New frontiers in operational oceanography*, 1-26.
2. Schiller, A., & Brassington, G. B. (Eds.). (2011). *Operational oceanography in the 21st century*. Springer Science & Business Media.

3. Le Traon, P. Y. (2011). Satellites and operational oceanography. In *Operational oceanography in the 21st century* (pp. 29-54). Dordrecht: Springer Netherlands.
4. Pillai, N.K. 1986. Introduction to Planktonology. Himalaya Publ. House.
5. Sournia, A. 1978. Phytoplankton Manual. UNESCO Publ.
6. Stephen J. Hawkins (ed.). 2019. Interactions in the Marine Benthos - Global Patterns and Processes. Cambridge University Press.
7. Checkley, D. M., Alheit, J., Oozeki, Y., & Roy, C. (2009). *Climate change and small pelagic fish*.
8. Sumich, J.L. 1999. Introduction to the Biology of Marine Life. 7th edn., The McGraw Hill Companies Inc.
9. Colin Reynolds, David Thomas, Peter Williams. 2002. Phytoplankton Productivity: Carbon Assimilation in Marine and Freshwater Ecology.402 pp.
10. Goswami, S.C. 2004. Zooplankton Methodology, Collection & identification - A field manual. NIO Goa.
11. I.S. Robinson, (1985): Satellite Oceanography- An Introduction for Oceanographers and Remote Sensing Scientists.
12. Seelye Martin (2014): An Introduction to Ocean Remote Sensing, 2nd Edition, Cambridge Press.
13. Motoyoshi Ikeda and Frederic W. Dobson (1995): Oceanographic Applications of Remote Sensing, CRC Press,USA.

[iv] OG-303D: Advanced Remote Sensing, GIS and AI/ML:

1. Joseph, George, (2003), Fundamental of Remote Sensing, University Press (India) Pvt. Ltd, Orient Longman Pte. Ltd., Hyderabad, India.
2. Jensen J.R. (2007) Remote Sensing of the Environment: An Earth Resource Perspective, 2nd ed., Prentice Hall.
3. Jensen J.R. (2005) Digital Image Processing: A Remote Sensing Perspective, 3rd ed., Prentice Hall.
4. Campbell J.B. (2002) Introduction to Remote Sensing, 3rd ed., the Guilford Press.
5. Burrough, Peter A. and Rachael McDonnell, 1998, 'Principles of Geographical Information Systems' Oxford University Press, New York.
6. Chakraborty and Sahoo, 2008, Fundamentals of Geographic Information Systems, Viva Books Private Limited, India.
7. C.P.Lo and Albert K.W.Yeung 2005 "Concepts and Techniques of Geographic Information Systems" Prentice Hall of India,New Delhi.
8. Kieffer, R.W., 2003. Remote Sensing and Image Interpretation, 5th Edition., Wiley, New York.
9. Jensen J.R. (2007) Remote Sensing of the Environment: An Earth Resource Perspective, 2nd ed., Prentice Hall.
10. Jensen J.R. (2005) Digital Image Processing: A Remote Sensing Perspective, 3rd ed., Prentice Hall.
11. Nag P. and Kudrat M. Digital Remote Sensing New Delhi: Concept Publishing.
12. Bonham Carter G.F (1994) GIS for Geoscientists: Modeling with GIS Pergamon Publications.
13. Methods of Satellite Oceanography: Robert H.Stewart, University of California Press, 1985.
14. Ocean Colour Remote Sensing in Polar Seas. Edited by Babin, M., Arrigo, K., Bélanger, S. and Forget, M-H. (pp. 129).

[v] OG-303E: Geological Oceanography:

1. Jon Erickson, Timothy, Ph.D. Kusky. 2002. Marine Geology: Exploring the New Frontiers of the Ocean. Facts on File 333 pp.
2. Kennish, M. J., 2001. Practical Handbook of Marine Science, Third Edition. CRC Press: 876 pp.
3. Arnold. 2002: Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford Univ. Press, New York.
4. Kennett, J.P., 1982: Laboratory Excercises in Oceanography Marine Geology, Prentice Hall.
5. Seibold, E. and Berger, W.H., 1982: The Sea Floor, Springer-Verlag.
6. Shepard, F.P., 1963: Submarine Geology, Harper Row.
7. Komar, P.D., 1976: Beach processes and sedimentation, Prentice Hall.
8. Thurman, H.V., Trujillo, A.P., Abe, D.C. and McConnell, R., 1999. Essentials of oceanography. Upper Saddle River, NJ: Prentice Hall.
9. Eugen Seibold, Wolfgang Berger. 2017. The Sea Floor: An Introduction to Marine Geology. Springer International Publishing.272 pp.
10. Pond, S., and Pickard. G.L. 1983. Introductory Dynamical Oceanography. 2nd ed. Pergamon Press, Oxford: 329 pp.
11. Introductory Dynamic Oceanography: S Pond & G L Pickard, 2nd Edn. Pergamon, 1983.
12. Ocean Currents, G Neumann, Elsevier Publishing Company, 1968.
13. Essentials of Atmospheric and Ocean Dynamics. Geoffrey K. Vallis, Cambridge University Press, 2019.
14. The Dynamic Method in Oceanography, L M Fomin, Elsevier Applied Science, 1964.
15. Ocean circulation in three dimensions, Barry A. Klinger and Thomas W.N. Haine, Cambridge University Press, 2019.

[vi] OG-303F: Geoinformatics and AI&ML in Coastal Management:

1. Coastal Zone Management: D R Green, Thomas Telford Pub., 2009.
2. Brahtz, J.F.P. 1972. Coastal Zone Management. UN Department of International Economic & Social Affairs, New York.
3. Estuary and Coastline Hydrodynamics: A T Ippen, McGraw Hill, 1966.
4. Clark, J.R. 1992.Integrated Management of Coastal Zones. FAO Fisheries Tech. Paper No. 327, FAO, Rome.
5. Estuary and Coastline Hydrodynamics: A T Ippen, McGraw Hill, 1966.
6. Beaches Processes and Sedimentation: P D Komar, Prentice Hall, 2nd Edn., 1997.
7. Paul, A., 2002. Coastal Geomorphology and Environment, ACB Publications, Kolkata, 582p.
8. Pethic, J., 1983. An Introduction to Coastal Geomorphology, Arnold Publishers.
9. Carter, R. W. G., 1989. Coastal Environments: An Introduction to Physical, Ecological and Cultural Systems of Coastlines, Academic Press Ltd.
10. Woodroffe, C. D. (2002). Coasts: form, process and evolution. Cambridge University Press.
11. Paul, A., 2002. Coastal Geomorphology and Environment, ACB Publications, Kolkata, 582p.
12. Smith,K. (2004): Environmental Hazards, Assessing Risk and reducing Disaster, 4th Edition, Routledge, London.
13. Coastal Hydrodynamics, Mani.J.S, PHI Pvt Ltd. New Delhi, 2012.
14. Sediment transport in coastal waters; Sylvian Quillon; MDPI Publishers; 2019.

15. Beaches and Coasts: R A Davis & D M Fitzgerald, Wiley Blackwell, 2004.

OG-304: MSD 011: Sustainability Science (MOOC):

1. De Vries, B. J. (2023). *Sustainability science*. Cambridge University Press.
2. König, A., & Ravetz, J. (Eds.). (2017). *Sustainability science: Key issues*. Routledge.
3. Ramirez-Montoya, M. S. (2020). MOOCs and OER: Developments and contributions for open education and open science. In *Radical solutions and Open Science: An open approach to boost higher education* (pp. 159-175). Singapore: Springer Singapore.
4. Bacelar-Nicolau, P., & Caeiro, S. (2019). Massive open online courses (MOOCs) and their role in climate change education. In *Climate Action* (pp. 680-698). Cham: Springer International Publishing.
5. Sosa-Díaz, M. J., & Fernández-Sánchez, M. R. (2020). Massive open online courses (MOOC) within the framework of international developmental cooperation as a strategy to achieve sustainable development goals. *Sustainability*, *12*(23), 10187.
6. Russell, A. (2014). Research resource review:'Introduction to Sustainability–a massive open online course (MOOC)'.
7. Delgado-Algarra, E. J., Román Sánchez, I. M., Ordóñez Olmedo, E., & Lorca-Marín, A. A. (2019). International MOOC trends in citizenship, participation and sustainability: Analysis of technical, didactic and content dimensions. *Sustainability*, *11*(20), 5860.
8. Carrera, J., & Ramírez-Hernández, D. (2018). Innovative education in MOOC for sustainability: Learnings and motivations. *Sustainability*, *10*(9), 2990.

Semester-III (Practical)

OG-305: Geo-statistics and Digital Cartography (Practical):

1. Pal, S. K. (1998). *Statisttics for Geoscientists Techniques and Applications*. Concept Publishing Company.
2. Chiles, J.P. (1999). Geo-statistics: Modelling spatial uncertainty, Wiley Interscience Publ.
3. Longley, P. and Batty, M. (eds.), 1996, Spatial Analysis: Modelling in a GIS Environment, Geoinformation International, Cambridge, 392pp.
4. Pal, S.K. 1999: Statistics for Geoscientists, Concept publishing Company, New Delhi
5. Journel, A. G., & Journel, A. G. (1989). *Fundamentals of geostatistics in five lessons* (Vol. 8). Washington, DC: American Geophysical Union.
6. Zhang, Y. (2011). Introduction to Geostatistics—Course Notes. *Dept. of Geology & Geophysics, University of Wyoming*, 6.
7. Hengl, T., Minasny, B., & Gould, M. (2009). A geostatistical analysis of geostatistics. *Scientometrics*, *80*(2), 491-514. Global Navigation Satellite Systems: Insights into GPS, GLONASS, Galileo, Compass and Others by Basudeb Bhatta, CRC Press.
8. GNSS – Global Navigation Satellite Systems, GPS, GLONASS, Galileo, and more by Hofmann-Wellenhof, Bernhard, Lichtenegger, Herbert, Wasle, Elmar, SPRINGER.
9. Introduction to GPS: The Global Positioning System, by Ahmed El-Rabbany, ARTECH House.
10. Robinson A.H. & Morrison J.L, (1995) Elements of Cartography, John Wiley & Sons
11. Keates, J.S. (1973): Cartographic Design and production, London, Longman.
12. Lillesand, T.M.and Kieffer, R.W., 2003.RemoteSensingandImageInterpretation,5th Edition., Wiley, New York.
13. Campbell J.B. (2002) Introduction to Remote Sensing, 3rd ed., the Guilford Press.

OG-306: Coastal and Ocean Modelling (Practical):

1. Modeling coastal and marine processes by Phil Dyke, Imperial College Press 2016.
2. Modelling and Prediction of the Upper Layers of the Ocean. Kraus, E. B, Pergamon Press, 1977.
3. Modelling Coastal and Marine Processes. Phil Dyke, Prentice Hall, 2016.
4. Numerical Modelling of Ocean Circulation. Cambridge, Robert N. Miller, 2007.
5. Numerical Modelling of Ocean Dynamics. Kowalik Z. & T. S. Murthy, World Scientific, 1995.
6. Agarwal, C.S. and Garg, P.K. 2000. Text book on Remote Sensing in Natural Resources Monitoring and Management. Wheeler Publishing, New Delhi.
7. Martin, S. 2004. An Introduction to Ocean remote sensing, Cambridge University Press.
8. Lilisand, M. 2003. Remote sensing and image interpretation, John Wiley and Sons.

Semester-IV

OG-401: Industry Readiness:

1. Beddie, F., Creaser, M., Hargreaves, J., & Ong, A. (2014). *Readiness to meet demand for skills: a study of five growth industries*. Adelaide: National Centre for Vocational Education Research.
2. Agca, O., Gibson, J., Godsell, J., Ignatius, J., Davies, C. W., & Xu, O. (2017). An Industry 4 readiness assessment tool.
3. Deka, B., Vani, K. N., Chatarajupalli, S., Manisha, Singh, A., & Sarma, K. V. R. S. (2014, September). Essential IT Skills to Learning Community for Industry Readiness. In *Proceedings of the International Conference on Transformations in Engineering Education: ICTIEE 2014* (pp. 179-189). New Delhi: Springer India.
4. Romanov, L. (2020). MODEL OF FORMATION OF READINESS OF FUTURE SKILLD WORKERS OF THE AUTOMOTIVE INDUSTRY FOR APPLICATION OF INNOVATIVE PRODUCTION TECHNOLOGIES. *Znanstvena Misel*, (49-2), 38-42.
5. Siddique, S., Ahsan, A., Azizi, N., & Haass, O. (2022). Students' workplace readiness: Assessment and skill-building for graduate employability. *Sustainability*, *14*(3), 1749.

OG-402: Term paper:

1. Alam, M., Khan, I. R., Siddiqui, F., & Alam, M. A. (2024). Artificial Intelligence as Key Enabler for Safeguarding the Marine Resources. In *Artificial Intelligence and Edge Computing for Sustainable Ocean Health* (pp. 409-451). Cham: Springer Nature Switzerland.
2. Dhanak, M. R., & Xiros, N. I. (Eds.). (2016). *Springer handbook of ocean engineering*. Springer.
3. Teshaev, N., Makhsudov, B., Ikramov, I., & Mirjalalov, N. (2024). Advances and Prospects in Machine Learning for GIS and Remote Sensing: A Comprehensive Review of Applications and Research Frontiers. In *E3S Web of Conferences* (Vol. 590, p. 03010). EDP Sciences.
4. Bharambe, S. N., Mathew, M. S., Khan, M. A., & Deore, R. R. (2024). GIS & Remote Sensing: Recent Trends and Applications.
5. Selmy, S. A., Kucher, D. E., & Moursy, A. R. (2025). Integrating Remote Sensing, GIS, and AI Technologies in Soil Erosion Studies.

OG-403: Research Dissertation:

1. Kothari, C. R., 1985. Research Methodology: Methods and Techniques, New Age International Pvt. Ltd.

2. Mishra, R. C. and Soota, T., 2005, Modern Project Management, New Age International Ltd.
3. W.E. Huxold & A.G. Lerinsons Aronoft.S. (1989) Managing Geographic Information Projects.
4. Berkun, Scott (2005). Art of Project Management. Cambridge, MA: O'Reilly Media.
5. Markel M. (1994) Writing in the Technical Fields: A Step-by-Step Guide for Engineers, Scientists and Technicians, publisher.

OG-404: Research Dissertation (Viva-Voce):

1. Lewis, James (2002). Fundamentals of Project Management, 2nd ed., American Management Association.
2. Markel M. (1994) Writing in the Technical Fields: A Step-by-Step Guide for Engineers, Scientists and Technicians, publisher.
3. Meredith, Jack R. and Mantel, Samuel J. (2002). Project Management: A Managerial Approach, 5th ed., Wiley. ISBN 0-471-07323-7.