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 the 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.) programme aims to develop postgraduate students who are highly competent, well-informed, and capable of consulting the evolving demands of their professional fields. The key programme outcomes for M.Sc. graduates include:

- ***Advanced Knowledge:*** Graduates acquire comprehensive and in-depth understanding of their discipline, covering theoretical concepts, practical applications, and emerging developments.
- ***Research Capability:*** Students build strong research skills that enable them to design, conduct, and analyse scientific investigations using modern methodologies and critical thinking.
- ***Technical Expertise:*** Training in advanced tools and technologies strengthens their analytical ability and problem-solving skills.
- ***Effective Communication:*** Graduates learn to present complex ideas clearly and concisely in both written and oral forms for specialist and non-specialist audiences.
- ***Ethical Responsibility:*** The programme promotes professional integrity and adherence to ethical standards and regulations in all professional activities.
- ***Professional Skills:*** Graduates develop the ability to work independently and collaboratively, manage projects efficiently, and make informed decisions based on expert knowledge.
- ***Innovation and Creativity:*** The curriculum encourages critical thinking and innovation, enabling students to develop original solutions to discipline-related challenges.
- ***Lifelong Learning:*** Graduates are prepared to continually update their knowledge and skills, ensuring adaptability and ongoing professional growth.

These outcomes equip graduates to perform successfully in their careers while contributing to the progress of their disciplines and addressing wider societal needs.

Programme Specific Outcomes (PSO)

The Master of Science (M.Sc.) in *"Ocean Geomatics with AI"* is designed to provide students with a strong foundation of knowledge and practical skills, enabling them to pursue diverse careers and advanced research in the geospatial domain in Ocean science. The key program outcomes are as follows:

- ***Technical Expertise:*** Graduates acquire advanced knowledge 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 Competence:*** Students develop the ability to analyze complex spatial problems using geospatial technologies. They learn to combine multiple data sources and apply both quantitative and qualitative analytical methods.
- ***Problem-Solving Skills:*** The program encourages students to plan and execute the application of 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 Proficiency:*** Graduates are prepared to conduct independent research using advanced tools and methodologies. They learn to design research proposals, manage projects, and present findings in a clear and organized manner.
- ***Technological Adaptability:*** Students become familiar with the latest version of remote sensing GIS software, AI/ML tools, ensuring they remain up to date with evolving technologies and industry demands.
- ***Communication Ability:*** The program emphasizes effective communication, enabling graduates to present complex geospatial information clearly to scientists, policymakers, and the public.
- ***Professional Growth:*** The course prepares students for careers in government, academia, private industry, and non-profit organizations while promoting ethical practice and lifelong professional development.
- ***Teamwork and Leadership:*** Collaborative projects and dissertations with government agencies and research institutions provide valuable experience in teamwork, coordination, and leadership.

Overall, the program ensures that graduates enter the workforce as skilled remote sensing, GIS and AI/ML professionals who can contribute innovatively and responsibly to their fields.

DIVISION OF MARKS

Total Marks: 1100

SEM-I Marks: 275

SEM-II Marks: 275

SEM-III Marks: 275

SEM-IV Marks: 275

Theoretical Marks: 475 (SEM-I: 150; SEM-II: 175; SEM-III: 150)

Practical Marks: 350 (SEM-I: 125; SEM-II: 100; SEM-III: 125)

Research Dissertation (Examination): 100 marks (SEM-IV)

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

Skill Enhancement Course/Term Paper: 25 (SEM-IV)

Grand-Viva: 100 marks (SEM-IV)

Important Note:

- The intake capacity for each special/elective paper in Semester III will be determined by the Departmental Committee prior to the start of Semester III classes.
- A minimum of 60% is required for First Class and 50% for Second Class; there will be no Third Class. The minimum passing marks are 25 for Theory and 26 for Practical.
- Fieldwork and community engagement are mandatory for students in Semesters I and III.
- Internal assessment will be conducted through seminar presentations, class tests, quizzes, and assignments.
- Students will be given a maximum of five months in Semester IV to complete their dissertation and all practical papers.
- Students may visit their field study areas during the dissertation period at their own expense.
- Dissertation work may need to be carried out at an outstation institution, also at the student's own expense.
- The Grand Viva will assess the student's overall understanding of the subject.

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	OGAC401X0	Fundamental Concept of Oceanography and Ocean Optics	50	40	4 (2-2-0)
	OGAC402X0	Physics of Remote Sensing and Fundamental of GIS	50	40	4 (2-2-0)
	OGAC403X0	Introduction to Operational Oceanography	25	20	2 (1-1-0)
	OGAO404VC	Indian Knowledge System (IKS)	25	20	2 (1-1-0)
	OGAO405NC	Life and Philosophy of Vidyasagar	Non-Credit		
		Practical			
	OGAC406X9	Conventional Surveying and Remote Sensing & GIS (Practical)	50	80	4 (0-0-4)
	OGAC407X9	Ocean Optics and Coding in Oceanography (Practical)	50	80	4 (0-0-4)
	OGAC408X9	Compulsory Field Survey (Practical)	25	20	2 (0-0-2)
	Total		**275**	**300**	**22**

Semester	Course No.	Course Titles	Full Marks	No. of Lectures (hours)	Credits (Lecture-Tutorial-Practical) (L-T-P)
Sem-II	OGAC451X0	Coastal Processes and Coastal Hazards	25	20	2 (1-1-0)
	OGAC452X0	Advance Operational Oceanography	50	40	4 (2-2-0)
	OGAC453X0	Geological Oceanography and Digital Image Processing	50	40	4 (2-2-0)
	OGAC454X0	Introduction to Machine Learning and Artificial Intelligence (AI)	50	40	4 (2-2-0)
		Practical			
	OGAC455X9	Ocean Data Analysis and Image Processing (Practical)	50	80	4 (0-0-4)
	OGAC456X9	Advanced Remote Sensing & GIS (Practical)	50	80	4 (0-0-4)
	Total		**275**	**300**	**22**

Semester	Course No.	Course Titles	Full Marks	No. of Lectures (hours)	Credits (Lecture-Tutorial-Practical) (L-T-P)
Sem-III	OGAO501X0	Massive Open Online Courses (MOOC)/SWAYAM	50	40	4 (2-2-0)
	OGAC502X0	Coastal Zone, Climate Change and Disaster Management	25	20	2 (1-1-0)
	OGAC503X0	Research Methodology and Ethics	25	20	2 (1-1-0)

	OGAE504 A-F (OGAE504A-OGAE509F)	Elective/Special Papers (Any One): *i. OGAE504A: Physical Oceanography;* *ii. OGAE505B: Chemical Oceanography;* *iii. OGAE506C: Geoinformatics and AI&ML in Operational Oceanography;* *iv. OGAE507D: Advanced Remote Sensing, GIS and AI/ML.* *v. OGAE508E: Geological Oceanography.* *vi. OGAE509F: Geoinformatics and AI&ML in Coastal Management*	50	40	4 (2-2-0)
		Practical			
	OGAC510X9	Geodesy and Geo-statistics (Practical)	50	80	4 (0-0-4)
	OGAC511X9	Ocean and Coastal Modelling (Practical)	50	80	4 (0-0-4)
	OGAC512X9	Industry and or Field Visit (Practical)	25	20	2 (1-1-0)
	Total		**275**	**300**	**22**
Semester	**Course No.**	**Course Titles**	**Full Marks**	**No. of Lectures (hours)**	**Credits (Lecture-Tutorial-Practical) (L-T-P)**
Sem-IV	OGAC551X9	Research Dissertation (Examination)	100	140	8 (0-0-8)
	OGAC552X9	Research Dissertation (Viva-Voce)	50	80	4 (0-0-4)
	OGAC553X9	Skill Enhancement Course/Term Paper	25	40	2 (0-0-2)
	OGAC554X9	Grand-Viva	100	40	8 (0-0-8)
	Total		**275**	**300**	**22**
GRAND TOTAL			**1100**	**1200**	**88**

STRUCTURE OF THE SYLLABUS (SEM-I)

SEMESTER-I: Theoretical Papers: 05; Elective Papers: Nil; Practical: 03.

Course Code	Title of the Papers	Marks Division			Theoretical / Practical	Credits	Exam. Time
		Internal Assessment	Examination	Total Marks			
OGAC401X0	Fundamental Concept of Oceanography and Ocean Optics	10	40	50	Theory	4	2 hrs.
OGAC402X0	Physics of Remote Sensing and Fundamental of GIS	10	40	50	Theory	4	2 hrs.
OGAC403X0	Introduction to Operational Oceanography	05	20	25	Theory	2	2 hrs.
OGAO404VC	Indian Knowledge System (IKS)	05	20	25	Theory	2	1 hrs.
OGAO405NC	Life and Philosophy of Vidyasagar	00	25		Theory	Non-Credit	1 hrs
OGAC406X9	Conventional Surveying and Remote Sensing & GIS	Notebook + Viva-Voce = 10; Practical = 40		50	Practical	4	4 hrs.
OGAC407X9	Ocean Optics and Coding in Oceanography	Notebook + Viva-Voce = 10; Practical = 40		50	Practical	4	4 hrs.
OGAC408X9	Compulsory Field Survey	Field Report + Viva-Voce = (15+10) = 25		25	Practical	2	4 hrs.
Total				**275**		**22**	**20**

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			
OGAC451X0	Coastal Processes and Coastal Hazards	05	20	25	Theory	2	1 hrs.
OGAC452X0	Advance Operational Oceanography	10	40	50	Theory	4	2 hrs.
OGAC453X0	Geological Oceanography and Digital Image Processing	10	40	50	Theory	4	2 hrs.
OGAC454X0	Introduction to Machine Learning and Artificial Intelligence (AI)	10	40	50	Theory	4	2 hrs.
OGAC455X9	Ocean Data Analysis and Image Processing	Notebook + Viva-Voce = 10; Practical = 40		50	Practical	4	4 hrs.
OGAC456X9	Advanced Remote Sensing & GIS (Practical)	Notebook + Viva-Voce = 10; Practical = 40		50	Practical	4	4 hrs.
Total				**275**		**22**	**15**

STRUCTURE OF THE SYLLABUS (SEM-III)

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

Course Code	Title of the Paper	Marks Division			Theoretical/ Practical	Credits	Exam. Time
		Internal Assessment	Examination	Total Marks			
OGAO 501X0	Massive Open Online Courses (MOOC)/SWAYAM	10	40	50	Theory	4	2 hrs.
OGAC502X0	Coastal Zone, Climate change and Disaster Management	05	20	25	Theory	2	1 hrs.
OGAC503X0	Research Methodology and Ethics	05	20	25	Theory	2	1 hrs.
OGAE504 A-F (OGAE 504A-OGAE509F)	Elective Special Papers (Any One)	10	40	50	Theory	4	2 hrs.
OGAC510X9	Geodesy and Geo-statistics	Notebook + Viva-Voce = 10; Practical = 40		50	Practical	4	4 hrs.
OGAC511X9	Ocean and Coastal Modelling	Notebook = 30 and Viva-Voce = 20		50	Practical	4	4 hrs.
OGAC512X9	Industry and or Field Visit	Field Report + Viva-Voce = (15+10) = 25		25	Practical	2	4 hrs.
Total				**275**		**22**	**18**

STRUCTURE OF THE SYLLABUS (SEM-IV)

SEMESTER-IV: Core Papers: 00; Elective Papers: Nil; Practical: 04

Course Code	Title of the Paper	Marks Division			Theoretical/ Practical	Credits	Exam. Time
		Internal Assessment	Examination	Total Marks			
OGAC551X9	Research Dissertation (Examination)	00	100	100	Practical	8	4 hrs.
OGAC552X9	Research Dissertation (Viva-Voce)	00	50	50	Practical	4	4 hrs.
OGAC553X9	Skill Enhancement Course/Term Paper	00	25	25	Practical	2	4 hrs.
OGAC554X9	Grand-Viva	00	100	100	Practical	8	4 hrs.
Total				**275**		**22**	**16**

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

i. OGAE504A: Physical Oceanography;
ii. OGAE505B: Chemical Oceanography;
iii. OGAE506C: Geoinformatics and AI&ML in Operational Oceanography;
iv. OGAE507D: Advanced Remote Sensing, GIS and AI/ML.
v. OGAE508E: Geological Oceanography.
vi. OGAE509F: Geoinformatics and AI&ML in Coastal Management

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

Distinctive features of course content:

- **Value-added course:** OGAC406X9, OGAC407X9, OGAC451X0, OGAC502X0, OGAC511X9.
- **Employability / entrepreneurship/ skill development:** OGAC407X9, OGAC408X9, OGAC452X0, OGAC453X0, OGAC454X0, OGAC455X9, OGAC456X9, OGAC512X9, OGAC401X0, OGAC402X0, OGAC403X0.
- **Ethics, environment & sustainability:** OGAC401X0, OGAC403X0, OGAC501X0, OGAE503A-F.
- **The new course introduced:** OGAO404VC, OGAO405NC, OGAC454X0, OGAO501X0, OGAC553X9.
- **Field Survey (academic excursion):** OGAC408X9**,** OGAC512X9**,** OGAC551X9**,** OGAC553X9**.**
- **Internship (optional):** OGAC551X9**,** OGAC553X9**.**

SEMESTER-I PAPER

Semester-I (Theory)

OGAC401X0: (*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: Six questions of 2 marks, six questions of 4 marks, four questions of 8 marks are to be set. Four questions of 2 marks, four questions of 4 marks, two questions of 8 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.

OGAC401X0: 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)

OGAC402X0: (*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: Six questions of 2 marks, six questions of 4 marks, four questions of 8 marks are to be set. Four questions of 2 marks, four questions of 4 marks, two questions of 8 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.

OGAC402X0: 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)

OGAC403X0: (*EXAMINATION TIME: 2 HOURS)*

Introduction to Operational Oceanography (25 Marks)

Full Marks 25. Number of lectures to be delivered for this paper is 20. Pattern of setting questions: Four questions of 2 marks, four questions of 4 marks, two questions of 8 marks are to be set. Two questions of 2 marks, two questions of 4 marks, one questions of 8 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

OGAC403X0: 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 (5 Marks)

OGAO404VC: (*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 2 marks, four questions of 4 marks, two questions of 8 marks are to be set. Two questions of 2 marks, two questions of 4 marks, one questions of 8 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

OGAO404VC: 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)

OGAO405NC: (*EXAMINATION TIME: 2 HOURS)*

Life and Philosophy of Vidyasagar (25 Marks) Non-Credit

Full Marks 25. Number of lectures to be delivered for this paper is 20 Approx. Pattern of setting questions: Seven questions of 2 marks, five questions of 3 marks, are to be set. Five questions of 2 marks, three questions of 5 marks one are to be answered from this module.

Course Outcome:

- Students will learn a blended approach combining traditional texts with modern subjects, using a vernacular (Bengali) medium of instruction.
- They also learn a methodology involved making education of Ishwar Chandra Vidyasagar's which is more accessible, practical, and relevant by introducing English, Western sciences, and mathematics alongside classical texts.
- They also emphasize the study of biography, history, and geography, and made education more engaging and child-friendly through simplified language and relevant texts.

OGAO405NC: Life and Philosophy of Vidyasagar:

i. Early Life and Education: Birth and Lineage; A journey from Iswar Chandra Bondopadhaya to Iswar Chandra Vidyasagar.

ii. Vidyasagar and Indian Education: The then Indian education system; Vidyasagarian plan for reformation of Indian education-Vidyasagar as teacher, Vidyasagar as writer. Planner, and reformer of Indian education.
iii. Vidyasagar and Women Emancipation: Introduction of widow remarriage; Struggle to stop child marriage.
iv. Philanthropist Vidyasagar: Vidyasagar's philanthropy as narrated by others; Vidyasagar: Tradition; Modernity and Vidyasagar as Traditional Moderniser.
v. Relevance of Vidyasagar Thoughts and Values: Vidyasagar and the then Society of Bengal; Lesson for future generations.

Semester-I (Practical)

OGAC406X9: 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.

OGAC406X9: 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.

OGAC407X9: 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.

OGAC407X9: 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 Automatic Satellite Data Processing Chain (ADPC) in Bio optics.
iii. Mathematical and Statistical Methods: linear algebra, probability, and statistics, providing the mathematical background for oceanographic modelling.
iv. Oceanographic Data Analysis: Focus on techniques for analyzing various types of oceanographic data (temperature, salinity, currents, etc.)
v. Data structures, syntax and data types, control Structures, Conditional statements, Loops of Python programming. Defining and calling functions, Modules and packages, Importing and using libraries.

OGAC408X9: PRACTICAL (*EXAMINATION TIME: 4 HOURS)*

Compulsory Field Survey (25 Marks)

Full Marks 25. At least even number of periods to be assigned (preferably in batches). Pattern of setting questions: 15 marks are to be allotted for evaluation of practical notebook and 10 marks for viva-voce. Right-hand side parentheses indicate lecture / demonstration hours.

Course Outcome:

- Students will able to conduct several respondent surveys including questionaries sheet and prepare communication skill.
- They will also prepare base map from Survey of India Toposheets and delineate various topographical features.
- They will operate hand held GPS receiver different processing tools and make capability to integrate the database in different GIS platforms.

OGAC408X9: Compulsory Field Survey:

Field survey and field report preparation (compulsory) using following methods:

i. Preparation of Base map from Survey of India Toposheets, Use of India topographical sheets for delineation of different features.
ii. Introduction to a GPS and initial setting, creating codes and attribute table for GPS receiver, Point Data collection using GPS with different datum, Line data collection using GPS and measurements, GPS data collection for area calculation, Post processing of the GPS data, creating attribute table in GPS software and Export functions, GPS and GIS integrations output preparation.
iii. Field validation of satellite imagery.
iv. Viva voce and Report presentation.

SEMESTER-II PAPER

Semester-II (Theory)

OGAC451X0: (*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 2 marks, four questions of 4 marks, two questions of 8 marks are to be set. Two questions of 2 marks, two questions of 4 marks, one questions of 8 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.

OGAC451X0: 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)

OGAC452X0: (*EXAMINATION TIME: 2 HOURS)*

Advance Operational Oceanography (50 Marks)

Full Marks 50. Number of lectures to be delivered for this paper is 40. Pattern of setting questions: Six questions of 2 marks, six questions of 4 marks, four questions of 8 marks are to be set. Four questions of 2 marks, four questions of 4 marks, two questions of 8 marks are to be answered from this module.

Course Outcome:

- Students will analyse satellite and in-situ observational systems related to ocean and coast.
- Students will understand the principles of operational oceanography, ocean information services, early warnings and forecasting system.
- Students will develop preliminary knowledge on ocean data modelling, product validation, data assimilation techniques.
- Students will develop knowledge how to develop operational products for fisheries, disaster warning, marine pollution, and coastal zone management.

OGAC452X0: Advance Operational Oceanography:

i. Satellite and in-situ observational system (ARGO floats, ADCP, drifters, different buoy network etc.)
ii. Satellite Oceanography, Satellite Altimetry, Ocean data analysis**,** Ocean modelling and Data Assimilation
iii. Ocean Services related to Ecology, Livelihood, Sea safety, Disaster, Marine Pollution, Coastal Zone Management etc.
iv. Early Warnings on Tsunami, Cyclone and Storm Surge, Ocean State Forecasting.
v. Fishery services, Oil spill modelling, Waves and Tides forecasting etc.

Internal Assessment (10 Marks)

OGAC453X0: (*EXAMINATION TIME: 2 HOURS)*
Geological Oceanography and Digital Image Processing (50 Marks)

Full Marks 50. Number of lectures to be delivered for this paper is 40. Pattern of setting questions: Six questions of 2 marks, six questions of 4 marks, four questions of 8 marks are to be set. Four questions of 2 marks, four questions of 4 marks, two questions of 8 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.

OGAC453X0: Geological Oceanography 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, radiometric and atmospheric correction.
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 and coastal studies, integration and linkage of digital image with ocean and coastal information services.

Internal Assessment (10 Marks)

OGAC454X0: (*EXAMINATION TIME: 2 HOURS)*
Introduction to Machine Learning and Artificial Intelligence (AI) (50 Marks)

Full Marks 25. Number of lectures to be delivered for this paper is 20. Pattern of setting questions: Six questions of 2 marks, six questions of 4 marks, four questions of 8 marks are to be set. Four questions of 2 marks, four questions of 4 marks, two questions of 8 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.

OGAC454X0: Introduction to Machine Learning and Artificial Intelligence (AI):

i. Introduction of Machine Learning Algorithms, data classification, Linear Regression, Logistic Regression, Neural Networks, Support Vector Machines, Recommender Systems.
ii. Introduction to artificial intelligence, background and applications, problems of AI techniques (State Space Search and Heuristic Search Techniques), knowledge representation issues using predicate logic as rules.
iii. Probability and Bayes Theorem, Certainty factors, Probabilistic Graphical Models, Bayesian Networks, Markov Networks, Fuzzy Logic, Symbolic Logic under Uncertainty.
iv. Use of scikit-learn Python library for various machine learning tasks like classification (supervised & unsupervised) and regression analysis of satellite imagery and spatial data
v. Exploration of various model validation metrics such as RMSE, F-score, confusion matrix, precision & accuracy.

Internal Assessment (10 Marks)

Semester-II (Practical)

OGAC455X9: PRACTICAL (*EXAMINATION TIME: 4 HOURS)*
Ocean Data Analysis and 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 skills on remote sensing and other forms of data in reliable techniques for the better identification ocean / coastal measures.
- They will also classify the satellite data methodically to represent various oceanographic and coastal features changeability in their environment.
- They will also upgrade their skills on algorithm-based model development, validation, assimilation and development of ocean and coastal services for societal and commercial benefits.

OGAC455X9: Ocean Data Analysis and Image Processing:

i. Introduction to Ocean Data (temperature, salinity, currents, sea level, chlorophyll, etc.) collected from various sources of data (satellites, buoys, ships, Argo floats, models), common data formats (CSV, NetCDF)
ii. Data Collection and Quality Control (Basic principles of ocean data collection, errors estimation, data cleaning and quality control methods

iii. Data Visualization, plotting time series, creating vertical profiles, mapping spatial data, Basic use of graphs and charts, Statistical Analysis Mean, median, standard deviation, Trends and variability, Correlation and simple regression using Software Tools and Case Studies using real ocean data and mini project.

iv. Creation of ROI/AOI, Sub-setting, mosaicking, spectral signature curve, feature extraction, image enhancement (Histogram, contrast, filtering, data scaling) and transformation.

v. Satellite image classification techniques (supervised, unsupervised, support vector machine, object-based classification & Spectral Angle Mapper), accuracy assessment, error matrix, kappa statistics and change detection analysis.

OGAC456X9: PRACTICAL (*EXAMINATION TIME: 4 HOURS)*

Advanced 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:

- They will learn to interpret and apply geospatial techniques to map, analyze, and model natural hazards, disasters and cyclones for risk assessment and management.
- Students will apply skills to access, integrate, and analyze diverse geospatial data, enabling the creation of meaningful information layers for solving spatial problems and supporting decision-making.
- They will utilize advanced techniques of Remote Sensing and GIS methods to develop proficiency in atmospheric and radiometric correction, image enhancement, filtering techniques for multispectral and hyperspectral data processing.
- Students will develop practical knowledge on ocean and coastal data analysis, modelling, product validation, data assimilation techniques.

OGAC456X9: Advanced Remote Sensing & GIS:

i. Thermal and Microwave: Thermal properties and preparation/interpretation of LST & SST Imagery, RADAR and LiDAR operation, relief displacement, shadows and speckle effect, Synthetic Aperture Radar (SAR), differential interferometry.

ii. Hyperspectral & Multispectral Data Processing: Atmospheric & bad band corrections, information extraction, Endmember collection, Minimum Noise Fraction, Pixel Purity Index, image arithmetic operations.

iii. Spatial analysis: Preparation of slope, aspect, drainage, contour plan, network analysis, proximity, buffer, topology, overlay & SQL. Application of multidimensional and statistical operations tools (DBMS, RDBMS, SDSS, conversion, layering).

iv. Digital cartography: Cartographic design and visual variables, map lettering, map composition, map scales, integrations and output preparation.

v. Advanced photogrammetry: Elements, interpretation, stereo pair of aerial photographs. Creation of TIN, DEM, DSM, DTM. UAV flight planning (altitude, overlap, GSD calculation).

SEMESTER-III PAPER

Semester-III (Theory)

OGAO501X0: (*EXAMINATION TIME: 2 HOURS)*
Massive Open Online Courses (MOOC)/SWAYAM (50 Marks)

Full Marks 50. Number of lectures to be delivered for this paper is 40. Pattern of setting questions: Four questions of 2 marks, four questions of 4 marks, two questions of 8 marks are to be set. Two questions of 2 marks, two questions of 4 marks, one questions of 8 marks are to be answered from this module.

OGAO501X0: Massive Open Online Courses (MOOC)/SWAYAM:

Students are required to complete a 4-credit, post-graduate (PG) level MOOC. The specific course must be selected from the available offerings on the SWAYAM platform for the current academic session.

Internal Assessment (10 Marks)

OGAC502X0: (*EXAMINATION TIME: 2 HOURS)*
Coastal Zone, Climate Change and Disaster Management (25 Marks)

Full Marks 50. Number of lectures to be delivered for this paper is 40. Pattern of setting questions: Four questions of 2 marks, four questions of 4 marks, two questions of 8 marks are to be set. Two questions of 2 marks, two questions of 4 marks, one questions of 8 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.

OGAC502X0: 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 (5 Marks)

OGAC503X0: (*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 2 marks, four questions of 4 marks, two questions of 8 marks are to be set. Two questions of 2 marks, two questions of 4 marks, one questions of 8 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.

OGAC503X0: 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)

OGAE504 A-F: (*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: Six questions of 2 marks, six questions of 4 marks, four questions of 8 marks are to be set. Four questions of 2 marks, four questions of 4 marks, two questions of 8 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.

OGAE504A-F: Elective Special Paper (Any One):

[i] OGAE504A: Physical Oceanography;
[ii] OGAE505B: Chemical Oceanography;
[iii] OGAE506C: Geoinformatics and AI&ML in Operational Oceanography;
[iv] OGAE507D: Advanced Remote Sensing, GIS and AI/ML;
[v] OGAE508E: Geological Oceanography;
[vi] OGAE509F: Geoinformatics and AI&ML in Coastal Management

[i] OGAE504A: 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] OGAE505B: 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] OGAE506C: 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] OGAE507D: 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] OGAE508E: 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] OGAE509F: 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)

Semester-III (Practical)

OGAC510X9: PRACTICAL (*EXAMINATION TIME: 4 HOURS)*

Geodesy and Geo-statistics (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 to understand the mathematical surface of the earth and Navigational satellite system.

OGAC510X9: Geodesy and Geo-statistics:

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. Fundamentals statistics of Z-Score, T-test, Correlation, Neighbourhood analysis and Principal Component analysis, moving average and cluster analysis.

iv. Zonal statistics, scatter plot, Bi-variate & multi variate correlation, linear regression, standard error estimation, significance level test and RMSE.

v. Role of interpolation techniques for surface modelling (IDW, kriging, topo to raster, spline and trend), Methods of Interpolation, types of kriging.

OGAC511X9: PRACTICAL (*EXAMINATION TIME: 4 HOURS)*

Ocean and Coastal 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 develop practical knowledge on ocean data analysis, modelling, product validation, data assimilation techniques.
- 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.

OGAC511X9: Ocean and Coastal Modelling:

i. Satellite Oceanography, Satellite Altimetry, Ocean data analysis**,** Ocean modelling, Data Assimilation and development of Ocean Services
ii. Machine learning analyses historical data to predict ocean features and development of ocean and coastal services.
iii. Coastal Processes: Machine learning models can predict sea level fluctuations and other coastal changes, which is vital for coastal management and infrastructure planning.
iv. Application of GIS with special reference to coastal vulnerability, disaster, risk, capacity building assessment and Coastal Regulatory Zone (CRZ) delineation and violation.
v. Shoreline dynamics and sediment transportation path assessment through transect method in the nearshore region.

OGAC512X9: PRACTICAL (*EXAMINATION TIME: 4 HOURS)*

Industry and or Field Visit (25 Marks)

Full Marks 25. At least even number of periods to be assigned (preferably in batches). Pattern of setting questions: 25 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 conduct several respondent surveys including questionaries sheet and prepare communication skill.
- They will also prepare base map from Survey of India Toposheets and delineate various topographical features.
- They will practically analyse real ocean data, develop model to generate ocean cervices, validate using real data and generate mini project report

OGAC512X9: Industry and or Field Visit:

Field survey and field report preparation (compulsory) using following methods:

v. Preparation of coastal Base map from Survey of India Toposheets, Use of India topographical sheets for delineation of different features.
vi. Introduction to a GPS and initial setting, creating codes and attribute table for GPS receiver, Point Data collection using GPS with different datum, Line data collection using GPS and measurements, GPS data collection for area calculation, Post processing of the GPS data, creating attribute table in GPS software and Export functions, GPS and GIS integrations output preparation.
vii. Satellite Oceanography, Satellite Altimetry, Ocean data analysis**,** Ocean modelling, Data Assimilation and development of Ocean Services.
viii. Field validation of satellite imagery.
ix. Viva voce and Report presentation.

SEMESTER-IV

OGAC551X9: Research Dissertation (Examination) (100 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

OGAC552X9: 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.

OGAC553X9: Skill Enhancement Course/Term Paper (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.
- 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.

OGAC554X9: Grand-Viva (100 Marks)

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

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Semester-I (Practical)

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OGAC407X9: 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.

OGAC408X9: Compulsory Field Survey (Practical)

1. Global Positioning System: Signals, Measurements, and Performance (Revised Second Edition) — Misra & Enge.
2. Global Positioning System: Principles And Applications: Satheesh Gopi (2017), Tata Mcgraw-Hill Publishing Company Limited.
3. GPS Principles and Applications: A.Ganesh & R. Narayanakumar (2019), Satish Serial Publishing House.
4. Kanetkar, T.P. and Kulkatni, S. V. 1.988: Surveying and Levelling, Part I, Pune VidyarthiGrihaPrakashan, Pune: 608p.
5. Berkun, Scott (2005). Art of Project Management. Cambridge, MA: O'Reilly Media.
6. Markel M. (1994) Writing in the Technical Fields: A Step-by-Step Guide for Engineers, Scientists and Technicians, publisher.

Semester-II (Theory)

OGAC451X0: 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. Alexander, D. (1993): *Natural Disasters*, Research Press, New Delhi: 619p.
18. Hazardous Materials Disaster Management-Arunkumar Talwar, Coomnwealth Publisher.

OGAC452X0: Advance Operational Oceanography:

1. Introduction to Satellite Oceanography - G.A. Maul.
2. Operational Oceanography: The Challenge for European Co-operation - Dahlin et al. (eds).
3. Coastal Zone Management - R.K. Sharma and G. Kulshrestha (www.incois.gov.in).

OGAC453X0: Geological Oceanography 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.

OGAC454X0: 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. Nils J. Nilsson, Artificial Intelligence: A New Sythesis, Morgan-Kaufmann.
11. Russell &Norvig, Artificial Intelligence-A Modern Approach, LPE, Pearson Prentice Hall, 2nd edition, 2005.
12. DAN.W. Patterson, Introduction to A.I and Expert Systems – PHI, 2007.
13. Ivan Bratko, Prolog Programming for Artificial Intelligence, Addison-Wesley, Pearson Education, 3rd edition, 2000.

Semester-II (Practical)

OGAC455X9: Ocean Data Analysis and 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. 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.
6. Xie, S. P. (2022). *Coupled atmosphere-ocean dynamics: From El Niño to climate change*. elsevier.

OGAC456X9: Advanced Remote Sensing & GIS (Practical):

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.

Semester-III (Theory)

OGAO501X0: Massive Open Online Courses (MOOC)/SWAYAM:

OGAC502X0: 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.

OGAC503X0: 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] OGAE504A: 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. 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] OGAE505B: 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. Biogeochemistry of Marine Systems, Kenneth D. Black, Graham B. Shimmield, Wiley, 384pp. 2009.
6. Nitrogen in the Marine Environment, Douglas G Capone, Deborah A Bronk, Margaret R Mulholland, Edward J Carpenter, Elsevier, 2008.

[iii] OGAE506C: 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. Sumich, J.L. 1999. Introduction to the Biology of Marine Life. 7th edn., The McGraw Hill Companies Inc.
8. Colin Reynolds, David Thomas, Peter Williams. 2002. Phytoplankton Productivity: Carbon Assimilation in Marine and Freshwater Ecology.402 pp.
9. Goswami, S.C. 2004. Zooplankton Methodology, Collection & identification - A field manual. NIO Goa.
10. I.S. Robinson, (1985): Satellite Oceanography- An Introduction for Oceanographers and Remote Sensing Scientists.
11. Seelye Martin (2014): An Introduction to Ocean Remote Sensing, 2nd Edition, Cambridge Press.
12. Motoyoshi Ikeda and Frederic W. Dobson (1995): Oceanographic Applications of Remote Sensing, CRC Press,USA.

[iv] OGAE507D: 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] OGAE508E: 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] OGAE509F: 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.
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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.

Semester-III (Practical)

OGAC510X9: Geodesy and Geo-statistics (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. Lu, Z., Qu, Y., & Qiao, S. (2014). Geodesy. *Introduction to Geodetic Datum and Geodesy*.
8. Hooijberg, M. (2012). *Practical geodesy: using computers*. Springer Science & Business Media.
9. Teunissen, P. J., & Kleusberg, A. (Eds.). (2012). *GPS for Geodesy*. Springer Science & Business Media.
10. Xu, G. (Ed.). (2010). *Sciences of geodesy* (pp. 83-85). Berlin, Germany: Springer.
11. Ogaja, C. A. (2022). *Introduction to GNSS Geodesy*. Cham, Switzerland: Springer.
12. Sharma, D.D. (2002). Geo-statistics with application in Earth Sciences, Capital Publ.
13. 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.
14. GNSS – Global Navigation Satellite Systems, GPS, GLONASS, Galileo, and more by Hofmann-Wellenhof, Bernhard, Lichtenegger, Herbert, Wasle, Elmar, SPRINGER.

15. Introduction to GPS: The Global Positioning System, by Ahmed El-Rabbany, ARTECH House.
16. Robinson A.H. & Morrison J.L, (1995) Elements of Cartography, John Wiley & Sons
17. Keates, J.S. (1973): Cartographic Design and production, London, Longman.
18. Lillesand, T.M.and Kieffer, R.W., 2003.RemoteSensingandImageInterpretation,5th Edition., Wiley, New York.
19. Campbell J.B. (2002) Introduction to Remote Sensing, 3rd ed., the Guilford Press.

OGAC511X9: 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. Introduction to Computer Programming using Python, John V Guttag.
4. Artificial Intelligence: A Modern Approach, Stuart Russel, Peter Norvig.
5. Optimization Concepts and Applications in Engineering, Belegundu. Machine Learning, Tom M. Mitchell.
6. Modelling Coastal and Marine Processes. Phil Dyke, Prentice Hall, 2016.
7. Numerical Modelling of Ocean Circulation. Cambridge, Robert N. Miller, 2007.
8. Numerical Modelling of Ocean Dynamics. Kowalik Z. & T. S. Murthy, World Scientific, 1995.
9. Agarwal, C.S. and Garg, P.K. 2000. Text book on Remote Sensing in Natural Resources Monitoring and Management. Wheeler Publishing, New Delhi.
10. Martin, S. 2004. An Introduction to Ocean remote sensing, Cambridge University Press.
11. Lilisand, M. 2003. Remote sensing and image interpretation, John Wiley and Sons.

OGAC512X9: Industry and Field Visit (Practical):

1. Denzin, N. K., & Lincoln, Y. S. (Eds.). (2011). *The Sage handbook of qualitative research*. sage.
2. Hillhouse, G. (2022). *Engineering in plain sight: An illustrated field guide to the constructed environment*. No Starch Press.
3. Rosenthal, M. (2016). Qualitative research methods: Why, when, and how to conduct interviews and focus groups in pharmacy research. *Currents in pharmacy teaching and learning*, *8*(4), 509-516.
4. Longhofer, J., Floersch, J., & Hoy, J. (2012). *Qualitative methods for practice research*. Oxford University Press.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.
5. Agca, O., Gibson, J., Godsell, J., Ignatius, J., Davies, C. W., & Xu, O. (2017). An Industry 4 readiness assessment tool.
6. 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.
7. Siddique, S., Ahsan, A., Azizi, N., & Haass, O. (2022). Students' workplace readiness: Assessment and skill-building for graduate employability. *Sustainability*, *14*(3), 1749.

Semester-IV (Practical)

OGAC551X9: Research Dissertation (Examination):

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.

OGAC552X9: 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.

OGAC553X9: Skill Enhancement Course/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.